Traditionally, the literature on transportation investment in developing countries has concentrated on the study of the relationships between socio-economic issues and investment and planning strategies in the sector; little attention has nevertheless been paid to the relation that exists between regulatory policies and transport investment in less developed countries. Poor understanding of this link has led in numerous instances to an incorrect diagnosis of transportation problems and to often unnecessary and/or inefficient investment outlays. In our opinion therefore, both international development agencies and financial institutions and national transport planning authorities in less developed countries would greatly benefit from a more comprehensive insight into the interrelationships that exist between regulatory policies and on how they affect investment in transportation in developing countries.

Chapter 1 will review previous work and advances in the analysis and evaluation of transport investment in less developed countries, and will investigate the relationships that exist between transportation regulation and investment in the sector.

Chapter 2 will review the different theories of economic regulation that have been established in the literature of public utility and will evaluate their applicability and adaptability to the regulation of the transport sector in less developed countries.

Chapter 3 will analyze the effects of both market and operating transportation regulations on the level, distribution and composition of investment in the sector in developing countries, with particular emphasis on the case of the Arab Republic of Egypt.

Finally, Chapter 4 will summarize the results and develop recommendations for future analysis and evaluation of transport investment strategies in the LDC's.
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title Page</td>
<td>1</td>
</tr>
<tr>
<td>Abstract</td>
<td>2</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>3</td>
</tr>
<tr>
<td>Table of Contents</td>
<td>4</td>
</tr>
<tr>
<td>List of Figures</td>
<td>8</td>
</tr>
<tr>
<td>List of Tables</td>
<td>9</td>
</tr>
<tr>
<td>1.0 INTRODUCTION</td>
<td>10</td>
</tr>
<tr>
<td>1.1 A Critical Appraisal of Previous Transport Investment Studies in Less Developed Countries</td>
<td>11</td>
</tr>
<tr>
<td>1.2 Purpose and Scope of this Study</td>
<td>15</td>
</tr>
<tr>
<td>2.0 THEORIES OF ECONOMIC REGULATION</td>
<td>17</td>
</tr>
<tr>
<td>2.1 Different Forms of Regulation</td>
<td>17</td>
</tr>
<tr>
<td>2.1.1 Market Regulations</td>
<td>17</td>
</tr>
<tr>
<td>2.1.2 Operating Regulations</td>
<td>20</td>
</tr>
<tr>
<td>2.2 The Public Interest Theory</td>
<td>25</td>
</tr>
<tr>
<td>2.2.1 The Basic Assumptions</td>
<td>25</td>
</tr>
<tr>
<td>2.2.2 Defining the Public Interest</td>
<td>26</td>
</tr>
<tr>
<td>2.2.2.1 The Case of Monopoly Pricing</td>
<td>27</td>
</tr>
<tr>
<td>2.2.2.2 The Case of Externalities</td>
<td>29</td>
</tr>
<tr>
<td>2.2.3 The Empirical Evidence</td>
<td>29</td>
</tr>
<tr>
<td>2.2.4 A Reformulation of the Public Interest Theory; The Theory of Public Management</td>
<td>30</td>
</tr>
<tr>
<td>2.2.5 A Further Reformulation of the Public Interest Theory</td>
<td>32</td>
</tr>
<tr>
<td>2.2.6 The Linkage Between the Public Interest Theory and the Underlying Political Structure</td>
<td>34</td>
</tr>
<tr>
<td>Section</td>
<td>Page</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>2.2.6.1 The Democratic State</td>
<td>36</td>
</tr>
<tr>
<td>2.2.6.2 The Totalitarian State</td>
<td>38</td>
</tr>
<tr>
<td>2.3 The Capture Theory of Regulation</td>
<td>38</td>
</tr>
<tr>
<td>2.3.1 The Marxist Formulation</td>
<td>39</td>
</tr>
<tr>
<td>2.3.2 The Classic Capture Theory of Regulation</td>
<td>39</td>
</tr>
<tr>
<td>2.4 The Economic Theory of Regulation</td>
<td>40</td>
</tr>
<tr>
<td>2.4.1 The Theory of Cartels and its Relation to the Economic Theory of Regulation</td>
<td>41</td>
</tr>
<tr>
<td>2.4.2 Differences Between the Economic Theory of Regulation and the Theory of Cartels in Relation to the Demand for Regulation</td>
<td>44</td>
</tr>
<tr>
<td>2.4.3 Differences Between the Economic Theory of Regulation and the Theory of Cartels in Relation to the Supply of Regulation</td>
<td>45</td>
</tr>
<tr>
<td>3.0 THE EFFECT OF REGULATION ON TRANSPORT INVESTMENT IN LESS DEVELOPED COUNTRIES</td>
<td>49</td>
</tr>
<tr>
<td>3.1 A Theory of Transport Regulation for Less Developed Countries</td>
<td>49</td>
</tr>
<tr>
<td>3.1.1 The Motives for Transportation Regulation in Developing Countries</td>
<td>49</td>
</tr>
<tr>
<td>3.1.2 The Costs of Regulation</td>
<td>53</td>
</tr>
<tr>
<td>3.2 The Egyptian Transportation Sector</td>
<td>54</td>
</tr>
<tr>
<td>3.3 The Effects of Market Regulation on Transport Investment in Developing Countries</td>
<td>66</td>
</tr>
<tr>
<td>3.3.1 The Averch-Johnson Hypothesis</td>
<td>68</td>
</tr>
<tr>
<td>3.3.1.1 Conclusions of the Averch-Johnson Hypothesis</td>
<td>68</td>
</tr>
<tr>
<td>3.3.1.2 The Empirical Evidence</td>
<td>70</td>
</tr>
<tr>
<td>3.3.1.3 Implications of the Averch-Johnson Theory for Transport Investment in Less Developed Countries</td>
<td>73</td>
</tr>
<tr>
<td>3.3.2 The Effects of Market Regulation on the Quality of Service</td>
<td>85</td>
</tr>
</tbody>
</table>
TABLE OF CONTENTS (continued)

3.3.2.1 Conclusions of the Level of Service Model ........................................ 86
3.3.2.2 Implications of the Effect of Market Regulation on Level of Service for Transportation Investment in Developing Countries ................................. 87

3.3.3 The Effects of Market Regulation on Technological Innovation ............ 92
    3.3.3.1 The Theory of Innovation and Regulation ........................................ 92
    3.3.3.2 Implications of the Theory for Transport Investment in Developing Countries ................................. 94

3.4 The Effects of Operating Regulations on Transportation Investment in Developing Countries .................................................. 97
    3.4.1 Axle Load and Total Truck Weight Limitations ..................................... 99
        3.4.1.1 Truck Weight and Pavement Deterioration ....................................... 101
        3.4.1.2 The Cost of Weight Limitations to Truck Operators ...................... 104
        3.4.1.3 Recommendations ................................................................. 105
    3.4.2 Truck Size Limitations ...................................................................... 108
        3.4.2.1 Straight Truck Versus Tractor Trailers ........................................ 108
        3.4.2.2 Single Versus Twin Trailer - Tractor Combinations ................... 114
        3.4.2.3 Recommendations ...................................................................... 118

4.0 SUMMARY AND CONCLUSIONS .................................................................. 122

REFERENCES ................................................................................................. 126

APPENDIX 1: The Social Cost of Monopoly ................................................... 130

        A2.1 The Single Market Model .............................................................. 138
        A2.2 The Multiple Market Case ............................................................ 143

APPENDIX 3: A Test of the Averch-Johnson Thesis Using the Transcendental-Logarithmic Production Function ............................................. 146
<table>
<thead>
<tr>
<th>Appendix</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPENDIX 4:</td>
<td>The Effects of Market Regulation on Quality of Service</td>
<td>152</td>
</tr>
<tr>
<td>APPENDIX 5:</td>
<td>The Effects of Market Regulation on Technological Innovation</td>
<td>157</td>
</tr>
<tr>
<td>APPENDIX 6:</td>
<td>Economies of Scale in the Provision of Transportation Services</td>
<td>160</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1</td>
<td>Cost of Structure of a Natural Monopoly</td>
<td>28</td>
</tr>
<tr>
<td>2-2</td>
<td>Political Transfer of the Public Interest Perception</td>
<td>35</td>
</tr>
<tr>
<td>3-1</td>
<td>The Averch-Johnson Thesis; Single Market Case</td>
<td>76</td>
</tr>
<tr>
<td>3-2</td>
<td>AASHO Road Test; Theoretical Pavement Near Curve, 9&quot; PCC Pavement</td>
<td>103</td>
</tr>
<tr>
<td>A1-1</td>
<td>Pricing in a Monopoly Market</td>
<td>131</td>
</tr>
<tr>
<td>A1-2</td>
<td>Monopoly Profits for Two Firms with Equal Degrees of Monopoly</td>
<td>133</td>
</tr>
<tr>
<td>A1-3</td>
<td>Differential Effects of Perfect Competition and Monopoly in a Market</td>
<td>135</td>
</tr>
<tr>
<td>A2-1</td>
<td>The Averch-Johnson Thesis; Single Market Case</td>
<td>142</td>
</tr>
</tbody>
</table>
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-1</td>
<td>Truck Fleet by Load Capacity</td>
<td>57</td>
</tr>
<tr>
<td>3-2</td>
<td>Truck Fleet by Type; 1973/74</td>
<td>59</td>
</tr>
<tr>
<td>3-3</td>
<td>Transport Volumes and Ton-KM by Mode</td>
<td>60</td>
</tr>
<tr>
<td>3-4</td>
<td>Type of Commodity Transported</td>
<td>62</td>
</tr>
<tr>
<td>3-5</td>
<td>Seibert; Survey Results</td>
<td>101</td>
</tr>
<tr>
<td>3-6</td>
<td>Seibert; Survey Results</td>
<td>109</td>
</tr>
<tr>
<td>3-7</td>
<td>Seibert; Survey Results</td>
<td>111</td>
</tr>
<tr>
<td>3-8</td>
<td>Seibert; Survey Results</td>
<td>112</td>
</tr>
<tr>
<td>3-9</td>
<td>Carrying Capacities and Fuel Use for Typical Combinations</td>
<td>116</td>
</tr>
<tr>
<td>3-10</td>
<td>Possible Percentage Savings in Truck Trips and Fuel Consumed in Hauling One Million Tons of Highway Freight in Various Truck Combinations</td>
<td>117</td>
</tr>
</tbody>
</table>
1. INTRODUCTION

The existence of a rather close correlation between transportation and socio-economic development is by now considered to be an axiom both in the case of developed and developing countries. The fact that comprehensive transportation investment programs are a necessary condition for overall economic development has been amply demonstrated by past experience in many less developed countries and by substantial overestimation of expected benefits of development programs which failed to take this factor into account and which obtained results that were rather modest when compared with the "a priori" benefit analysis.

As pointed out by Owen (1968) though, the dangers of excessive concern with the transport sector, and the consequent neglect of other complementary investment areas, should be emphasized. Improvements in the country's transportation network will not "per se" necessarily boost economic development if they are not complemented by additional investment in areas such as fertilizer and machinery production, irrigation, capital expansion, tax breaks, technical and credit assistance, training and education.

Improvements in the transport sector are therefore a necessary but
not sufficient condition for overall socio-economic development; on the one hand relative underinvestment vis-à-vis other sectors will considerably, if not totally, reduce the effectiveness of development programs; on the other hand relative overinvestment in transportation should be carefully avoided since it causes a major waste of scarce, high opportunity cost, capital resources.

Developing countries have traditionally invested a considerable share of their available capital in the transport sector; in 1977, for example, 14.8% of all lending by the World Bank and the International Development Association to developing countries was destined to the transport sector. Its share was second only to that of the agricultural sector which has generally been an important recipient of funds from these organizations in the past and which very often covers transport related investments such as rural road development programs. [World Bank (1977)]

The importance of the transport sector in less developed countries has also been amply recognized in the literature on transportation investment analysis and transport project evaluation where considerable effort has been devoted in recent years to the improvement and development of analytical tools on the subject.

1.1 A CRITICAL APPRAISAL OF PREVIOUS TRANSPORT INVESTMENT STUDIES IN LESS DEVELOPED COUNTRIES.

A review of the literature on transport investment in less developed countries [Irwin (1975)] shows that even though considerable work has been devoted to the analysis of the relationships between
socio-economic issues and investment and planning strategies in
the transportation sector and substantial advances have been made in
improving transport investment analysis methodologies, little attention
has been paid to the relation that exists between the institutional
and regulatory environment and investment in the transport sector in
developing countries. (1)

As a review of literature suggests, no significant body of
work exists presently on the analysis of the relationships that exist
between institutional and regulatory policies and investment in the
transportation sector in less developed countries; most transport
investment studies in LDC's have been conducted in an institutional
and regulatory "vacuum". This isolation of the transport sector from
institutional and regulatory issues has led in numerous instances to
an incorrect diagnosis of transportation problems and to often un-
necessary and/or inefficient investment outlays.

As a result, both national transport institutions and inter-
national lending and development agencies have realized the importance
of becoming involved not only in the funding and evaluation of new
investment projects involving construction of infrastructure but,
in addition, in the analysis of the institutional and regulatory (as
well as socio-economic) issues and process that have made these invest-
ment outlays necessary.

In our opinion, therefore, both international development agencies
and financial institutions and national transport planning authorities
would greatly benefit from a more comprehensive insight into the links
that exist between regulatory structures and investment strategies
in the sector.
There are basically two questions that are very relevant in the analysis of these links:

- To what extent have transport regulations contributed to present shortcomings and problems in the system and how have they affected past investment strategies?

- What will be the impact of specific changes in regulations on transport investment decisions?

The first question relates to the fact that the appearance of bottlenecks and deficiencies in the transportation network cannot be solely attributed to a shift in demand determined by socio-economic development or to scarcity of available capital resources. Very often the argument is made in developing countries that these bottlenecks could be avoided, or at least considerably reduced, if only planning capabilities in the sector were improved and sufficient capital investment funds made available.

The fact is that capital resources are scarce in developing, as well as in developed, countries; the problem is therefore not one of expanding resource availability exclusively but, rather, one of improving the allocation of existing capital inputs so as to minimize present and future bottlenecks. Naturally, better planning should contribute to an improved allocation process; but it is important to realize that it will do so only to the extent that its results are reflected in the government's transportation policies and regulatory structure.
It is therefore important to identify, in addition to deficiencies in transportation planning, the discrepancies between stated transport planning objectives and existing regulatory structures that have led to the development of problems in the transportation system. Considerable insight into this question can be thus gained from an "ex post" analysis of how regulations have affected transport investment in less developed countries and how this effect has contributed to existing transportation shortcomings.

Once the nature of this relationship is established, the impact of specific changes in regulations on transport investment decisions can be anticipated; it is then possible to add a new regulatory dimension to the analysis of transport investment problems. This dimension can be developed for any particular transport deficiency along the following lines:

- What regulations, if any, have contributed to the development of the problem?
- Is direct government investment really needed to improve the situation or would a change in regulations suffice to generate private investment that would correct the problem?
- What regulatory changes should be made so as to affect investment decisions in a way that would preclude the recurrence of the problem?
- What are investment areas and directions could be created by a better understanding of the
1.2 PURPOSE AND SCOPE OF THIS STUDY

This study will primarily focus on the analysis of both market and operating regulatory policies and on how they may affect transportation investment in developing countries.

Chapter 2 will review the different theories of economic regulation that have been established in the literature of public utility regulation and will evaluate their applicability and adaptability to the regulation of the transport sector in less developed countries. In particular, we will cover the public interest theory and several of its reformulations, the capture theory of regulation and the economic theory of regulation.

Chapter 3 will analyze the effects of market regulation on capital/output ratios, market expansion, level of service and technological innovation in transportation and will particularly concentrate on the application of the obtained theoretical results to railroad-truck competition in Egypt. In addition, the issues involved in the implementation of three operating regulations - axle load limitations, total truck weight limits and truck size specifications will be considered.

Finally, Chapter 4 will summarize the results and develop recommendations for future analysis and evaluation of transport investment strategies in LDC's.
2.0 THEORIES OF ECONOMIC REGULATION

2.1 DIFFERENT FORMS OF REGULATION

Regulations in general and transport regulations in particular can be usually classified in two main categories: those designed to affect primarily the structure and other characteristics of the market in which the firms operate - market regulations - and those destined to influence the operation of firms within that market - operating regulations. Naturally, market regulations will very often have effects on the operation of firms and operating regulations will modify market characteristics; it should be nevertheless emphasized that these are secondary effects which, even though very often considered at the time of the design of a regulatory policy, are, in general, not the primary objective being pursued by the implementation of said policy.

Our classification of regulatory policies is therefore based on the primary objective being sought by the legislature or the relevant government agency through its introduction rather than on secondary effects that this policy might have in the end.

2.1.1 Market Regulations

The structure of government market regulation is generally constructed on four basic types of policies which jointly work towards the achievement of the objectives that the government intends to attain through the regulation of a particular market. These four basic types of policies are:
Regulation of entry into and exit from a market; entry and exit are therefore limited to firms which meet a set of conditions put forward by the responsible government agency.

Regulation of price levels in that particular market to check the monopolistic or oligopolistic power that has been conferred to the firms operating in it by the imposed restrictions on free entry and exit.

Control of rate of return on capital investment for the firms operating in the market to ensure a "fair" regulated price.

Taxes and subsidies to correct discrepancies between the desired "fair" rate of return and the one resulting from the set price level. These may be needed when objectives other than a reasonable rate of return on capital are taken into consideration when determining the regulated price level.

Regulations in these four categories can take different forms, depending on the particular industry and market being considered and on the secondary goals that are pursued through their implementation. A brief and clearly not exhaustive list of different policies of the four types is provided here for purposes of illustration.
Entry Regulations
- Licensing
- Concession of operating authority
- Entry minimum capital level requirements
- Entry minimum service requirements
- Entry permit conditional to service of other market
- Private/Public market share constraints

Exit Regulations
- Obligation to service under operating authority
- Exit minimum service requirements
- Interconnection of separate market licensing

Price Regulations
- Exogenously determined price level
- Cost-related level of price linked to rate of return regulation
- Free price linked to parametric profit tax levels determined by rate of return regulation
- Cross subsidization of markets
- Exogenously determined price level with negative (positive) profit linked to subsidy (tax) level determined by rate of return regulation.

Taxes and Subsidies
- Taxes and subsidies applied to profit component linked to rate of return regulation.
- Taxes and subsidies on specific inputs
- Taxes and subsidies on specific markets

Rate of Return Regulation

Determination of minimum/maximum rate of return interval
coupled with an appropriate price cum tax cum subsidy policy.

2.1.2 Operating Regulations

While market regulations are generally based on economic
efficiency or public economic interest considerations, operating
regulations are usually closely related to operating and safety
characteristics of the particular industry and on issues arising
from its effects on other social sectors such as labor and the
environment. Thus, while market regulations can be analyzed abstractly
in terms of the problems of economics and public interest that are
common to all relevant industries, operating regulations are much
more conveniently evaluated in the context of the specific industry
being considered.

In the particular case of transportation, operating regulations
can be classified in four basic, not totally exclusive, categories:

- **Service regulations** specifying the minimum standards
  and safety requirements demanded in the provision
  of a given service in a particular market.

- **Equipment regulations** detailing the performance
  and safety standards of equipment to be used
  in the provision of the service.
• **Labor regulations** determining safety requirements and minimum compensation for personnel to be employed in the production of the service.

• **Environmental regulations** controlling the levels of deterioration of the environment caused by externalities of the service.

Some examples of regulations in these four categories for the transport sector are given in the list below.

**Service Regulations**

- Minimum frequency of service standards
- Minimum quality of service requirements (time, time reliability, product deterioration standards)
- Maximum speed on a link
- Maximum load factor
- Maximum weight limit
- Axle load limitation

**Equipment Regulations**

- Minimum power requirements
- Equipment safety standards
- Vehicle size limitations
- Minimum maintenance requirements

**Labor Regulations**

- Minimum wages
- Minimum crew requirements
- Maximum work time limitations
• Labor safety standards

Environmental Regulations
• Fuel emission standards
• Noise level standards

In order to evaluate the effects of regulation on transportation it is important to understand not only the changes that regulation has brought about in investment strategies (the costs or indirect benefits of regulation) but also the expected direct benefits or objectives that are pursued by the government agencies when imposing regulation on an industry (the anticipated direct benefits of regulation). It is therefore important to gain some insight into the economic and public interest motives for regulation before attempting to investigate or evaluate its effects on investment in the sector.

To be sure, government control is not restricted exclusively to the so-called "regulated" industries. The government influences the functioning of the competitive sectors of the economy in many ways as well; be it through monetary and fiscal policy, by enforcing contract law, by levying taxes, by setting safety and product standards, or simply by guaranteeing labor's rights to union association or collective bargaining. This role is nevertheless conceived as one of maintaining the framework and the institutions within which competitive markets can continue to function; the influence of its actions, however strong, are intended to operate at the periphery of the affected markets and to correct the imperfections of competition, rather than supplanting it. In these sectors government does not, or at least is not supposed to, directly affect the structure of the
market (by controlling entry into and exit from it) or the production decisions within it (by controlling prices and guaranteeing service) or the flow of investment (by determining and fixing rates of return on capital).

The role and the objectives of the government in relation to the so-called "regulated" industries is therefore clearly beyond aiding or facilitating the functioning of the economic system and very much a result of an apparent desire to effectively control all aspects - both market-related and operating - of a specific industry. The question therefore arises of why should the government want to regulate these particular, so-called today, "regulated" industries and not others.

Several economic justifications are often offered for the need for direct government regulation of certain industries [Kahn 1970]:

- The importance of these industries as measured by their significant share of total national output as well as by their great influence, as suppliers of essential inputs and/or services to other industries, on the size and rate of growth of the total economy. These industries constitute a substantial segment of the infrastructure whose existence and smooth functioning is a fundamental prerequisite for economic growth and development. Furthermore, these industries are generally characterized by economies of scale and are therefore quite dependent for their profitability on the rate at which the
economy and consequently the demand for their product (services) is expanding.

• Because of the above mentioned economies of scale many of these industries are so-called "natural monopolies" which will have lower costs and operate more efficiently if they consist of a single supplier. The existence of decreasing marginal costs over a considerable range will thus allow the firm to expand volume and, in doing so, to diminish the elasticity of its demand curve, and will require the intervention of the government to protect the consuming public from "monopolistic exploitation" [Robinson(1933)].

• For a number of different possible reasons, competition does not work well in these industries.

In fact, the various motives that are given for the necessity of imposing regulation on certain industries depend on the assumptions that are made on the objectives that the government is pursuing when establishing said regulation.

Several theories of economic regulation have been developed in recent years, both by economists and political scientists, to explain the objectives and motives behind government regulation of some industries. Three basic theories have been proposed: the public interest theory; the capture theory and the economic theory.
2.2 THE PUBLIC INTEREST THEORY OF REGULATION

The public interest theory of economic regulation has been widely used and quoted both by economists and lawyers in their analysis of the government regulatory process. [See for example Bonbright (1961), Davis (1972) and Friendly (1962)]. The theory states that regulation of some industries is established in response to public implicit or explicit demands for the correction of inefficient or unfair market practices.

2.2.1 The Basic Assumptions

The theory of public interest is based on two main assumptions which, in the particular case of the U.S., were the rationale behind government regulation roughly from the time of the enactment of the first Interstate Commerce Act of 1887 until the late 1950's. These two assumptions are [Posner (1974)]:

- Competitive economic markets are under some circumstances (such as high market concentration, decreasing cost structures and existence of positive or negative externalities) extremely fragile and apt to operate quite inefficiently or inequitable if left alone.

- Government regulation is virtually costless.

Under these two assumptions, it is argued that the principal government interventions in the economy are simply in response to public demands for the rectification of easily recognizable and corrigeible inefficiencies and inequities in the competitive operation of the free market. Behind each regulatory framework a market
imperfection can, according to this theory, be identified, the existence of which provides the rationale for the imposition of said regulations, provided that these are assumed to operate effectively and in a costless way.

This theory has been used to justify the establishment of regulations as diverse as trade union protection, public utility and common carrier regulation, public power and reclamation programs, farm subsidies, minimum wages and even tariffs. [Posner (1974)]. In this study we will be mainly concerned with the arguments which have been developed for the cases of public utility and common carrier regulation which are the ones which can be applied to the transport sector.

2.2.2 Defining the Public Interest

The public interest theory, as constructed in most treatises on public utility economics, is a normative rather than a positive theory. It is mainly concerned with the rationalization of regulation on the basis of an implicit government obligation to serve the "public interest"; in its acceptance of a norm or objective by which to evaluate different decisions it is similar to other purposive theories, but it is almost unique in the extreme vagueness of the definition of its ultimate norm, the public interest, and in the highly indirect and unprovable relationship between regulatory changes and effects on social welfare.

In the particular case of public utility and common carrier regulation though, the definition of the public interest and the effects of regulatory changes on social welfare are easily identifiable, at least on a theoretical basis, for virtually all the
factors that have in the past generated public demand for the regulation of these sectors. These factors can be basically classified in two categories: the presence of decreasing cost structures leading in the long run to finite elasticity of demand and monopoly pricing and the existence of externalities. The effects of monopoly pricing and externalities on social welfare have been thoroughly analyzed by economic theory and the rationale for regulation based on public interest becomes therefore quite clear in these cases.

2.2.2.1 The Case of Monopoly Pricing

The existence of decreasing marginal (and average) cost structures over a wide range of output levels in a given market will induce production volume expansion as firms find it profitable to drive others out of the market by price-cutting. In the long run only the most efficient producer will remain and a monopoly will have been established. (See Figure 2-1). Once a monopoly been established, entry into the market will be difficult since any new firm will have to produce at relatively low levels of output where costs will be higher than the market price determined by the monopolist's output*

The cost of monopoly pricing in terms of social welfare is discussed in Appendix 1.

*It is important to emphasize that the range of decreasing costs has to be large only relatively to the total volume of the market in question.
FIGURE 2-1 COST STRUCTURE OF A NATURAL MONOPOLY
2.2.2.2 The Case of Externalities

Another case in which free competition can also fail to allocate resources efficiently is the case where externalities, or interactions among firms and individuals that are not adequately reflected in market prices, are present. Examples of such occurrences are numerous. One of the most commonly found is the case of a firm that pollutes the environment with its industrial waste. Such an externality will result in a positive divergence between the social marginal cost and the private marginal cost of its product. This divergence will cause a misallocation of resources (with excess relative production of its output) in a free market economy.

Under these circumstances, government regulation will be needed to correct the misallocation of resources.

2.2.3 The Empirical Evidence

If the public interest theory were correct, we would find regulation imposed primarily on highly concentrated industries or industries where decreasing cost structures exist (where the development of a monopoly is more likely) and on industries that generate significant external costs or benefits (where failure of the free market to achieve an efficient allocation of resources is more likely. In fact, the evidence of theoretical and empirical research on the matter conducted mainly by economists in the last twenty years points to the fact that there is no such positive correlation between the level of regulation and the monopolistic market structure or the
presence of external economies or diseconomies of scale. [Posner (1974)].

Furthermore, the conception of government regulation as a costless and dependably effective instrument for influencing and directing the behavior of a market has also been found to be inaccurate [see, for example, Hirshleifer et al (1960), Posner (1969, 1970)]. This revision of the theory has prompted numerous case studies of regulation in particular industries in the U.S. such as natural gas production, trucking, airlines and broadcasting; the results have shown that in many industries regulation cannot be explained by the classic theory of public interest and, furthermore, that regulation has not increased either the wealth or the equity of the society by any widely accepted standard [see, for example, Cabinet Task Force on Import Control (1970), Hilton (1966), Jordan (1970, 1972)].

As a consequence of these findings, several reformulations of the public interest theory of regulation have been developed.

2.2.4 A Reformulation of the Public Interest Theory; the Theory of Public Mismanagement.

This reformulation of the theory of public interest attempts to reconcile the theory with the evidence referred to above by arguing that the disappointing performance of the regulatory process is not caused by any unsoundness of its original objectives or its course of action but, rather, by problems of mismanagement and/or procedure that are a result of inexperience and that can and will be corrected, at a low cost, as the concerned agencies become more familiar with the mechanisms of public regulation. In its reformulation, therefore, the public interest theory of regulation states that regulatory agencies
are created for the bona fide purposes described in 2.2.2 above; these objectives are, nevertheless, not always achieved as a result of mismanagement and lack of public administrative experience.

As pointed out by Posner (1974) this reformulation is quite unsatisfactory on three grounds:

- First, it fails to take into consideration the fact that many of the socially undesirable results of regulation have been actively pursued by some groups that have been influential in the enactment and the defense of regulation on the particular industry. Thus, in the U.S., for example, both the trucking and airline industries sought the extension of common carrier status to their sectors as a way to neutralize what they considered excessive competition under unregulated conditions. Furthermore, the ICC regulatory statute was in itself contrary to competition in these transport markets in a way hardly explicable through any public interest criterion.

- Second, very little evidence has been provided to prove the alleged mismanagement of the regulatory agencies. On the other hand, there is considerable evidence that appears to support the claim put forward by the capture theory of regulation discussed in 2.3 below that regulatory agencies are, in general, operated quite efficiently to attain simply inefficient or inequitable objectives contained in the regulatory statutes.
Very often regulatory agencies are criticized for failing to engage in policy planning and for relying, rather, on a case by case adjudication to develop regulatory policies. In fact, the agencies that have attempted any such planning in the U.S. (the Federal Communications Commission in particular) have met with disastrous failures in policy design.

- Finally, there appears to be no reason as to why regulatory agencies should, in particular, be expected to be less efficient than other organizations. The usual argument that lower salaries in government regulatory agencies could explain the relative inefficiency of its members ignores the fact that service with a government agency enlarges the expected future stream of earnings of an individual in the private sector (expansion of human capital base), and the existence of many efficient public bodies.

2.2.5 A Further Reformulation of the Public Interest Theory.

A further reformulation of the public interest theory has been developed to attempt to show that while regulatory objectives are concordant with the public interest, problems associated with the implementation of regulations make them appear not to be. This new formulation is based on two premises:

- Most of the tasks assigned to regulatory agencies
are, by their own nature, of an intractable character. A good example is the regulation of price levels charged by public utilities and regulated carriers; in general, the agency is required to determine the cost structure of the concerned firm and to fix its prices so as to link its profits to its capital base via a "fair" rate of return. Since there is ground to believe that the methodologies of measurement and control necessary for this task simply do not exist, the agency is clearly being asked to perform beyond its limitations and it is therefore not surprising that it should fail.

The second premise is that the cost associated with regulation rises rapidly with volume. As pointed out by Ehrlich and Posner (1974), legislative bodies are a type of operation in which the costs of "production" are very high and, furthermore, rise very fast with increases in output. This is largely due to the fact that "legislative production" consists of a number of bargains between numerous and dissimilar groups; since the cost of bargaining increases with the number of groups or individuals involved, a legislative body cannot respond to a growth in workload simply by enlarging its memberships. As its business expands, a legislature has to rely
increasingly on its dependent agencies for the completion of the work and must, therefore relinquish part of its control over said agencies. This "life cycle" hypothesis suggests that as regulatory problems become more extended and complex control of the regulatory process is further and further diverted from the legislature which originally enacted regulation to the agencies responsible for its enforcement; in this way a divergence between the originally stated public interest objectives of the legislative body and the goals actually achieved by the agency may occur.

2.2.6 The Linkage Between the Public Interest Theory and the Underlying Political Structure

As can be clearly identified in all three formulations of the public interest theory, the regulatory process is significantly influenced by the underlying political structure of the country under consideration. The political structure will provide the institutional mechanisms by which the public perception as to what legislative policies or procedures would maximize public welfare (public interest) are translated into legislative action and later implemented (see Figure 2-2). Thus, the same public perception of the common interest would produce very different legislative result under a U.S. type democratic political structure than under a Soviet style centralized regime.

This fact will be of particular importance later, in 2.5 below, when we turn to the specific analysis of regulation in developing
FIGURE 2-2 POLITICAL TRANSFER OF THE PUBLIC INTEREST PERCEPTION
countries. Here we will briefly discuss the regulatory implications of two extreme political organizations: the democratic free market state and the totalitarian centrally planned state; the effects of the institutional setting on government regulation in these two border cases will help us analyze other intermediate political scenarios, particularly in less developed countries.

2.2.6.1 The Democratic State

In a democratic state the public perception of the common interest is indirectly translated into legislative action and implementation through the electoral process. In such a political framework the problem arises that even if the individual can clearly identify his personal perception of the public interest he might not vote for it but, rather, against it if it should conflict with his own perception of his personal interest. Thus, it does not suffice to assume that the individual will vote for the candidate who promises to implement the policies that the voter perceives to be in the public interest, since policies which go against the public interest might benefit the particular voter more. Faced with this conflict between principle and interest it is not clear what any individual's decision would be. If we assume that individuals' perceptions of the public interest differ, the answer to the question of how public perceptions are transformed into regulatory actions in such a political structure is clearly not a simple one.

Two alternative hypothesis have been proposed to explain this "transfer" process: the theory of principle and the theory of political collusion.
• The theory of principle [Coase (1959)] argues that there are "moral" differences between private and political action. When faced with a political decision (voting) in which his personal interest and principles conflict, the individual will (hopefully) opt for the choice which benefits the public interest even if it implies a potential detriment to his own personal welfare. If some homogeneity of perceptions on basic public issues exists, it is argued that a political consensus can be reached. This theory is clearly based on very strong behavioral assumptions whose validity is, to say the least, questionable.

• The theory of political collusion [Posner (1974)] argues that, given the high potentiality for collusion among politicians that exists in a democracy, there appear to be numerous opportunities for the politicians who dominate the leading parties to impose some of their own policy preferences on the electorate. In this view, many policies are adopted and implemented because they conform to the public interest - as conceived by the politicians. To anybody familiar with the workings of a democracy this theory should not appear to be so implausible.
Even though both theories are clearly different, they seem to agree on one important issue; even in a democracy the view of the public interest that is held by politicians and decision makers is, at the very least, somewhat divorced from the public interest as perceived by the electorate.

2.2.6.2 The Totalitarian State

The above conclusion is even more warranted in the case of a totalitarian state where decision makers, free from the constraint of having to please an electorate with their policies, are capable of interpreting the public interest at will and to design and implement policies accordingly, as long as they do not violate the rules that control the internal balance of power of the government. This is not to say that the policies so generated will serve the public interest any worse than those developed in a democracy or that they will less readily be supported by the general public. In fact, political approval by an electorate is no guaranty of rational distinction and, as far as generating public support for government policies goes, a government controlled mass media system should be a much better job than an uncensured one.

2.3 THE CAPTURE THEORY OF REGULATION

The capture theory contends that regulation of industry is not at all imposed to defend the public interest but, rather, that it is a process by which different interest groups seek to promote their own private interests.
2.3.1 The Marxist Formulation

This formulation of the theory, which has been put forward by Marxist economists and consumer advocates states simply that the regulatory process is, in fact, controlled by big business which utilizes it as a mean to further its own objectives vis-a-vis those of the general public. It clearly fails to take into consideration the numerous instances in which regulation serves the interests of small business (or non-business) groups and even labor (as is the case of trade unions).

2.3.2 The Classic Capture Theory of Regulation

A more useful version of the capture theory has been developed by political scientists along the lines suggested by Bentley (1908) and Truman (1951). This formulation states that over time regulatory agencies came to be dominated ("captured") by the industries which they are supposed to regulate. In this way, the objectives of the regulatory agency are changed from the original goals set forward by the legislature at the time of enacting regulation to the final objectives which are more concordant with those of the regulated industries.

Although this theory provides new insight into the relationship between the regulated industries and the regulatory agency that complements some of the concepts addressed by the public interest theory, a number of unanswered questions remain. No reason is given as to why the regulated industry should be the only interest group to gain ascendancy over the regulatory agency; customers (both individuals and firms) have an interest at stake.
in the regulation of the supplier firm and it is not clear why they should not attempt to, and succeed in achieving control over the agency. Furthermore, no reason is suggested as to why industries that are strong enough to modify an agency's objectives did not have the strength to avoid its creation in the first place.

In addition, there is considerable empirical evidence that appears to contradict the theory. As mentioned earlier, a major purpose of the original Interstate Commerce Act of 1887 in the U.S. was to fortify the existing railroad cartels. Subsequent amendments and measures by the Interstate Commerce Commission have been less and not more favorable to the railroads. (The Hepburn Act, for example, which gave the I.C.C. the power to determine maximum rate). This sequence of events is clearly not in accordance with the capture theory. The theory does not further explain how the capture process works when a single agency regulates several competing industries (as is the case with the I.C.C.).

2.4 THE ECONOMIC THEORY OF REGULATION

The economic theory of regulation was first proposed by Stigler (1971) in an article that builds on the earlier work of Buchanan and Tullock (1962), Downs (1957), and Olson (1965) on the political system. The theory is, in certain aspects, similar to, but more refined than, the capture theory of regulation; it de-emphasizes the role of the public interest in motivating regulatory legislation, it admits the possibility of capture of the regulatory agency by the regulated industry as well as by other interest groups, and it coincides
with the capture theory in recognizing that regulation will usually serve the private interests of politically powerful groups.

The theory is based on two basic principles:

- The coercive power of government can be applied to give valuable benefits to particular individuals or interest groups through the application of regulation in the economic environment. The allocation of said regulation within each market or group of markets is governed by the laws of supply and demand.
- The theory of cartels might provide some information as to the supply of and demand for regulation in a particular market.

2.4.1 The Theory of Cartels and its Relation to the Economic Theory of Regulation

If regulation is assumed to be allocated in response to the laws of supply and demand, then it is important to evaluate what the benefits of regulation will be for different individuals, since, ceteris paribus, we should expect regulation to be supplied to those who value it the most. Furthermore, the factors affecting the cost of regulation should also be analyzed since they will be important determinants of its supply.

The theory of cartels provides valuable insight into both the benefit and the cost aspects of regulation. This theory states that the value of cartelization in an industry is inversely related to the elasticity of demand for the industry's product and directly
related to the cost of or the impedance to new entry into the industry or into the cartelized markets within the industry.

The two major costs (leaving aside punishment or legal defense costs in countries where cartelization is illegal under anti-trust laws) are (i) the costs to the suppliers of arriving at an agreement on the price to be charged for the product and on the relative output shares of the cartel members that will set the individual members' profits and (ii) the cost of enforcing the cartel agreement by punishing non-participants or price-undercutters inside the cartel. This second cost is particularly significant since the problem of "free riders" is common in all cartel agreements and is probably the most frequent factor behind the dissolution of many such understandings.

After an agreement has been reached on price and market shares, any supplier will benefit from selling at a slightly lower-than-the-agreed price and expanding his volume share at the expense of the other members. If several members fail to stick to their commitment, a price war will ensue and the cartel will collapse. Thus, a cartel will be particularly vulnerable if its members are, at least in the short run, able to conceal price cuts from one another since then every member will have a strong inclination to attempt to recoup some short-term profits from other members.

Given that the effect of market regulation in the form discussed above (entry and exit control, price and rate of return regulation, and exemption from antitrust laws) is identical to that
cartelization - to raise prices above competitive levels - the benefit aspects of the theory of cartels is clearly relevant to the analysis of regulation. The cost sides of cartelization also appear to be closely related. The firms in the industry will have a saying in the design of regulation and will have to agree to some specific form of it. Furthermore, the individual firm's profits will be maximized, as in the case of cartelization, by avoiding regulation, as long as all other firms in the industry are regulated. Thus, a firm will always have an incentive to avoid becoming regulated; if he is regulated after all he will nevertheless benefit from it since he cannot be excluded from the protection of an overall regulation.

In conclusion, many findings of the theory of cartels can be successfully applied to the analysis of government regulation of industry [Posner (1971)].

- As is the case with cartelization, the fewer the prospective beneficiaries of a regulation, the easier it will be for them to coordinate their efforts to obtain such regulation. It will also be harder for any one individual firm to refuse to participate in the procurement effort without causing it to collapse.

- The homogeneity of the interests of the affected firms will also have a positive effect on the advent of regulation since it will make it easier for them to reach a consensus which is
not detrimental to any one member in particular.

Even though the theory of cartels is relevant to the theory of regulation there are still important differences between the two. If this would not be so, we would observe the same industries forming stable cartels and obtaining government regulation as is clearly not the case. Many industries such as agriculture, textiles and some branches of retail trade, which clearly have not characteristics that are favorable for cartelization, have obtained supportive government regulation in the U.S. Actually, it has been observed that highly concentrated industries are less likely to obtain favorable regulation than less concentrated industries, contrary to the expectation of the theory of cartelization [see, for example, MacPherson (1972)].

This evidence points out to specific differences that exist between the theory of cartels and the economic theory of regulation, both on the demand and supply side of regulation.

2.4.2 Differences Between the Economic Theory of Regulation and the Theory of Cartels in Relation to the Demand for Regulation

The demand for regulation, which is derived from its potential contribution to raise the profits of the regulated industries, is greater within industries for which cartelization is either not feasible or, if feasible, very costly. These industries lack an implementable substitute for regulation for a number of reasons such as low market concentration, diversity of interests, physical dispersion, etc. As a result the pattern of demand for private cartelization and the pattern of demand for regulation will, in
2.4.3 Differences Between the Economic Theory of Regulation and the Theory of Cartels in Relation to the Supply of Regulation

While cartelization requires solely the cooperation of the affected firms in reaching a consensus (provided that cartelization is not prohibited by anti-trust laws or that, if it is, the agreement is kept secret), favorable regulation will be implemented only if, in addition, the positive intervention of the political system is secured. Some industries may be capable of obtaining the necessary political support easier than others and they will not by force be the same industries which can establish cartelization at a low cost. Thus, in addition, the patterns of supply for both theories will differ.

As pointed out by Stigler (1971) the effects of a large number of members on the successful obtainment of cartelization and regulation as a result of the existence of intra-industry asymmetry. Cartelization will have a quite homogeneous effect on different individual firms; regulation, on the other hand, can take numerous forms (entry and/or exit control, price regulation, taxes and/or subsidies, etc.) and may therefore have varied effects on distinct firms. Thus, assuming a certain degree of asymmetry between the different suppliers of the industry, we can conclude that they will all be interested in participating in the industry campaign for regulation in order to attempt to secure that the form of regulation chosen is the most favorable to their situation. Therefore, the free rider problem could be easily overcome in the case
of regulation, even if there are a large number of firms in an industry, if sufficient asymmetry exists among them. In this case it would be cheaper for these firms to obtain protective regulation than to cartelize.

Furthermore, the determinants of political leverage have to be introduced into the analysis of the supply side of regulation. In order to do so we have to specify the character of the political environment with which the problem is being considered (compare with 2.2.6 above) Posner (1974) considers three alternative political scenarios:

- **The entrepreneurial system** where favorable regulation is "sold" to the industries that value it most and that can therefore bid the highest price for it. As was mentioned before, these would be the same industries that have highest cartel benefits. The costs of cooperative action do not need to be considered in this case since the government can use its coercion powers to eliminate any intra-industry "free rider" problems, so that the industry can raise the maximum price for the regulatory legislation.

- **The coercive system** in which regulation is awarded to the groups that are able to generate the most power of coercion and apply it on the government in the form of public opinion pressure, strikes or street violence. In the context of
this scenario it appears that the relative size of the demanding group might have a significant influence on the outcome of the awarding process.

- The democratic system where regulatory legislation is awarded by elected representatives of the people. As in the coercive system the ability of the demanding group to muster political support, be it in terms of number of voters or amount of political campaign contributions, will be decisive in influencing the awarding procedure. In both the coercive and the democratic systems, the "free rider" problem remains unsolved since the existence of free riders will clearly limit the capacity of the demanding group to apply pressure on the government. Note that the demanding group may be the same or different from the group on which regulation is sought to be imposed upon.

As this analysis shows, while that characteristics that predispose an industry to seek cartelization successfully may also help it obtain supportive government regulation, there is a factor which discourages cartelization - a large number of parties whose consensus is needed to establish and maintain the cartel - that will encourage the generation of demand for regulation (due to the difficulty of implementing cartelization as a viable alternative and to an increased probability of the existence of assymetries as well as the supply of regulation.
(since large numbers have significant voting and coercive power at their disposal)
3.0 THE EFFECT OF REGULATION ON TRANSPORT INVESTMENT IN LESS DEVELOPED COUNTRIES

3.1 A THEORY OF TRANSPORT REGULATION FOR LESS DEVELOPED COUNTRIES

3.1.1 The Motives for Transportation Regulation in Developing Countries.

Given the close relationship that exists between the mobility of nations and their level of economic growth and the general acceptance of the fact that transportation investment is a necessary, albeit not sufficient, condition for economic development, developing countries have characteristically invested heavily in transport facilities as part of an effort to stimulate their own growth. Thus, while developed countries usually allocate 10 to 15 percent of their social investment to transportation, less developed countries commonly destine 20 to 40 percent of their national budgets to capital investments in the different transport modes.

In view of the importance of the transportation sector as a recipient of public investment funds, it is not surprising to find that governments in developing countries have been particularly concerned with exercising some degree of control over said sector.

Four basic rationales for the need of government control of the transport sector in less developed countries can be identified.

- Given the magnitude of transport investment relative to total capital investment outlays and the important role that transportation plays in the development of both industry and agriculture, it is necessary for the government to be able to control the transport sector to a certain extent,
if it is to effectively manage the country's economy.

- Since transportation activities are, as discussed in Appendix 6, often characterized by decreasing marginal (and average) cost structures and economies of scale, the government is forced to intervene, through regulation, to defend the "public interest" in the cases where existing or potential private or public autonomous natural monopolies threaten the efficient and equitable operation of free markets.

- In some cases, existing powerful interest groups which are either involved in the provision of, or affected by, transport services manage to obtain supportive or protective regulation from the government.

- Finally, considerations of efficient operation, design and safety are generally behind the imposition of operating regulations on the transport sector.

Furthermore, since in many developing countries the private very often lacks the necessary capital to enter into the provision of transport services, the government has, either directly or through public corporations, considerable control over the transportation sector.

In general, both the relative weights of the motives for transport regulations as well as the particular way in which these regulations are imposed considerably depend on the socio-economic and political environment in which these decisions are made. As pointed out by Friedlander et al (1977), transportation regulatory policy often
attempts to satisfy a broad range of social and economic objectives which in themselves may not be entirely consistent; the design and implementation of said policy will therefore be the result of implicit or explicit trade-offs among the various objectives which will in their turn respond to the constraints of the established political scenario.

In the context of developing countries the following socio-economic objectives of transport regulatory policy can be enumerated:

- To exercise government control over an important sector of the economy
- To secure adequate transport infrastructure and service that will support the development of backward regions and rural agricultural areas
- To provide a stable transportation rate environment within which an orderly industrial development process can take place.
- To protect users and the public in general from inefficient or inequitable pricing and service practices of monopolistic transportation firms.
- To protect transportation firms from the effects of disruptive price competition and to secure, in this way, the provision of transport services required for socio-economic development.
- To ensure that the operation of transportation modes is consistent with standards of design of the infrastructure and with pre-established norms.
Figure XII
FINANCIAL COST SUMMARY
(Million Egyptian Pounds)

<table>
<thead>
<tr>
<th>YEAR</th>
<th>LINK CONSTRUCTION COSTS</th>
<th>LINK MAINTENANCE COSTS</th>
<th>USER COSTS</th>
<th>GROSS REVENUES</th>
<th>FLEET OPER. COSTS</th>
<th>FLEET MAINT. COSTS</th>
<th>FLEET INVEST. COSTS</th>
<th>TOTAL COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>19xx</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Totals

Salvage Values (1) 
Discounted at

| % | % | % | % |

(1) Total link value in final year
(2) Total fleet value in final year
Figure XIII
ECONOMIC COST SUMMARY
(Million Egyptian Pounds)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>19xx</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Totals| | | | | | | |
|-------| | | | | | | |

Salvage Values (1) (2)

Discounted at

(1) Total link value in final year
(2) Total fleet value in final year
CHAPTER III

TRANSPORTATION COST FUNCTIONS

Introduction: the two basic approaches.

A literature review showed that there are two main approaches to transportation cost functions from the operator's point of view:

i. an econometric approach, based on economic theory, which can be summarized this way. The transportation system is characterized by a cost minimization behavior, given a level of production, represented by a production function. The solution of a mathematical program provides a cost function, either short-term, where capital is considered as fixed or long term when it is an optimization variable. The functional result is then estimated through econometric methods.

ii. an engineering approach, which focuses on technical operations. Then deriving unit costs and assuming that they are constant in a relatively small range of technology options and levels of output, this approach allows to calculate estimates of costs in various conditions of investment, organization, regulation and technology.

The following section will be a literature review related to these two approaches and through it, a description of their main features.

N.B.: a particular focus will on railroads as regards specific examples.
I. Economic theory and econometric approach.

Relationship between production function and cost function.

The basic assumption involved in the theory of production and cost is that firms are cost-minimizers at a given level of output. Therefore the basic theoretical framework is the solution of a mathematical program of the following form:

\[
\text{Minimize } \sum_{j} Y_j \cdot w_j \\
\text{s.t. } P(\{X_i\}, \{Y_j\}) = 0
\]

where:  
- \( X_i \) = outputs  
- \( Y_j \) = inputs  
- \( P(\{X_i\}, \{Y_j\}) \) = production function  
- \( w_j \) = cost of input \( j \)  
- \( C = \sum_{j} Y_j w_j \) = cost of inputs

If the input "capital" is held constant, then the solution of this mathematical program is the short-run cost function. If all inputs (energy, labor, capital...) are variable, then the solution is the long-run cost function.

Duality theory implies that the long-run cost function describes a well-behaved technology as well as a production function, provided certain mathematical properties. Therefore, in theory, provided that cost-minimization holds, the mere data of short-run cost functions at various
levels of capital allow to deduce the long-run cost function, as their envelope, and consequently the structure of technology.

Then within this framework, if the purpose is to derive cost-functions, either short-term or long-term, we need:

- a functional expression of the production function
- prices of inputs.

Reversely, cost-functions allow to go back to the structure of technology.

Now the validity of econometric estimates derived from the framework described above is highly questionable. According to Ann Friedlaender there are three major reasons to this phenomenon: (13).

1. The output of transportation firms is multidimensional. Transportation services have very different characteristics within the same firm: different users, origins, destinations, quality of service. The mix of outputs can have a major impact upon costs of any given firm. Consequently, an aggregate measure of output is not adequate. The quality of services must be incorporated. There is a tradeoff at this point between data requirements and theoretical relevance.

2. Because of joint and common costs, transportation industry is characterized by joint production. Therefore a separable Clobb Douglas production function, which is the most widely used in the literature is not necessarily a good representation of reality.
<table>
<thead>
<tr>
<th>Truck Size (Tons Load Capacity)</th>
<th>Registered Fleet (% of fleet)</th>
<th>Rolling Fleet (% of trips)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 3</td>
<td>12.5</td>
<td>11.5</td>
</tr>
<tr>
<td>3-5</td>
<td>25.1</td>
<td>13.4</td>
</tr>
<tr>
<td>5-10</td>
<td>40.8</td>
<td>45.0</td>
</tr>
<tr>
<td>10-15</td>
<td>6.5</td>
<td>12.0</td>
</tr>
<tr>
<td>15-20</td>
<td>2.1</td>
<td>5.7</td>
</tr>
<tr>
<td>20-25</td>
<td></td>
<td>5.4</td>
</tr>
<tr>
<td>25-30</td>
<td>13.0</td>
<td>5.3</td>
</tr>
<tr>
<td>Over 30</td>
<td></td>
<td>1.7</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: Berger (1977)
truck fleet load capacity distributions by relative numbers and relative share of total trips are shown in Table 3-1.

No reliable data exists as to the age distribution of the vehicle fleet, although it is clear that many trucks are more than 20 years old. This has been caused by limited local production and heavy import restrictions coupled with a large demand for vehicles, which have determined low scrapping rates and a generalized obsolescence of the fleet. This on the other hand has resulted in high operating and maintenance cost and unreliability of service caused by frequent break-downs.

Table 3-2 summarizes data on the type of trucks for general and specialized transport provided by the Ministry of Transport for 1973/1974. There is a high percentage of general purpose trucks (open, closed and flat vehicles) comprising an 80 percent of the total fleet. The low percentage of dump cars in the view of the large volume of bulk carried by road seems to suggest that most of the loading and unloading of bulk commodities is largely done manually.

The estimated freight traffic by mode for 1975 and forecasts for 1980 and 1985 are shown in Table 3-3.

The predominant types of commodities carried by each mode of transport are shown in Table 3-4. The following is a review of some of the individual commodity groups. [Berger (1977)].

1. **Corn, Wheat, Maize**

   Of this commodity group, 85 percent of the tonnage is transported on highways. For the Cairo-Alexandria movements, highways account for 67 percent, railways 25 percent and inland waterways 8 percent.
### Table 3-2

**Truck Fleet by Type, 1973/74**

<table>
<thead>
<tr>
<th>Truck Type</th>
<th>Percent of Trucks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open</td>
<td>59.2</td>
</tr>
<tr>
<td>Closed</td>
<td>13.9</td>
</tr>
<tr>
<td>Flatbed</td>
<td>6.4</td>
</tr>
<tr>
<td>Dump</td>
<td>5.3</td>
</tr>
<tr>
<td>Refrigerated</td>
<td>0.2</td>
</tr>
<tr>
<td>Special</td>
<td>9.3</td>
</tr>
<tr>
<td>Tank</td>
<td>5.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

*Source: Berger (1977)*
### Table 3-3

**TRANSPORT VOLUMES AND TON-KM BY MODE**

<table>
<thead>
<tr>
<th></th>
<th>(000) Tons</th>
<th>Million Ton-Km</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1975</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Railways¹</td>
<td>7,803</td>
<td>2,190</td>
</tr>
<tr>
<td>Highways²</td>
<td>58,278</td>
<td>12,206</td>
</tr>
<tr>
<td>Waterways³</td>
<td>4,248</td>
<td>1,888</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>70,329</td>
<td>16,284</td>
</tr>
<tr>
<td><strong>1980</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Railways</td>
<td>10,300</td>
<td>2,781</td>
</tr>
<tr>
<td>Highways</td>
<td>80,704</td>
<td>16,348</td>
</tr>
<tr>
<td>Waterways</td>
<td>6,356</td>
<td>2,336</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>97,360</td>
<td>21,465</td>
</tr>
<tr>
<td><strong>1985</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Railways</td>
<td>22,900</td>
<td>7,900</td>
</tr>
<tr>
<td>Highways</td>
<td>94,056</td>
<td>16,842</td>
</tr>
<tr>
<td>Waterways</td>
<td>18,105</td>
<td>5,661</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>135,061</td>
<td>30,403</td>
</tr>
</tbody>
</table>

¹ Excludes railways' own - account freight
² Includes only interzonal traffic; figures shown are from Consultants' 1976 O-D Survey, reduced by 8%.
³ Estimated minimum.

**Note:** The highway and waterway statistics for 1975 are broad estimates. Exclusion of intrazonal and local traffic from the highway statistics and the error inherent in a single brief O-D Survey make the drawing of other than general conclusions about modal split on the basis of the table inadvisable.

**Source:** Berger (1977)
The only other significant corridor where more than one mode is involved is the Cairo-Aswan corridor, where waterways carried more than highways in 1976. It is expected that the share of highways in the Cairo-Alexandria flows will decrease to 50 percent by 1980 and to 13 percent by 1985. For the entire network, the modal splits are expected to be 77 percent, 15 percent, and 8 percent for highways, railways and waterways respectively by 1980 and 57 percent, 20 percent and 23 percent by 1985. The present splits are 83 percent, 12 percent and 5 percent.

2. **Cotton**

Only one percent moved on railways and none on inland waterways in 1976. In the future, highways are expected to be the only mode to transport this commodity.

3. **Farm Products**

The present modal splits are 95 percent, 2 percent and 3 percent for highways, railways and waterways respectively. These are not expected to change significantly by 1980 but should be 86 percent, 6 percent and 8 percent by 1985. Little intermodal competition exists outside of the Alexandria-Cairo-Aswan corridor.

4. **Livestock**

Only highways are involved and this is expected to remain the case.

5. **Ores (Including Phosphate)**

In this group, 28 percent were moved on highways in 1976 with the highway movements being mainly short haul. The share of highways is expected to decline to 20 by 1980 and 3 percent by 1985.
<table>
<thead>
<tr>
<th>Railways$^1$ Commodity</th>
<th>% of Total</th>
<th>Inland Waterways$^2$ Commodity</th>
<th>% of Total</th>
<th>Highways$^3$ Commodity</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-perishable foods</td>
<td>42.9</td>
<td>Raw and processed fertilizer; mineral and non-mineral ores</td>
<td>24.0</td>
<td>Farm products (excluding cotton and cereals)</td>
<td>31.8</td>
</tr>
<tr>
<td>Corn and Wheat</td>
<td>12.0</td>
<td>Refined petroleum and products</td>
<td>16.7</td>
<td>Construction materials</td>
<td>16.3</td>
</tr>
<tr>
<td>Sand, gravel, clay, limestone</td>
<td>9.7</td>
<td>Sugar, sugar products, molasses</td>
<td>14.8</td>
<td>Manufactured goods</td>
<td>14.3</td>
</tr>
<tr>
<td>Other petroleum products</td>
<td>6.0</td>
<td>Sand, gravel, clay, stones</td>
<td>11.0</td>
<td>Sand, gravel, clay, limestone</td>
<td>14.2</td>
</tr>
<tr>
<td>Perishable foods</td>
<td>5.2</td>
<td>Coal, coke</td>
<td>8.7</td>
<td>Corn, wheat, maize</td>
<td>7.2</td>
</tr>
<tr>
<td>Total</td>
<td>75.8</td>
<td>Total</td>
<td>75.2</td>
<td>Total</td>
<td>83.8</td>
</tr>
</tbody>
</table>

1 February, 1975 data
2 1975 reports of two Organization Companies and lock registration of April, 1976 for Sugar Company, private barge and sailing boats.
3 1976 O-D survey.

Source: Berger (1977)
6. **Coal, Coke**

The share of highways is insignificant and is expected to remain so.

7. **Sand, Gravel, Clay and Limestone**

The share of highways is very large (94 percent) probably due to the short transport distances involved and the extra loading and unloading involved in railways and waterways. Over 50 percent is transported on highways, even for the relatively long hauls in the Cairo-Alexandria corridor.

8. **Steel**

Movements on railways account for 7 percent of the total in 1976 and are expected to reach 18 percent by 1980 and 27 percent by 1985. Waterways are not involved. The bulk of the Cairo-Alexandria flows, which account for 70 percent of the total, are transported on highways with a share of 96 percent.

9. **Construction Materials**

This category consists mainly of cement and 98 percent is transported on highways, with the only significant intermodal competition being in the Cairo-Aswan corridor where railways and waterways transported 25 percent of the movements. The share of highways is expected to decline to 94 percent by 1980 and 82 percent by 1985 with the bulk of the remainder being on waterways.

10. **Manufactured Fertilizers**

The 91 percent share of highways is expected to decline to 87 percent by 1980 and 80 percent by 1985. The only significant
intermodal competition should be in the Alexandria-Cairo-Aswan corridor. The share of railways is expected to increase from 6 percent in 1976 to 10 percent by 1980 and 7 percent by 1985, while that of waterways should remain at 3 percent to 1980 and increase to 13 percent by 1985.

11. Manufactured Goods

Highways carried 98 percent in 1976. This is expected to decrease to 87 percent by 1985 with the bulk of the remainder to be handled by railways.

As noted previously, the most outstanding feature of the traffic allocation is the predominance of highways, even for relatively low-value goods suitable for bulk handling, such as cereals, sand, gravel, cement and fertilizer. Since the analysis considers only inter-zonal movements, it is unlikely that any significant proportion of this highway transport represents movements to and from the railway and waterways. This tends to be confirmed by the average lengths of haul for freight: 282 km by highway. It is apparent that freight which would normally be attracted to the other modes is moving on the highways, even though it should be possible to carry it at lower cost on the other modes given adequate capacity and reasonably efficient operation.

Passenger traffic appears to be more evenly distributed between road and rail, which is as expected as the railway has concentrated on maintaining its passenger service and has allocated motive power accordingly.
In conclusion then, the highways in Egypt are carrying a large amount of freight traffic which could be carried at lower costs by the railway given efficient operation. The allocation of freight traffic among the three major modes is strongly influenced at present by capacity constraints on the railway and the inland waterways. The freight capacity of the railway has declined in recent years, primarily because of inadequate serviceability of rolling stock, and the railway's freight traffic has diminished at the same time that total freight traffic was increasing. The railway is further penalized by inadequate access to the Port of Alexandria. The main result of these circumstances is that much of the traffic which would normally travel by rail and inland waterways, if cost and service characteristics were the ruling factors, instead travels by highway. This is made possible by the facts that the highways themselves generally have excess capacity and the vehicle fleet can be expanded (or its utilization increased) relatively rapidly. Thus, the available excess highway capacity permits the capacity constraints on the railway and inland waterways to exist without dramatic consequences in the form of obvious and severe transport bottlenecks. However, this results in a higher-than-necessary cost of transport in the short run. In the long run, especially with the expected increase in transport demand for bulk commodities such as wheat and phosphates, it will not be possible to maintain a reasonable level of transport costs and service without additional capacity in these modes. It is unlikely that measures to restore and/or increase capacity will have a significant effect prior to 1980, and this is reflected in the forecasts made in this
However, by 1985, significant growth in the traffic carried by these modes is expected.

3.3 THE EFFECTS OF MARKET REGULATION ON TRANSPORT INVESTMENT IN DEVELOPING COUNTRIES

Both market and operating regulations affect the level, timing and distribution of investment in transportation. Market regulations usually have more significant effects on investment than operating regulations in the short run since they determine the structure of the market in which the firm operates, the amount of competition that it faces and the rate of return on any imputed capital. In the long run though, the effects of operating regulations will become much more substantial as the constraints they impose on the relevant firms will reshape old markets and create new ones.
The effects of market regulation on investment can be classified into two categories:

- Changes in the structure of the capital market that the firm uses as a source of financial resources for capital investment.
- Changes in the management and operation of the firm that will affect the level and time and space allocation of its investment outlays.

The first category of changes is related to the theory of capital markets; the magnitude of such changes will depend on the relative importance of private versus public funds as sources of capital for transportation investment programs. The analysis of the effects of risk reduction on the availability and cost of investment funds is based on the mean variance formulation of the classic economic theory of portfolio selection [Fama (1968) a,b), Long (1972), Markowitz (1959), Mosin (1966), Sharpe (1964)]. This theory states that the capital market places a positive price on risk-bearing in the form of higher rates of return, where the risk is defined in relation to the investor's total portfolio.

In this chapter we will be mainly concerned with the analysis of how market regulations affect (i) the output, capacity and operating efficiency of transport firms and (ii) the investment on new transportation technology, and of how particular operating regulations can affect investment in both capacity and new technology in the sector. With respect to the application of our results we will mainly concentrate on the issue of railroad truck competition which is the case which is more relevant to the Egyptian Transport situation, as discussed in 3.2 above.
3.3.1 The Averch-Johnson Hypothesis [Averch and Johnson (1962)]

The Averch-Johnson hypothesis of rate of return regulation attempts to develop a theory of the monopoly firm seeking to maximize profit subject to a government regulatory constraint on its rate of return. Two cases are analyzed; the first in which the monopoly firm is restricted to produce in a single market, and the second where the firm, in addition to operating in a single market, can also enter other regulated markets and where the regulatory agency bases its calculations of the "fair" rate of return on the firm's overall value of plant and equipment for all markets rather than computing a separate rate of return for each market. A mathematical derivation of the theory is given in Appendix 2.

3.3.1.1 Conclusions of the Averch-Johnson Hypothesis

The conclusions of the Averch-Johnson theory of rate of return regulation can be summarized as follows:

- **In the single market case**
  
  If the rate of return permitted by the regulatory agency is greater than the market or shadow cost of capital but is less than the rate of return that the monopoly firm would get were it free to maximize profits without the regulatory constraint, then the firm will substitute capital for the other factor of production (labor) to a point where the marginal rate of factor substitution is not equal to the ratio of factor costs and will therefore operate inefficiently in the sense that capital over-
capacity exists and (social) cost is not minimized at the chosen output level.

- **In the multiple market case**

  If in addition to operating in a single market, the firm can also enter into other regulated markets and the regulatory agency bases its estimation of the "fair" rate of return on the firm's overall assets rather than computing a separate rate of return for each market, then the firm will have an incentive, which it would not have in the absence of regulation, to enter into these other markets, even if the cost of doing so exceeds the additional revenues.

  By expanding into other markets the firm will be able to enlarge its rate base to satisfy the regulatory constraint and earn a greater total profit than would have been allowed in the absence of other markets. As a result, the expanding firm may have an advantage over competitors in oligopolistic or competitive second markets since it will be able to take long run losses in these markets that competing firms cannot. It could, therefore, conceivably drive lower cost producers out of the secondary markets or discourage their entry into it if the loss it can take exceeds the differential between its costs and the lower costs of the more
efficient firms. It should be noted that unlike the case of predatory discount pricing where the monopolist may cut prices at a loss, temporarily, to drive out competitors in the expectation of making positive long term economic profits, the regulated monopolist will undercut its competitors in the secondary markets, even at a long run loss, as long as it can derive additional overall profits from including its capital input in these markets in its rate base.

3.3.1.2 The Empirical Evidence

Considerable empirical evidence supporting the Averch-Johnson hypothesis in different regulated industries has been provided in recent years [Averch and Johnson (1962), Courville (1974), Spann (n.d., 1974), Westfield (1965)].

The U.S. Telephone and Telegraph Industry [Averch and Johnson (1962)]

This study attempts to find empirical evidence of the Averch-Johnson hypotheses stated above in the U.S. telephone and telegraph industry which has a market structure and a regulatory setting consistent with those assumed by the theory. Basically, the industry's market structure is characterized by varying degrees of competition from one subsector to another. Bell Telephone System, a subsidiary of the American Telephone and Telegraph Company, through its 22 associated regional subsidiaries, and other common carriers have monopoly positions in the provision of public message telephone and telegraph services, while they compete with each other in supplying private line services to customers who are,
in addition, free to construct private wire facilities for their own use as an alternative to buying the service from the common carriers. Both state regulatory commissions (which regulate intrastate services of common carriers) and the Federal Communications Commission (which regulates interstate operations) use a "fair" rate of return criterion in regulating prices within their respective jurisdictions.

While no clear cut empirical evidence is available that supports the hypothesis that the common carriers in the industry overinvest in plant and equipment capacity, there is considerable evidence at hand that supports the contention of expansionary "dumping" of services in secondary markets. In particular, fears of "unfair" competition based on operations at "noncompensatory" prices in private line markets play a prominent role as a source of conflict among the common carriers and between them and the F.C.C. Furthermore, in establishing a commercial communications satellite system, the U.S. federal government has enacted a law containing provisions that apparently exploit, "in the public interest," the willingness of common carriers to operate at a loss in secondary markets.

Overcapitalization in the U.S. Electric Utility Industry [Spann(1974)]

This study attempts to show the overcapitalization hypothesis, argued by Averch and Johnson, for the case of the regulated U.S. electric utility sector. It assumes a transcendental-logarithmic production function for electric utilities with three factor inputs (capital, labor and fuel) and proves that with such a production function the Averch-Johnson Hypothesis implies a specific set of constraints on the factor share equations. [See Appendix 3 for
mathematical formulation]. These constraints are then used to
test the validity of the Averch-Johnson thesis.

The Averch-Johnson theory of overcapitalization in industries
under rate of return regulation was accepted in almost all cases
for the electric utility sector.
3.3.1.3 Implications of the Averch-Johnson Theory for Transport Investment in Less Developed Countries

The Averch-Johnson thesis has important implications for transport investment in developing countries. There are basically two transportation modes that fulfill the hypotheses of the Averch-Johnson theory: railroads and trucking. Both can be assumed to produce, to a considerable extent, a homogeneous product; both are natural monopolies characterized by decreasing cost structures; and both are generally subjected to market regulation.

First we will attempt to show that, in the particular case of less developed countries, the Averch-Johnson thesis cannot be applied to the railroads, but that it is, on the other hand, applicable to the trucking sector. Next we will analyze what the implications of the theory are for transportation in general and for rail truck competition in the context of developing countries.

The railroads are usually operated by the government in LDC's either directly or through public "independent" corporations. As pointed out by Due (1979), they have been characterized, in most cases, by heavy losses as a result of some combination of the following factors:

- Rates have been purposely held down by the government as a way to achieve developmental, export expansion, or inflation control objectives.
- Operations are inefficient due to poor management, inadequate equipment and lack of spare parts.
Railroads have lost increasing amounts of volume to the trucking sector. Operations are overstaffed as a result of government employment generation objectives and strong labor unions.

As a consequence of these factors railroad operations in less developed countries have generally experienced losses, at least sporadically and, very often, consistently. We can, therefore, conclude that, even if some internal rate of return regulation exists for public railroad corporations, the regulated rate is likely to be considerably lower than the market cost of capital, particularly since the government is the only source of capital. Thus, a fundamental hypothesis of the Averch-Johnson theory is violated. Furthermore, given the general stagnation of new rail rights-of-way construction that exists in most LDCs we can hardly consider the railroads as capable of aggressively expanding into new markets.

In conclusion, in view of the relatively low and even negative low predominant rates of return on capital for the sector and its inability to expand rapidly into new markets, given the rigidity of its infrastructure, the railroad sector in less developed countries does clearly not fulfill the hypotheses of the Averch-Johnson theory.

The trucking sector in LDCs, on the other hand, falls within the assumptions of the theory. Most developing countries have a significant private trucking sector supported by private capital subjected to market regulation and capable, if they find it profitable, to expand into new markets. In the light of the fact that this
sector draws investment resources from private capital markets, it is reasonable to conclude that, in equilibrium, the allowed rate of return has to exceed the private cost of capital, that is, \( s_1 > r_1 \).

Based on the Averch-Johnson theory, the following conclusions can be made in relation to private regulated trucking in less developed countries.

**Overcapitalization in the Private Regulated Trucking Sector**

If a private trucking firm is subjected to rate of return regulation and is restricted to operate in a certain fixed number of markets and if it is assumed that the permitted rate of return is greater than the private cost of capital and less than the unconstrained rate of return, and that the firm is a profit maximizer, then we can conclude that the firm will substitute capital for the other factor of production, so that marginal rates of factor substitution are different from factor cost ratios. Rate of return regulation under these conditions have the effect of making capital less expensive relative to other inputs (such as labor).

The net result of this undervaluation of capital is that it will be overutilized at the detriment of other factor inputs. In the context of less developed countries this will have the following three connotations:

- As shown in Figure 3-1, at the chosen regulated output there will be a divergence \( \bar{0} \) between the "private" factor cost ratio to the firm and the marginal rate of factor substitution in production. Thus, as a result of rate of return
FIGURE 3-1  THE AVERCH-JOHNSON THESIS; SINGLE MARKET CASE.
regulation the trucking firm will be choosing a socially inefficient combination of inputs, since at the socially optimum input combination it has to be true that the marginal rate of factor substitution in production is equal to the factor cost ratio.

Given this non-zero divergence we have that the output \( Q' \) which is currently being produced by the trucking firm with capital input \( K_1 \) and labor input \( L_1 \) could be produced more efficiently (\( \phi = 0 \)) if regulation were removed with factor inputs \( K_2 \) and \( L_2 \) respectively, where \( K_2 < K_1 \) and \( L_2 > L_1 \). This is particularly relevant for developing countries where capital is, in general, in very scarce supply and has a high opportunity cost, and where there are, usually, ample supplies of labor.

The negative effects of the overutilization of capital described above are not restricted to problems arising from the high opportunity cost of capital in LDC but includes also balance of payments considerations since most of the capital equipment utilized by trucking firms has to be imported. Therefore, overcapitalization of trucking firms will result also in overexpenditure of foreign exchange.
Expansion of Private Regulated Trucking Firm into Secondary Markets

If the private trucking firm is subjected to rate of return regulation under the assumptions given above and, in addition, it is allowed to expand into new markets so that the regulatory agency bases its "fair rate of return" criterion on the firm's over-all value of capital equipment rather than computing a separate rate of return for each market, then the firm will have an incentive to expand into secondary markets (which it would not have in the absence of regulation) in order to enlarge its rate base even if it has to incur a long run loss in these markets. Under these circumstances, it is conceivable that the firm could drive out lower cost producers in the secondary if the loss that it would be willing to take exceeds the cost advantage of more efficient producer.

Naturally, the trucking firm can expand into markets where other trucking firms operate; the case on which we will concentrate though, since it is in our opinion the most relevant to transportation investment in developing countries, is the one in which the regulated trucking firm will expand into markets previously dominated by the railroads.

As pointed out by Friedlander (1979), the railroad industry is relatively homogeneous in the sense that railroads usually carry all kinds of traffic and face relatively similar markets. The trucking industry, on the other hand, is quite segmented and different types of trucking firms face quite different markets. In this context, the most important difference probably lies between the general commodity and the specialized commodity carriers.
General commodity carriers are characterized by a considerable proportion of less-than-truckload (LTL) shipments, small loads, and a large cost component of terminal and consolidation operations. Carriers of specialized commodities, on the other hand, have a significant proportion of truck-load (TL) shipments, large loads and little terminal or consolidation activities.

Given the operating characteristics of railroads, trucking firms clearly have a comparative advantage in the transportation of small shipments of general commodities in LTL lots. There is, therefore, little long run potential competition between railroads and LTL general commodity trucking firms. Thus, even though in many developing countries the railroads continue to provide less-than-carload transport service for general commodities, it is obviously an area where truck have a cost advantage and where they do not need to operate at a loss to capture an increasing market share from the railroads.

Consequently, the main area for future competition between railroads and trucking firms is in the transport of specialized bulk commodities, where railroads traditionally have had a comparative cost advantage and where the trucking firms ability to operate at a long-run loss may allow them to expand into new markets at the expense of the more cost efficient railroads.

When analyzing the effects of the Averch-Johnson rate of return regulatory theory on rail-truck competition, in developing countries, two basic conclusions can be drawn:
• The incentive to regulated trucking firms to expand into secondary markets will accentuate the growth of the trucking sector vis-a-vis the railroads in the shipment of general commodities in less-than truck (car)load lots. This effect is not particularly serious since trucking firms already enjoy a price advantage in this sector (due to lower costs and better level of service) and they would thus enter this market even in the absence of rate of return regulation.

• As shown by the Averch-Johnson thesis regulated trucking firms will have a motive to compete with railways even in new markets where they do not enjoy a price advantage and where they will have to take a long run loss. This implies that, as a result of rate of return regulation, the trucking sector will have an inducement to move into the transport of specialized commodities in truck(car)load lots, where it is generally at a cost disadvantage with the railroads.

In the context of developing countries this second effect of regulation is particularly important since it may fundamentally affect the process of investment in transportation infrastructure in a number of ways:
(i) Sunken Investment versus New Construction

The railway network represents, in most developing countries a substantial amount of sunken capital investment which, if maintained and/or rehabilitated properly, generally has a significant expected useful life left during which it can continue to provide transportation services for which the railroads continue to enjoy a comparative cost advantage (CL transport of specialized commodities, unit trains, etc.). An expansion of truck hauling of specialized commodities will not only considerably deteriorate the existing road system (given the type of equipment and the frequencies of service involved) but will, in addition, require significant new investment in highway infrastructure that is capable of handling the new volumes and loads.

In essence therefore, the shift of this type of cargo from the railways to trucking will require substantial capital investment in new right-of-way infrastructure and decreased utilization, and probably less maintenance, of already established infrastructure in which important amounts of capital have already been sunken. In the capital scarce environment of a less developed country such a policy appears to be, at the very least, questionable.

(ii) Duplication of Transportation Links

The investment inefficiency discussed in (i) above is further aggravated by the fact that the shift of bulk commodities from railroads to trucking will, very often, result, in the long run, in parallel duplication of transport links operating (at least in one case) below right-of-way volume capacity.
(iii) Increased Losses in the Railroads

Railroads have experienced, in recent years, considerable losses in most developing countries. As economic conditions change in the development process, they find it increasingly hard, due to their structural rigidity and to organizational and managerial deficiencies, to cope with newly arisen problems.

By virtue of being government owned and operated, they have not exerted strong political pressure for capital funds, as long as real or monetary salaries have been maintained, even in cases where under or disinvestment has taken place. As a result, both their infrastructure and equipment have generally deteriorated considerably. In addition, limitations on income caused by government imposed "sticky" price structures; overstaffing and labor inefficiency determined by public employment generation and strong labor unions; managerial deficiencies due to lack of adequately prepared personnel; and losses of traffic volume to an increasingly aggressive trucking sector have all combined to push the railroads in most less developed countries further and further into deficit.

It has been frequently argued [Friedlander (1979), Mohring (1976)] that the transportation of specialized bulk commodities in carload shipments between specific geographical locations is one of the areas in which the railroads maintain an important comparative cost advantage and where newly developed rail technology could be successfully applied to accentuate said advantage even further.

By stimulating the competition of the trucking sector in this area at a long run loss, rate-of-return regulation may considerably help to deprive the railroads of one of the few profitable
markets which they have left and to further worsen their presently
difficult financial and operating situation by diverting public
funds from the railways to highway construction programs and by
increasing their losses. This, on its turn, will lead to less
track and equipment maintenance and replacement, more level of
service deterioration and further market contraction and financial
losses.

(iv) Comparative Energy Efficiency

In addition to resulting in an inefficient allocation
of transport investment funds, indirect government "subsidization"
of trucking firms in traditional railway markets through rate-of-
return regulation will have important implications for energy con-
sumption and the balance of payments in non-oil producing less
developed countries. The railroads are clearly more energy efficient
long-haul transporters of bulk specialized commodities than trucks
[Roberts and Kneafsey (1975)]. A shift of volume in this market segment
from the former to the latter will determine an increase in energy, and
specifically oil, consumption which can hardly benefit non-oil
producing developing countries already faced with considerable oil
related balance of payment difficulties.

Summarizing then, developing countries are in general
presently facing difficult choices in the allocation of investment
funds between the railroad and the highway sector. Many of them
have developed rather comprehensive and ambitious highway construction
programs responding, in part, to the belief, probably inspired by
the example set by more developed nations, that highway development is
a prerequisite for overall economic development and, in part, to political pressures from existing and potential trucking entrepreneurs. As a result of these new and substantial demand for capital in the highway sector, less resources have been made available to the railroads further worsening their already weak financial and operating position which has been caused, to a large extent, by a loss of market to trucking and by consequently poor financial performance, inadequate maintenance of track and equipment and inefficient management.

Within this changing railroad/trucking equilibrium, rate-of-return regulation of trucking firms may have contributed, by indirectly "subsidizing" their entry at a loss in specialized commodity markets, to accelerate the market share loss of the railroads even in areas where they still hold a comparative cost advantage and to encourage the growth of demand for highway construction. In addition, rate-of-return regulation is likely to have caused an excessive and socially inefficient use of imported capital equipment vis-a-vis labor in the trucking sector.

The potential detrimental consequences of these effects for transportation investment in the capital and foreign exchange scarce environment of less developed countries should be again emphasized.

In the particular case of Egypt, it is clear that the relative shift from railroads to trucks in freight transportation has been considerable, and that the financial losses of the railways as a result of this shift has been significant. As discussed in 3.2 above, the trucking sector has expanded into areas where railways have traditionally had comparative cost advantage. Even though it is very difficult to determine to what extent the appearance of railroad undercapacity and
the shift in freight volume have been caused by market regulations (in view of the fact that there is an important public trucking sector in Egypt and that the private trucking sector is mainly composed of co-operatives), it is important to take the issues discussed above into consideration, particularly since an expansion of the relative freight market share of the railroads appears to be at the moment a primary objective of Egyptian transportation policy.

3.3.2 The Effects of Market Regulation on the Quality of Service

Our analysis of the effects of market regulation on the level of service in transportation and their consequences for investment in the sector will be based on the model developed by White (1972). This model is based on the basic assumption that quality of service variables are essentially a secondary output of a firm complementary to its primary output. As a second output of the firm, a quality parameter has two important characteristics. First, it influences the market demand for the firm's primary output, either by affecting the overall market demand for the product or by changing the firm's relative share of the total unchanged market demand or by a combination of the two effects.

Second, it is connected to the primary product, both in production and consumption. If we assume that the secondary quality output is viewed by consumers as being identical across all firms in the industry, then the only possible quality difference among firms is the variation in the \textit{level of service} provided by various firms as perceived by consumers. Two types of quality variables can complement the primary product; an "operation" quality variable that is produced
and consumed in units that are tied directly to each unit of primary product (the time reliability of a given trip for example) on a "fixed" quality variable which is not tied to units of primary output but is, instead, set at an overall level (e.g., a conveniently located terminal) and does not, in the short run, vary directly with primary output.

The difference between these two kinds of quality variables is similar to that which exists between variable and fixed costs; in the long run all costs (and all quality parameters) are variable, but in the short run some costs are fixed and some quality parameters do not vary directly with output.

The model's hypotheses are that there is an industry composed of n firms subjected to market regulation which produce a basic output, transportation, and two secondary quality aspects (one fixed, the other variable). Furthermore, the overall market demand functions for transportation and level of service are supposed to be complementary and, at the limit, independent. A mathematical treatment of the model is contained in Appendix 4; a summary of its conclusions is given in 3.3.2.1 below.

3.3.2.1 Conclusions of the Level of Service Model [White (1972)]

As shown in Appendix 4 the model has important implications for the analysis of the effects of market regulation on the transportation level of service. Its conclusions can be summarized as follows:

- A competitive or oligopolistic industry under market regulation will offer more quality per primary output unit than would a pure monopolist*

*Empirical evidence supporting this point is given by Caves (1962) for the airline industry.
In consequence, a regulated competitive or oligopolistic industry will sell more units of the primary product than will a regulated monopolist.

The level of quality per unit of primary product that will be provided by a competitive or oligopolistic regulated industry will be positively related to the price set by the regulatory agency.

The monopolist's quality response to price changes is not predictable a priori. In particular, if the demand for transportation becomes less responsive to the level of service as the price of transportation increases, then quality per unit might actually decrease rather than increase as a result of a price rise.

Finally, a decrease in the regulated price will not necessarily cause an increase in the quality of transportation services demanded.

The same above conclusions apply for the case of fixed overall quality of service.

3.3.2.2 Implications of the Effects of Market Regulation on Level of Service for Transportation Investment in Developing Countries.

The conclusions of this model on the effects of market regulation as described in 2.1.1 above on level of service have important
implications for transportation investment in less developed countries, particularly on the distribution of capital resources between the railroad and the highway sectors.

As was mentioned in 3.3.1.3 above, the railroads are a publicly owned and operated monopoly in most developing countries and are therefore subjected to rate of return regulation where it is reasonable to assume that, in general, the rate of return $s_1$ is less than the market cost of capital $r_1$. On the other hand, the trucking firms can be usually considered to be oligopolistic and is also under government market regulation with $s_1 > r_1$.

Given these characteristics and in the light of the level of service model discussed above we can conclude that the market regulation may have affected the comparative railroad/trucking levels of service in the following ways:

**Deterioration of Railroad Level of Service**

Since the railroads operate as monopolists in the sense that they usually do not follow an aggressive strategy of capturing market from the trucking sector but rather continue to operate defensively by attempting to maintain their market share through low prices, we can expect that, given market regulation and the oligopolistic or competitive character of trucking in most developing countries, for a common price the quality of service of the railroads will be lower than that of competing trucking firms. Thus market regulation of trucking and railroads will favor the creation of a level of service differential between the two modes that will accentuate the one arising from the financial difficulties experienced by the railways which have already been discussed.
As a result of this difference in quality of service (expressed in terms of disparities in waiting and travel time, time reliability, breakage and pilferage, etc.) a change in the composition of freight carried by the two modes will occur over time as high value concentration commodities shift from railway to highway transportation. This transfer accelerates with economic development since as developing countries diversify their production by moving gradually from the exploitation and export of bulky, low value concentration primary commodities into the manufacture and export of less bulky, high value concentration industrial goods transport requirements tend to de-emphasize low cost and to stress lower risk and higher reliability of the system. The shift which is considerable in terms of freight ton-miles is even more important in revenue-miles, as the railroads become increasingly limited to the transport of low value primary commodities.

We can, therefore, conclude that market regulation, by encouraging level of service differentials, may have accelerated the switch of high value commodities (including passengers) from the railroads to trucking and bus transportation. This transfer of transport revenue away from the railways is undoubtedly responsible to a large extent for the deterioration of the railroads financial and operating situation.

The Effect of Price Increases on Level of Service

While in the case of the oligopolistic or competitive trucking firms it is clear from the theory that a price increase will result in an improvement in the level of service, it is possible that
a rise in railroad fares results in an even lower quality of rail service. As we have argued, the quality differential between rail and trucking transportation have led, in developing countries, to a considerable shift in high value commodities from the former to the latter.

If under these circumstances an increase in railway prices takes place, some additional transfer of high value freight is likely to occur. In that case the ex-ante average value of freight will be higher than that of the ex-post average and it is conceivable that, as a result, the shippers' demand responsiveness to changes in quality decreases. If this reduction is of sufficient magnitude we have, according to the theory, that the price increase will actually result in a deterioration of the level of service.

Summarizing then, government imposed price rigidity has been often blamed [Due (1979)] for the poor quality of railroad transportation in less developed countries. Our analysis shows though that, given market regulation and under some assumptions that are likely to hold in LDC's, railroad level of service might worsen even in the face of rising prices.

In conclusion, market regulation has accentuated quality differences between rail and truck transportation and has therefore speeded up the shift of the high value commodity market segment from the former to the latter in developing countries. The resulting transfer of demand and, especially of revenue has had and will continue to have important implications for transportation investment. (For a discussion of these refer to 3.3.1.3 above).
This argument is particularly relevant in the case of Egypt where the loss of traffic of the railroads to the trucking sector has been substantial and where the transport authorities are presently attempting to induce a comeback of the railways. Level of service is clearly an important component of transportation cost and thus will significantly influence the decision of a shipper as to the mode to choose. If market regulation provides an incentive for truckers to maintain a higher level of service while no such incentive is given to the railroads, then it is in the government's interest, if the volume expansion of the railroads is to be achieved, to establish strict quality control in the sector that will ensure that quality of service equilibrium is established with other modes.
3.3.3 The Effects of Market Regulation on Technological Innovation

3.3.3.1 The Theory of Innovation and Regulation

The timing of the process by which regulation acts to eliminate the Ricardian rents of an innovating firm has a significant effect on the rate of technological innovation of said firm since it will modify the magnitude of the financial incentive that the firm has to introduce new technology. The concept is illustrated in Figures 3-3(a) and (b). In Figure 3-3(a) the regulated firm has an average cost curve $AC_o$ and a marginal cost curve $MC_o$; these costs include a rate of return on capital which is equal to the maximum rate of return $s$ allowed by the regulatory agency. The firm faces a less than perfectly elastic demand $D$; the regulated price has been set at $p_o$ where the demand curve intersects the average cost curve, that is, economic profits for the firm are zero; output is $q_o$. We will further assume that the price level $p(t)$ is dynamic; the regulatory body has the ability to change it over time to adjust for changes in the firm's cost structure, which always includes a rate of return on capital $s$. In Figure 3-3(b) the firm has introduced a technological innovation which has reduced its average and marginal cost curves to $AC_1$ and $MC_1$, respectively. Let $t = 0$ be the time at which the innovation is introduced. At $t = 0$ the regulated price is still $p_o$ and output volume continues to be $q_o$. The firm is now making a positive economic profit

$$\Pi = q_o[p_o - AC_1(q_o)] = q_o p_o - \int_{q=0}^{q_o} MC_1(q) dq$$

(3-24)
We therefore have that the regulatory agency will reduce the regulated price until \( p = p_1 \) where \( p_1 \) is determined by the intersection of the demand curve \( D \) and the new average cost curve \( AC_1 \)

\[
\frac{dp(t)}{dt} < 0 \quad 0 < t < T \tag{3-25}
\]

\[
\lim_{t \to T} p(t) = p_1 \tag{3-26}
\]

where \( T \) is the period of total regulatory price adjustment.

If the inverse market demand function is given by

\[ q = \phi(p) \tag{3-27} \]

we have that the total gross economic profits accrued to the firm as a result of technological innovation are given by

\[
\Omega(T,r) = \int_{t=0}^{T} \left[ \phi[p(t)]p(t) - \phi[p(t)]MC_1(q)dq \right] e^{-rt} dt \tag{3-28}
\]

where \( r \) is the market rate of return (cost) of capital.

By changing the length of \( T \), the regulatory review period, the regulatory body can control the magnitude of the Ricardian rents and, thus, the level of financial incentive permitted for technological innovation.

Given a value of \( T \), the firm will select an optimal level of innovative activity. The mathematical derivation of said optimal level is given in Appendix 5.

As proved in the Appendix, the level of technological innovation will be directly and positively related to the length of the regulatory review period; the shorter the regulatory lag the less the regulated firm will invest in technological innovation.
3.3.3.2 Implications of the Theory for Transport Investment in Developing Countries

This result has important consequences for railroad-trucking competition in less developed countries and, through it, on the relative modal demands for transportation investment.

The level of service in any transport mode will, in general, be positively correlated with degree of technological innovation since better technology will improve service both directly, and indirectly by allowing higher profits that can be later, at least in part, ploughed back into the firm. In consequence, less innovation will, in the long run, cause a deterioration in the quality of service and will thus affect the demand for the firm's product.

As we have seen before, railroads are, in most developing countries, government owned and operated, whereas trucking companies are, to a large extent, private enterprises subject to government regulation. Within this framework of operation we would expect the railroads to have a considerably shorter regulatory review period than the trucking sector and, therefore, a much smaller incentive to invest in new technology. In fact, in the particular case when the government operated railway enterprise is currently experiencing financial losses the review period will have zero length; that is, an introduction of new cost-saving technology will only have the effect to reduce the losses of the enterprise and, in consequence, the magnitude of government subsidies. Nevertheless, since the government would have taken care of these additional losses through larger subsidies anyway, it is clear that the firm has no incentive
whatsoever to be innovative even if the funds should be made available for that purpose. It should be emphasized that this is the case that will most likely be encountered in the majority of developing countries. In the more unlikely event that the public railway company is not making a loss, the review period will still be limited in its length by the government budget process and will thus generally be limited to a maximum of one year.

Since the government control of the private trucking firms, by virtue of being indirect and of depending on privately generated information, is more relaxed, we can safely assume that the regulatory lag for said firms will be significantly longer than for even a profitable public railroad firm. In conclusion then, the trucking firms will have a stronger incentive to introduce technological innovations than railway firms in less developed countries.

The effect of such a differential in innovative activities on the quality of service will be considerable, particularly since, given that railroads operate and maintain their own tracks and traffic systems, the resulting relative obsolescence of the railways will not be limited to their rolling stock but will extend, in addition, to the rights of way, terminals, traffic and signalling, etc. (sectors whose technological development in the highway sector is the responsibility of government agencies and, therefore, independent of the trucking firms' desire to invest or not.

The technological obsolescence of the railroads vis-a-vis the trucking sector can be observed in many developing countries, and, as discussed above, is clearly recognizable in the case of Egypt; in
their tracks, their locomotives, their rolling stock, their marshalling yards, and the signalling equipment. It is often blamed on a lack of investment resources and on the poor financial situation of the enterprises; as our model shows though, even if the resources were available the railways might not invest in new technology given that, as a result of being government owned and operated, they lack the economic incentive to engage in innovative activities. This factor again points out to the fact that government market regulation has, by discouraging technological innovation in the railroads, has accelerated the deterioration of their level of service vis-a-vis the trucking sector and encouraged the shift of freight demand from the former to the latter. Such a shift has expanded, as we discussed before, the demand for new investment in the highway network while it has encouraged the underutilization and abandonment of a substantial sunken investment in the railway system.
3.4 THE EFFECTS OF OPERATING REGULATIONS ON TRANSPORTATION INVESTMENT IN DEVELOPING COUNTRIES

Until now we have concentrated on the analysis of transportation market regulations and on their effect on investment in the sector in less developed countries. As was mentioned before though, operating regulations will also have a significant impact on the level and time and space allocation of transport investment; in this section we will concentrate on the study of three operating regulations on the trucking sector which can be found in virtually any country: axle load limitations, total weight limits and truck size specifications.

As has been argued by Crandall (1979) operating regulations are essentially different from market regulations. In the case of the latter there appears to be agreement among economists on the fact that they tend to raise the cost of transportation above what it would be without regulation, but both market and public opinion forces tend to limit the additional costs that the regulatory agencies can impose on the rest of society. If prices are set too much higher than the cost of production, customers will seek alternative sources of transport services supply. In the U.S., for example, the decision by the Interstate Commerce Commission to allow value-of-service pricing for interstate trucking which in many densely travelled corridors exceeds the cost of service has led shippers to find alternative, unregulated forms of carriage. Furthermore, decisions to set rates at excessively high levels generally bring about public scrutiny of the responsible agency; as a result, public reaction to rising utility rates has been, in the U.S., an important constraint on public utility regulatory commissions.
These automatic correcting forces do not exist in the area of operating regulations, be they motivated by safety or design standards considerations. A transportation firm has no alternative but to comply with a mandatory operating regulation if the regulatory agency has sufficient enforcement power at its disposal. Moreover, the cost of said regulation to the firm, and ultimately to the user who will be the one to pay for it, cannot be directly observed, since it cannot be discerned from other costs which are incurred in the production of the service. And since operating regulations usually involve issues of design limitations and/or safety that a regulator can invoke to justify his actions, even if the costs of the regulation can be isolated, an evaluation of its appropriateness is still difficult.

Operating regulations have very substantial effects on transport investment. They affect the supply side of transportation by determining the level of deterioration and safety of the infrastructure and thus the requirements for maintenance work and new investment. They also influence the demand side since, by changing the operating characteristics of individual firms, they modify their cost structure and therefore the price they charge for their services.

In order to analyze these effects in more detail in the context of less developed countries, we will turn our attention in the following sections to three specific operating regulations which are applied to the trucking sector in most countries: axle load and total truck weight limitations and truck size specifications.
3.4.1 Axle Load and Total Truck Weight Limitations

Axle load and total truck weight limitations are an important component of trucking operating regulation in most countries. They have generally been established in response to the need to preserve the quality of highway systems and to retard the excessive pavement deterioration that vehicle weights in excess of the road maximum design standards may cause. They are therefore considered to be important regulatory complements to highway investment programs since, it is argued, they contribute to: (i) slow down the pace of real depreciation of newly constructed infrastructure and (ii) diminish the amount of resources needed for maintenance of said infrastructure.

While the effects of axle load and total truck weight limitations on investment in construction and maintenance of highway infrastructure have been generally understood and used by regulatory agencies to justify their usefulness and application, less attention has been paid on the public sector to the consequences that these operating regulations have had for the operations and cost structures of individual trucking firms and on transport economic efficiency, modal split and energy use. Since all these areas of highway freight transportation are clearly influenced by vehicle weight regulations, an analysis of these relationships is warranted if the overall effect of said regulations on transport investment is to be evaluated. Furthermore, an appraisal of these issues in developed countries could prove very useful in providing transport planners and policy makers in developing countries with a broader perspective of the problems and tradeoffs involved in the matter.
Developing countries which have chosen to engage in comprehensive and ambitious highway construction programs have found that these programs have absorbed a very substantial proportion of available investment resources for a considerable number of years and, moreover, that after a certain point, deterioration of the system has picked up with or even surpassed the pace of new construction creating an additional and growing demand for highway maintenance funds. The case for the protection of such major investment from excessively fast deterioration is therefore quite clear and, in our opinion, beyond argument.

With respect to weight limitations on trucks though, several important issues arise which have to be carefully considered:

- To what extent is abnormal pavement wear brought about by abuse of the system, in the form of excessive axle loads and vehicle weights, by truck traffic?
- What are the tradeoffs between infrastructure construction and maintenance costs, and truck operating costs caused by more or less severe weight regulations?
- If abnormal pavement deterioration occurs because of excessive axle loads and/or vehicle weight, is it the result of too lenient regulations or of lax enforcement?
Should the problem be corrected by stricter weight limitations or by higher truck taxes?

Should weight limitations be set at the national or regional level.

3.4.1.1 Truck Weight and Pavement Deterioration

The relationship that exists between truck weight and highway design standards is one that is difficult to explain, given its technical character and the multitude of interacting parameters, concepts, criteria and design standards, and quite controversial. There is thus generally no unique answer to the question of what specific weight a pavement is designed for. This is not because vehicle weight is not an important part of any pavement design procedure (as it surely is) but, rather, because of the fact that, very often in practice, the same axle load and weight limits are used for pavements of different thicknesses under similar conditions or pavements of the same thicknesses have different weight regulations under similar conditions.

In response to this relative uncertainty several pavement deterioration tests were conducted by AASHO (American Association of State Highway Officials) in the 1950-1960 decade. The AASHO Road Test was the largest and most comprehensive of these experiments; it introduced new concepts into pavement design thinking, and provided new tools for use in pavement design which contributed to improve design techniques and to create a measure of uniformity in the subject. In its broadest sense, the applications and interpretations of the AASHO Road Test can be classified into two
categories. The first category includes the observations of the road test, as supported by experience and subsequent research, which represent reasonable applications of the research findings to new concepts of pavement. The second group consists mainly of applications of said findings to pavement deterioration prediction and prevention.

Figure 3-2 illustrates the concept of pavement wear as analyzed by the AASHO Road Test. A mean deterioration graph is given together with a 90% confidence interval. The vertical axis shows the subjective, non-dimensional pavement condition rating. The horizontal axis depicts the cumulative traffic in terms of 18,000 pound single axle load equivalents. In addition, the relative performance of two highway pavements are shown; A (which has carried no truck traffic) and B (which has carried a very heavy concentration of truck traffic). As shown by the graph, the "no truck" road A has performed far worse than the Road Test predicts, and the "heavy truck" road B has performed much better than forecasted by the test. Both points are outside the 90% confidence interval of the AASHO wear curve, which predicts pavement deterioration for a portland cement pavement that is 9 inches thick as determined by the AASHO Road Test equations.

The evidence shows that traffic and traffic weight are not the only factors that influence pavement performance. They are nevertheless important factors which have been shown to significantly and positively affect pavement deterioration. We can therefore conclude that:
Figure 3-2: AASHA Road Test; Theoretical Pavement Wear Curve, 9" PCC Pavement
Axle load and total weight limitations should be imposed that are within the maximum design standards of pavements and bridges respectively. Failure to impose or enforce said standards will cause a more rapid deterioration of highway pavement and bridge infrastructure, shortening their useful life and increasing the demand for highway maintenance funds. The magnitude of the increase in deterioration will depend upon other road and environmental conditions.

3.4.1.2 The Cost of Weight Limitations to Truck Operators.

Axle load and total weight limitations clearly impose certain additional costs on truck operators. They influence their choice of equipment and, by limiting their maximum legal payload, they determine the allocation of fixed costs (depreciation of equipment, interest on capital, insurance) and variable costs (fuel, oil, tires, driver's and helper's wages) per ton of commodity transported. There exists therefore a tradeoff between infrastructure construction and maintenance costs and truck operating costs in the determination of the "optimum" axle load and weight limits.

From a social point of view, the incidence of these costs is significantly different. Excessive deterioration of the highway infrastructure will not only adversely affect all other users of the system but will, in addition, cause an accelerated depreciation of the investment and an increased need for maintenance, both of which will result in a larger demand for public funds and, therefore,
either in an impoverishment of this or other services or in higher taxes. The increase in trucking costs, on the other hand, will only affect users of truck transportation services, if it is reflected in higher prices, or truck operators, if it results in lower profits, or both, if it impedes the transport of certain goods by truck. In any case, the incidence of an increase in truck costs as a result of axle load and/or weight limitations will be much narrower in social terms and less significant from an economic development point of view than the excessive use of investment funds in the highway sector that the absence or exaggerated relaxation of said limitations could cause. Furthermore, the cost effects will be more substantial in the case of trucking firms which are engaged in the transportation of bulk, low value concentration commodities since, as we have seen, they do not enjoy a comparative cost advantage vis-a-vis the railroads and have often managed to expand into these markets behind the protective barrier of government regulation.

3.4.1.3 Recommendations

In view of these facts we can make the following recommendations in relation to axle load and total weight regulations in less developed countries:

- Under no circumstances should these limits be relaxed beyond a level which is larger, by a significant safety factor, than the maximum allowed design standards of the highway system in question. The protection of the important capital investment
that many developing countries have devoted to the construction of highway networks is too crucial a factor for socio-economic development to be sacrificed for the benefit of a narrow group of trucking operators and/or users.

- Weight limitations clearly affect to a larger extent those truck operators who are engaged in the penetration of markets which traditionally and from an economic efficiency point of view belong to the railroads. By manipulating these limits the government could not only avoid excessive deterioration of the highway system but could, in addition, protect the railroads' traditional markets and avoid economic inefficiency in transportation.

- Weight regulations, once implemented, should be strictly enforced. Only in this way will they perform their function. This implies, of course, more investment in fixed and portable scales and trained personnel.

- Weight regulations should be set at a common national, rather than regional, level to avoid costly rerouting and operator uncertainty.
Finally, truck taxes should be levied to contribute in the construction and maintenance of highways. Subsidizing the trucking sector by providing free or very cheap rights of way will only contribute to create duplication of transport links, inefficiency and stagnation of the railways.
Another important area of government operating regulations of the trucking sector is that constituted by truck size limitations. These limitations are imposed in order to ensure that the size of trucks conforms to the design of the highways they are driven on and that their operation does not imperil the safety of other vehicles which share the roads with them. The trucking industry, on the other hand, generally argues for less stringent limitations on truck and truck combination dimensions which, in their view, would allow for more efficient, more flexible, safe and more energy saving trucking operations. As the positions of both sides show, the issues that are involved in the problem of determining appropriate truck size standards are of particular relevance for developing countries.

3.4.2.1 Straight Truck Versus Tractor Trailers

In his paper on the relative advantages and disadvantages of straight trucks and tractor trailers, Seibert (1977) includes results of a survey he conducted on seven representative freight terminals in the U.S. to determine the comparative labor productivity of both types of equipment. The survey covered a period of two weeks (one week for each type of truck) in which both the driver and the area served remained constant. As Table 3-5 shows, the tractor trailer combination was considerably more productive in terms of pounds per man-hour than the straight truck.

Using the productivity figures of his survey, Seibert calculated the net-after-tax present discounted value of two investment outlays, one on three tractor-trailer combinations and one on four straight
### TABLE 3-5

**SURVEY RESULTS**

<table>
<thead>
<tr>
<th>TERMINAL</th>
<th>STRAIGHT TRUCK</th>
<th>TRACTOR-TRAILER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LBS.</td>
<td>HRS.</td>
</tr>
<tr>
<td>A</td>
<td>105,651</td>
<td>40.7</td>
</tr>
<tr>
<td>A</td>
<td>71,917</td>
<td>42.7</td>
</tr>
<tr>
<td>B</td>
<td>64,616</td>
<td>23.0</td>
</tr>
<tr>
<td>B</td>
<td>22,729</td>
<td>22.8</td>
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<td>57,102</td>
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</tr>
<tr>
<td>D</td>
<td>51,881</td>
<td>39.0</td>
</tr>
<tr>
<td>D</td>
<td>27,220</td>
<td>33.0</td>
</tr>
<tr>
<td>E</td>
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</tr>
<tr>
<td>F</td>
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<td>43.0</td>
</tr>
<tr>
<td>G</td>
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</tr>
<tr>
<td>G</td>
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<td><strong>TOTAL</strong></td>
<td><strong>612,157</strong></td>
<td><strong>394.6</strong></td>
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</tbody>
</table>

### TABLE 3-6

<table>
<thead>
<tr>
<th>Year</th>
<th>Truck Maintenance</th>
<th>Tractor Maintenance</th>
<th>Trailer Maintenance</th>
<th>T.T Maintenance</th>
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<tr>
<td>1</td>
<td>$ 600</td>
<td>$ 700</td>
<td>$100</td>
<td>$ 800</td>
</tr>
<tr>
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<td>900</td>
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</table>
trucks (the four to three ratio is determined by their relative pounds per man-hour productivities; 2,133 lbs/hr. divided by 1,551 lbs/hr. = 1.38). Three tractor-trailers can do the work of four straight trucks on the average and thus one less driver will be required; in the U.S. at today's rates, one driver is costing $19,800 a year including base pay, social security, health and welfare, pension and unemployment taxes. The differential tax effects of depreciation are also considered in the study. Since three tractor trailer units still cost more than four straight trucks, the annual depreciation charges are greater; this will result in lower income taxes. For tax purposes, all units are depreciated over an eight-year life using the accelerated depreciation of double-declining balance. Since trailers' useful life can be of up to eight years while trucks and tractors will only last for four years, it is assumed that trucks and tractors are traded in at book value at the end of the fourth year and everything is traded in at book value at the end of eight years. A tax rate of 50% was chosen.

Average prices used are $17,000 for a single axle tractor, $6,000 for a 32' trailer and $13,000 for a straight truck. Maintenance costs are given in Table 3-6, a $200 a year licensing difference in favor of the straight truck and a 10% cost of capital are also assumed. The total maintenance costs are tabulated in Table 3-7 and total annual cash flows are summarized in Table 3-8. The operational cost savings is the cost of one less driver ($19,800) reduced by the 50% tax rate. Annual maintenance savings are also reduced by 50%.
### MAINTENANCE COST DIFFERENTIAL

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<tr>
<th>Year</th>
<th>T-T Maintenance</th>
<th>ST Maintenance</th>
<th>T-T License</th>
<th>ST License</th>
<th>T-T Total</th>
<th>ST Total</th>
<th>Difference</th>
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<td>$600</td>
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<tr>
<td>4</td>
<td>4,800</td>
<td>4,000</td>
<td>1,050</td>
<td>600</td>
<td>5,850</td>
<td>4,600</td>
<td>1,250</td>
</tr>
<tr>
<td>5</td>
<td>2,400</td>
<td>2,400</td>
<td>1,050</td>
<td>600</td>
<td>3,450</td>
<td>3,000</td>
<td>450</td>
</tr>
<tr>
<td>6</td>
<td>3,000</td>
<td>2,800</td>
<td>1,050</td>
<td>600</td>
<td>4,050</td>
<td>3,400</td>
<td>650</td>
</tr>
<tr>
<td>7</td>
<td>3,900</td>
<td>3,200</td>
<td>1,050</td>
<td>600</td>
<td>4,950</td>
<td>3,800</td>
<td>1,150</td>
</tr>
<tr>
<td>8</td>
<td>4,800</td>
<td>4,000</td>
<td>1,050</td>
<td>600</td>
<td>5,850</td>
<td>4,600</td>
<td>1,250</td>
</tr>
</tbody>
</table>

### TABLE 3-7

#### NET TAX CASH FLOW

<table>
<thead>
<tr>
<th>COST</th>
<th>Total</th>
<th>Difference</th>
<th>Investment Tax Credit Difference @ 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Single-Axle Tractors</td>
<td>$51,000</td>
<td>$17,000</td>
<td>1,767 (1)</td>
</tr>
<tr>
<td>3 32' Trailers</td>
<td>$18,000</td>
<td>$52,000</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$69,000</td>
<td>$17,000</td>
<td></td>
</tr>
</tbody>
</table>

#### YEAR | T-T BOOK | ST BOOK | T-T DEP | ST DEP | NET DEP | TAX SAVINGS
0 | $69,000 | $52,000 | $30,000 | $26,000 | $4,000 | 2,000 |
1 | 39,000 | 26,000 | 16,125 | 13,000 | 3,125 | 1,513 |
2 | 22,875 | 13,000 | 8,906 | 6,500 | 2,406 | 1,203 |
3 | 13,969 | 6,500 | 5,086 | 3,250 | 1,836 | 918 |
4 | 56,695 | 52,000 | 26,924 | 26,000 | 924 | 429 (2) |
5 | 29,771 | 26,000 | 13,810 | 13,000 | 818 | 409 |
6 | 15,593 | 13,000 | 7,176 | 6,500 | 676 | 338 |
7 | 8,777 | 6,500 | 3,789 | 3,250 | 539 | 269 |

(1) This figure is slightly different from 10% because the trucks and tractors are only eligible for one-third of the credit because they only last four years, instead of the eight necessary for the full credit.

(2) The normal 50% rate of $462 is reduced $33 because of the investment tax credit differential.
**TABLE 3-8**

MEASURING THE BENEFIT OF PURCHASING THREE TRACTOR-SHORT TRAILERS VS. FOUR STRAIGHT TRUCKS - NO INCREASE IN FREIGHT: NET PRESENT VALUE METHOD

<table>
<thead>
<tr>
<th>YR</th>
<th>Operational Cost Savings</th>
<th>Net Tax Savings</th>
<th>Maintenance Cost Savings</th>
<th>Net Cash Flow</th>
<th>Present Value Cash Flow (10%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$(17,000)</td>
<td>$1,767</td>
<td>$</td>
<td>$(15,233)</td>
<td>$(15,233)</td>
</tr>
<tr>
<td>1</td>
<td>9,900</td>
<td>2,000</td>
<td>(225)</td>
<td>11,675</td>
<td>10,613</td>
</tr>
<tr>
<td>2</td>
<td>9,900</td>
<td>1,513</td>
<td>(325)</td>
<td>11,088</td>
<td>9,159</td>
</tr>
<tr>
<td>3</td>
<td>9,900</td>
<td>1,203</td>
<td>(575)</td>
<td>10,528</td>
<td>7,907</td>
</tr>
<tr>
<td>4</td>
<td>9,900</td>
<td>918</td>
<td>(625)</td>
<td>10,193</td>
<td>6,962</td>
</tr>
<tr>
<td>5</td>
<td>9,900</td>
<td>429</td>
<td>(225)</td>
<td>10,104</td>
<td>6,275</td>
</tr>
<tr>
<td>6</td>
<td>9,900</td>
<td>409</td>
<td>(325)</td>
<td>9,984</td>
<td>5,631</td>
</tr>
<tr>
<td>7</td>
<td>9,900</td>
<td>338</td>
<td>(575)</td>
<td>9,663</td>
<td>4,957</td>
</tr>
<tr>
<td>8</td>
<td>9,900</td>
<td>269</td>
<td>(625)</td>
<td>9,544</td>
<td>4,457</td>
</tr>
</tbody>
</table>

Net Present Value = $40,726
The project of investing in three tractor-trailer units instead of four straight trucks is clearly a profitable one. The annual cash flows are substantial, the payback period for the project is around 16 months, and its internal rate of return is 69%. From a financial point of view this is obviously a good investment, whatever investment evaluation method may be used. Nevertheless, the other aspects of the project should also be taken into consideration:

- The productivity figures used in the financial calculations are averages; as Table 3-5 shows they will substantially change from terminal to terminal depending on its location and the traffic congestion existing within it.
- In addition to being able to carry more freight per driver, the tractor-trailer combination can load larger shipments. This allows for the pickup of some shipments that do not fit on a straight truck.
- A shipper is more likely to load an extra shipment on a trailer simply because the extra capacity is available.
- Additional tractors add to the flexibility of the operation. If a tractor breaks down, instead of having to re-handle all the freight it is carrying (as would happen in the case of a straight truck) the tractor can simply be switched by another.
3.4.2.2 Single Versus Twin Trailer-Tractor Combinations

The economic case for twin trailer-tractor combinations has been argued for many years by the American Trucking Association in the U.S. The present status of twin trailers in the United States varies from region to region; virtually all Western and Midwestern states permit the operation of twins equipment at the effective 65 feet length limit. These twins are also allowed in the Eastern states of Maryland and Delaware; in all 31 states permit the 65 feet long twins. In addition, twin trailers at the lengths of 55 and 60 feet overall, which are less efficient, are allowed to operate in four states and one state respectively. While the majority of states authorize twins to operate unrestricted on all highways, eleven states limit them to specially designated highways.

In a recent study of the operating characteristics of the twin trailer the American Trucking Association (1978) concluded that:

- Twin trailer combinations consist of a truck tractor drawing two short semi-trailers with an overall length of 65 feet, only 5 to 10 feet longer than the tractor-single trailer now operating everywhere. Twin trailer units are no wider, no higher and operate at no greater weights than other trucks. Yet they provide up to one-third more loading space for light and bulky commodities and can reduce
fuel consumption by more than 20 percent.\(^{(1)}\)

- Twin trailer combinations have operated in and around the congested urban centers of San Francisco, Chicago, and Cleveland for many years. The two short trailers can be readily disassembled to form two separate small city delivery type truck units. This has reduced urban congestion caused by trucks as shorter units operate into the city center. Twins' shorter trailers mean easier loading for shippers, easier access to loading and unloading facilities. Such greater flexibility provides an opportunity for lower costs.

- Billions of miles of operating experience have demonstrated that twin trailer combinations are among the safest trucks on the road today. Studies by state and Federal agencies, including the Bureau of Motor Carrier Safety of the Department of Transportation and the National Highway Traffic Safety Administration have verified the safety of these combinations when compared with any other vehicles on the highways. Insurance company executives and

\(^{(1)}\) The potential fuel savings in hauling one million tons of highway freight in twin trailer combinations rather than in other truck combinations are given in Tables 3-9 and 3-10.
### Table 3-9

**Carrying Capacities and Fuel Use for Typical Combinations**

<table>
<thead>
<tr>
<th>Type of Combination</th>
<th>Average Gross Combination Weight (in pounds)</th>
<th>Maximum Payload Per Truck (in tons)</th>
<th>Number of Loads Required to Carry 1 Million Tons of Freight</th>
<th>Fuel Consumption Rate (Gallons Diesel Fuel Per Mile)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>55 Foot Tractor Semitrailer</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light and Bulky Freight</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With 40 Foot Semitrailer</td>
<td>60,725</td>
<td>16.0605</td>
<td>62,265</td>
<td>0.156</td>
</tr>
<tr>
<td>With 45 Foot Semitrailer</td>
<td>65,250</td>
<td>18.1250</td>
<td>55,172</td>
<td>0.161</td>
</tr>
<tr>
<td>Dense Freight</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With 40 Foot Semitrailer</td>
<td>73,280</td>
<td>22.3400</td>
<td>44,763</td>
<td>0.169</td>
</tr>
<tr>
<td>- Old Limit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- New Limit</td>
<td>79,000</td>
<td>25.0000</td>
<td>39,683</td>
<td>0.176</td>
</tr>
<tr>
<td>With 45 Foot Semitrailer</td>
<td>73,280</td>
<td>22.1400</td>
<td>45,167</td>
<td>0.169</td>
</tr>
<tr>
<td>- Old Limit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- New Limit</td>
<td>79,000</td>
<td>25.0000</td>
<td>40,000</td>
<td>0.176</td>
</tr>
<tr>
<td><strong>65 Foot Twin Trailer</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Freight - Old Limit*</td>
<td>73,280</td>
<td>22.0515</td>
<td>45,348</td>
<td>0.167</td>
</tr>
<tr>
<td>Light and Bulky Freight - New Limit</td>
<td>76,677</td>
<td>23.7500</td>
<td>42.105</td>
<td>0.171</td>
</tr>
<tr>
<td>Dense Freight - New Limit</td>
<td>80,000</td>
<td>25.4115</td>
<td>39,352</td>
<td>0.175</td>
</tr>
</tbody>
</table>

**Notes:**
- Gross weights based on typical vehicle configurations used in intercity service.
- Number of loads (or trucks) required to move one million tons of freight computed by dividing payload (in tons) into 1,000,000.
- Fuel consumption rates obtained from Cummins Engine Company's vehicle simulator computer based on a typical intercity trip (405 miles) at a scheduled maximum speed of 55 miles per hour, utilizing current fuel saver equipment (engine, transmission, clutch fan, radial tires and air deflector).
- As of 1975 states could raise gross weight restrictions to 80,000.
### Table 3-10

**Possible Percentage Savings in Truck Trips and Fuel Consumed in Hauling One Million Tons of Highway Freight in Various Truck Combinations**

<table>
<thead>
<tr>
<th></th>
<th>Percent of Truck Trips Saved</th>
<th>Percent of Fuel Saved</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Light and Bulky Freight</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substitute 45 foot for 40 foot Semitrailers</td>
<td>14.4%</td>
<td>8.5%</td>
</tr>
<tr>
<td>Substitute 65 foot Twin Trailers for 40 foot Semitrailers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- At old Twin Trailer Weight Limit</td>
<td>27.2%</td>
<td>22.0%</td>
</tr>
<tr>
<td>- At new Twin Trailer Weight Limit</td>
<td>32.4%</td>
<td>25.9%</td>
</tr>
<tr>
<td>Substitute 65 foot twin trailers for 45 foot Semitrailers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- At old Twin Trailer Weight Limit</td>
<td>17.8%</td>
<td>14.7%</td>
</tr>
<tr>
<td>- At new Twin Trailer Weight Limit</td>
<td>23.7%</td>
<td>18.9%</td>
</tr>
<tr>
<td><strong>Dense Freight</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substitute new for old Weight Limits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- With 40 foot Semitrailers</td>
<td>11.3%</td>
<td>7.7%</td>
</tr>
<tr>
<td>- With 45 foot Semitrailers</td>
<td>11.4%</td>
<td>7.8%</td>
</tr>
<tr>
<td>- With 65 foot Twin Trailers</td>
<td>13.2%</td>
<td>9.1%</td>
</tr>
<tr>
<td>Substitute 65 foot Twin Trailers at new Limit for</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 40 foot Semitrailer at old Limit</td>
<td>12.1%</td>
<td>9.0%</td>
</tr>
<tr>
<td>- 45 foot Semitrailer at old Limit</td>
<td>12.9%</td>
<td>9.8%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(Legal or Maximum Practical)</th>
<th>Old Limit</th>
<th>New Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Light and Bulky Freight</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 foot Semitrailer</td>
<td>60,725</td>
<td>60,725</td>
</tr>
<tr>
<td>45 foot Semitrailer</td>
<td>65,250</td>
<td>65,250</td>
</tr>
<tr>
<td>65 foot Twin Trailer</td>
<td>73,280</td>
<td>76,677</td>
</tr>
<tr>
<td><strong>Dense Freight</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 foot Semitrailer</td>
<td>73,280</td>
<td>79,000</td>
</tr>
<tr>
<td>45 foot Semitrailer</td>
<td>73,280</td>
<td>79,000</td>
</tr>
<tr>
<td>65 foot Twin Trailer</td>
<td>73,280</td>
<td>80,000</td>
</tr>
</tbody>
</table>

117
state safety administrators from their own experience and records strongly support twin trailer safety. They have been operated over every type of terrain in all kinds of weather with no problems. Tests have shown that twin trailers track and turn better than many other types of trucks, and that they have stopping ability which is at least comparable to any other combinations.

3.4.2.3 Recommendations

From the above facts we can conclude that the main arguments of the trucking industry in favor of larger truck combinations are based on the fact that they are more productive in terms of pounds per man-hour of operation, that they provide more flexibility to the operator, that they generate extra freight volume demand by their greater capacity and that they are more fuel efficient. The main government concerns on the matter are, on the other hand, that larger trucks may negatively affect the operations of other road users and that they may reduce highway safety and increase congestion in urban areas.

In the context of developing countries, even though the main issues remain the same, their relative weights are somewhat different, given the differences that do exist both in economic and transportation conditions. On the position of the trucking industry it can be argued that higher productivity in terms of pounds per man-hour for larger trucks is less of an advantage in
developing countries where wages are relatively lower and where capital and specially foreign exchange is scarce. From an economic point of view a shift towards larger trucks is a shift towards higher capital/labor and foreign exchange/labor ratios which in a labor surplus economy will not necessarily result in an efficient allocation of resources.

On the other hand, the fact that larger trucks are more fuel efficient than smaller trucks is particularly significant in the case of most less developed countries which are net oil importers. It should be nevertheless emphasized again that trucks are a considerably less fuel efficient transport mode than the railways; in facilitating the erosion of railroad markets, particularly in long range transportation of bulky, low value concentration commodities, by allowing larger truck combinations on the road, the government will be taking a position that may, in the long run, result in more rather than less overall fuel consumption.

On the questions of safety of operation and highway congestion it is clear that road infrastructure in most developing countries is not up to U.S. or Western European standards. It may therefore very well be the case that truck combinations that have circulated without major problems in developed countries for years might cause excessive congestion or deterioration of safety levels when transferred to developing countries with poorer road conditions.

Moreover, one of the greatest advantages of larger truck combinations that has been heralded by the trucking industry in developed countries is that they better adapt to the new character-
istics of technologically advanced manufactures which tend to be bound by volume rather than by weight constraints given the fact that they contain increasing amounts of plastics, resins and aluminum, and that they are usually packaged in plastic foam or other low density material. The power of this argument is obviously reduced in less developed countries in view of their different composition of industrial production.

On the balance it appears that the argument for larger truck combinations, and particularly for twin trailer units, is weaker in developing countries than in the more advanced industrialized nations. Authorization for larger combinations to operate on the roads will cause an increase in the demand for government funds for the construction of better, limited access highways, a deterioration of road quality and safety, a worsening of congestion problems, and further expansion of the trucking sector into railroads. In the light of all these factors, the contention that larger truck combinations are more labor productive and fuel efficient than smaller ones seems to be weak indeed.

Within this framework of analysis the Egyptian situation is somewhat unique. As discussed above, there is substantial excess capacity (except for a few links) in this country's highway system to accommodate the overflow traffic from the other modes during the time required for planning and implementing the additional capacity in those modes. During this period over which the highways will carry large volumes of freight more suited to the other modes, care should be taken to ensure that there are no restrictions of a nature which
will inhibit or prevent the import or production of the necessary quantity of large and more efficient highway vehicles. The ability to use such large freight vehicles on relatively uncongested highways is the only factor which has prevented the shortage of capacity in railways and waterways from having more serious consequences.
4.0 SUMMARY AND CONCLUSIONS

Given the importance of the transportation sector both as a recipient of public funds and as a necessary factor for economic development, government in developing countries have been particularly concerned with exercising some degree of control over said sector. This control has been materialized in the form of market and operating regulations being imposed on the sector. Market regulations, on the one hand, have been established generally in response to a desire by the government to be able to control the effects of transportation on socio-economic development; to the fact that transportation activities are often characterized by decreasing cost structures and economies of scale which force the government to intervene, through regulation, to defend the "public interest" in cases where existing or potential natural monopolies threaten the efficient and equitable operation of free markets; and to pressures from powerful interest groups which are either involved in the provision of, or affected by, transport services and which manage to obtain supportive or protective regulation from the government.

Operating regulations, on the other hand, have evolved as a result of considerations of efficient operation, design standards and levels of safety.

As our study shows, market regulation of transportation may have contributed in less developed countries to accelerate the operating and financial decline of the railroads and the expansion of the trucking sector by providing an incentive for trucking firms to capitalize beyond the economically efficient capital/output ratio.
and to expand, even at a long run loss, into markets that have traditionally, and from an economic efficiency point of view, belonged to the railways; and by providing a relative disincentive for the railroads vis-a-vis trucking firms to maintain a high level of service and to invest in new technology.

These mostly unintended potential consequences of transport market regulation could have significant repercussions for transportation investment in less developed countries:

- The overcapitalization of the trucking sector is a particularly relevant problem for developing countries where capital is, in general, in very scarce supply and has a high opportunity cost, and where usually are vast supplies of surplus labor. Furthermore, since most of the capital equipment utilized by trucking firms is imported, a considerable overexpenditure of foreign exchange could result.

- The incentive to regulated trucking firms to expand into railroad markets (particularly the transportation of bulky specialized commodities) will not only speed up the deterioration of the existing highway system but will, in addition, require significant new investment in highway maintenance and con-
struction of new infrastructure that is capable of handling the new volumes and loads.

- Furthermore, the shift in freight from the railways to highway transportation will result, in the long run, in parallel duplication of transport links operating sometimes below volume capacity.

- By stimulating the competition of the trucking sector in markets where the railroads have comparative cost advantage, market regulation may help to deprive the railways of one of the few profitable markets which they have left and to further worsen the presently difficult operating situation and large financial losses.

- Finally, in a period of high energy prices worldwide a relative expansion of truck freight transportation at the expense of the railroads will result in an increase in energy consumption.

In conclusion, governments in less developed countries should carefully evaluate the costs and benefits of transportation regulation, taking into account not only its supposed "public
interest" benefits, but also the inefficiency which they create and, most importantly, the way in which, by protecting special interest groups, they have affected the constitution of the transportation sector and the supply of and demand for transport investment funds. Moreover, in the crucial area of railroad-truck competition an end to the regulatory market protection of trucking firms should be considered, to put a halt to the continuous and very costly deterioration of the railroads, and a firm position should be taken against the demands by trucking firms for a relaxation of operating regulations, which would permit them not only to make further incursions into railroad markets but, in addition, to deterioration at an accelerated pace the highway systems that have been constructed in recent years at a very high social and economic cost and for their virtually exclusive benefit.

As our analysis suggests, considerable work remains to be done in the area of transportation regulation and its effect on investment in the sector in less developed countries. In particular, we propose two alternative directions for future research on the subject to take:

(i) Further investigation of the objectives envisioned by the governments in developing countries when imposing both market and operating regulations on the transport sector.

(ii) Empirical verification in the particular field of transportation of the above discussed theories on the effect of market regulations on capital investment, competition, level of service and technological innovation.
REFERENCES


Moore, T.G.; Freight Transportation Regulation: Surface Freight and the I.C.C. American Enterprise Institute, Washington, D.C., 1972.


APPENDIX 1 - THE SOCIAL COST OF MONOPOLY

Since the monopolistic firm faces a less than perfectly elastic demand, its output decision will, in fact influence the good's market price.

If we assume that the monopolist will maximize profits \( \Pi \) we have:

\[
\Pi = p(q).q - c(q)
\]  \hspace{1cm} (A1-1)

where

\( p(q) \) is the market price
\( c(q) \) is the total cost of production
\( q \) is the quantity produced

Maximizing profits we get:

\[
\frac{d\Pi}{dq} = p(q) + q \frac{dp(q)}{dq} - \frac{dc(q)}{dq} = 0 \]  \hspace{1cm} (A1-2)

\[
\frac{d\Pi}{dq} = p(q)(1 + 1/\varepsilon_D) - \frac{dc(q)}{dq} = 0 \]  \hspace{1cm} (A1-3)

where

\( \varepsilon_D = \frac{dq/q}{dp/p} \)

\[
\frac{d}{dq} [p(q).q] = \frac{dc(q)}{dq}
\]

The monopolist will therefore produce at \( q_0 \) where the marginal cost
FIGURE A1-1  PRICING IN A MONOPOLY MARKET
curve intersects the marginal revenue curve. The price charged will be $P_0$.

$MC = MR = P_0 (1 + 1/\epsilon_D) < P_0$ \hspace{1cm} (A1-4)

since $\epsilon_D < 0$

In this case the monopolist will earn positive long run economic profits equal to $q_0 (P_0 - P_1)$; it is therefore true that a firm in a monopoly market can earn higher profits than if it were to operate in a competitive market (note that in a purely competitive market long run economic profits will always be zero). This does not imply, though, that monopolies will always earn large "excess" profits; two monopolies of equal "strength" can earn profits of very different magnitude. A measure of monopoly strength has been proposed by Lerner (1934); the degree of monopoly $D$ is defined as the divergence between marginal cost and price relative to the price. As (A1-4) shows, a monopoly market will always be characterized by a positive divergence between equilibrium price and marginal cost; Lerner's definition measures this divergence.

\[ D = \frac{p - MC}{p} = \frac{p - (dc(q)/dq)}{p} \hspace{1cm} (A1-5) \]

At equilibrium $MC = MR$

\[ \therefore D = \frac{P_0 - MR}{P_0} = \frac{P_0 - P_0 (1 + 1/\epsilon_D)}{P_0} \hspace{1cm} (A1-6) \]

\[ \therefore D = -\frac{1}{\epsilon_D} \hspace{1cm} (A1-7) \]

Applying (A1-3) to (A1-5)
FIGURE A1-2 MONOPOLY PROFITS FOR TWO FIRMS WITH EQUAL DEGREES OF MONOPOLY
Since we have that

\[ MC \geq 0 \]

then \( MR \geq 0 \) for a profit maximizing monopolist

\[ \therefore p \left(1 + \frac{1}{\varepsilon_D}\right) \geq 0 \]

and since \( \varepsilon_D \leq 0 \) we have

\[ \varepsilon_D \leq -1 \]

\[ (A1-8) \]

\[ \therefore \text{For a profit maximizing monopolist we have} \]

\[ D \leq 1 \]

\[ (A1-9) \]

And therefore

\[ 0 \leq D \leq 1 \]

\[ (A1-10) \]

Note that under perfect competition \( \varepsilon_D \rightarrow -\infty \)

\[ \dot{\varepsilon}_{im} D = \dot{\varepsilon}_{im} \left(\frac{1}{\varepsilon_D}\right) = 0 \]

\[ (A1-11) \]

\[ \varepsilon_D \rightarrow -\infty \]

Two firms with similar degrees of monopoly power \( D \) may have very different degrees of profitability as Figure A1-2) shows. The level of profits will depend on the relative positions of the average cost and the average revenue (demand) curves but not necessarily on the degree of monopoly [Nicholson (1978)]. That is:

\[ \Pi = p(q_o) - c(q_o) \]

\[ = p_o q_o - \int_{q = 0}^{q_o} \frac{dc(q)}{dq} dq \]

\[ = q_o \left[ p_o - \int_{q = 0}^{q_o} \frac{dc(q)}{dq} dq \right] \]

\[ (A1-14) \]
FIGURE A1-3 DIFFERENTIAL EFFECTS OF PERFECT COMPETITION AND MONOPOLY IN A MARKET
The two monopolies in Figure Al-2 have the same degree of monopoly; the monopoly in Al-la earns a high level of economic profits while the one shown in Al-lb actually earns zero economic profits. The main objection to monopoly profits is therefore not the inevitability of the existence of such profits or their size (since, as we have seen, these may vary with market characteristics), but rather, the distributional effects of monopoly profits created by the relative income and wealth distribution of both producers and consumers. If monopoly profits are made by relatively well-off producers at the expense of less well to do consumers, there may be validly objectionable, independently of their size.

A second cost associated with monopolies is the distortion in the allocation of resources that their existence will cause. By restricting their output in order to maximize profits, monopolies produce at an equilibrium output level $q_0$ [see Figure Al-3] price consumers are willing to pay for the good is higher than the marginal cost of producing it. From a social point of view, then, output should be expanded.

Figure Al-3 compares the output that would be produced in a given market under conditions of monopoly and perfect competition. It is assumed that in both cases the firm will have constant marginal costs as a simplification. A monopolist will choose an output level of $q_0$ at an average cost $p_1$ and he will sell it at price $p_0$. Total monopoly profits are $q_0(p_0 - p_1)$. Under perfect competition the supplier would produce $q_1$ at an average cost $p_1$ and he will sell it at $p_1$. Economic profits are zero. By restricting his
output the monopolist has not only gained a monopoly profit $q_0(p_0 - p_1)$ at the expense of the consumer but has, in addition, deprived him of the consumer surplus represented by the area BAE.

By regulating industries where decreasing costs occur over the relevant range of output and thus where only one supplier would subsist in the long run, the government can correct the inequity (monopoly profits) and the inefficiency (output restriction) which would arise from the competitive operation of a natural monopoly market; the rationale for regulation in this case is therefore quite clear.
APPENDIX 2 - THE AVERCH-JOHNSON THEORY OF BEHAVIOR OF THE FIRM UNDER REGULATORY CONSTRAINT [Averch and Johnson (1962)]

A2.1 THE SINGLE MARKET MODEL

We will assume for this problem a monopoly firm operating in a single market with two factor inputs, labor and capital, which is subjected to rate of return regulation where the allowed rate of return is less than the rate that the firm would receive without regulation but greater than the cost of capital. We will prove that in this case the firm will substitute capital for labor to a point where marginal rates of substitution are different from the factor cost ratio and where, therefore, social cost is not minimized for the given output.

Assume that the firm produces one homogeneous product using the two inputs with the production function:

\[ Q = Q(x_1, x_2) \quad (A2-1) \]

\[ \frac{\partial Q}{\partial x_1} > 0 \quad (A2-2) \]

\[ \frac{\partial Q}{\partial x_2} > 0 \quad (A2-3) \]

\[ x_1 \geq 0, x_2 \geq 0 \quad (A2-4) \]

\[ Q(0, x_2) = Q(x_1, 0) = 0 \quad (A2-5) \]

where

- \( Q \) is the volume of output of the firm
- \( x_1 \) is the amount of capital used by the firm
- \( x_2 \) is the amount of labor used by the firm

The inverse demand function of the firm is given by

\[ P = \varnothing (Q) \quad (A2-6) \]
Profit is defined by

$$\Pi = P \cdot Q - r_1 x_1 - r_2 x_2$$  \hspace{1cm} (A2-7)$$

where

$r_1$ is the (constant) unitary "interest" cost of capital
$r_2$ is the (constant) unitary cost of labor.

If we define:

$c_1$ is the acquisition cost per unit of capital
$u_1$ is the value of depreciation of capital during the considered time interval
$U_1$ is the cumulative value of capital depreciation

then the regulatory constraint can be defined as

$$\frac{P \cdot Q - r_2 x_2 - u_1}{c_1 x_1 - U_1} \leq S_1$$  \hspace{1cm} (A2-8)$$

where $S_1$ is the maximum rate of return on capital allowed by the regulatory agency.

For simplicity we assume

$u_1 = 0$
$U_1 = 0$

and define arbitrarily the unit of capital so that

$c_1 = 1$

The constraint (A2-8) can then be rewritten as

$$\frac{P \cdot Q - r_2 x_2}{x_1} \leq S_1$$  \hspace{1cm} (A2-9)$$

$$P \cdot Q - r_2 x_2 - S_1 x_1 \leq 0$$  \hspace{1cm} (A2-10)$$

If $S_1 < r_1$ we get from (A2-10)

$$\Pi = P \cdot Q - r_1 x_1 - r_2 x_2$$

$$= P \cdot Q - S_1 x_1 + (S_1 - r_1)x_1 - r_2 x_2 \leq (S_1 - r_1)x_1 < 0$$
and therefore the firm will not produce at all, that is, \( Q = x_1 = x_2 = 0 \)

\[ \therefore S_1 \geq r_1 \]  

(A2-11)

The decision problem of the firm is then to maximize (A2-7) subject to (A2-10)

The Lagrangian is defined by

\[ L(x_1, x_2) = P.Q - r_1 x_1 - r_2 x_2 - \lambda (P.Q - S_1 x_1 - r_2 x_2) \]  

(A2-12)

The Kuhn-Tucker necessary conditions for a maximum are

\[ r_1 \geq (1 - \lambda) \left[ \frac{d}{dQ} \frac{\partial L}{\partial x_1} + \lambda S_1, x_1 \geq 0 \right] \]  

(A2-13)

\[ r_1 > (1 - \lambda) \left[ \frac{d}{dQ} \frac{\partial L}{\partial x_1} \right] \text{ implies } x_1 = 0 \]  

(A2-14)

\[ (1 - \lambda) r_2 \geq (1 - \lambda) \left[ \frac{d}{dQ} \frac{\partial L}{\partial x_2} \right] \geq 0 \]  

(A2-15)

\[ (1 - \lambda) r_2 > (1 - \lambda) \left[ \frac{d}{dQ} \frac{\partial L}{\partial x_2} \right] \text{ implies } x_2 = 0 \]  

(A2-16)

\[ P.Q. - S_1 x_1 - r_2 x_2 \leq 0, \lambda \geq 0 \]  

(A2-17)

\[ P.Q. - r_2 x_2 < S_1 x_1 \text{ implies } \lambda = 0 \]  

(A2-18)

If we assume \( \lambda > 0 \) then from (A2-13) it is clear that \( \lambda = 1 \) if and only if \( r_1 = S_1 \). In this case any \( x_1, x_2 \) which satisfies (A2-17) will be a solution.

For \( S_1 > r_1 \) we have \( 0 \leq \lambda < 1 \). From (A2-18) we get that if \( S_1 \) is large enough then \( \lambda = 0 \) (at some high level of allowable rate of return \( S_1 \) the value \( x_1(S_1 - r_1) \) is larger than the unconstrained maximized profit and the constraint becomes ineffective).

If we now let \( S_1 \rightarrow r_1 \), \( \lambda \) varies continuously and given that \( \lambda \neq 1 \) we have \( 0 < \lambda < 1 \). For the unregulated monopoly the marginal conditions are
\[ r_1 = [P + Q \frac{dP}{dQ}] \frac{\partial Q}{\partial x_1} \]  
(A2-19)

\[ r_2 = [P + Q \frac{dP}{dQ}] \frac{\partial Q}{\partial x_2} \]  
(A2-20)

Under conditions of effective regulatory constraint \((\lambda > 0)\) we have from \((A2-15)\) and \((A2-20)\) that, as in the case of an unregulated monopoly, the input of \(x_2\) is such that its marginal cost \(r_2\) is equal to its marginal revenue product. In contrast \((A2-13)\) and \((A2-19)\) show that, under regulation, the input of \(x_1\) is such that its marginal cost \(r_1\) is greater than its marginal revenue product since

\[
\frac{r_1 - \lambda S_1}{1 - \lambda} = r_1 \frac{\lambda}{1 - \lambda} (S_1 - r_1) \geq [P + Q \frac{dP}{dQ}] \frac{\partial Q}{\partial x_1}
\]

and therefore, given that \(0 < \lambda < 1\) and \(S_1 > r_1\)

\[ r_1 > [P + Q \frac{dP}{dQ}] \frac{\partial Q}{\partial x_1} \]  
(A2-21)

From \((A2-13)\) and \((A2-15)\) when the equalities hold we have that

\[
\text{MRS}_2 = - \frac{dx_2}{dx_1} = \frac{\frac{\partial Q}{\partial x_1}}{\frac{\partial Q}{\partial x_2}} = \frac{Q}{Q_0}
\]

\[
\text{MRS}_2 = \frac{\frac{r_1 - \lambda S_1}{1 - \lambda}}{r_2}
\]

\[
= \frac{r_1 - \lambda r_1 - \lambda S_1 + \lambda r_1}{r_2 (1 - \lambda)}
\]  
(A2-23)

\[
\text{MRS}_2 = \frac{\frac{r_1}{r_2}}{\frac{\lambda S_1 - r_1}{r_2 (1 - \lambda)}}
\]  
(A2-24)

Given that \(0 < \lambda < 1\) and \(S_1 > r_1\) we have

\[
\text{MRS}_2 = - \frac{dx_2}{dx_1} < \frac{r_1}{r_2}
\]  
(A2-25)
FIGURE A2-1 THE AVERCH-JOHNSON THESIS; SINGLE MARKET CASE
The regulated firm, therefore, adjusts to the rate of return constraint by substituting capital \((x_1)\) for labor \((x_2)\), until the marginal rate of substitution of capital for labor is less than the ratio of the cost of capital to the cost of labor, and by expanding its total output.

Rate of return regulation has made the "private" cost of capital to the firm different from the market cost. For each additional unit of capital used the firm can earn a profit equal to the differential between the rate of return allowed by the regulatory body \((S_1)\) and the market cost of capital. As a result private cost is less than market cost by an amount equal to said difference.

Figure A2-1 shows the firm's possible choices of technology and total output in a capital/labor diagram. The market "social" relative capital/labor cost is given by line \(\alpha\); the smaller regulated private relative capital/labor cost to the firm is determined by line \(\beta\). The level of total output is denoted by the homotetic isoquant level curves \(Q^1\). Without regulation the firm would produce output \(Q^0\) at A and would be constrained to expand along path 1. If the firm is regulated at rate \(S_1 > r_1\) it will, for constant total input resources evaluate in terms of \(x_2\), expand output to \(Q^1\) at B and its future expansion path will be 2.

A2-2 THE MULTIPLE MARKET CASE

Suppose that, in addition to operating in its original market, the firm can also enter other regulated markets and the regulatory "fair" rate of return is based on the overall value of the firm's capital assets.
Let us further assume, for simplicity, that operating in a second market (2) allows the firm to act as an unconstrained monopolist in its original market, and that any combination of factors along the socially optimal expansion path in market 2 will result in zero economic profits in that market, that is

\[ P_2Q_2 - r_1x_{12} - r_2x_{22} = 0 \] (A2-26)

\[ \Psi x_{12}, x_{22} | - \frac{dx_{22}}{dx_{12}} = \frac{r_1}{r_2} \] (A2-27)

The overall regulatory constraint for n markets can be expressed as:

\[ \sum_{i=1}^{n} P_i Q_i - S_i \sum_{i=1}^{n} x_{1i} - r_2 \sum_{i=1}^{n} x_{2i} \leq 0 \] (A2-28)

If the unconstrained profit maximum vector in market 1 is \( \overline{(Q_1, x_{11}, x_{21})} \) then we have

\[ P_1Q_1 - S_1x_{11} - r_2x_{21} = m, m > 0 \] (A2-29)

and, therefore, constraint (A2-27) would be violated if the firm produced only in market 1. We then choose an output level \( \overline{Q_2} \) on the socially efficient path in market 2 such that

\[ P_2\overline{Q_2} - r_1\overline{x}_{12} - r_2\overline{x}_{22} = 0 \] (A2-30)

and

\[ P_2\overline{Q_2} - S_1\overline{x}_{12} - r_2\overline{x}_{22} = -m \] (A2-31)

Subtracting (A2-30) from (A2-29) we have

\[ \overline{x}_{12}(S_1 - r_1) = m \] (A2-32)

\[ \therefore \overline{x}_{12} = \frac{m}{S_1r_1} \] (A2-33)
Thus, the system (A2-33), (A2-27), (A2-26) determines the vector 
\((\bar{Q}_2, \bar{x}_{12}, \bar{x}_{22})\).

Given (A2-29) and (A2-31) we see that the firm will now satisfy constraint (A2-28). While an unregulated monopolist would be indifferent between producing in market 2 at \((\bar{Q}_2, \bar{x}_{12}, \bar{x}_{22})\), the regulated firm finds market 2 attractive because it can add capital to its rate base at no loss. Since in market 2 the cost of capital is less than the allowed rate of return, the firm can use the difference to satisfy its constraint in market 1 and enlarging its profit by \(S_1 - r_1\) for each unit of capital used in market 2.

Even if a loss is incurred in market 2 in terms of market prices \(r_1, r_2\) it will still pay the firm to operate in it as long as the loss is smaller than \(x_{12}(S_1 - r_1)\), that is:

\[ P_2 \bar{Q}_2 - r_1 \bar{x}_{12} - r_2 \bar{x}_{22} < x_{12}(S_1 - r_1) \quad (A2-34) \]

\[ \therefore P_2 \bar{Q}_2 - S_1 \bar{x}_{12} - r_2 \bar{x}_{22} < 0 \quad (A2-35) \]
APPENDIX 3

A Test of the Averch-Johnson Thesis Using
The Transcendental-Logarithmic Production Function
[Spann (1974)]

The Averch-Johnson model assumes that the regulated monopoly firm produces a homogeneous output using at least two inputs. In the case of the electric utility industry, on which this statistical study is based, there are three inputs: capital, labor and fuel. The regulatory agency constrains the firm to a maximum fixed rate of return on its capital investment; it is assumed that this allowed rate of return is greater than the firm's cost of capital but less than the rate of return the monopoly firm would obtain if it would not be subjected to rate of return regulation.

If we assume, further, that the firm's objective is to maximize profits subject to the regulatory constraint, we can express the firm's decision problem mathematically as a Lagrangian (note that the regulatory constraint is set as an equality):

\[
\begin{align*}
\text{Max} & \quad \left[ R(K,L,F) - wL - rK - gF \right. \\
& \quad - \lambda \left[ R(K,L,F) - wL - gF - sK \right] \\
& \quad \left. \left( A3-1 \right) \right)
\end{align*}
\]

where

- \( Q \) is the firm's output
- \( K \) is the amount of capital employed by the firm
- \( L \) is the amount of labor employed by the firm
- \( F \) is the amount of fuel used by the firm
- \( P \) is the price of the firm's output
r is the cost of capital
w is the wage rate
g is the price of fuel
s is the allowed rate of return

R(K,L,F) is the firm's revenue function given by

\[ R(K,L,F) = \phi[f(K,L,F)] \cdot f(K,L,F) \] (A3-2)

\[ R(K,L,F) = \frac{\partial R}{\partial X} \] (A3-3)

\[ R(K,L,F) = P \cdot Q \] (A3-4)

where

P = \phi(Q) is the firm's inverse demand function
Q = f(K,L,F) is the firm's production function

First order conditions for a maximum are obtained by differentiating equation (A3-1) with respect to K, L, F and \lambda.

\[ \frac{\partial R}{\partial K} - r - \lambda \frac{\partial R}{\partial K} + s = 0 \] (A3-5)

\[ \frac{\partial R}{\partial L} - w - \lambda \frac{\partial R}{\partial L} - \lambda w = 0 \] (A3-6)

\[ \frac{\partial R}{\partial F} - g - \lambda \frac{\partial R}{\partial F} - \lambda g = 0 \] (A3-7)

\[ R(K,L,F) - wL - gF - sK = 0 \] (A3-8)

These equations are equivalent to:

\[ \frac{\partial R}{\partial K} = \lambda \frac{r-s}{1-\lambda} \] (A3-9)

\[ \frac{\partial R}{\partial L} = w \] (A3-10)

\[ \frac{\partial R}{\partial F} = g \] (A3-11)

\[ R(K,L,F) = wL + gF + sK \] (A3-12)

* For second order conditions see Baumol and Klevorick (1970)
since as proved by Baumol and Klevorick (1970)
\[ 0 < \lambda < 1. \]
Furthermore, since \( 1 - \lambda > 0 \), equation (A3-9) implies that the regulated firm is too capital intensive given that, at equilibrium, the marginal revenue product of capital is less than the cost of capital.
\[
\frac{\partial R}{\partial K} = \frac{\lambda}{1-\lambda} (r-s) < 0 \quad (A3-13)
\]
since
\[ 0 < \lambda < 1 \]
\[ r < s \]

In order to test the Averch-Johnson thesis, the transcendental-logarithmic production function developed by Christensen, Jorgenson and Lau (1970) is used by Spann (1974). This production function is a very general production function of which the Cobb-Douglas and CES functions are special cases:
\[
\log Q = \log \alpha_0 + \beta_1 \log K + \beta_2 \log L + \beta_3 \log F \\
+ \beta_4 (\log K)^2 + \beta_5 (\log L)^2 + \beta_6 (\log F)^2 \\
+ \beta_7 \log K \log F + \beta_8 \log K \log L + \beta_9 \log F \log L \quad (A3-14)
\]
By taking the logarithmic derivative of (A3-14) with respect to capital \( K \) we obtain
\[
\frac{\partial \log Q}{\partial \log K} = \beta_1 + 2\beta_4 \log K + \beta_7 \log F + \beta_8 \log L \quad (A3-15)
\]
By definition
\[
\frac{\partial \log Q}{\partial \log K} = \frac{\partial Q}{\partial K} \cdot \frac{K}{Q} = f_K \cdot \frac{K}{Q} \quad (A3-16)
\]
where \( f_K \) is the marginal product of capital
\[
f_K = \frac{\partial Q}{\partial K} \quad (A3-17)
\]
If we assume that the monopolist is facing a constant elasticity demand curve and differentiate (A3-4) with respect to Q we obtain:

\[
\frac{\partial R}{\partial Q} = P + Q \frac{dP}{dQ} = P \left(1 + \frac{dP}{dQ} \cdot \frac{Q}{P}\right) \quad (A3-18)
\]

\[
\therefore \frac{\partial R}{\partial Q} = P \left(1 + \frac{1}{\varepsilon}\right) \quad (A3-19)
\]

where \(\varepsilon\) is the constant elasticity of demand.

\[
\therefore \frac{\partial R}{\partial K} \cdot \frac{\partial Q}{\partial K} = P \left(1 + \frac{1}{\varepsilon}\right) f_K \quad (A3-20)
\]

Thus equation (A3-9) may be rewritten as

\[
P \left(1 + \frac{1}{\varepsilon}\right) f_K = r + \frac{\lambda(r-s)}{1-\lambda} \quad (A3-21)
\]

Substituting (A3-21) into (A3-15) we obtain

\[
K \left(r + \frac{\lambda r}{1-\lambda} - \frac{s \lambda}{1-\lambda}\right) \frac{1}{PQ \left(1 + \frac{1}{\varepsilon}\right)} = \beta_1 + 2\beta_4 \log K + \beta_7 \log F + \beta_8 \log L \quad (A3-22)
\]

Rearranging terms and renaming parameters

\[
\frac{rK}{PQ} = \frac{b_1 + b_2 \log K + b_3 \log F + b_4 \log L + \lambda sK}{PQ} \quad (A3-23)
\]

\[
\mu K = \frac{b_1 + b_2 \log K + b_3 \log F + b_4 \log L + \lambda Z}{PQ} \quad (A3-24)
\]

where

\[
\mu K = \frac{rK}{PQ} \quad \text{the required payments to capital per unit of revenue.}
\]

\[
Z = \frac{sK}{PQ} \quad \text{the allowed payments to capital per unit of revenue.}
\]

Taking the logarithmic derivative of the trans-log production function with respect to the fuel input \(F\) we get

\[
\frac{\partial \log Q}{\partial \log F} = \beta_3 + 2\beta_6 \log F + \beta_7 \log K + \beta_8 \log L
\]

\[
= \frac{\partial Q}{\partial F} \cdot \frac{F}{Q} = f_F \cdot \frac{F}{Q} \quad (A3-25)
\]
where \( f_F = \frac{\partial Q}{\partial F} \) is the marginal product of fuel.

Substituting (A3-25) into the first order condition for fuel we obtain

\[
\frac{3R}{3F} = k(1 + \frac{1}{\epsilon})f_F = g \tag{A3-26}
\]

\[
\frac{gF}{PQ} = (1 + \frac{1}{\epsilon})[\beta_3 + 2\beta_6 \log F + \beta_7 \log K + \beta_9 \log L] \tag{A3-27}
\]

rearranging terms and renaming parameters

\[
\mu_F = b_3 + b_6 \log K + b_7 \log F + b_8 \log L \tag{A3-28}
\]

where

\[
\mu_F = \frac{gF}{PQ} \text{ required payments of fuel per unit of revenue.}
\]

(A3-24) and (A3-28) form a system of two estimable equations which can be used to estimate \( \lambda \). All the parameters of these equations are not functionally independent

\[
b_3 = \frac{(1 + \frac{1}{\epsilon})\beta_7}{(1 + \frac{1-\lambda}{1-\epsilon})} = 1 + \frac{\lambda}{1-\lambda} = \frac{1}{1-\lambda}
\]

\[\therefore \ b_3 = (1-\lambda)b_6 \tag{A3-29}\]

Equation (A3-29) is a constraint on the two equation system (A3-24), (A3-28) for factor shares that is determined by the firm's profit maximization subject to the regulatory constraint. This constraint can be therefore used to construct an empirical test of the Averch-Johnson thesis.

The Averch-Johnson thesis states that a monopoly firm under rate of return regulation will maximize profits subject to the regulatory restraints. If it does it will overcapitalize as proved by (A3-13) above.
The Averch-Johnson thesis can thus fail to be true for regulated firms if either or both of the following hold:

i) The regulatory constraint does not enter the firm's Lagrangian as in (A3-1)

ii) Regulated firms do not maximize profits.

Condition i) implies the testable hypothesis

\[ H_1 : \lambda = 0 \]

Condition ii) implies the testable hypothesis

\[ H_2 : b_3 \neq (1-\lambda)b_5 \]

If both hypotheses are rejected, then the regulated firm maximizes profits subject to the regulatory constraint and, therefore, the Averch-Johnson overcapitalization thesis cannot be rejected.
APPENDIX 4
The Effects of Market Regulation on Quality of Service

Suppose an industry composed of n firms produces a basic homogeneous output, transportation, and a secondary output, level of service per unit of transportation. Assume also that the industry is under market regulation as described in 2.1.1 above and that the regulatory agency sets the price of transportation at $P_T$. Firms are free to provide any level of quality but they can only charge $P_T$ for transportation regardless of that level of quality. Entry to and exit from the industry is, of course, controlled.

The transportation market demand function is then given by:

$$Q_T = Q_T(P_T, Q_S) \quad (A4-1)$$

where

- $Q_T$ is the total quantity of transportation
- $Q_S$ is the average market level of service per unit of transportation
- $P_T$ is the fixed price of transportation

$$\frac{\partial Q_T}{\partial P_T} < 0 \quad \frac{\partial Q_T}{\partial Q_S} > 0$$

The profit function for a transport firm is

$$\Pi = P_Tq_T - C_Tq_T - C_Sq_Sq_T \quad (A4-2)$$

where

- $q_T$ is the quantity of transportation provided by the particular firm
- $q_S$ is the firm's level of service per unit of transportation
- $C_T$ is the unit cost of transport
- $C_S$ is the unit cost of service
and we further assume

\[
\frac{dC_T}{dq_T} = 0 \quad (A4-3)
\]

\[
\frac{dC_S}{dq_s} = 0 \quad (A4-4)
\]

over the relevant range.

If the individual firms are profit maximizers then we have that the optimum level of service per unit of transportation will be determined by:

\[
\frac{d\Pi}{dq_s} = P_T \frac{\partial q_T}{\partial q_S} - C_T \frac{\partial q_T}{\partial q_S} - C_Sq_T - C_Sq_S \frac{\partial q_T}{\partial q_S} = 0
\]

Which can be rearranged to:

\[
q_S = \frac{P_T - C_T}{C_S} - \frac{q_T}{\partial q_T/\partial q_s} \quad (A4-5)
\]

And by:

\[
\frac{d^2\Pi}{dq_s^2} = P_T \frac{\partial^2 q_T}{\partial q_s^2} - C_T \frac{\partial^2 q_T}{\partial q_s^2} - C_S \frac{\partial q_T}{\partial q_s} - C_S \frac{\partial q_T}{\partial q_s} - C_Sq_S \frac{\partial^2 q_T}{\partial q_s^2} < 0
\]

\[
(P_T - C_T - C_Sq_S) \frac{\partial^2 q_T}{\partial q_s^2} - 2C_S \frac{\partial q_T}{\partial q_s} < 0 \quad (A4-6)
\]

Substituting (A4-5) into (A4-6) we get

\[
\frac{C_Sq_T}{\partial q_T/\partial q_s} \frac{\partial^2 q_T}{\partial q_s^2} - 2C_S \frac{\partial q_T}{\partial q_s} < 0 \quad (A4-7)
\]

\[
q_T \frac{\partial^2 q_T}{\partial q_s^2} - 2 \left( \frac{\partial q_T}{\partial q_s} \right)^2 < 0 \quad (A4-8)
\]

given that

\[
C_S > 0
\]

\[
\frac{\partial q_T}{\partial q_s} > 0
\]
that is, an increase in unitary quality will result in an increase in demand for transportation.

Equation (A4-5) gives the equilibrium unitary level of service for the individual transportation firm. For a monopolist the term $\frac{\partial q_T}{\partial q_S}$ represents the overall market’s response to a marginal increase in quality; for an oligopolist or a competitor this term represents in addition the potential of capturing a larger share of the transport market from its competitors by increasing his level of service.

We therefore have:

$$\frac{\Delta (\frac{\partial q_T}{\partial q_S})}{\Delta n} > 0$$  \hspace{1cm} (A4-9)

$$\lim_{n \to +\infty} (\frac{\partial q_T}{\partial q_S}) = +\infty$$  \hspace{1cm} (A4-10)

and from (A4-5)

$$\frac{\Delta q_S}{\Delta n} > 0$$  \hspace{1cm} (A4-11)

$$\lim_{n \to +\infty} (q_S) = \frac{P_T - C_T}{C_S}$$  \hspace{1cm} (A4-12)

where $n$ is the number of firms in the industry.

Thus, the larger the number of firms in an industry the larger $\frac{\partial q_T}{\partial q_S}$ and the individual firm's unitary quality offering will be.

According to this model then, a regulated monopolist will offer a lower level of quality per ton-Kilometer or per passenger than will a regulated oligopolistic or competitive transport industry. In the perfectly competitive case each expands $q_S$ to (A4-12) until zero economic profits are made on each customer; that is until the cost of quality per passenger $(q_S \cdot C_S)$ just equals the potential net revenue from transportation. Since
$P_T$ is fixed, all competitive firms will offer the same unitary quality level $q_S$ if we assume identical cost structures.

Since the demand for transportation is positively related to the level of unitary quality, we can conclude that the more competitive the industry is the more total primary output it will sell.

If the number of firms in the industry is more than one and price and/or service collusion is not legally permitted we can approximate the equilibrium level of service per unit of primary output for the individual firm by (A4-12). Then for an oligopolistic (or competitive) transport market we have that

$$\frac{\partial q_S}{\partial P_T} = \frac{1}{C_S} > 0$$  \hspace{1cm} (A4-13)

Thus, the level of quality of an oligopolistic industry will be directly proportional to the price allowed by the regulatory agency.

The monopolist's quality response to a price change cannot be a priori predicted as can be seen by taking total differentials in equation (A4-5) and solving for $dq_S/dP_T$

$$\frac{dq_S}{dP_T} = \frac{1}{C_S} \left( \frac{\partial q_T}{\partial q_S} \right)^2 - \frac{\partial q_T}{\partial q_S} \frac{\partial^2 q_T}{\partial P_T} + q_T \frac{\partial^2 q_T}{\partial q_S \partial P_T} \right) \right)$$  \hspace{1cm} (A4-14)

The denominator of this expression is greater than zero by (A4-8) the second order condition for a profit maximization. The sum of the two first terms of the numerator is positive, since $(\partial q_T/ \partial q_S) > 0$ and $(\partial q_T/ \partial P_T) < 0$, but the sign of the third term is indeterminate. If this term is negative and sufficiently large, then for the monopolist $dq_S/dP_T < 0$. 

155
This could only happen if

\[
\frac{\partial}{\partial P_T} \left( \frac{\partial q_T}{\partial q_S} \right) = \frac{\partial^2 q_T}{\partial P_T \partial q_S} \leq 0 \tag{A4-15}
\]

that is, if as the price of transportation increases, the demand for transportation becomes less responsible to quality.

Finally, a decrease in the regulated price will not necessarily generate an increase in the quantity of the primary output demanded (and produced). From (A4-1) we get:

\[
\frac{dQ_T}{dP_T} = \frac{\partial Q_T}{\partial P_T} + \frac{\partial Q_T}{\partial q_S} \cdot \frac{\partial q_S}{\partial P_T} \tag{A4-16}
\]

For an oligopolistic industry the first term is negative and the second is positive. For a monopolist the first term is negative and the second is indeterminate. In either case we cannot predict what effect a change in price will have on total demand.
This model is based on the thesis developed by Schumpeter (1934) that while competition (or price regulation) tends to eliminate economic profits in the long run, the positive economic profits that it allows in the short run are essential for economic profits in that they motivate the individual firm to innovate technologically in order to reduce its costs.

The model is mainly concerned with innovations which reduce the costs of production and not with new product innovations. We assume that both the demand for the product and factor prices are constant, that the innovation process is deterministic and that the length of the regulatory review period $T$ is non-stochastic. Given these assumptions we can conclude that the firm's objective is to select that level of innovative activity which, for a given length of the regulatory lag $T$, maximizes its net present discounted stream of profits. (See Figure A5-1).

Mathematically this can be expressed as:

$$\text{MAX PV} = \int_{t=0}^{T} \left[ p_0 - [p_0 - B(I)]\right] q_0 e^{-rt} dt - cI \quad (A5-1)$$

where

- $p_0$ is the price the regulated firm faces at $t = 0$, which is equal to the firm's average cost of production before the introduction of the innovation.
- $q_0$ is the output that clears the market at $p_0$
- $c$ is the unitary cost of innovation at $t = 0$
- $r$ is the cost of borrowed funds to the firm
$T$ is the length of the regulatory review period
$I$ is the level of innovative input
$B(I)$ is the cost savings per unit time and output for an
innovative input level $I$
$PV$ is the net present value of the innovative project's cash flow.

The benefits of innovation will last only for the review period $T$,
that is, until the regulatory agency reduces the maximum allowed price
to the level of the new average cost.

If we normalize $p_o = q_o = 1$ we can rewrite (A5-1) as

$$\text{MAX PV} = \int_{t=0}^{T} B(I) e^{-rt} dt - cI$$

$$= \frac{1 - e^{-rT}}{r} B(I) - cI \quad (A5-2)$$

The first order condition for a maximum is given by

$$\frac{d(PV)}{dI} = \frac{1 - e^{-rT}}{r} dB - c = 0 \quad (A5-3)$$

The second order condition is

$$\frac{d^2(PV)}{dI^2} = \frac{1 - e^{-rT}}{r^2} \frac{d^2B}{dI^2} < 0 \quad (A5-4)$$

Condition (A5-4) implies that $(d^2B/dI^2) < 0$ since $r > 0$, $T > 0$;
that is, investment in technological innovation has to exhibit
decreasing returns to scale. The general argument implying that
this is so was given by Machlup (1962) who suggested that as research
becomes more intensive the frontier of available knowledge is approached
and further reductions in production costs become more difficult and
expensive to achieve. The optimum innovation input level $I^*$ is
given by:
\[ \frac{dB}{dI} [I^*] = \frac{cr}{1-e^{-rT}} \quad (A5-5) \]

By taking the total differential of (A5-3) with respect to I and T and setting it equal to zero we get:

\[ d \left[ \frac{d(PV)}{dI} \right] = \frac{1-e^{-rT}}{r} \frac{d^2B}{dI^2} dI + e^{-rT} \frac{dB}{dI} dT = 0 \quad (A5-6) \]

Rearranging terms

\[ \frac{dI}{dT} = -\frac{re^{-rT}}{1-e^{-rT}} \cdot \frac{dB/dI}{d^2B/dI^2} > 0 \quad (A5-7) \]

A decrease in the regulatory review period will therefore result in a decrease in the technological innovative input. In the limit, if \( T = 0 \) then (A5-1) will be transformed into

\[ \text{Max} (-cI) \quad (A5-8) \]

and the optimum will obviously be \( I = 0 \)
APPENDIX 6 - ECONOMIES OF SCALE IN THE PROVISION OF TRANSPORTATION SERVICES

As we saw in Section 2.2.2 above the shape of a firm's cost curve and, in particular, the sign of its first derivative over the relevant volume range are important in determining the existence of a "natural monopoly" in the particular industry and the consequent need for imposing government regulation on it.

As it turns out, many transportation activities are characterized by economies of scale - a doubling of inputs will result in a more than doubling of output - and, therefore, by decreasing long run marginal (and average) cost structures. This point is illustrated by the following example [Mohring (1976)].

The provision of transportation services by a firm can be represented by the following simplified model. Customers arrive at the place where the service is provided (railroad classification yard, bus station, etc.) at a constant rate of \( n \) per hour. Production of the transportation service involves three different types of costs:

- A fixed cost \( C_F \) which is independent of the number of customers served (depreciation of equipment, driver's or helper's wages, etc.)
- A variable cost per passenger \( C_V \) which is also independent of the number of passengers served.
- A delay cost per customer-hour \( C_D \) which reflects the amount the average passenger would be willing to pay to avoid a one hour delay in being served and the cost for the supplier of providing storage space during that time.
If service is provided in batches of $N$ customers, the interval between batches will be $N/n$ hours and, therefore, the average customer will wait $N/2n$ hours and will incur a delay cost of $NC_D/2n$.

Thus, the average per passenger total cost of providing the service in batches of $N$ for the given demand is:

$$AC(n,N) = \frac{C_F}{N} + C_V + \frac{NC_D}{2n}$$  \hspace{1cm} (A6-1)

Note that

$$\frac{3}{3N} [AC(n,N)] = -\frac{C_F}{N^2} + \frac{C_D}{2n}$$  \hspace{1cm} (A6-2)

That is an increase in the size of the batch $N$ will decrease the fixed cost component of average cost and increase the delay cost component. By setting (3-15) equal to zero we obtain the optimum batch size $N^*$ for which average cost is minimized.

$$\frac{3}{3N} [AC(n,N)] = 0 \rightarrow N^* = (2nC_F/C_D)^{1/2}$$  \hspace{1cm} (A6-3)

Total costs are given by

$$TC(n,N) = C_F - NC_V + \frac{NC_D}{2n}$$  \hspace{1cm} (A6-4)

And marginal costs are

$$MC(n,N) = C_V + \frac{NC_D}{n}$$  \hspace{1cm} (A6-5)

Thus we can also obtain the optimum batch size $N^*$ by equating (3-14) and (3-18)

$$AC(n,N^*) = MC(nN^*)$$  \hspace{1cm} (A6-6)

$$N^* = (2nC_F/C_D)^{1/2}$$  \hspace{1cm} (A6-7)
By substituting (3-20) into (3-14) and (3-18) we can obtain the minimum average and marginal cost of transportation at the given level of demand.

\[
AC^*(n) = \left( \frac{2CFCD}{n} \right)^{1/2} + CV \tag{A6-8}
\]

\[
MC^*(n) = \left( \frac{2CFCD}{n} \right)^{1/2} + CV \tag{A6-9}
\]

Observe that

\[
\frac{dAC^*(n)}{dn} \cdot \frac{dMC^*(n)}{dn} = \frac{1}{2} \left( \frac{2CFCD}{n^3} \right)^{1/2} < 0 \tag{A6-10}
\]

Therefore, average and marginal costs of providing transportation services decline with increases in demand volume.

In conclusion, transportation activities are very often characterized by economies of scale and decreasing marginal and average cost structures, thus providing an incentive for the firms that are engaged in the provision of said services to expand their output capacity.

As was discussed in Section 2.2.2 above, the existence of such a "natural monopoly" situation has very often been used as an economic rationale for imposing government regulation on an industry.