Externalities, Property Rights and Transaction Costs

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A THESIS SUBMITTED TO
THE UNIVERSITY OF MACEDONIA AT THESSALONIKI
IN THE SUBJECT OF ECONOMICS
FOR THE DEGREE
OF MASTER OF SCIENCE

By
George E. Gavris
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G. G.

CONTENTS

PART II

List of Figures

PART I

1. INTRODUCTION

1.1 A BRIEF PRESENTATION OF THE EXTERNALITY CONCEPT

The notion external economies or externalities make their appearance in Marshall's 'Principle of Economics', almost one hundred year ago. Marshall tried to explain the long-run decrease in costs associated with an expansion of a particular industry in a way that would be consistent with increasing or horizontal marginal costs faced by individual firms within the industry. By trying to explain the existence of increasing returns to scale in a highly atomized industrial structure, he introduced the notions of the internal and external economies to the firms. Economies that are external to the firm could be internal to the industry. Little attention was given to this concept until Pigou's celebrated 'Economics of Welfare', where, developed and extended, it appears as one of the chief causes of divergences between private net product and social net product.

The Marshall-Pigou analysis had flaws, which became clear only with some thirty or so years of vigorous debate involving Young, Clapham, Robertson, Robinson, Knight, Sraffa, and Viner. In this controversy two related questions were at issue: (1) whether the upward-sloping supply curve, in which case the competitive equilibrium output would be too large, and (2) whether the traffic-congestion problem was an instance of external diseconomies within the industry or else of the misuse of a scarce resource – in particular, of the zero pricing of scarce land. This period could be argued that extends until the time that Viner made his contribution in 1930, by which the issue centred on the clarification of the upward and downward sloping supply curves.

The next stage would cover about thirty years up to 1960 with Coase's seminal article. Over these years there was an accumulation of new interpretations of the notion of externality with various possible associations with real-word phenomena (synergies among firms, congestion, envy, etc.). Externality also, was seen as either a subset of market failure or as a cause of market failure.

The third stage covers the last thirty years. The central features of this phase, as Papandreou (1994) indicates, are: '(a) the rising interest in environmental matters forging a strong association of externalities with pollution and raising interest in the externality question; (b) the ascendance of an institutional dimension in economics, concurrent with the notion of transaction costs, which came under focus with the debate on externalities; (c) an increasing separateness of the contexts of debate over externalities; this of course reflects the general trend of specialization and compartmentalization of economic discourse'. Externalities became the link between ecology and economics in a relatively new field of the Economics Science that of Environmental Economics.

The concept of externality was associated with the term of non-convexity, missing markets and more generally market failure. But, at the same time, there was a strong temptation to avoid an explicit definition of the term externality. The externality debate has influenced our perception of the role of government authorities. According to R. Cornes and T. Sandler a study of externalities, public goods and clubs, could give insight into the government's role in allocating resources. The theory of externalities, public goods, and club goods can help determine corrective taxes, provision levels, tools or user fees, and financing decisions.

Baumol and Oates (1975) in the book 'Theory of Environmental Economics' offered the following characterization of externalities:

'Condition 1. An externality is present whenever some individual's (say A's) utility or production relationships include real (non-monetary) variables, whose values are chosen by others (persons, corporations, government) without particular attention to the effects on A's welfare.

Condition 2. The decision maker, whose activity affects others' utility levels or enters their production functions, does not receive (pay) in compensation for this activity an amount equal in value to the resulting (marginal) benefits or costs to others.'

First condition is the test of whether an externality exists. The second condition refers to whether an externality leads to inefficiency.

From a more recent source (lecture notes on *"Economics of Resources and the Environment", Pr. David Zilberman, Department of Agricultural and Resource Economics, University of California, Berkeley)* we are reading:

'Externalities are a type of market failure. When an externality exists, the relative prices existing in a market do not reflect the true marginal costs and/or marginal benefits associated with the goods and services traded in the market. A competitive economy will not achieve a Pareto optimum, (i.e., will not achieve efficiency) in the presence of externalities, because individuals acting in their own self interests in the presence of externalities will not have the correct incentives to maximize total surplus. (The "Invisible Hand" of Adam Smith will be "pushing folks in the wrong direction.") Governments often take

policy action in attempts to correct externalities, because competitive markets will be inefficient if externalities are present.

Externalities may be related to production activities, consumption activities, or both. Production externalities occur when production activities by one individual, firm, or group impose costs on other individuals, firms or groups and those costs are not transmitted through a market.... ...consumption externalities, which occur when consumption activity by one individual imposes costs on other individuals and those costs are not transmitted through a market.'

Somewhere else from the same sources:

'Externalities exist when the activities of one or more agents affect the preferences or technologies of other agents.

- *Negative Externalities reduce utility or productivity. Example: pollution.*
- *Positive Externalities increase utility or productivity. Example: an apple farmer might receive unpaid for benefits from a neighboring honey producer if the honey producer's bees pollinate the apple farmer's apple trees.*
- *Production Externalities occur when the productivity of an individual is affected by activities of others. Example: The smoke from a factory decreases the productivity of a nearby "air-dry" laundry.*
- *Consumption Externalities occur when the welfare of some individuals is affected by the consumption activities of other individuals. Examples:*
  - *Noise pollution.*
  - *Sympathy -- People may feel bad (suffer reduced utility) when other people starve, for example.*
  - *Envy -- People's welfare may be reduced when viewing other people's success or high consumption levels.'*

From the citations above, becomes clear that the generally held view is that the existence of any kind of externalities, as well as environmental externalities, leads to an inefficient allocation in the economic system. In this work I am going to deal with this allocation problem and I shall exhibit an alternative approach to externality problem. With this approach the miss-allocation, or market failure by other words, could be avoided.

1.2 THE PLAN OF THIS THESIS

This work is divided into two parts. The environmental perspective is present in both of them. Sometimes more, and sometimes less. In the first part I will present the concepts of externality, non-convexity, transaction costs, market failure, and property rights. It concerns the traditional approaches to these concepts.

In particular, Chapter 2 begins by presenting the place of externality within the general-equilibrium framework. I shall follow Bator's (1958), Arrow (1970), and Heller & Starrett (1976) approaches to show the relationship between externalities and market failure. These authors are not looking for some phenomena to identify as externality. They are more concerned with understanding market failure and what causes it. Bator treats externality as synonymous to market failure. According to Arrow and Heller & Starrett, externalities are a subset of non-existence of markets. These approaches are also going to touch the notion of non-convexity, transaction costs and property rights.

Chapter 3 takes on the task of examining the relationship between non-convexity and externalities. Non-convexity is a notion that has been closely related to externalities and market failure. According to Baumol & Bradford the existence of non-convexity in the production set depends on the strength of the externality. Starrett talks about fundamental non-convexities and Burrows uses the external damage cost function to introduce non-convexity into the economic system. The first two approaches are frictionless, i.e. they do not take into account the role of endogenous transaction costs.

In Chapter 4 I shall discuss the usefulness of property rights. The main idea is that, if there are clear and tradable property rights for detrimental externalities then it is possible that the market will not fail. But, establishing and enforcing property rights is not cost-less; transaction costs are present and they could prevent property rights from being formed. I shall also discuss alternative property rights regimes, the notion of private and public goods and the feasibility of establishing property rights.

The second part illustrates some of the ideas that have been presented in the first part. Starrett claims (Chapter 3) that the presence of externalities implies fundamental non-convexities, which cause Arrow markets to fail. But, I attribute this failure to the structure of the Arrovian markets that Starrett uses and not to the presence of externalities. In Chapter 5 I shall construct several models in which there will be a detrimental externality, smoke for example. Assuming well-established and enforced, limited and tradable property rights for the detrimental externality, or more precisely for its supplementary (clean air in our case), I shall show that the models end up in a Pareto efficiency allocation that depends only on agents' endowments. In an effort to present better this approach, I shall present Boyd and Conley (1997) model. They introduce property rights into a general-equilibrium framework when externalities are present, and they define a notion of Coasian equilibrium for this economy showing first and second welfare theorem.

In this framework the non-convexities are not fundamental. In fact there are no non-convexities. The only non-convexities, that might be present, are due to non-convex technologies (for example, a production technology with setup cost) or non-convex consumer's preferences, because externality conditions do not affect directly the agents. In this framework there is a market system for them, with well-established rights. So, the clean air is treated like a traditional good. The problem now, is shifted to the way the limit of the detrimental externality is estimated, and to the legal system or institutions under which the trade will take place.

But, even if we know that the more efficiently way to get rid of externality conditions is to construct a market for them, many times this is not practicable. Partly because of the nature of goods like air, land or water and their social values (as I am discussing in Chapter 4). Another reason could be the cost of setting up such markets. In Chapter 6 I am going to follow Yang and Wills (1990), in setting up a model, which takes into account the cost of establishing property rights as well as the trade cost for all goods. This model demonstrates to what extent the existence of a potential market is dependent on these costs. High costs hinder the creation of this market.

2. General Equilibrium Approaches

A large part of the literature on the nature of externality is dedicated in determining its meaning and place within the Arrow-Debreu General-Equilibrium framework. In this section I will be presenting a few General-Equilibrium approaches to externality, in order to touch the concepts of market failure, non-convexities, transaction costs, and externalities.

Bator's (1958) approach is going to be the first. According to him externality is synonymous to market failure. A different approach is those of Arrow (1970), and Heller & Starrett (1976). They treat externalities as a subset of causes to the non-existence of market, or as synonymous to the non-existence of market. At the same time, they introduce the concept of transaction costs into externalities' modeling, signaling the movement to a more institutional way of thought.

2.1 Externality as Synonymous to Market Failure

According to Bator, externality is equivalent to market failure. Pareto-inefficiency is the hallmark of externality, which should also be used to classify alternative causes of market failure. He distinguishes three alternative causes been grounded to non-appropriability, public-goods and non-convexities. But this attempt of distinction seems to be problematic, as the ramifications of incorporating transaction costs in the model are not confronted.

2.1.1 The Necessary Conditions for Efficiency

Bator, in his seminal article 'The Anatomy of Market Failure', argues that 'by market failure...at least in allocation theory, we mean the failure of a more or less idealized system of price-market institutions to sustain "desirable" activities or to stop "undesirable" activities. The desirability of an activity, in turn, is evaluated relative to the solution values of some explicit or implied maximum-welfare problem'. This article is an 'attempt to explore and order those phenomena which cause even errorless profit-and preference-maximizing calculation in a stationary context of perfect (though limited) information and foresight to fail to sustain Pareto-efficient allocation'.

First, he is setting up the necessary conditions for efficiency of decentralized price-profit calculations both in a "laissez-faire" and in a "socialist" setting of Lange-Lerner civil servants. In fact, he starts presenting fivefold classifications of possible modes of market failure. These are:

1. *Failure of existence* - the failure of the Pareto efficient input-output points and associated commodity distribution points, which associate with the maximum of the welfare function, to be characterized by a complete set of marginal-rate-of-substitution (MRS) equalities (or limiting inequalities) that yield a set of price-like constants.
2. *Failure by signal* - in this case the bliss configuration of inputs and outputs, evaluated in terms of price-like constants, will yield: (a) a local profit-maximum position for each producer, rather than, as possible, a profit minimum, (b) maximum profits-in-the-large for each producer (this leads both to signaling and to incentive troubles).
3. *Failure of incentive* - if the bliss configuration of inputs and outputs will yield: (c) non-negative profits for all producers from whom production is required.
4. *Failure by structure* - According to Bator, market mediation may fail in production, even if all efficient production configurations coincide with points of maximum and non-negative producer's profits. Prices, which are determined by market forces, will correspond to a Pareto maximum, if self-policing perfect competition is obtaining in all markets. But, self-policing requires 'very many' producers in every market. If, for whatever reason, some markets are saturated by a few firms of 'efficient' scale, the full-maximum solution of inputs, outputs and prices will not sustained.
5. *Failure by enforcement* - market performance could fail in a statically sense, due to arbitrary legal and organizational 'imperfections', or feasibility limitations on 'keeping book', such as leave some inputs or outputs 'hidden', or preclude their explicit allocation or capture by market processes.

Bator's next step is a brief review of the neoclassical doctrine of external economies. But, as he argues 'the relevant literature is rich but confusing. It abounds in mutually reinforcing and overlapping descriptions and explanations of market failure: external economies, indivisibility, non-appropriability, direct interaction, public goods, atmosphere, etc. In a sense our problem is simply to sort the relations among these'.

Bator points out Marshall-Pigou approach, Viner's technological external economies and pecuniary external economies. He uses a simplified variant of the well-known apple-honey production model to formulate external economies in terms of 'direct interaction'. Finally, he deals with Ellis-Fellner notion of market failure. He is critical of viewing all market failure as non-appropriability and by narrowing the definition of appropiability he attempts to make room for other causes of market failure.

2.1.2 Types of Market Failure

Bator distinguishes three types of causes of market failure in terms of different kinds of externality: (1) Ownership Externalities, (2) Technical Externalities, and (3) Public-Good Externalities.

The first type, *ownership externalities,* entails failure caused by deficiency in institutional arrangements and in particular, it is not feasible to keep tab of certain values, it is too costly to enforce payments for certain activities, which as a result, escape accounting. The presence of transaction costs implies that efficient institutional arrangements are lacking, and are thus a cause of departure from ideal allocation. This type of failure is similar Meade's "unpaid factor" case. According to Bator, only this type of externality is due to non-appropriability, it's the only institutional cause of failure.

Technical Externalities represent failure caused by technology that exhibits indivisibility or smooth increasing returns to scale in the relevant range of output. Suppose that all goods and services are rationalble, exhaustible, scarcities, that individual ordinal indifference maps are convex and sensitive only to own consumption and that there exist no ownership defects of type (1) externalities (Ownership Externalities). Even then, according to Bator, the essential analytical consequence of indivisibility, whether in inputs, outputs or processes, as well as of smooth increasing returns to scale, is to render the set of feasible points in production non-convex. Non-convexity, in turn, has a devastating effect on efficiency.

Finally the third type, p*ublic-good externalities,* entails failure caused by outputs with important "public" qualities. According to Bator, any kind of price-market routine in this case become virtually useless for the computation of output-mix and of distribution, hence, also for organizational decentralization, even if preference and production functions are of well-behaved curvature, all is convex.

Since Bator has provided an ordering of types of market failures, he is making next some comments on the Meade and Scitovsky classifications of external economies. According to him, Meade's first category of market failure, 'unpaid factors', is identical to his type (1), *ownership externalities*. Meade's second type, 'atmosphere', despite its composite character, resembles to his public-good notion. Scitovsky's examples and conclusion suggest, as Bator argues, that Scitovsky was thinking primarily of type (1) of market failure: nonappropriability.

Bator also tries to present the analytical link between indivisibility and public goods, the significance of exclusion, the organizational arrangements designed to offset externality and the blends of various types of market failure. He claims that in the most cases of failure, type (1) is really a compound of types (2) and (3). He gives an example about skill training of people. While initially, the problem seems to be the institutional difficulty associated with effective control over skill, Bator argues that the difficulty may be caused by the fact that property rights for labor enter preferences as a public good. So, he emphasizes the public-nature aspect as being the cause of failure. But in fact, the way he has framed this example would seem to greatly increase the importance of institutional causes of failure. As the property rights for labor enter preferences, one has to consider how different institutions affect agent's utility directly. In that sense, type (1) of failure isn't going to shrink.

The same arguments could be posed, when Bator suggest that technical externalities (indivisibilities) may provide a better explanation of failure than ownership externalities, or when he argues that technical externalities can be traced to public-good externalities. Additionally, his discussion about exclusion and organizational arrangements seems to introduce the notion of transaction costs from the back door. As Papandreou (1994) says, 'failure, as Bator's own intuitive notion of externality seems to insist, is the failure of the system to take into account certain costs'.

2.2 Externality as a Subset of the Non-Existence of Market

Another resembling approaches are these of Arrow (1970), and Heller & Starrett (1976). Arrow is treating externality as a subset of causes of the non-existence of markets. For Heller and Starret externality is nearly synonymous with non-existence of markets. Transaction costs become a significant notion in their point of view. The difference between the two approaches is in the interpretations of the relationship of non-existence of markets with market failure.

2.2.1 Arrow's Absolute and General Market Failure

Arrow (1970) claims that the problem of externalities is a special case of a more general phenomenon, the failure of markets to exist (market failure). Market failures in general and externalities in particular are relative to the mode of economic organization and they differ from increasing returns. Increasing returns are essentially a technological phenomenon.

According to Arrow market failure is not absolute: '...in fact the situation is more complex than this. A more general formulation is that of transaction costs, ...'. For him, it is better to consider a broader category, which of transaction costs, which in general impede and in particular cases completely block the formation of markets. This point of view composes the notion of 'general market failure'. He argues that the transaction costs are attached to any market and indeed to any mode of resource allocation. Market failure is 'the particular case where transaction costs are so high that the existence of the markets is no longer worthwhile'.

Absolute market failure is based to two hypotheses made about perfectly competitive equilibrium. He argues that the two hypotheses frequently not valid are: (a) the convexity of household indifference maps and firm production possibility sets; (b) the universality of markets. By the last hypothesis he means that 'the consumption bundle which determines the utility of an individual is the same as that which he purchases at given prices subject to his budget constraint, and that the set of production bundles among which a firm chooses is a given range independent of decisions made by other agents in the economy'. Arrow treats failure by non-convexity and non-universality as absolute because there is no reference to other modes of organization in describing this failure.

He sets up a simple model in which he argues that 'by suitable and indeed not unnatural reinterpretation of the commodity space, externalities can be regarded as ordinary commodities, and all the formal theory of competitive equilibrium is valid, including its optimality. It is not the mere fact one man's consumption enters into another man's utility that causes the failure of the market to achieve efficiency'. But Arrow does not simply define externalities as synonymous with the non-existence of markets. He treats externality as a subset of causes of non-existence of market (market failure).

2.2.1.1 Causes of Market Failure

For Arrow, 'The problem of externalities is thus a special case of a more general phenomenon, the failure of markets to exist. Not all the examples of market failure can fruitfully be described as externalities'. He alludes two examples: markets for many forms of risk-bearing and for most future transactions do not exist and their absence is surely suggestive of inefficiency. Also, he suggests three possible causes for market failure:

1. *Inability to exclude.*
2. *Lack of necessary information to permit market transactions to be concluded.*
3. *Supply and demand are equated at zero; the highest price at which anyone would buy is below the lowest price at which anyone would sell.*

Arrow points out that the failure of futures markets cannot be directly explained in terms of the two first causes. The third cause of market failure may help to the explanation of the absence of futures markets to form. But, unlike the first two, this case is by itself in no way presumptive of inefficiency. However, it may usually be assumed that its occurrence is the result of failures of the first two types on complementary markets.

2.2.1.2 Transaction Costs and Market Failure

It seems that transaction costs are central to Arrow's understanding of externalities and general market failure. He argues that the transaction costs are attached to any market and indeed to any mode of resource allocation. Market failure is 'is the particular case where transaction costs are so high that the existence of the markets is no longer worthwhile'. He distinguishes the transaction costs from production costs. The first can be varied by a change in the mode of resource allocation, while the second depend only on the technology and tastes, and would be the same in all the economic systems.

Arrow suggests also three sources of transaction costs:

1. *Exclusion costs.*
2. *Costs of communication and information.*
3. *Costs of disequilibrium.*

All the above costs vary from system to system. The second source includes both the supplying and the learning of the terms on which transactions can be carried out. The third source, according to Arrow is associated with other kinds of costs: 'in any complex system, the market or authoritative allocation, even under perfect information, it takes time to compute the optimal allocation, and either transactions take place which are inconsistent with the final equilibrium or they are delayed until the computation are completed'.

Arrow's approach to market failure is concentrated to the following two points: (a) externality is a subset of causes of non-existence of markets and (b) relative market failure; non-existence of a market because of high transaction costs. The first point is similar to the Heller and Starrett (1976) approach to market failure. The difference is in the second point.

2.2.2 Heller and Starrett 's Private Economy Failure

Heller and Starrett (1976) for first time point out the significance of an institutional framework on the notion of externality. They argue that externalities are nearly synonymous with non-existence of markets. According to them 'we define an externality to be a situation in which the private economy lacks sufficient incentives to create a potential market in some good and the non-existence of this market results in losses in Pareto efficiency'.

In Arrow's definition of relative market failure, the market fails where it is too costly for it to be worthwhile. The situation is different in Heller and Starrett approach. The private economy fails because a market is not created where one should be created. So, opposite to Arrow's 'relative market failure' there is Heller and Starrett's approach:

Private-economy failure: failure of a private economy to create markets where Pareto-optimality could be achieved through the formation of markets.

They 'shall argue ... that situations usually identified with "externality" have more fundamental explanations in terms of (1) difficulties in defining private property, (2) noncompetitive behavior, (3) absence of relevant economic information, or (4) non-convexities in transactions sets'.

They use an example of garbage disposal to illustrate their aspects. They suppose in this example that individuals consume commodities and absorb garbage. c^i is a vector of consumption of goods by i individual and (z^i, z^i_g) his exogenous holdings of goods and garbage respectively. At the outset, they assume that there are competitive markets for goods, but not market (or other institutional arrangements) for garbage. In absence of such arrangements, individuals dump their garbage on each other. If d^i_j is the garbage dumped by j to i then i's utility function will take the form:

$$U^i = U^i(c^i, d^i_1, \ldots, d^i_n).$$

Given prices p in the existing markets, individual i faces the problem:

$$\max_{c^i, d^i} U^i(c^i, d^i) \qquad \text{subject to} \qquad p \cdot c^i \leq p \cdot z^i.$$

'On the other hand, if one establishes a property right (effectively forcing each person to be responsible for his own garbage) and sets up a market for garbage, the externality disappears: letting p_g be the price of garbage, and g^i the net amount sold by i, i's problem may now be stated as:'

$$\max_{c^i, c^i_g} U^i(c^i, c^i_g) \qquad \text{subject to} \qquad p \cdot c^i + p_g \cdot c^i_g \leq p \cdot z^i + p_g \cdot z^i_g,$$

where $c^i_g = z^i_g - g^i$.

This model, expect for the fact that price of garbage will be negative, is classical in form and there are no externalities. According to Heller and Starrett, there would be some problems, which might hinder the establishment of the potential market of garbage (and more general every other potential market): (a) high transaction setup costs, (b) absence of relevant information, (c) difficulty defining property rights, (d) even the market is established, it may be operated in a noncompetitive way.

After Heller and Starrett examine the concepts of 'publicness of external diseconomies', 'exclusion on cost' and 'pecuniary externalities', they try to give a broader definition of externality and to associate it with market failure. The definition of externality is not institution free. 'We have argued that instances of externality can always be associated with failure of some potential market to operate properly. Therefore, all externality problems can be traced to some more fundamental problem having to do with market failure. Therefore, one might take the position that the concept of externality should be dropped altogether. Our taxonomy of market failure might then consist of (1) non-exclusiveness of commodities, (2) non-convexities, (3) noncompetitive behavior, and (4) imperfect or incomplete information'.

When Heller and Starrett discuss remedies for correcting the non-optimality created by externalities they argue that one 'cannot ignore the costs of the institutions in making the social decisions since these costs are now the primary reason the externality is there in the first place'. They point out that one should be interested in net optimality, the level of social satisfaction attained after institution costs are netted out.

2.3 Non-Existence of Market and Market Failure

The approach of market failure as the non-existence of markets gives rise to some problem. Papandreou (1994) gives a briefly summary of the problems associated with viewing market failure, or a subset of market failure, as the non-existence of markets.

1. 'It presumes that the existence of a market is sufficient to establish its efficiency, i.e. existing market equals optimal institution. ... The simple presence of an institution, market or non-market, is no evidence that it uses resources efficiently in the organization of economic activity.
2. It is indirect and perhaps misleading in avoiding explicit mention of a comparison set of institutions. Once transactions costs have been introduced, the failure of a market is deduced by comparison to alternative institutions and not by whether a market exists or not.
3. It treats all imperfect markets as non-existent markets, and this include markets for proxies. In a world of transaction costs many markets will be 'imperfect', or many private property rights may be 'imperfect', yet one could not deduce inefficiency from this alone. ...
4. Distinction between specific market and market system blurred.
5. A lot of the conceptual problems present in Arrow's notion of relative market failure and Heller and Starrett's notion of private-economy failure, seem to emanate from the transference of non-existence as a cause of failure in a transaction-costless world, to a model with endogenous transaction costs.'

2.4 CONCLUSION

The transition from Bator's interpretation of externality, externality as synonymous to market failure, to Arrow, and Heller & Starrett notion as non-existence of markets is an effective one. Despite certain problems in Arrow's, and Heller & Starrett's characterization of externality, their approach remains a good metaphor in conveying the highly contingent nature of the thin line separating commodities from 'externalities' in a general-equilibrium model' (Papandreou 1994). Arrow introduces transaction costs into a general-equilibrium setting. In this way he takes an important step outside the Arrow-Debreu model closer to an institutional perspective. Heller and Starret move even closer to the institutional school of thought. It seems that 'an understanding of institutions and their economic function becomes a central objective' to the understanding of the notion of externalities and their relationship with the concept of market failure.

3. Externality and Non-Convexity

In the previous chapter we met the concept of non-convexity many times. According to Arrow, non-convexity could be one of the causes of 'absolute market failure'. Heller and Starrett point out the notion of fundamental non-convexities arising from forming markets for detrimental externalities. The relationship between externalities and non-convexities is extensively dealt with in this chapter. The very presence of non-convexity, in the production or consumption side of economy, could prevent a competitive economy from achieving a Pareto optimum. There are quite a few bibliography references connecting externality and non-convexity. I shall refer to Baumol & Bradford (1972), Starrett (1972), and Burrows' (1995) approaches.

According to Baumol and Bradford the existence of non-convexity in the production set depends on the *strength of the externality*. Starrett extends the commodity space to include the externality as input in the production process. In this way the production space becomes *fundamentally non-convex*. Burrows uses an alternative notion, *external damage costs function*, to introduce non-convexity in externality modeling, not only on the production but also on the consumption side of economy.

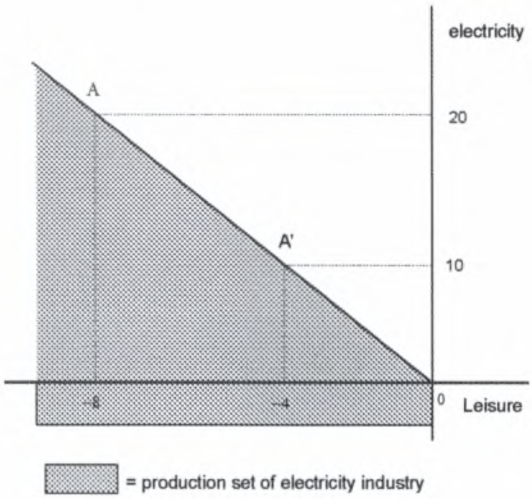
The first two approaches that I shall present are frictionless, i.e. they do not take into account the role of endogenous transaction costs. By examining policy actions, i.e. control actions taken often by government authorities in their attempts to achieve efficiency, as with Pigouvian taxes, I am going to reach their controversial results.

3.1 Detrimental Externalities and Non-Convexity on Production

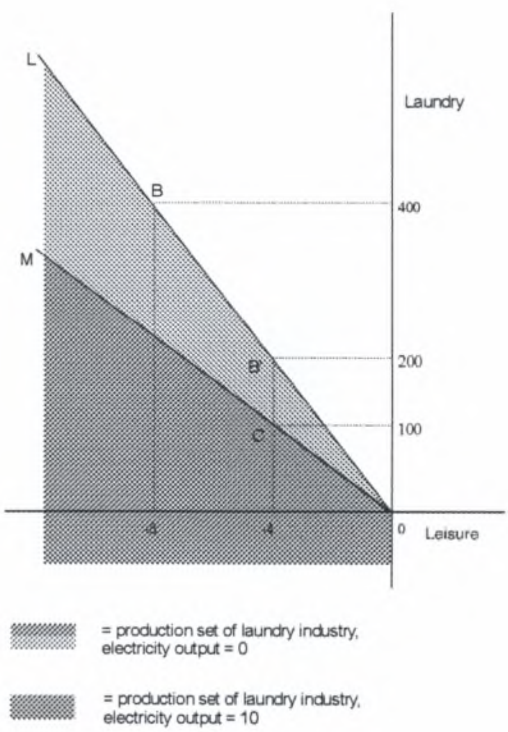
In this section I shall present the bibliography references that connect externality and non-convexity on production, the supply side of the economy. These approaches are great many. Baumol & Bradford, Starrett, as well a part of Barrows approaches belong to this categoty.

3.1.1 Externality's strength and Non-Convexity

We are going to follow close Baumol and Bradford's (1972) article to show their argument, that detrimental externalities tend to induce non-convexity of the social production possibility set. They argue that if externalities are sufficiently strong, convexity conditions must break down. To illustrate this aspect they use three examples, two graphic and one algebraic.



(a)



(b)

Figure 1.

Baumol and Bradford begin with an example of a power station that inflicts a detrimental externality on a laundry firm through its generation of smoke. It's a model of a two output and one input economy in which each output is produced by a single industry. Electricity and laundry services are the two outputs, while labor is the only input. They assume also that each industry has a convex, fixed, technology in terms of its own inputs and outputs. Fixed technologies means that there is a fixed ratio between power station's output and the level of produced smoke. The presence of detrimental externality, the smoke, means that increases in the output of the power station raises the laundry's costs of production, i.e. there is a external to laundry firm originated cost.

Figure 1a shows the production set for the electricity industry, with constant returns to scale for simplicity, hence the straight-line boundaries. Figure 1b displays the production set for the laundry industry, again with the constant returns to scale simplified assumption, under two alternative output in the electricity industry. The detrimental externality generated by the electricity industry means that, for a given input of labor to laundry, less will be produced when electricity output is positive. Consider now, two technically feasible social production vectors: *OA* (8 labor, 20 electricity, 0 laundry) and *OB* (8 labor, 0 electricity, 400 laundry). However, the vector *OC* (8 labor, 10 electricity, 200 laundry), which is a convex combination of *OA* and *OB* since $OC = \frac{1}{2}OA + \frac{1}{2}OB$, is not feasible technically: if we insist on 10 units of electricity, requiring 4 units of labor, the most we can obtain with the rest 4 units of labor, is 100 units of laundry. So, the convexity conditions of the social production possibility set must be break down.

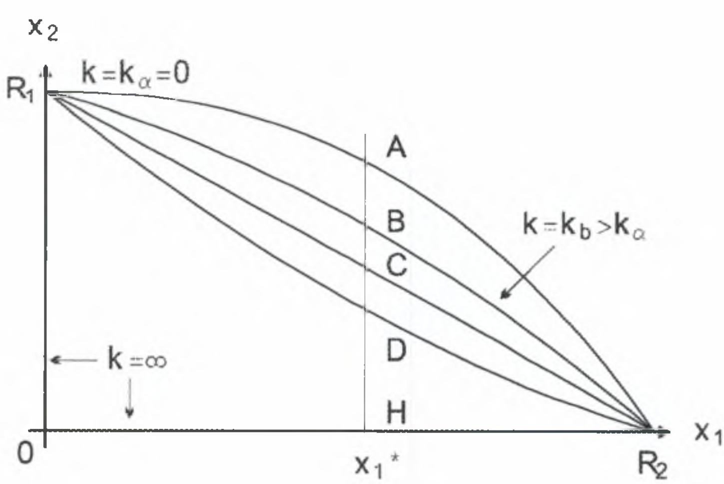


Figure 2.

An alternative, again graphically, illustration of the convexity break down is given in Figure 2. Let x_1 and x_2 represent, respectively, quantities of electricity and laundry, and suppose that locus OR_1AR_2 represent the convex set of output combinations attainable from a fixed amount of labor in the absence of externalities, dropping earlier assumption of constant rate of transformation between outputs. We introduce a parameter k measuring the strength of externality. Parameter k can be taken to measure the mean addition to the resources cost of cleaning a given batch of laundry that occurs when an added unit of electricity output causes smoke to increase. So, an increase in k means that with a given amount of electricity and a given quantity of resources, a smaller quantity of clean laundry can be produced than before. Consequently point A must shift downward to some lower point, and it is possible for some value of k the entire possibility locus to pull below line segment $R_1C\,R_2$. Then the possibility set becomes a non-convex region such as shaded region OR_1DR_2.

The next example is algebraic. Let l_i stand for the amount of labor used in industry i, x_1 for the output of electricity, and x_2 for the output of laundry services, and again the separate production sets of the two industries to be strictly convex:

$$l_1 = x_1^2/2$$
$$l_2 = x_2^2/2 + a\,x_1\,x_2$$

The coefficient α measures the strength of the effect of electricity output on laundry costs. If a total of $L = l_1 + l_2$ units of labor are made available, we can write the implicit equation for the laundry-electricity possibility frontier as:

$$L = x_1^2/2 + a\,x_1\,x_2 + x_2^2/2$$
$$x_1 \geq 0, \quad x_2 \geq 0.$$

By differentiation the relationship between the marginal rate of transformation and the pattern of output can be expressed as:

$$\frac{d\,x_2}{d\,x_1} = -\frac{x_1 + a\,x_2}{x_2 + a\,x_1}$$

If α is greater than one, the production possibility set becomes non-convex. However, generally the appearance of the non-convexity will depend both on the magnitude of the externality parameter and on the values of x_1 and x_2. For example, suppose that the laundry resource requirement function becomes:

$$l_2 = x_2 + a\, x_1\, x_2$$

while the electricity resource requirement function is left unchanged. Now, the production possibility locus is given by:

$$L = x_1^2/2 + a\, x_1\, x_2 + x_2$$

Calculation of the second derivative shows that convexity will now be violated if and only if:

$$2\,\alpha^2 x_2 + \alpha x_1 \succ 1\,.$$

Clearly, for α or x_1 or x_2 sufficiently large, this requirement will not be satisfied, and the non-convexity will be appeared in the aggregate production set.

Although the aggregate production set may be non-convex, the individual production sets are convex. In this example the individual feasible sets over which competitive electricity generators and launders optimize are convex, so the competitive market equilibrates. The equilibrium will be inefficient, but with appropriate Pigouvian taxes the decentralized market could be relied on. A sufficiently ingenious use of Pigouvian taxes can keep a competitive economy at any desired point that is technologically efficient so long as detrimental externalities are the only source of non-convexity. But the Pigovian taxes cannot change the shapes, at least in the short or mid run, of the technological relationships in the economy, and hence cannot remove the problems of evaluation of efficiency which non-convexity introduces. Equilibrium prices can no longer be depended upon to give us the right signals about to the current allocation, if it is Pareto-optimal, or what the direction of improvement should be.

3.1.1.1 Pigouvian taxes and Non-Convex Social Production Set

We are going to follow Papandreou (1994) to illustrate the problem of Pigouvian tax mechanism, when the aggregate production set is non-convex.

Continuing the use of the previous example, let the production sets for the electricity and laundry firms be represented by the following general functional forms:

$$x_1 \leq h(l_1)$$

$$x_2(l_2, x_1) = \frac{f(l_2)}{1 + v(x_1)}$$

where $h(0) = 0$, $h'(l_1) \geq 0$, $h''(l_1) \leq 0$,

and $f(0) = 0$, $f'(l_2) \geq 0$, $f''(l_2) \leq 0$, $v(0) = 0$, $v'(x_1) \succ 0$.

The production function of the electricity firm is straightforward. The production function of the laundry firm incorporates the detrimental impact of the electricity firm's output. As we shown in Figure 1b, every increase in electricity output, increasing of function $v(x_1)$, causes a decrease in laundry's output, while the particular functional form of the detrimental impact is left unspecified. The main object of the government authorities is to maximize the joint profits of these two firms. Before examine the jointed profits maximization, we are going to look at the maximum attainable profits of both firms at different levels of electricity output, or equivalent different pollution levels as we suppose that there is a fixed ratio between electricity output and produced smoke. For the electricity firm this means simply to take the profit maximizing labor-input level. For the laundry firm the result from this maximization is a parametric profit function of the electricity output:

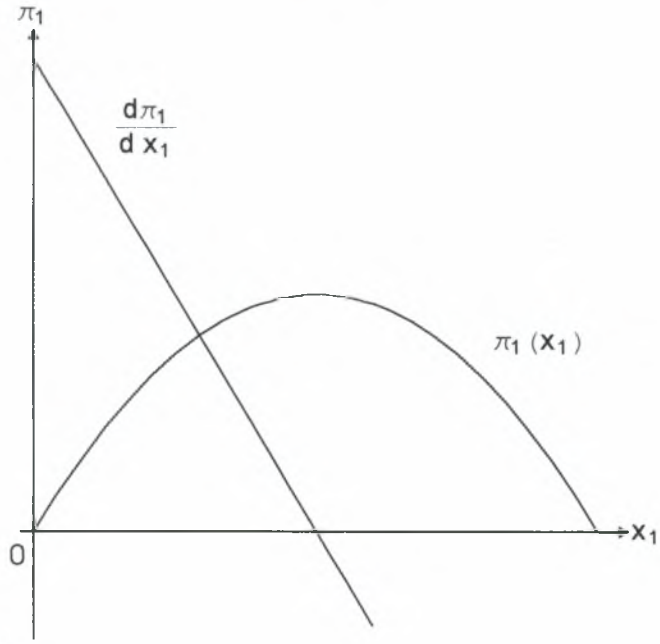
$$\pi_1(x_1) = \max_{l_1}[p_1 x_1 - w_1 l_1]$$

with respect to: $x_1 \leq h(l_1)$,

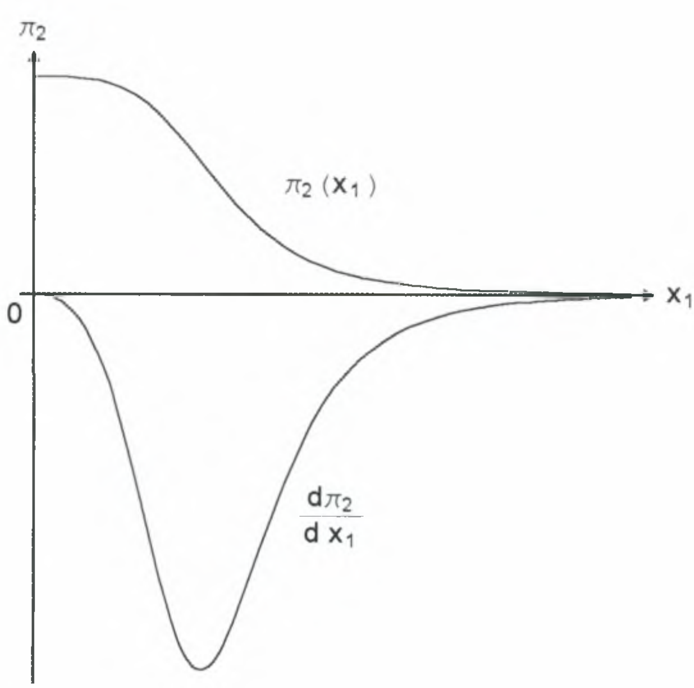
and

$$\pi_2(x_1) = \max_{l_2}[p_2 x_2(l_2, x_1) - w_2 l_2]$$

For illustrative purposes we suppose that the two profits function have the form in Figure 3a and 3b. In the same figure there are the marginal profit functions $d\pi_1/dy_1$ and $d\pi_2/dy_1$. For the electricity firm the first units of output, and at the same time of pollution, bring in the greatest profits. Additional increments of output raise smaller amounts of profit. For the laundry firm, the impact of the first units of pollution is small, but it raises as the level of pollution increases. However, at some point of pollution level, after the serious damage has been done, additional units of pollution will no longer have an impact on the spillee.



(a)



(b)

Figure 3.

Figure 4a gives us the joint profits, $\pi_1 + \pi_2$, of the two firms associated with the electricity output level x_1, or the corresponding pollution level. In Figure 4b the marginal profits functions are superimposing. The marginal profit $d\pi_1/dy_1$ can be interpreted as the marginal benefit function, while $|d\pi_2/dy_1|$ as the marginal cost function associated with different levels of pollution. If the authorities adjust Pigouvian taxes according to marginal damages done by the polluting firm, then the economy

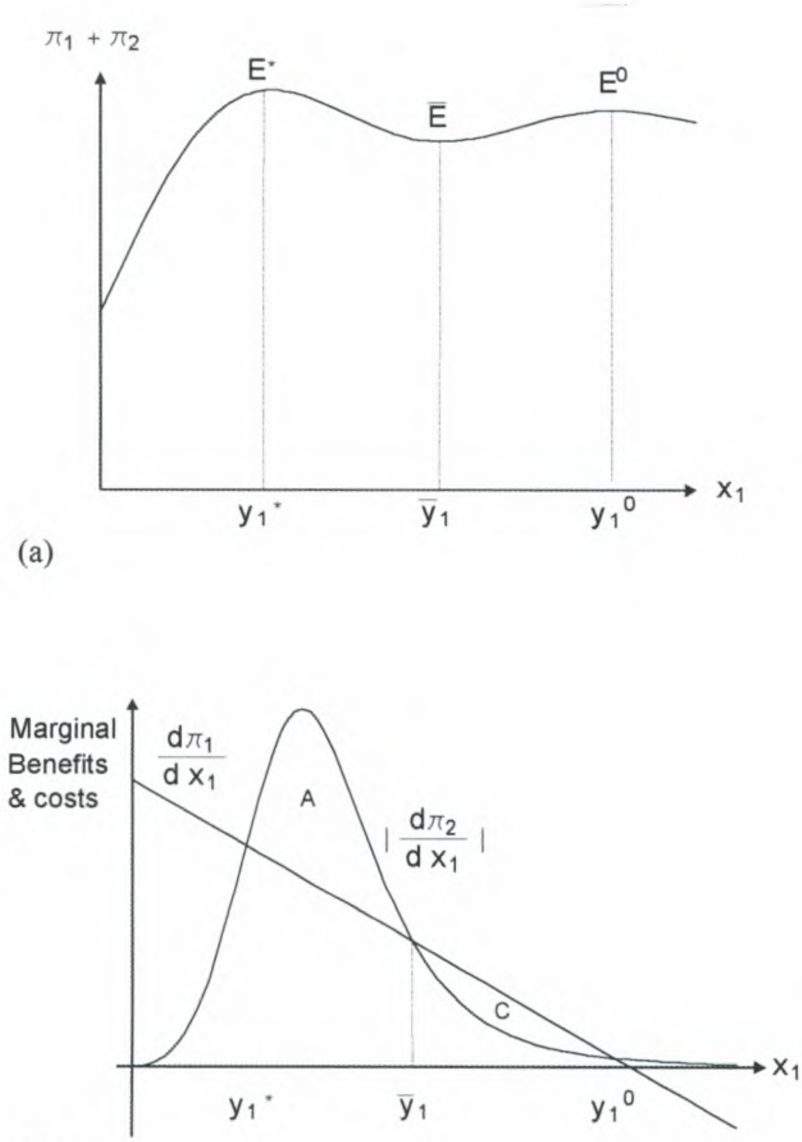


Figure 4.

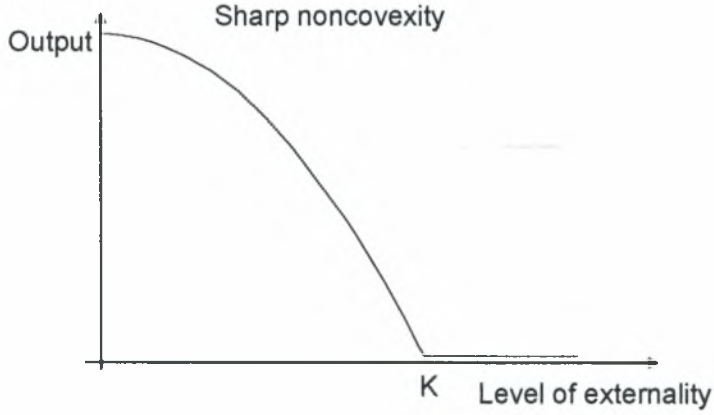
could easily end up at a suboptimal competitive equilibrium with a pollution level of y_1^0, depending on the initial level of pollution (if initial level of pollution is beyond $\overline{y}_1$). Pollution level y_1^0 is associated with a local maximum of joint profits, while there is a global maximum point, E^*, in which the net social benefit is larger. Point E^* is an equilibrium point associated with the joint profit maximizing level of output y_1^*, although the marginal benefits and costs are higher. Pigouvian taxation based on marginal damages may lead to a tax supported competitive equilibrium that is not Pareto-optimal. In our case there are three Pigouvian tax-competitive equilibria, E^*, $\overline{E}$, and E^0.

Thus, it is obvious that the government authorities cannot rely only on marginal information to determine the optimal Pigouvian tax. If there are multiple Pigouvian tax-compensated equilibria, then the economy, by this mechanism and depending from the initial point, may move to a suboptimal equilibrium. It would need detailed information to be able to locate the global maximum of combined profits. The problem is rather one of information.

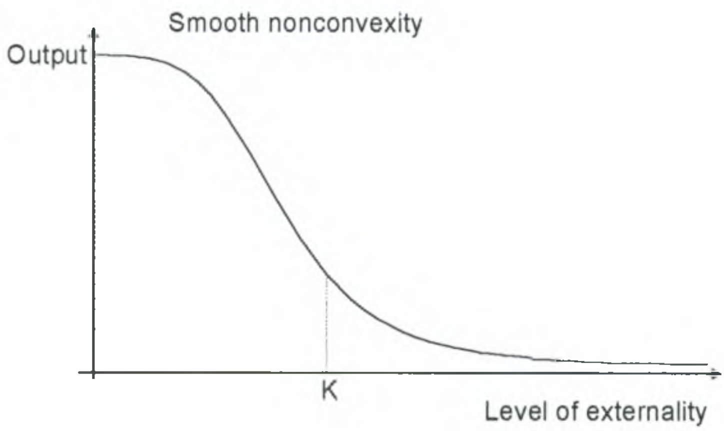
3.1.2 Externality and Fundamental Non-Convexity

Starrett (1972) identifies a quite distinct phenomenon, which he calls *fundamental non-convexity* associated with externalities. In contrast to Baumol and Bradford's example, this fundamental non-covenxity does not depend on the externality being sufficiently strong. Starrett extends the commodity space of the spillee to include the spillover, smoke in our previous example, as input in the production process. If a firm is the recipient of a detrimental externality, which potential harm is serious enough, it always has the option of going out of business. Thus, if the commodity space is defined to include the externality *smoke*, there is an inherent non-convexity. The main point is if a market created in the spillover and it becomes a control variable in the individual processes, then the production space becomes non-convex irrespective of the severity of the detrimental externality.

Figure 5 gives us a graphical treatment of this fundamental non-convexity. Let the level of labor in laundry industry be fixed. Then generation of further smoke at the point K cannot further reduce the output of the laundry. Figure 5a display the case of *sharp non-convexity*, in which the laundry firm is going to shut down operations. Figure 5b represents what is called a *smooth non-convexity*. For the laundry firm the impact of the first units of pollution on its profits is small. But as pollution accumulates, it seriously damages productivity. At some point, however, after the serious damage has been done, additional units of pollution will no longer have an impact on the spillee.



(a)



(b)

Figure 5.

The introduction of a market for externality raises automatically a number of serious questions associated with the externality nature. If we were dealing with natural resources the major question would be of the kind: *How can be rights on natural resources defined and enforced?* The way in which rights are defined will determine the progress of the economic system. Also, this approach does not eliminate the case in which a competitive equilibrium may fail to exist.

To illustrate the above assertion let see two examples. Suppose that the rights to enjoy clean air, or conversely to pollute the air, can be cost-less defined and enforced. First we consider the case in which the laundry firm may possess the right to enjoy clean air in the neighborhood of his laundry. It may, however, choose to sell some of this right, in the form of tickets or permits, each of that allows its buyer, electricity firm in this case, to inflict a unit of pollution on the laundry. Let s be the number of units of pollution, smoke, and p_s be the price per unit charged by the laundry. Then the profits of the electricity and laundry firm are, respectively:

$$\pi_1 = p_1 y_1 - w_1 l_1 - p_s s$$

and

$$\pi_2 = p_2 y_2 - w_2 l_2 + p_s s.$$

Laundry firm has two sources of profit: the provision of laundry services and the sale of his clean air rights. Figure 6 shows a functional form of profit maximizing levels of laundry output associated with different levels of pollution, and the price that maximize joint profits. At that price the laundry firm could get more profits by selling more units of pollution than indicated by quantity B. In fact at such a price it would rather shut down and sell an infinite number of pollution rights, while the electricity firm will demand only a finite number of rights. On the other hand, at a price of zero the laundry will supply no rights, while the electricity firm's demand will be positive. Thus, no price equates supply and demand, and the market necessarily fails. Even if an arbitrary finite limit, at point N, to the number of rights is imposed, a problem remains. If the limit exceeds the point B, the laundry firm can maximize profits by shutting down and selling the maximum number of permits.

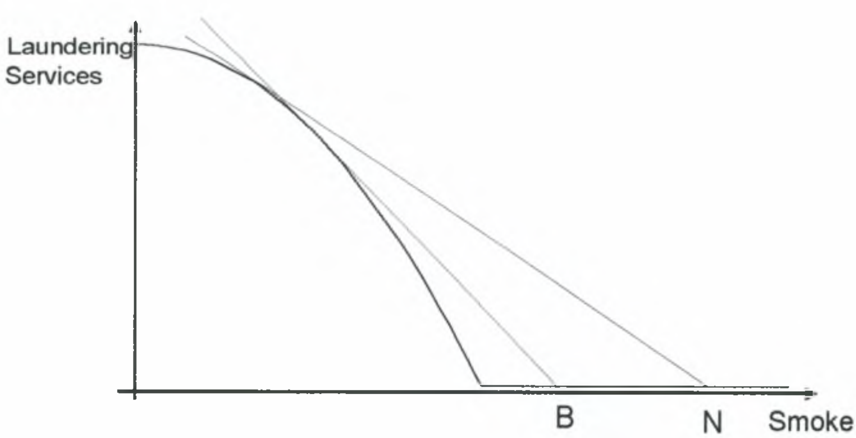


Figure 6.

Suppose now, that initially the electricity firm has the right to pollute, producing $\bar{s}$ units of smoke. The launderer may pay a price p_s to obtain a reduction of one unit in smoke production. The profits of the two firms are:

$$\pi_1 = p_1 y_1 - w_1 l_1 + p_s(\bar{s} - s)$$

and

$$\pi_2 = p_2 y_2 - w_2 l_2 - p_s(\bar{s} - s).$$

For a given value of p_s, these expressions differ from the previous case only by virtue of an exogenous redistribution of profits. Firms' choices will be unaffected by this.

Equilibrium may fail to exist in the space of commodities that includes externalities. In previous examples it is tempting to suggest that the problem can be overcome by choosing the upper limit to the number of rights appropiarty. For example, if it is made small enough then the problem may overcome. But, this raises an information problem. In general the social optimum allocation is not known. Choosing a small upper limit there is the risk the social equilibrium point to be over this limit, ruling out the optimum. Thus, the definition and enforcement of property rights appears to have a sensational role. About the role of property rights we are going to discuss in next chapter.

According to Baumol and Bradford the non-convexity in the externality modeling is imported through the social production set. They claim that due to the existence of externality the convexity condition of social production set is breaking down. According to Starrett's approach, by extending the commodity space to include the externality as input in the production process, the production space becomes fundamentally non-convex. An additional approach is this of Burrows. He uses the notion of external cost, in the production and in the consumption side of the economy, as synonymous to the concept of externality. These external costs have as result the existence of a damage cost function. In this approach the non-convexity is introduced into economic modeling from the shape of damage cost function when external costs are present.

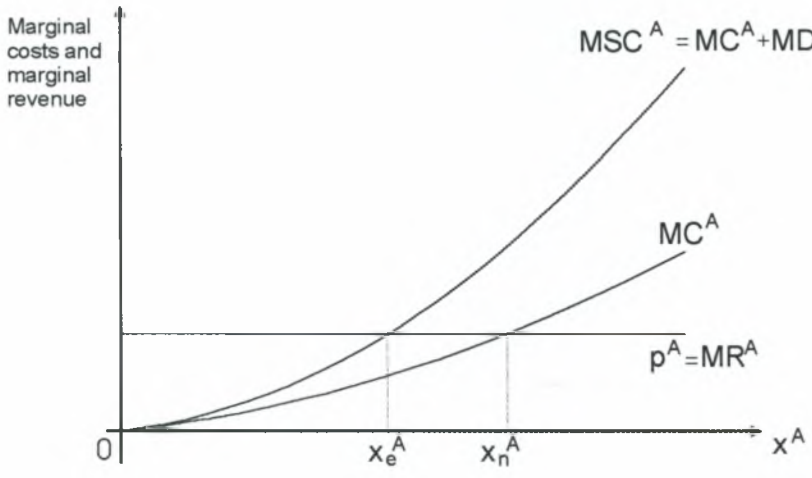
3.1.3 Total Damage Cost Function and External Costs

Burrows' analysis resembles the previous examples about externality and non-convexity. Again, he claims that the existence of externalities, external costs, causes the non-convexity of the production set. The main difference here is that he uses an additional step in introducing the effect of externalities: he associates the external cost with the total damage cost function. As the total damage cost function deviates from convexity, due to external costs, the non-convexity of the social production set is presented.

He is starting with a case in which external cost is due to pollution with the following characteristics:

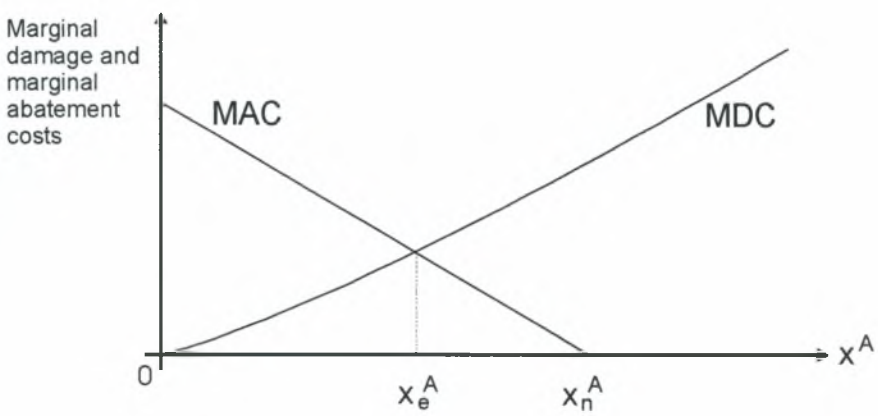
1. It is a production on production case. The polluter is a firm (A), like the electricity firm, whose pollution from production damages the production of the second firm (B), say the laundry firm. The damage is imposed unilaterally. Firm B cannot damage firm A, without any prospect of negotiation between the two firms.
2. Both firms are profit maximizers, and they operate in competitive goods and factor market. They utilize fixed technologies. The polluter can abate pollution only by cutting output level, since there is fixed ratio between A's output and the level of produced pollution.
3. Total external damage cost is a positive function of the level of pollution, and therefore of the level of firm A's output. Total abatement cost is a positive function of the level of pollution, and by implication is a negative function of the level of pollution up to some level of pollution where total abatement cost is zero.

If the polluter, firm A, ignores the external cost then it will choose the output level x_n^A at which marginal private cost equals marginal revenue, Figure 7a. This minimizes abatement costs at zero, Figure 7b, and maximizes profit π^A, Figure 7c. While x_n^A is the preferred equilibrium production level of firm A, society would prefer to maximize the social gain from the two activities, i.e. the sum of the profits of the polluter and the victim. By other words society would prefer to judge the efficiency of the polluter's activity on the basis of the net profit of the polluter's output together with the damage cost, i.e. loss of firm B's profit, it brings about. Thus, the social optimum would be the global maximum of the social gain at point E, Figure 7c. Output x_e^A can be said to be socially efficient.



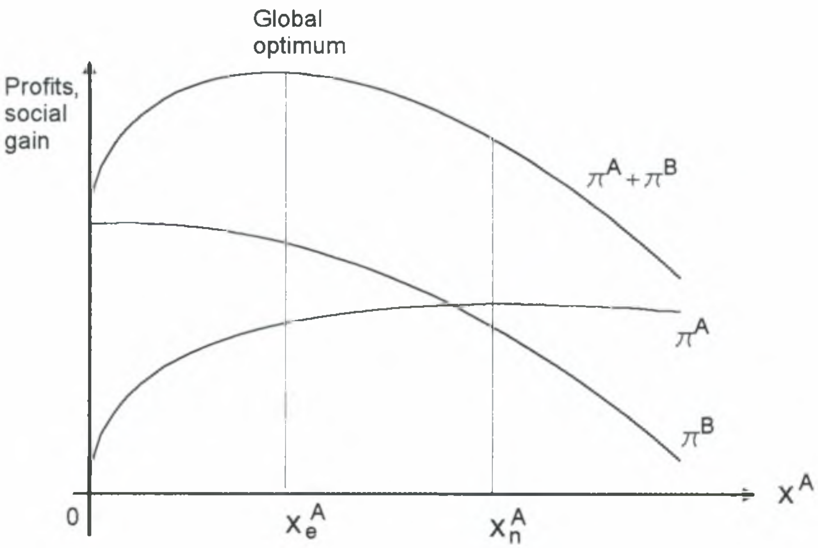
Marginal costs and marginal revenue
MSC^A = MC^A+MDC
MC^A
p^A=MR^A
0
x_e^A
x_n^A
x^A

(a)



Marginal damage and marginal abatement costs
MAC
MDC
0
x_e^A
x_n^A
x^A

(b)



Global optimum
Profits, social gain
$\pi^A+\pi^B$
π^A
π^B
0
x_e^A
x_n^A
x^A

(c)

Figure7.

Burrows offers three different theories to rationalize the existence of a non-convexity somewhere in the damage cost function:

1. a firm shut-down theory
2. a pollution saturation theory
3. a theory of the multiplicative interdependence between firms' production functions.

3.1.3.1 Firm shut-down theory

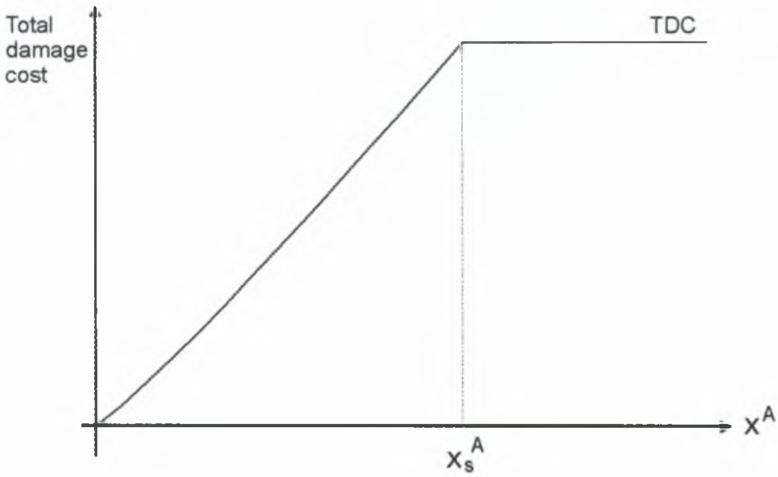
The shut-down theory consists of the rather obvious point that as the polluter's output rises the profit level of firm B cannot decline indefinitely: there must be a level of firm A's output, x_s^A, and hence of pollution, at which firm B's profits fall to zero and the firm goes out of business. There is an abrupt change of gradient of the total damage cost curve at point x_s^A, Figure 8a. After point x_s^A the total damage cost curve has zero gradient, so marginal damage cost is zero, Figure 8b.

There exists a sharp non-convexity of the total damage cost curve. This case is associated with the Starrett's sharp non-convexity case and it rises the problems that we have encountered with Papandreou's (1994) example previously.

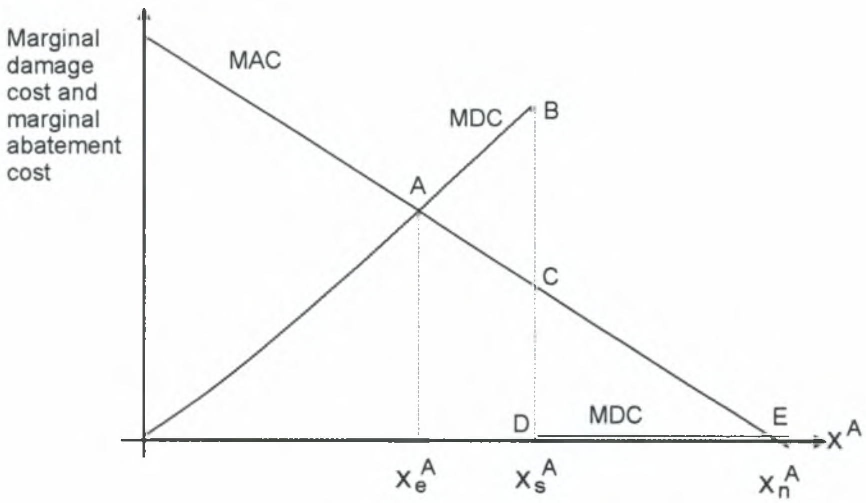
3.1.3.2 Pollution saturation theory

The difference between this case and the case of shut-down is depicted in Figure 9. The victim firm may experience a decline in damage at the margin before they reach the shutdown point. If x_s^A is the polluter's output at which the marginal damage cost ceases to rise as pollution increases, at this point the gradient of the total damage cost curve begins to decline and above this point the associated marginal damage cost curve, Figure 9b, has a negative slope.

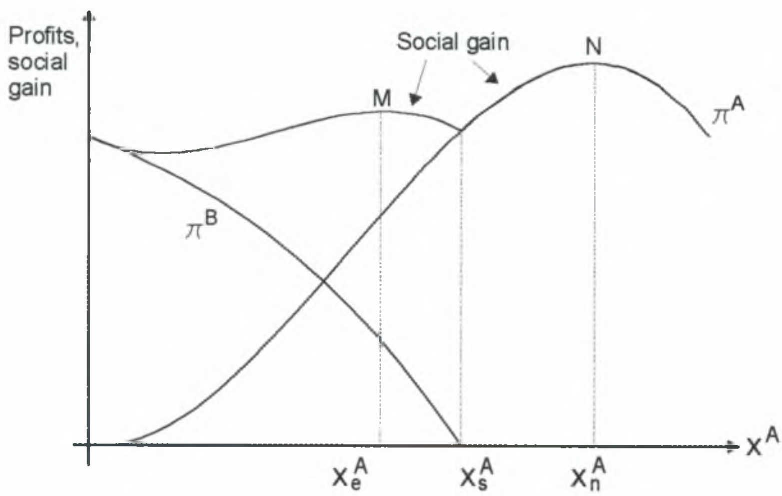
This case resamples to Starrett's smooth non-convexity condition. The implications of the pollution saturation case are similar to these on the firm shutdown case.


Total damage cost
TDC
x^A
x_s^A

(a)


Marginal damage cost and marginal abatement cost
MAC
MDC
B
A
C
D
MDC
E
x^A
x_e^A
x_s^A
x_n^A

(b)


Profits, social gain
Social gain
N
M
π^A
π^B
x^A
x_e^A
x_s^A
x_n^A

(c)

Figure 8.

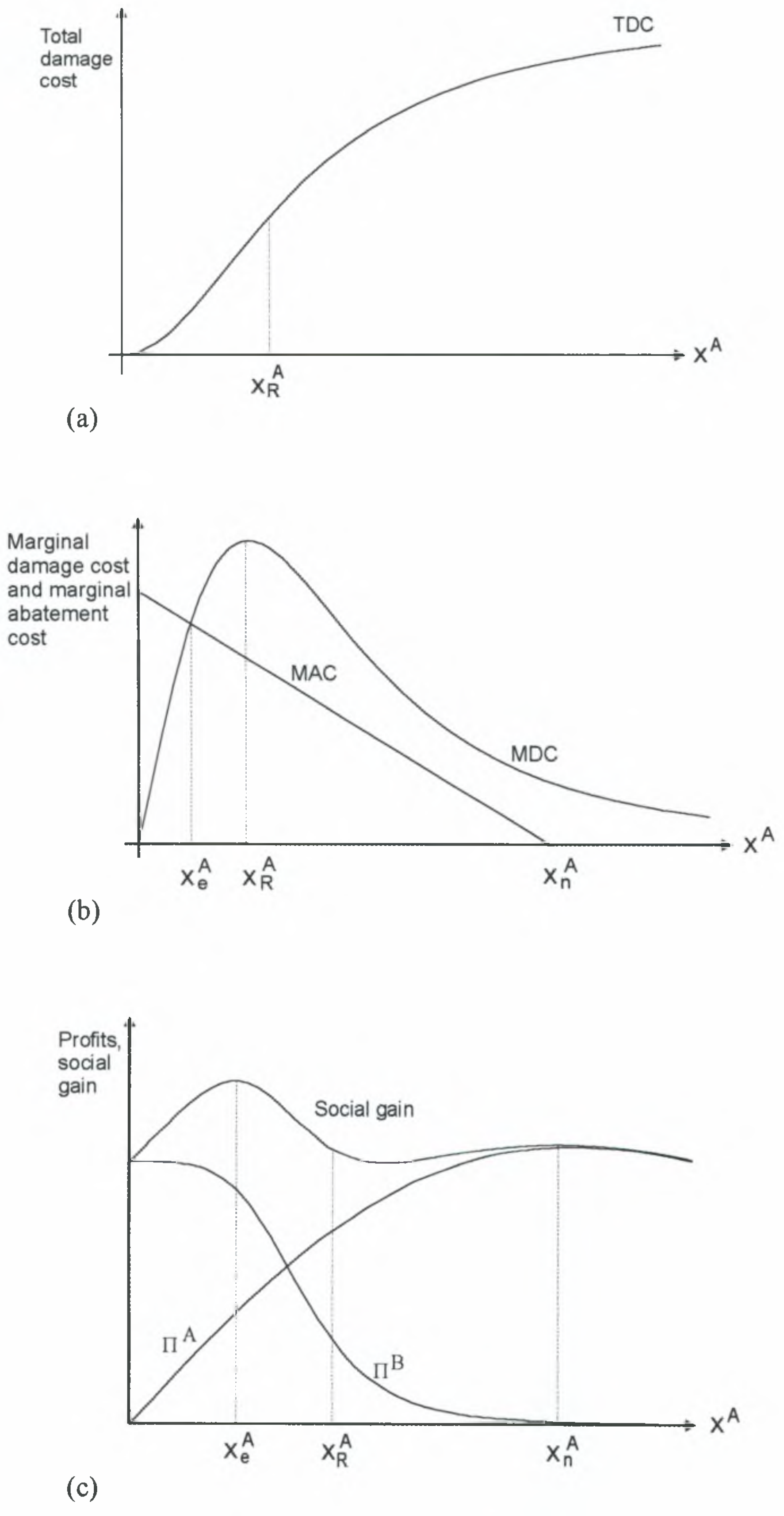

Total
damage
cost
TDC
x^A
x_R^A
(a)
Marginal
damage cost
and marginal
abatement
cost
MAC
MDC
x^A
x_e^A
x_R^A
x_n^A
(b)
Profits,
social
gain
Social gain
Π^A
Π^B
x^A
x_e^A
x_R^A
x_n^A
(c)

Figure 9.

3.1.3.3 Multiplicative interdependence between firm's production functions.

The essential feature of the model used to represent this source of non-convexity is that the size of the total damage cost depends upon the multiple of the outputs of the polluter and of the victim firm. In particular, if α is a parameter that measures the strength of the externality the total damage cost is function of the term $ax^A x^B$.

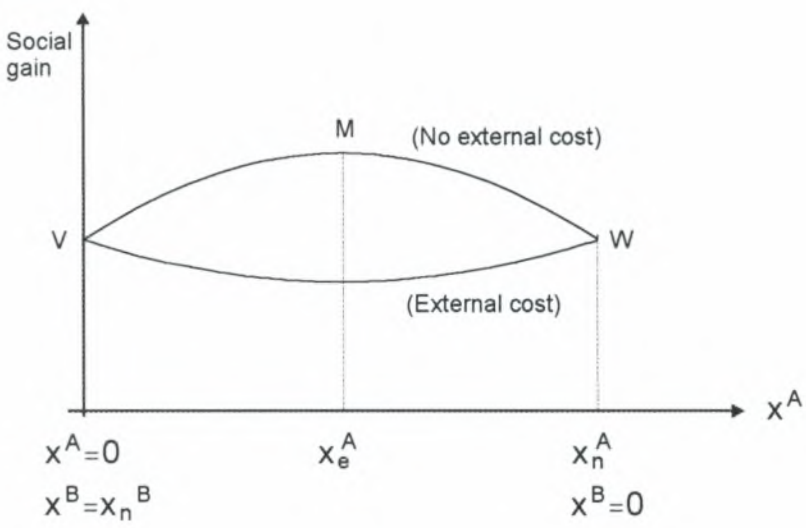


Figure 10.

So, if x^A =0 and the victim produces undisturbed at x_n^B, or if the victim does not produce at all, x^B =0, while the polluter produces freely at x_n^A, then the total damage cost is zero. In between these extreme points total damage cost depends upon the multiple $x^A x^B$. This model assumed a resource constraint where the resources available are used either by firm A or by firm B, and A's and B's outputs are reciprocally related. Thus, as the polluter's output rises the victim's output falls. There will be some intermediate output at which the multiple $x^A x^B$ is maximized and, given α constant at different levels of the polluter's output, total damage cost is maximized as well. If α is large enough, the non-convex total cost function will result in the system operating on a non-convex social production set. Figure 10 illustrates all the above.

This model of multiplicative interdependence is similar to the algebraic example used from Baumol and Bradford. The major difference is the explicit introduction of the cost function. The analysis of the consequences of the non-convexity would have the same results as for the shutdown and saturation non-convexities. In all the three cases the shape of the social gain curves are similar. Thus, the existence of non-convexity in the production space, due to the externalities' existence, causes the possibility the social allocation not to be efficiency.

3.2 DETRIMENTAL EXTERNALITIES AND NON-CONVEXITIES ON CONSUMPTION

Although literature has tended to be dominated by the case of external costs on production, the case of externalities affecting individual consumption is not less important. Is the case of external costs, externalities, relate to the harm suffered by people as a result of their exposure to pollutants. Burrows classifies the existed theories, about the non-convexity of the total damage cost function which represents the harm suffered by individuals, in two general categories:

1. A consumer-withdrawal theory,
2. The existence of non-convex preferences concerning the quality of life.

3.2.1 Consumer Withdrawal

Consider the consequences of a pollutant that affects the use of a particular consumption good, such as the loss of pleasure from a walk in our town's sea front because of the smell from the urban wastes. The consumer's preference for sea front walking, relative to alternative uses of one's time, is clearly altered by the pollution. Consumer's reaction to this can take either, or both, of two forms:

(a) gradually withdraw from the action or the use of the specific product; so as to mitigate the effect of the external cost that is reducing the quality of the product,
(b) at some pollution level, stop using the consumption good altogether.

When a consumer is exposed to a pollutant that affects the use of a product, the quality of the product effectively is reduced. The effect of the increases in the level of pollution is to push the product to lower and lower levels of quality. The loss of quality is increasing valuable at the margin. But as the consumer responds by gradually withdrawing from the use of the product there is, as pollution rises, less and less of the product left for the pollution to reduce in quality. Consequently, if the withdrawal is rapid enough increasing pollution may cause further damage at the margin that is less serious because fewer units of consumption are affected. Thus, the marginal physical damage may decline. This case of smooth non-convexity, reaction (a), is the consumption equivalent of the pollution saturation theory, examined earlier.

However, the consumer whose consumption good is decreasing in quality as a result of its exposure to increasing levels of pollution may give up and terminate consumption of the product. This reaction, reaction (b) associated with sharp non-convexity, is the equivalent of the firm shutdown production's case.

But, in some cases the withdrawal is not a feasible option and much more stopping the use of the specific good is not possible, such as air or water. For example, if the air quality in a town is poor it is not feasible breath less or to stop breathing it, unless one can move to a town with a better air quality, and this is not feasible for most individuals. Even if the withdrawal is feasible, there are still the possibility individual's preferences to be strongly convex and the value of the marginal damage continues to rise as pollution increases. Then, the smooth non-convexity will not take place at all, unless the withdrawal of consumption is sufficient large to offset the convexity of consumer preferences. Another point is that the existence of a micro non-convexity does not necessarily imply a macro non-convexity at that pollution level. As the emissions of a pollutant increase the tendency of some consumers to withdraw may be offset by the expansion of the number of consumers who suffer damage, so that the aggregate marginal damage cost continues to rise, perhaps with a decline rate, and the non-convexity will not take place in the macro level. The case of Athens' inhabitants is an example. Without any doubt, the air quality and generally living quality, in Athens is not the best. But Athens is a city with special weight. For example, the most intensive activities, political-economic and so on, are strongly concentrated there. Thus, individual's preferences for living in this city may take strongly convex form, preventing the non-convexity in the marginal damage cost associated with the life in Athens. Additional, according to the last argument, the macro level of pollution after that the non-convexity is present, might be larger than in micro level.

3.2.2 Non-Convex Preferences

These kinds of theories are different from any of the theories of non-convexity, which have been considered before. It is not suggested that the non-convexity of preferences be caused by an external cost. In such models, individual's preference is inherently non-convex and that has as result a non-convex marginal damage cost.

An example of inherently non-convexity is the preference of an individual to mix his drinks. He may enjoy to mix his drink with a specific amount of water. But, more water than this amount might be less preferable.

However, there are some doubts that non-convex preferences of this kind generate non-convex total damage costs functions. We are not going to deal more with this theory, as it is not associated with the existence of external costs or externalities.

3.3 CONCLUSIONS

We examined Baumol & Bradford, Starrett, and Burrows' approaches to externalities and non-convexity in the economic system. The conclusion was that externalities cause the non-convexity of the social production possibility set or the non-concavity of the social gain. The non-convexity prevents market from achieving Pareto optimal allocation. Society would prefer to allocate resources in the most efficient manner and it is for this very reason that there are policy tools such as taxes, subsidies, quotas, and standards. But as we saw in Papandreou's (1994) example an efficient allocation is not always possible. The problem seems to be the lack of information on the explicit operation of economy when externalities are present. Even the use of these particular policy tools cannot offer an essential confrontation of the problem since they do not alter the external character of the interaction. An alternative approach would be the establishment and enforcement of property rights over 'externalities'. Although, there are well established markets and property rights for other resources, that is not the case with detrimental externalities as pollution and moreover for environmental resources as air or ocean fishing. If property rights are clearly defined and additional trading of rights is possible, the production space that incorporates detrimental externalities as input turned out to be convex, and the economic system may achieve a Pareto optimum allocation. The concept of property rights and allocation of detrimental externalities is examined in the next chapter and furthermore in the second part of this thesis.

4. Property Rights and Detrimental Externalities

The conclusion of the previous chapter was that when property rights are clearly defined and additionally, trading of rights is possible, then the production space that incorporates detrimental externalities as input turns out to be convex, and the economic system may achieve a Pareto optimum allocation. Thus, if property rights can be adequately defined, optimal allocation will be attained through private decisions, and government intervention will be necessary only in order to define and secure property rights. In fact, it is conceivable that property rights could even be established through private bargaining without any government intervention. In this chapter I shall examine the notion of property rights and detrimental externalities.

First, following Tietenberg (1996), I shall present how efficient property rights structures lead to efficient allocations in a well-functioning market. Next, I shall discuss the modification of the detrimental externalities' effect on the market allocation, when tradable property rights are going to be defined. The impact of the transaction costs on market operation cannot be by-passed.

Since the property rights approach represents the counterpoint to the public-good character of many resources, I shall discuss briefly the concept of public-goods. The remaining part of this chapter deals with the presentation of different property rights regimes, and a discussion about the possibility to specify property rights.

4.1 Efficient Property Right Structures

A property right can be defined as a set of rules specifying the use of resources and goods. The set of rules includes obligation and rights; the rules may be codified by law, or they may institutionalized by other mechanisms such as social norms together with a pattern of sanctions. Describing the structure of property rights that could produce efficient allocations in a well-functioning market, four main characteristics could be suggested about an efficient structure:

'*Universality* - All resources are privately owned, and all entitlements complete specified.

Exclusivity - All benefits and costs accrued as a result of owning and using the resources should accrue to the owner, and only to the owner, either directly or indirectly by sale to others.

Transferability - All property rights should be transferable from one owner to another in a voluntary exchange.
Enforceability - Property rights should be secure from involuntary seizure or encroachment by others.'

An owner of a resource with well-defined property rights has a powerful incentive to use that resource efficiently because a decline in the value of that resource represents a personal loss. Farmers who own the land have an incentive to fertilize and irrigate it because the resulting increased production raises income level.

When well-defined property rights are exchanged, as in market economy, this exchange facilitates efficiency. We can illustrate this point by examining the incentives consumers and producers face when a well-defined system of property rights is in place. Because the seller has the right to prevent the consumer from consuming the product in the absence of payment, the consumer must pay to receive the product. Given a market price, the consumer decides how much to purchase by choosing that amount which maximizes his or her individual net benefit.

As Figure 1a illustrate, the consumer's net benefit is the area under the demand curve minus the area representing cost. The cost to the consumer is the area under the price line, since that area represents the expenditure on the commodity. Obviously, for a given price p^*, consumer net benefit is maximized by choosing to purchase Q_d units. Area A is then the geometric representation of the net benefit received, known as consumer surplus.

Meanwhile, sellers face a similar choice, Figure 1b. Given price p^*, the seller maximizes his or her own net benefits by choosing to sell Q_s units. The net benefit received, area B, by the seller is called producer surplus. The price level which producers and consumers face will adjust until supply equals demand, as depicted in Figure 1c. Given this price consumers maximize their surplus, similar the producers, and the market clears.

The net benefit is maximized by the market allocation, and it is equal to the sum of consumer and producer surpluses. Thus, this allocation is efficiency. We have established a procedure for measuring net benefits, and a means of describing how the net benefits are distributed between consumer and producers.

This distribution is crucially significant. Efficiency is not achieved because consumers and producers are seeking efficiency. In fact they are not. In a system with well-defined property rights and competitive markets in which to sell those rights producers try to maximize their surplus and consumers try to maximize their surplus. The price system, then, induces those self-interested parties to make choices that are efficient from the point of view of society as a whole. It channels the energy motivated by self-interest into socially productive paths.

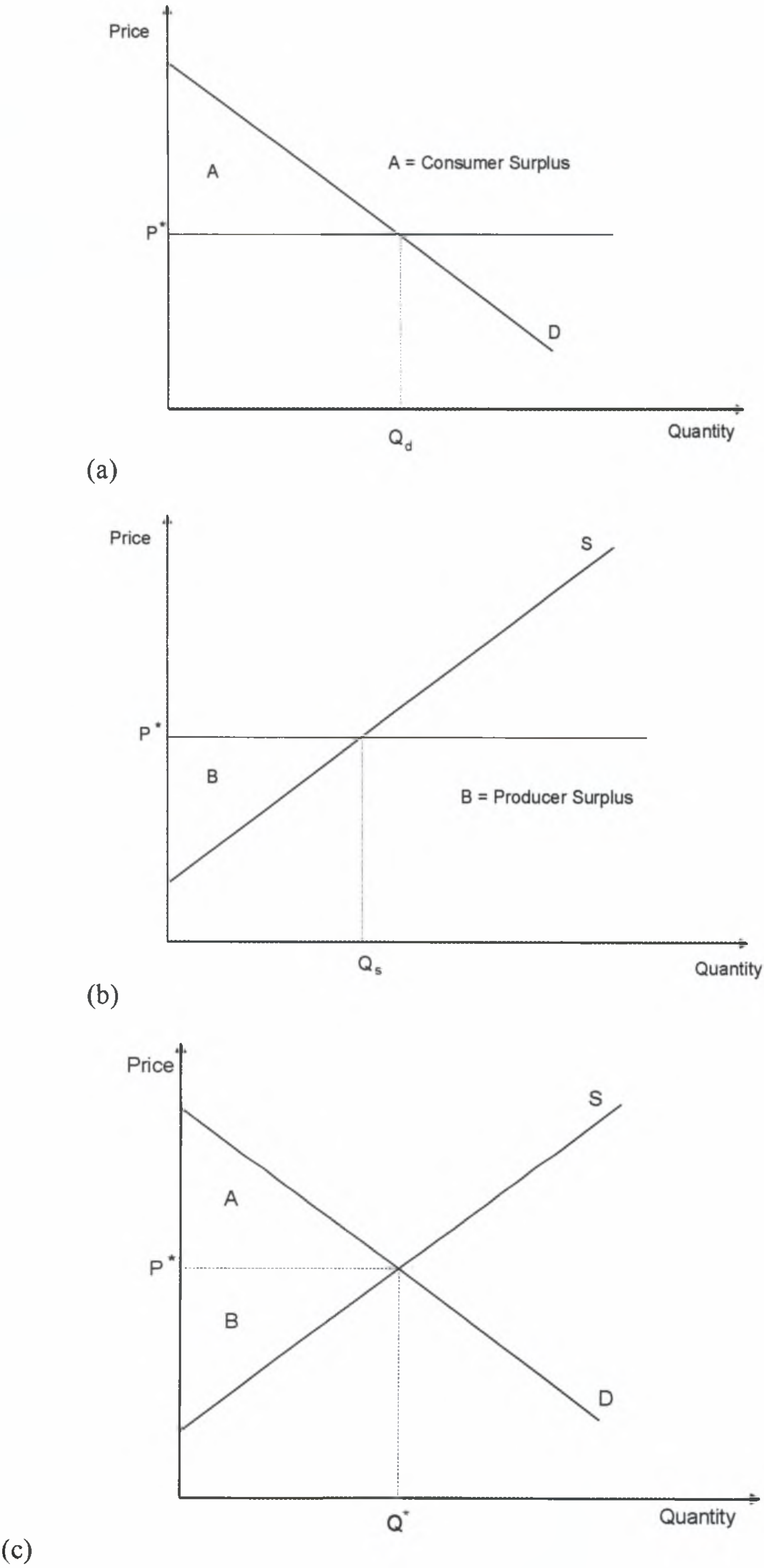

Price
A
A = Consumer Surplus
P*
D
Q_d
Quantity
(a)
Price
S
P*
B
B = Producer Surplus
Q_s
Quantity
(b)
Price
S
A
P*
B
D
Q*
Quantity
(c)

Figure 1.

4.2 EXTERNALITIES AND PROPERTY RIGHTS

Suppose two firms that are located by a river. The first produces steel, while the second, somewhat downstream, operates a resort hotel. Both use the river, though in different ways. The steel firm uses it as a receptacle for its waste, while the second to attract customers seeking water recreation. If these two facilities have different owners an efficient use of the water is not likely to result. Because the steel plant does not bear the cost of reduced business at the resort resulting from waste dumped into the river, it is not likely to be very sensitive to that cost in its decision making. As a result, it would be expected to dump too much waste into the river, and an efficient allocation of the river would not be attained.

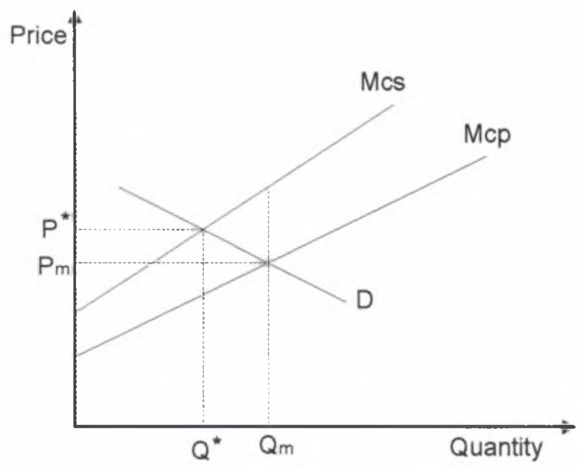


Figure 2.

The demand for steel is shown by the demand curve D, Figure 2, and the private marginal cost of producing the steel, exclusive of pollution control and damage, is depicted as MC_p. Because society considers both the cost of pollution and the cost of producing the steel, the social marginal cost function MC_s, includes both of these costs as well.

Why does the steel firm pay for ore and not for the river? The firm pays when someone else owns the effect or someone else makes a bid to avoid the effect. To own is able to create costs for others. Owners act as they wish and, if rights are exchangeable, listen for bids from non-owners to do otherwise. If those who care about the river, and more generally the environment, are non-owners, they can always make a bid to the steel firm to reduce output. This bid is part of the opportunity cost of steel production and steel firm will face only one marginal cost function, MC_s, not two.

If the river is owned by someone else, the hotel owner, the situation is reversed. The steel firm must purchase inputs to steel production from their owners and environment becomes input into the production process like ore, labor and machines. All inputs have prices as a function of being owned by others. The existence of prices leads to an efficiency allocation of resources as we pointed out in the previous paragraph.

But there isn't any claim that one firm rather the other should be the owner of the particular resource opportunity. Steel firm and hotel are interdependent and will affect each other regardless of who owns. The only choice to be made then is the distribution of ownership. Economists have been careful not to argue for one person's ownership rather than another's because they have no basis for discussing interpersonal welfare distribution. On this view, to find an externality is not to find cause for property right change.

The effect of rights distribution on behavior can be widely observed. A study was made of the interdependence between phosphate processing and citrus growing in Florida (Crocker, 1971). When the phosphate company owned the environment, the company ignored the reduced citrus harvest caused by phosphorus particles on the leaves. The citrus growers did not make any bids to the phosphate company. When the law has changed giving ownership to the citrus growers, then the company began to purchase citrus lands rather than face suits for damage. The interdependence, or the externality, was there regardless of whom owned, only its direction changed. If the phosphate company owned, the citrus growers had reduced harvest because of a missing environmental input. If the citrus growers owned, the phosphate company had to buy a place to put their dust. The company is as surely damaged by the rights and existence of phosphate processing.

The interdependence is internalized by the existence of tradable ownership rights. If the company owns, they consider the interests of growers to the extent of the growers' bid. If the growers own, they consider the interest of the company to the extent of the company's bid. The externalities are internalized in this sense.

From a more technical production function of view, the use of different environmental resources, as air, river or land, are not different from any other purchased input necessary to production process. But, this is not always clear in human cognition. For example, some people regard certain actions, including the use of environmental resources, as a wrong and not matters of ordinary commerce. In the previous chapter we have dealing with externalities using Pigouvian taxes and Lindahl prices to encounter the non-convexity problems that cause the inefficient allocations in the economy system. There is also another way of viewing detrimental spillovers.

Papandreou (1994) claims: 'Rather than extending the market space, or "ownership" over activities, one could extend the property rights space to the channels of interaction.' In the well know example of the laundry service and electricity station, the spillover occurs through the channel of air. 'The problems arise because it is treated [air] as a free good, when clearly it is very scarce. If the resource 'air' was owned by individuals, then sure enough a competitive equilibrium would result, as long the new production space (that incorporates air as an input) of the individual firms turned out to be convex. The air would be distributed so that it was put to its most productive use.' Papandreou continues insisting that by changing the way property rights are defined, one is changing the definition of inputs that enter into production functions and altering the shape of production functions. A production function that is convex on one definition of inputs may be non-convex on another. Non-convexity is closely related to how property rights are defined.

The existence of an externality in a system could be due to alternative property rights structures. If any common input into a production process is effectively modeling as open access scarce resource, then probably this resource become a detrimental spillover. 'If labor were treated as a free-access resource (although it is difficult to visualize this), then as firms used up labor in their production processes, they would be imposing a detrimental effect on other firms requiring this scarce resource. It might be objected that with pollution the detrimental interaction is strong or somehow direct ...'. The failure of property rights to be well defined is then an important ingredient of many externality situations. The difference between the externalities in buying a pound of oranges and buying clean air is a difference of degree of vagueness in specifying and enforcing property rights, rather than a difference of substance. Oranges, as well, are associated with externalities resulting from vagueness estimating their weight and quality. The major problem is to find a way to envisage property rights to resources like air, due to the physical nature of this input, which gives its attributes of a public good. This problem is related to the costs of forming institutions, which do not enter into frictionless general equilibrium model.

4.3 Transaction Costs

In a word without costs, Coase theorem argues: if property rights are clear and enforceable, all economic agents have full information regarding the situation at hand, then there is no need for government intervention to correct externalities because the economic agents themselves can bargain to achieve a Pareto optimal allocation of resources. Furthermore, the ability of economic agents to bargain among themselves to achieve a Pareto optimal allocation of resources does not depend on which economic agent has the property rights.

In the previous paragraph we have argued that an alternative approach to externality problem is the establishment and enforcement of property rights over the resources that causes the externality effect, creating by this way a additional market for the externality. Furthermore, as we have seen and also as we are going to conclude below, information (or uncertainty as lack of information) is a significant factor in facing such problems.

But, almost in any economic activity there are transaction costs as well as production costs. Establishment and enforcement of entitlements is not cost-less. To acquire a resource controlled by someone requires effort in negotiation and coordination between buyers and sellers and among buyers (sellers) if this resource serves more than one person simultaneously (these costs are including in a model in Chapter 6). Furthermore, the acquisition of information is costly. Thus, transaction costs must be taken into account in any attempt to encounter such problems. Coase theorem, also, brings transaction costs from the backdoor (the same holds for the government intervention) as it requires clear and enforceable property rights and full information. The concept of transaction costs here at least includes the costs of monitoring, information acquisition, enforcement, and negotiation.

Moreover, the way, by which institutions are forming, can affect the size of transaction costs and/or the consequences of a given cost. If transaction costs are low enough, then private parties might be able to negotiate among themselves to reach an efficient (Pareto optimal) resource allocation. High transaction costs can hinder the efforts of private parties to negotiate efficient solutions among themselves. Consider again the case of phosphate-citrus interdependence. When the phosphate company owned the environment, the right to pollute, citrus harvest was reduced and certainly, growers' situation was worse. But, no bids were forthcoming from the citrus growers. One possible reason is that the transaction costs of getting all the growers together to make the bid were quite high. When citrus growers owned the environment, phosphate company had to buy a place to put their dust. In the first case the costs of coordination necessary for the commodity 'environment' to be traded was very high, so that markets for this 'commodity' was not active. There wasn't any reaction from growers, without any improvement opportunity. In the second case, where transaction costs get in the way of trade, there may be a possibility to make both parties better off, and thus the economic system to be efficiency.

If transaction costs allow the existence of the 'externality' market, then profit maximization considerations suggest that private parties will negotiate to maximize joint net benefits, regardless of who has the property rights. However, the distribution of welfare (consumer and producer surplus) among the parties may depend very much on which party has the property rights. In other words, if transaction costs are low enough, then parties will negotiate among themselves to make the "consumer plus producer surplus pie" as large as possible, regardless of who has the property rights. However, property rights will determine "how large a slice of the surplus pie" each party will end up receiving. Game theoretic models (beyond the scope of this work) may be needed to pinpoint the size of each party's “slice of pie”. But, only the establishment of property rights isn’t enough. The regime under which property rights will be established and enforced might be essential for the progress of the economic system.

4.4 PROPERTY RIGHTS REGIMES

Well-established and enforced property rights are substantial in treating economic systems that include externalities. Problems arise when property rights are ill defined, and when these rights are exchanged under something other than competitive conditions. Entitlement's existence 'transforms' a resource, which may cause an externality condition, into a common good, preventing the market from failure, the first step for optimum allocation achievement. The major problem that seems to remain is how property rights are going to establish with the more efficiency way and obviously to be a continuously enforcement of them, keeping always in mind the transaction costs that are associated with them. In this paragraph I shall present some of the possible property regimes and their advantages or disadvantages.

Under a *private property regime*, the owner of a resource has a powerful incentive to use that resource efficiently, since the failure to do so results in a personal loss. But in some circumstances the private regime is not the most efficiency way do define entitlements. Because the strong public character of some natural resources, the speculative treatment of those goods are not possible. Only no-profiteering private organizations could tread such resources.

The Nature Conservancy is an example. The purpose of this private organization is to establish natural area reserves to preserve and/or aid in the preservation of areas, objects, and fauna and flora, which have scientific, educational, or aesthetic significance. This organization purchases, or accepts as donations, land that has some unique ecological or aesthetic significance, to keep from being used for other purposes. Additional, these areas serve as home to rare and endangered species of wildlife and plants. In so doing Nature Conservancy preserve many species by preserving the habitat. This private organization provides a public good as the preservation of nature, and as we are going to discuss in next section it contributes to the biological diversity. But because it has a limited budget, the Nature Conservancy sets priorities and concentrates on acquiring the most ecologically unique areas. Thus, despite the significant effort of this organization, it isn't enough to achieve an efficiency level of conservation.

But private regimes are not the only possible way of defining entitlements to resources use. Other possibilities include state property regimes, common property regimes, and open access regimes.

State property regimes, where the government authorities owns and controls the property, exist not only in former communist countries, but also to varying degrees in virtually all countries of the world. Parks and forests, for example, are frequently owned and managed by the government in capitalist as well as in socialist nations. Problems with both efficiency and sustainability can arise in state property regimes when the incentives of bureaucrats who implement and/or make the rules for resource use diverge from collective interests.

Since environmental problems are thought to be caused by a divergence between individual and collective incentives, it is not uncommon to hear that centrally planned economies avoid environmental problems. But, studies of air and water pollution in the previous Soviet Union and other Eastern European countries suggest that the problems found in market economies occur with equal intensity in the Eastern block. Copsa Mica, in Romania, is called Europe's most polluted urban area. Weakened by acid rain, monuments in Krakow, Poland, are crumbling. Goldman (1985) suggests that the centralized planning system creates different, but not less potent, divergences between individual and collective incentives. For example, in decade of '70s, 65% of all factories in the Russian Soviet Federated Socialist Republic, discharged their waste into the water without any attempt to clean it up. They did this because the managers were being judged solely in terms of output, not in terms of the harm they caused to the environment. The central plans that set the priorities to be followed by the managers very simply emphasized economic growth over the environment. Seems that the industrialization and not the private enterprise is the primary cause of environmental disruption. These suggest that state ownership of all the productive resources is no cure-all.

Common property resources are those which is jointly owned and managed by a specific group of co-owners rather than privately. Entitlements to use common-property resources may be formal, protected by specific legal rules, or they may be informal, protected by tradition or custom. Common property regimes exhibit varying degrees of efficiency and sustainability, depending on the rules that emerge from collective decision making. While some very successful examples of common-property regimes exist, unsuccessful examples are even more common.

One successful example of a common property regime involves the system of allocating grazing rights in Switzerland. Though agricultural land is normally treatment as private property in Switzerland, grazing rights on the Alpine meadows have been treated as common property for centuries. Overgrazing is protected by specific rules, enacted by an association of users, which limit the amount of livestock permitted on the meadow. The families included on the membership list of the association have been stable over time as rights and responsibilities have passed from generation to generation. This stability has apparently facilitated reciprocity and trust, thereby providing a foundation for continued compliance with the rules.

Unfortunately, that kind of stability may be the exception rather than the rule, particularly in the face of heavy population pressure. The more common situation can be illustrated by the experience of Mawelle, a small fishing village in Sri Lanka. Initially, a complicated but effective rotating system of fishing rights was devised by villagers to assure equitable access to the best spots and best times while protecting the fish stocks. Over time, population pressure and the infusion of outsiders both raised demand and undermined the collective cohesion sufficiently that the traditional rules became unenforceable, producing overexploitation of the resource and lower incomes for all the participants.

Open access property resources are those in which no one owns or exercises control over the resources. This regime has given rise to what has become known popularly as the 'tragedy of the commons', like fishing from an open access sea, or grazing on open access land. Two characteristics of the open access allocation are worth noting: (1) In the presence of sufficient demand, unrestricted access will cause resources to be overexploited. (2) The scarcity rent is dissipated; no one appropriates the rent, so it lost.

But, the property regime of a good does not remain constant over time. As necessities and people's values change over time, the property regime of a good may change. In instance, in ancient times water may have been used as a free good because of its bounty. But, as water became scarce, a system of modified property rights was developed for the different services water did provide and it has loosed the free good character.

4.5 PUBLIC GOODS

Public goods represent a particularly complex category of resources. Pure public goods defined as those that have two characteristics: they are both non-rival and non-exclusive.

A good is non-rival if for any given level of production, the marginal cost of providing it to an additional consumer is zero. For most goods that are provided privately, the marginal cost of producing more of the good is positive. But for some goods, additional consumers do not add to cost. Consider the use of a lighthouse by a ship. Once the lighthouse is built and functioning, its use by an additional ship adds nothing to its running costs. Most goods are rival in consumption. Goods that are rival must be allocated among individuals. Goods that are non–rival can be made available to everyone without affecting any individual's opportunity for consuming them. One person's consumption of good does not diminish the amount available for others.

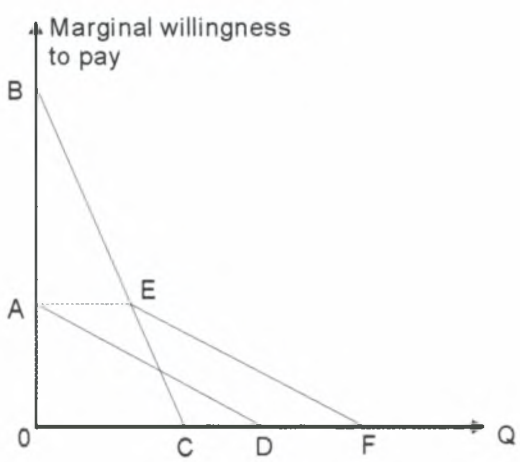
The non-exclusive's characteristic refers to circumstance where, once resource is provided, even those who fail to pay for it cannot be excluded from enjoying the benefits it confers. One example of non-exclusive good is the national defense. Once a nation has provided for its national defense, all citizens enjoy its benefits. A lighthouse and public television are also examples of non-exclusive goods.

Some goods are exclusive but non-rival. A television signal is an example of a non-rival good. Once a signal is broadcast, the marginal cost of making the broadcast available to another user is zero. But broadcast signals can be made exclusive by scrambling the signal and charging for the code that allows it to be unscrambled.

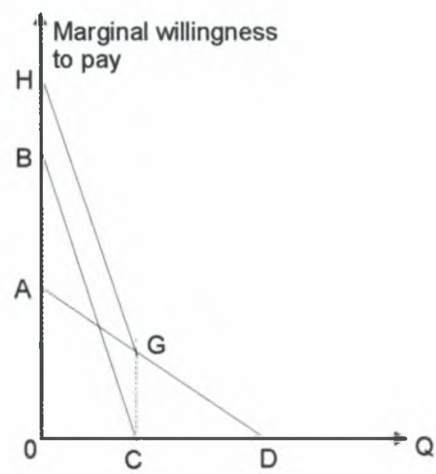
Some goods are non-exclusive but rival. Air is non-exclusive but can be rival if the emissions of one firm adversely affect the quality of the air and the ability of others to enjoy it. An ocean is nonexclusive, but fishing is rival because it imposes costs on others. The more fish caught the fewer fish available to others.

Pure pubic goods, which are both non-rival and non-exclusive, provide benefits to people at zero marginal cost, and no one can be excluded from enjoying them. In another intermediate form, a public good may be limited by membership (club good), by space (local public good), or by time. In this case, there exists some form of exclusion. The terms public good and common-property resource are often used synonymously. However, they should be clearly distinguished. A common-property resource is a good that is owned in common rather than privately. The users of this good compete each other eventually affecting the quantity available or the quality. Also, in the past, many goods were free goods and common-property resources simultaneously. But, today, because of increased scarcity and the more comprehensive definition of property rights, several free goods have become private goods.

There are two polar cases of goods: private and public goods. First of all, the two characteristics of pure public goods, nonexclusive and nonrival, are not valid in the case of private goods. The difference is illustrated in Figure 3. Total demand for a private good is summed horizontally; we add quantities. In Figure 3a curves *BC* and *AD* indicate the marginal willingness to pay of two different individuals for a private good. Curve *BEF* denotes total marginal willingness to pay of both individuals. In the case of a public good, Figure 3b, quantities cannot be added. We add vertically, we sum the individual evaluations. Again curves *BC* and *AD* denote the willingness to pay of both individuals, while *HGD* is the total willingness to pay.



(a) the case of private good



(b) the case of public good

Figure 3.

Several common environmental resources are public goods, including life-supporting systems like air and water, beautiful landscapes, or even the biological diversity. Biological diversity includes two related concepts: the amount of genetic variability among individuals within a single species and the number of species within a community of organisms. Genetic diversity, critical to species survival in the natural world, has also proved to be important in the development of new crops and livestock. It enhances the opportunities for crossbreeding and, thus, the development of superior strains. The availability of different strains was the key, for example, in developing new disease-resistant barley. At the same time, certain species contribute balance and stability to their ecological communities by providing food sources or holding the population of the species in check.

The richness of diversity within and among species has provided new sources of food, energy, industrial chemicals, raw materials, and medicines. Yet there is considerable evidence that biological diversity is decreasing. Of the 3 to 30 million species currently existing, about 12 percent of mammal species and 11 percent of bird species were classified as threatened in 1990. Certainly, we can not rely on the private sector to produce the efficient amount of public goods such as biological diversity.

Suppose that in response to diminishing ecological diversity we decide to take up a collection to provide some means of preserving endangered species. Suppose, also two potential consumers, A and B, who are going to contribute to the collection. The preferences of the two consumers determine the demand curve for ecological diversity. Because consumer A values diversity more, his demand curve always lies above that of person, Figure 4. He is willing to pay more for any given quantity than B. The market demand is represented by the vertical summation of the individual demand curves. A vertical summation is necessary because everyone can simultaneously consume the same amount of ecological diversity. Therefore, we are able to add the amounts of money they would be willing to pay for that level of diversity.

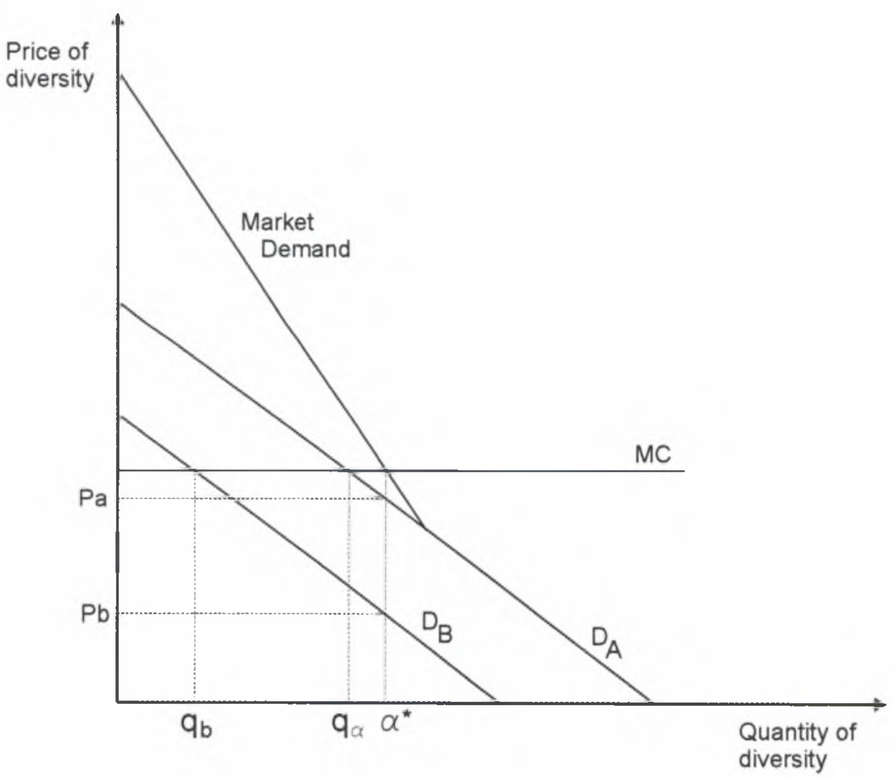


Figure 4.

This is in contrast to a market demand curve for a divisible good, which is constructed by a horizontal summation of the individual demand curves. The marginal cost of providing cleanup services is represented by the MC curve. The allocation, which maximizes net benefits in our system, is α^*, the allocation where the demand curve crosses the marginal cost curve.

But, the revenues to supply this level of diversity most possible would not be enough. Consider the following sequences of events: consumer B comes first and notices nothing in the collection. Therefore he chooses to contribute. He contributes until his net benefits are maximized, at q_b. Consumer A comes after B. He notices that person B has already purchased q_b. So, he is contributing by the amount q_a-q_b, because this maximizes his net benefits, given that q_a maximizes his benefit and q_b is already purchased. The total collection, therefore, is q_a and not α^*. The outcome is not efficient.

Inefficiency results because each person is able to become a free rider on the other's contribution. Because of the consumption indivisibility and non-excludability properties of the public good, consumers receive the benefits of any diversity purchased by other people. When this happens, it tends to diminish incentives to contribute, and the contributions are not sufficiently large to finance the efficient amount of the public good. The efficient market equilibrium for a public good would require different prices for each consumer. If consumer A is charged P_a and consumer B is charged P_b then both consumers would be satisfied with the efficient allocation, as the efficient allocation would have maximized their net benefits given the prices. Furthermore, the revenue collected would be sufficient to finance the supply of the public good. Thus, while an efficient pricing system exists, it is very difficult to implement. The efficient pricing system requires charging a different price to each consumer, and, in absence of excludability, consumers may not choose to reveal the strength of their preference for this commodity. Therefore, the producer could not possibly know what prices to charge. It's about an information problem. This information problem could become a transaction cost problem, as information's acquisition is costly.

4.6 Specification of Property Rights on Environmental Resources

When we are dealing with environmental resources always a question raises: can property rights be specified in all the cases? With respect to the definition of property rights, we have to investigate two thinks: first, if is the exclusion technically feasible? Second, if so, is it normatively acceptable?

Property rights for using the environment as a receptacle of waste can be defined so as to include even difficult cases such as the fluorocarbons from spray cans, which affect the ozone layer. We can envision international treaties banning or reducing the production of fluorocarbons. In the case of regional or national environmental problems, property rights may also be established. Additionally, property rights can be defined for using natural resources such as fish in ocean. Via international negotiations, fishing permits may be introduced and allocated to different nations by means of auctions or political bargaining.

In the examples given above, however, even with property rights defined, there remains the public goods problem. The ozone layer is a public good, and from a policy point of view we have to determine how much of the ozone layer ought to remain pollution free. In solving this question, we meet the free rider issue again. The willingness to pay of different individuals (or more realistic in this case of different nations) may not be truly revealed. The same problem arises in the case of oceans when the existence of a species such as whales is interpreted as being a public good to be enjoyed be all.

Whereas in the case of global or international environmental goods, such as the ozone layer or the Mediterranean Sea, the public good remains, more local types of environmental quality may lose their public good character through exclusions. Exclusions exist for national parks, for instance, when limits are placed on the number of overnight permits granted in order to reduce congestion. It is also conceivable to limit access by an entrance fee, that is, to exclude those not willing to pay a given price. In other instances, the price of land or houses denotes an implicit evaluation of a beautiful location and serves as a mechanism of exclusion and of revealing willingness to pay. Finally, we can envision a setting where the exclusive property right for the environment, such as the air quality of a region, is given to an individual or a government agency, and the owner charges a price for providing this environmental quality. Those not willing to pay the price have to leave the region, while others willing to pay could move into the area.

It is probable that today we are unable to conceive of all possible exclusion technologies that may eventually arise. A hundred years ago people would not have believed that it would be possible to sell the airspace above one's house. This, however, happened in Manhattan as a result of new zoning laws. The definition of property rights has been historical process. Many years ago, when land was in ample supply, property titles for land were not necessary. When people competed for the scarce good land, property titles became relevant. Similarly, water once was a free good, but today property titles for water are well accepted. The continuing endangerment of wildlife species or fish induces institutional arrangements for conserving these resources. And the increasing scarcity of energy or raw materials leads to property rights for energy and raw materials.

However, the problem arises as to whether technically possible exclusion mechanisms are morally acceptable. The idea of giving the exclusion right of the environment to an individual or a government agency and forcing those not willing to pay to leave the area may not easily be acceptable. Further, such an exclusion right would impede the citizens' freedom of movement. Thus, basic values of a society limit the range of possibilities in which property rights may be defined. However, from an allocation point of view, in our modern world, exclusion is a necessary element in solving the environmental problem. This issue could raise an endless discussion. The history teach us that the values change over time, and additionally, there is a stimulated imagination with respect to the question of whether property rights can be specified. So, the property rights approach to economic problems associated with the environment will remain interesting counterpositions in the future.

4.7 Ending Up

The environment may be understood as the set of natural conditions which define the human space. It fulfills many functions for the economy: it serves as a public-consumption good, as a provider of natural resources, as well as a receptacle of waste. These different functions compete with each other. Releasing more pollutants into the environment reduces environmental quality, while a better environmental quality implies that the environment's use as a receptacle of waste has to be restrained. Additionally, whereas in the past people lived in a paradise of environmental superabundance, at present the environmental goods and services are no longer in ample supply. Consequently, environmental disruption and environmental use are by nature allocation problems.

If a resource is scarce and if a zero price is charged for its use, misallocation will result. This is the case of many environmental resources, for example the environment as a receptacle of waste is heavily overused. In the literature there are different approaches to this allocation problem, including benefit-cost analysis, economic policy and public-finance reasoning, international trade theory, optimization theory, risk analysis, property-rights ideas, etc.

The property rights approach seems to be more efficient, since it alters the external character of many environmental resources. In the next part of this work, I am going to show that many problems associated with non-convexities and the market failure will disappear as long as property rights are well defined. This does not happen when other policy instruments, as taxies, subsidies, quotas or standers, are used. But, policy instruments are well accepted as solutions to the environmental allocation problem. The same is not valid for the case of property rights. The reasons lie in the nature of the environmental resources, as we have discussed in the previous paragraph. So, we are going to end up once more that the property rights approach to economic problems associated with the environment will remain interesting counterpositions in the future.

PART II

5. A Coasian Solution to the Problem of Externalities

5.1 Introduction

In the first part I have presented the traditional approaches to the problem of externalities and market failure. According to these approaches, the presence of externalities causes market failure in ordinary competitive economies. Arrow (1970) suggested that since this failure was due to missing externality markets, the solution would be to extend the commodity space in a way that would permit such markets to exist. In particular, he proposed that each agent's observations on every other agent's consumption and production choices should be traded as 'artificial' commodities and included as arguments in utility and production. Extending the market to include these artificial commodities makes it possible to treat economies with externalities as a special case of the standard Arrow-Debreu general equilibrium model.

According to the second welfare theorem, it is critical that the feasible set will be convex, and that the efficient allocations lie on its boundary. Starrett (1972) argued that it was far from trivial to assume that these conditions would be satisfied in an economy with externalities. He claimed that the presence of externalities necessarily implies the existence of a 'fundamental non-convexity' in the underlying Arrow markets.

Consider again Starrett's example: a laundry suffers a negative externality from smoke release in the air when electricity is produced. The laundry's observation of electricity production becomes then an input that affects laundry production negatively. Laundry's production, given a fixed quantity of all other inputs versus electricity output, is shown in Figure 1. More electricity leads to less laundry output. There are two possible cases. Either the laundry output is eventually forced to zero (Figure 1a), or it becomes asymptotic to the axis as steel production increases (Figure 1b). In either case, the production set is non-convex.

As we saw in Chapter 3 this non-convexity, according to Starrett, leads to a market failure. In this chapter I am going to show that there isn't anything essential about externalities that drives to this result. I argue that it is the unboundedness of the endowment, and not the presence of externalities, which drives Starrett's market to failure. If there are well establish property rights and there are limits on endowment's rights, then the market will not fail.

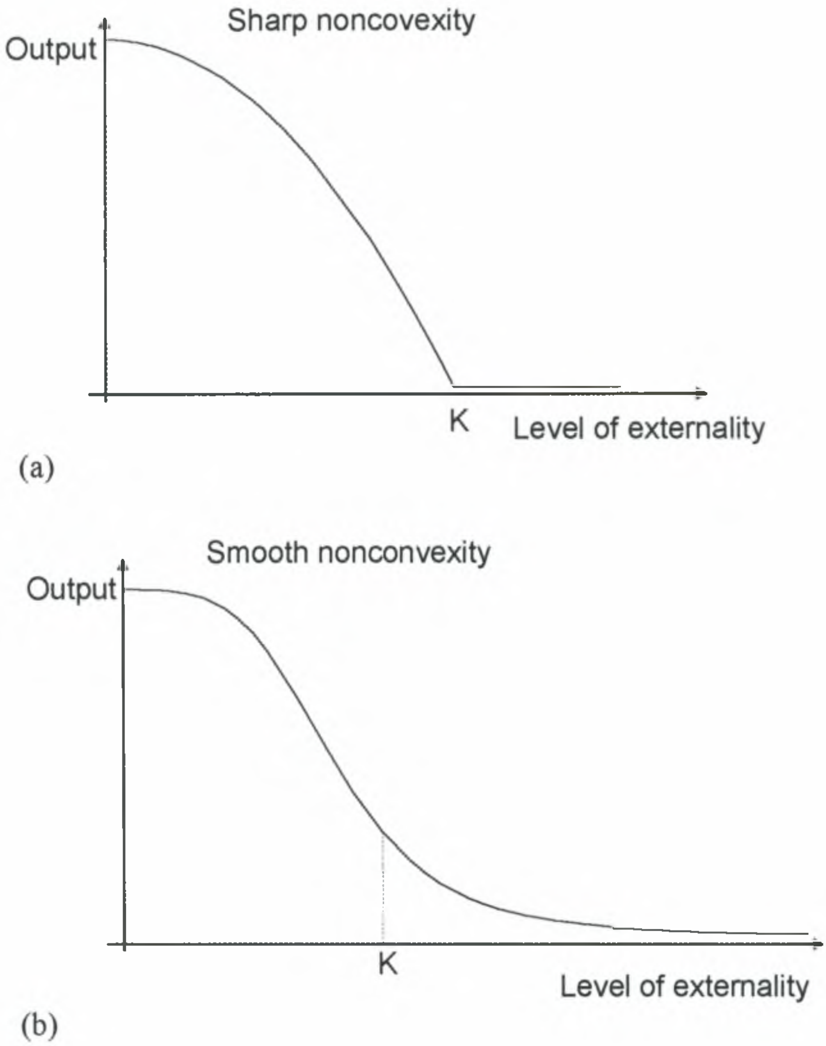


Figure 1.

In this framework I shall present two categories of models. The first category includes three 2x2 production models. In the first two models there is a trade of clean air between laundry and electricity firm. Air enters explicitly in the production function of the laundry firm. For the electricity firm the pollution, or complementary the necessary air, is given as a function of electricity production level. In the third model, air enters explicitly as traditional input in the production functions of the two firms.

The second category includes a model of one-consumer and one-producer. It applies to the same principles as the previous first two models. Finally, I shall revise Boyd and Conley (1997) general equilibrium model. They provide an extension of a general equilibrium model in which property rights are explicitly treated, and they suggest a notion for Coasion equilibrium for this economy.

5.2 2x2 PRODUCTION MODELS

Starrett in his approach assumed that the laundry could sell an infinite quantity of rights. But, it is clearly not plausible that the laundry firm would be able to sell an infinite unit of right to pollute, because only a finite amount of air exists to be polluted. Almost, any environmental resource has an upper bound. For example, the land has an inherent limit on the amount of waste that can be stored. A stream can only hold so much effluent. An airport can generate noise pollution at most 24 hours in a given day. This limit is not imposed by any human agency.

Suppose again that there are two industries, laundry and electricity. The existence of an upper limit of property rights is the main assumption in this model. Suppose that the upper limit of rights on clean air is z_2. We are going to assume that the pollution level is initially zero, and can rise to z_2. The output levels of laundry and electricity are denoted by l and e, respectively. Let p_1 to be the price of laundry output and p_2 the output of electricity industry.

The inputs for these two industries are labor and externality rights. Let the labor inputs for these two industries be denoted by z_l and z_e, and externality rights be denoted e_l and e_e. We interpret the consumption of externality rights differently depending on the firm. When the laundry consumes rights, it is consuming clean air as an input. When the electricity industry consumes rights, on the other hand, it is generating smoke. Also we assume that the labor and externality markets always clear.

5.2.1 Quasilinear Laundry Production Function

Laundry production function is:

$$l = z_l + (e_l - c)^{1/2} \tag{5.1}$$

Laundry industry produces only when externality rights are above c, i.e. there is a setup cost relative to externality rights. Figure 2 gives the production set of laundry industry relative to externality rights. Figure 2 corresponds to Starrett's sharp non-convexity.

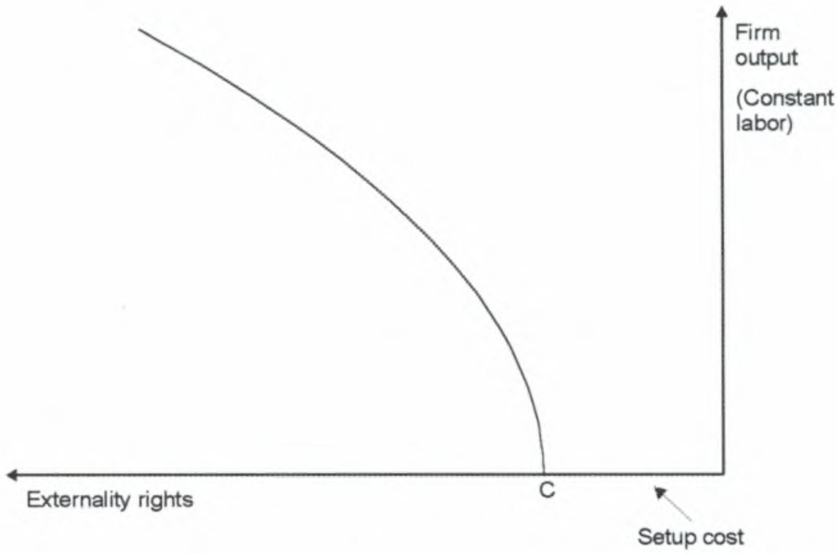


Figure 2.

The production technology of electricity industry is:

$$e = z_e \tag{5.2}$$

In addition, the production of electricity generates an externality according to the following equation:

$$e_e = \frac{1}{2} e \tag{5.3}$$ [1]

Let now take initial endowments of property rights into account. Let n_l and n_e denote the endowment of externality rights to laundry and electricity industry, respectively. Thus, $n_l \geq 0$, $n_e \geq 0$, and $n_l + n_e = z_2$. If the laundry goes out of business can sell at most n_l rights to pollute. In a sense, n_e is the 'benchmark' level of

[1] There may not be a fixed relationship between production and effluent. For example, different ways of making paper, i.e. different technologies, may put more or less toxic waste into a river. It is not the observation that paper is produced, but the fact of pollution that causes damage to other firms. But, most times, it is easier to observe directly the production level and not the pollution level. This problem seems to be one of information. If the production technology is known then it is possible to determinate the pollution level from observing the production level. In another model I shall use a different relationship between production and pollution.

pollution, and rights must be traded to move away from this point. Also, we suppose that $n_l \succ c$. Let also, the total labor to be z_1.

So, profit functions are:

$$\pi_l = p_l\, l - w_1\, z_l - w_2\left(e_l - n_l\right) \tag{5.4}$$

and

$$\pi_e = p_2\, e - w_1\, z_e - w_2\left(e_e - n_e\right), \tag{5.5}$$

where w_1 and w_2 are the prices of labor and rights inputs, respectively. The maximization problem of the two firms is:

$$\max_{z_l, e_l} \ \pi_l = p_l\, l - w_1\, z_l - w_2\left(e_l - n_l\right) \tag{5.6}$$

and

$$\max_{z_e, e_e} \ \pi_e = p_2\, e - w_1\, z_e - w_2\left(e_e - n_e\right) \tag{5.7}$$

The first order conditions are:

$$\begin{aligned}
&\frac{\partial \pi_l}{\partial z_l} = 0 \Rightarrow p_l - w_1 = 0 && \text{(a)} \\
&\frac{\partial \pi_l}{\partial e_l} = 0 \Rightarrow \frac{p_l}{2\left(e_l - c\right)^{1/2}} - w_2 = 0 && \text{(b)} \\
&\frac{\partial \pi_e}{\partial z_e} = 0 \Rightarrow p_l - w_1 - \frac{w_2}{2} = 0 && \text{(c)}
\end{aligned} \tag{5.8}$$

Let denote by z_1 and z_2 total labor and total rights on clean air, respectively. The restrictions about labor and rights on clean air are:

$$z_l + z_e = z_1 \qquad \text{(labor constraint)} \tag{5.9}$$

and

$$e_l + e_e = z_2 \qquad \text{(externality rights constraint)} \tag{5.10}$$

Let the price of the labor to be normalized to one, i.e. $w_1 = 1$. From the first order conditions (5.8) and the restrictions (5.9-10) we are going to find at equilibrium:

$$p_l = w_1 = 1, \qquad w_2 = 2\left(p_2 - 1\right)$$

$$e_l^* = \frac{p_l^2}{4w_2^2} + c, \qquad e_e^* = z_2 - e_l^* \tag{5.11}$$

$$z_e^* = 2(z_2 - e_l^*), \qquad z_l^* = z_l - 2(z_2 - e_l^*)$$

or equivalent:

$$p_l = w_l = 1, \qquad w_2 = 2(p_2 - 1)$$

$$e_l^* = \frac{1}{16(p_2 - 1)^2} + c, \qquad e_e^* = (z_2 - c) - \frac{1}{16(p_2 - 1)^2} \tag{5.12}$$

$$z_e^* = 2(z_2 - c) - \frac{1}{8(p_2 - 1)^2}, \quad z_l^* = z_l - 2(z_2 - c) + \frac{1}{8(p_2 - 1)^2}$$

Thus, the profits of the two firms under the above solution is:

$$\pi_l^* = 2(p_2 - 1)(n_l - c) \qquad \text{(a)}$$

and (5.13)

$$\pi_e^* = 2(p_2 - 1)n_e \qquad \text{(b)}$$

We cannot determine the price p_2 because our model includes only the supply side of the economy. It is not out of place to assume that $p_2 \succ 1$ and so the profits become strictly positive. The profits of the two firms depend on the endowments regardless of the level of output. Going out of business and selling all the property rights gives exactly as much profit as any other output choice.

5.2.2 Cobb-Douglas Laundry Production Technology

Now, we suppose that the laundry production function is of Cobb-Douglas type:

$$l = 2z_l^{1/4}(e_l - c)^{1/4} \tag{5.14}$$

Electricity production function remains the same as in the previous model, equations (5.2)-(5.3). Similarly, all restrictions are the same, equations (5.9)-(5.10). The maximization problem is given again by equations (5.4)-(5.5), where the output of laundry firm, l, is given by equation (5.13). So, first orders conditions are:

$$\frac{\partial \pi_l}{\partial z_l} = 0 \Rightarrow \frac{p_l (e_l - c)^{1/4}}{2 z_l^{3/4}} - w_l = 0 \qquad \text{(a)}$$

$$\frac{\partial \pi_l}{\partial e_l} = 0 \Rightarrow \frac{p_l z_l^{1/4}}{2(e_l - c)^{3/4}} - w_2 = 0 \qquad \text{(b)} \qquad (5.15)$$

$$\frac{\partial \pi_e}{\partial z_e} = 0 \Rightarrow p_l - w_l - \frac{w_2}{2} = 0 \qquad \text{(c)}$$

From relationships (5.14a-b) we can find z_l and e_l at equilibrium:

$$z_l^* = \frac{p_l^2}{4 w_l^{3/2} w_2^{1/2}}, \qquad \text{(a)} \qquad (5.16)$$

$$e_l^* = c + \frac{p_l^2}{4 w_l^{1/2} w_2^{3/2}}. \qquad \text{(b)}$$

If we normalize labor price to unit, i.e. $w_l = 1$, then from equations (5.14)-(5.15) and (5.9)-(5.10) we are going to find:

$$\begin{aligned} w_l &= 1, & w_2 &= 2(p_2 - 1) \\ z_l^* &= \frac{p_l^2}{4 w_2^{1/2}}, & e_l^* &= c + \frac{p_l^2}{4 w_2^{3/2}} \\ z_e^* &= z_1 - z_l^*, & e_e^* &= z_2 - e_l^* \end{aligned} \qquad (5.17)$$

So, choices of laundry firm are a function of p_1, p_2 and c. Similarly, choices of electricity firm are a function of p_1, p_2, z_1, z_2, and c:

$$\begin{aligned} z_l^* &= z_l^*(p_1, p_2), & e_l^* &= e_l^*(p_1, p_2, c) \\ z_e^* &= z_e^*(p_1, p_2, z_1, c), & e_e^* &= e_e^*(p_1, p_2, z_2, c) \end{aligned} \qquad (5.18)$$

But, externality rights of electricity firm are also a function of used labor from the same firm, equation (5.3):

$$e_e^*(p_1, p_2, z_1, c) = \frac{1}{2} z_e^*(p_1, p_2, z_1, c)$$

Thus, there are two expressions of electricity externality rights, equations (5.3) and (5.17). From these expressions, that should be equal, we can express p_2 as a function of p_1, z_1, z_2, and c (Figure 3):

$$p_2 = p_2(p_1, z_1, z_2, c) \tag{5.19}$$

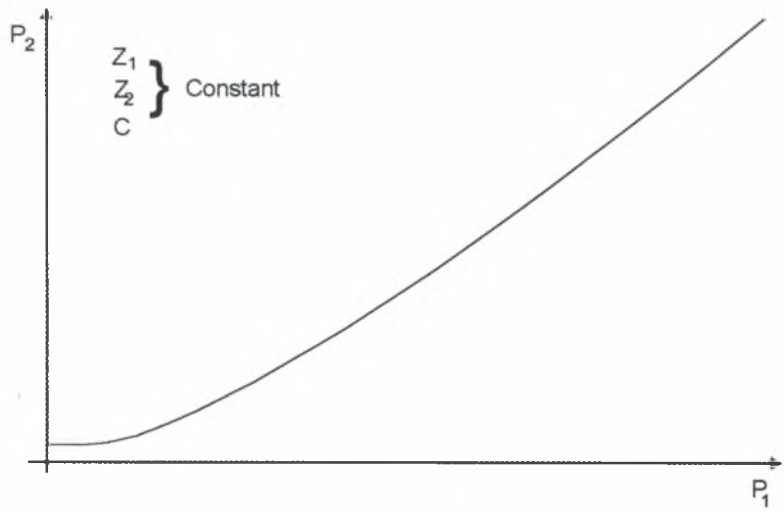
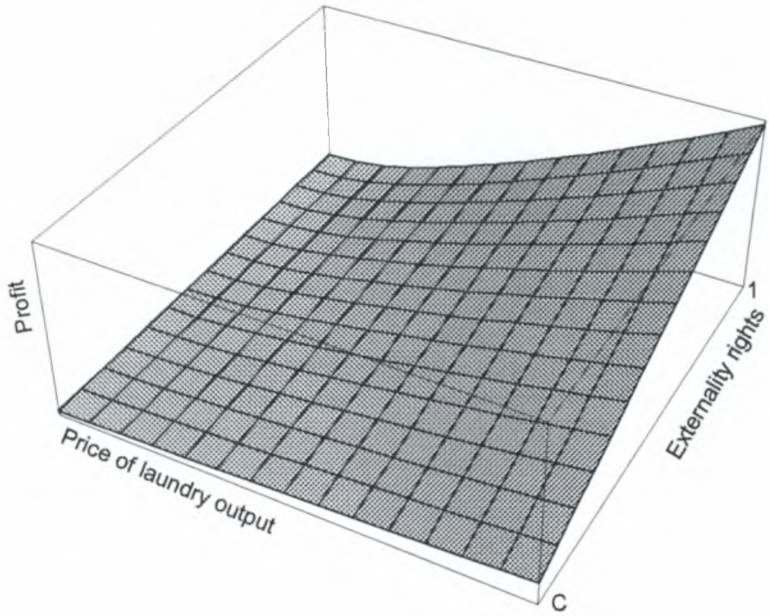


Figure 3.

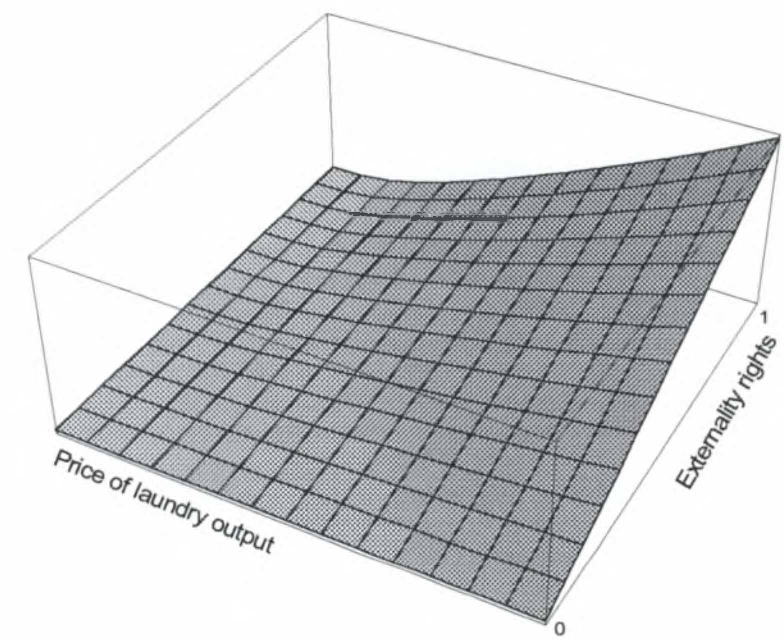
So, the profit functions of the two firms are functions of p_1, z_1, z_2, c, n_l, and n_e:

$$\begin{aligned} &\textit{Laundry firm (Figure 4a):} && \pi_l^* = \pi_l^*(p_1, z_1, z_2, c, n_l) && \text{(a)} \\ &\textit{Electricity firm (Figure 4b):} && \pi_e^* = \pi_e^*(p_1, z_1, z_2, c, n_e) && \text{(b)} \end{aligned} \tag{5.20}$$

Let $z_1 = z_2 = 1$. Then the profit of each firm is given by a point (p_1, n_x), where $x = l$, e, on the surface of the corresponding figure.



(a)



(b)

Figure 4.

The result from this model is the same as in previous model. Output price p_1 can not be determined, because in this model there is only the supply side of the economy. Thanks to the additional relationship (5.3) the second price of output, p_2, was possible to be determined. Again, profits depend on the endowments of property rights. It does not matter that the endowments are property rights.

5.2.3 Cobb-Douglas Technologies

Starrett supposes that the laundry suffers a negative externality from smoke put into the air when steel is produced. The laundry's observation of steel production is then an input, which affects laundry production negatively. Our approach differs from Starrett's approach. I have supposed that laundry firm uses clean air directly as an input to production process. But, the same does not happen with the electricity firm. The smoke that is released from the electricity firm, and respectively the necessary air, is given as a function of production. Air doesn't enter explicitly into electricity production function as direct input. Also, the additional relationship between smoke and electricity production decreases by one the degree of freedom in our model (that's why it was possible to determine one of the two output prices).

The above approach is one of the possible approaches. Another approach is to suppose that air is used as direct input in all production functions. This approach is much closer to the traditional treatment of the allocation problem. Also, in previous models I suppose that there is a trade between rights of using the air and not directly of amounts of air. The legal system or institutions under which the trade is going to take place is an additional important and great subject to investigate. Here, I am not going to consider furthermore the subject of legal system.

The model that I am going to present is a simple 2x2 production model with Cobb-Douglas technologies. Suppose that the production function of the first firm is:

$$f_1(l_1, e_1) = 2l_1^{2/5} e_1^{2/5} \tag{5.21}$$

where l_1, e_1 are the used labor and clean air as input to production function of the first firm. Profit function is:

$$\pi_1 = p_1 f_1(l_1, e_1) - w_1 l_1 - w_2 e_1 \tag{5.22}$$

where p_1 is the price of first firm output, w_1 is the price of labor, and w_2 is the price of air.

Suppose now, that the production function of the second firm is:

$$f_2(l_2, e_2) = 2l_2^{2/5}(e_2 - c)^{2/5} \tag{5.23}$$

Here, c could be seen as setup cost. Second firm requires at least c units of clean air to operate.

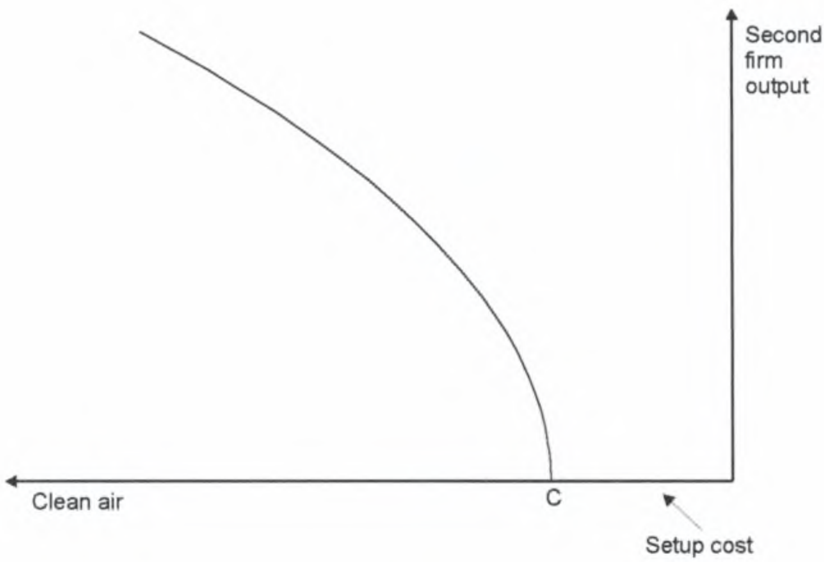


Figure 5.

Profit function of the second firm is:

$$\pi_2 = p_2 f_2(l_2, e_2) - w_1 l_2 - w_2 e_2 \tag{5.24}$$

So, the maximization problem of the two firm is:

$$\max_{l_1, e_1} \ \pi_1 = p_1 f_1(l_1, e_1) - w_1 l_1 - w_2 e_1 \qquad \text{(a)}$$

and (5.25)

$$\max_{l_2, e_2} \ \pi_2 = p_2 f_2(l_2, e_2) - w_1 l_2 - w_2 e_2 \qquad \text{(b)}$$

If we maximize π_2 only with respect to l_2 we can express l_2 as a function of prices and e_2:

$$\frac{\partial \pi_2}{\partial l_2} = 0 \Rightarrow l_2 = \left[\frac{4p_2 (e_2 - c)^{2/5}}{5w_1} \right]^{5/3} \tag{5.26}$$

If we replace labor l_2 from equation (5.26), then the production function (5.23) of the second firm can be expressed as a function only of the second input, clean air. Figure 5 shows the production level of the second firm for different levels of clean air, e_2.

Let's return now to the initial maximization problem. First order conditions are:

$$\frac{\partial \pi_1}{\partial l_1} = 0 \Rightarrow \frac{4 p_1 e_1^{2/5}}{5 l_1^{3/5}} - w_1 = 0 \quad \text{(a)}$$

$$\frac{\partial \pi_1}{\partial e_1} = 0 \Rightarrow \frac{4 p_1 l_1^{2/5}}{5 e_1^{3/5}} - w_2 = 0 \quad \text{(b)} \qquad (5.27)$$

$$\frac{\partial \pi_2}{\partial l_2} = 0 \Rightarrow \frac{4 p_2 (e_2 - c)^{2/5}}{5 l_2^{3/5}} - w_1 = 0 \quad \text{(c)}$$

$$\frac{\partial \pi_2}{\partial e_2} = 0 \Rightarrow \frac{4 p_2 l_2^{2/5}}{5 (e_2 - c)^{3/5}} - w_2 = 0 \quad \text{(d)}$$

Solving equations (5.27) we are going to find:

$$l_1^* = \left(\frac{4}{5}\right)^5 \frac{p_1^5}{w_1^3 w_2^2}, \quad e_1^* = \left(\frac{4}{5}\right)^5 \frac{p_1^5}{w_1^2 w_2^3} \qquad (5.28)$$

$$l_2^* = \left(\frac{4}{5}\right)^5 \frac{p_2^5}{w_1^3 w_2^2}, \quad e_2^* = c + \left(\frac{4}{5}\right)^5 \frac{p_2^5}{w_1^2 w_2^3}$$

If we denote by L the total labor and by A total available clean air, then the restrictions are:

$$l_1 + l_2 = L \qquad (5.29)$$

$$e_1 + e_2 = A \qquad (5.30)$$

Of course, we assume that the setup cost c is smaller than A, i.e. $A - c \geq 0$. Using the restrictions (5.29)-(5.30) and the relationships (5.28) we can calculate w_1 and w_2 as functions of p_1, p_2, L, A, and c:

$$w_1 = \frac{4}{5}\left[\frac{(A-c)^2 (p_1^5 + p_2^5)}{L^3}\right]^{1/5} \qquad (5.31)$$

$$w_2 = \frac{4}{5}\left[\frac{L^2 (p_1^5 + p_2^5)}{(A-c)^3}\right]^{1/5} \qquad (5.32)$$

Thus, from equations (5.21)-(5.24), (5.28), and (5.31)-(5.32) profit functions are expressed as functions of p_1, p_2, L, A, and c:

$$\pi_1 = \pi_1(p_1, p_2, L, A, c) \tag{5.33}$$

$$\pi_2 = \pi_2(p_1, p_2, L, A, c) \tag{5.34}$$

The results from this model are similar to any other traditional model. Profits depend only on output prices, total labor and total clean air. It does not matter that there is a non-traditional good as input like the clean air. The same result would hold with any type of input. The significant point here is that the presence of externalities does not generate a market failure in this type of Coasian model.

5.3 One-Consumer, one-Producer Model

The previous models include only the supply side of the economy. In this section I am going to examine one simple general equilibrium model with one consumer and one producer. Consumer is also the owner of the firm. Thus, firm's profit enters into consumer budget constraint.

Traded goods are labor, rights of clean air, and firm output (electricity). I suppose that clean air doesn't enter explicitly on firm's production function. There is an additional relationship between electricity output and generated smoke, or equivalent, necessary rights of air. In next section, I am going to give a more general model in the framework of general-equilibrium approach, where many simplifications of these models shall drop out.

5.3.1 Quasilinear Utility Function and Linear Production Technology

The production side is again an electricity firm, which uses labor to produce electricity and at the same time it releases smoke into air. We suppose that firm doesn't have initially any unit of rights to pollute. The production function is:

$$f(z_1) = z_1 \tag{5.35}$$

where z_1 is the used labor. The released smoke z_2 is a function of the production level:

$$z_2(z_1) = \frac{1}{2}[f(z_1)]^2 \tag{5.36}$$

The profit function is:

$$\pi = p_1 f(z_1) - w_1 z_1 - w_2 z_2(z_1) \tag{5.37}$$

where p_1 is electricity price, w_1 is the price of labor and w_2 the price of rights. The firm is solving the following maximization problem:

$$\max_{z_1} \ \pi = p_1 f(z_1) - w_1 z_1 - w_2 z_2(z_1) \tag{5.38}$$

$$\text{with respect to: } z_2(z_1) = \frac{1}{2} f(z_1)$$

First order condition of the above problem is:

$$\frac{\partial \pi}{\partial z_1} = 0 \Rightarrow p_1 - w_1 - w_2 z_1 = 0 \tag{5.39}$$

Given prices (p_1, w_1, w_2), we can find from equation (5.39) the firm's optimal labor demand:

$$z_1^*(p_1, w_1, w_2) = \frac{p_1 - w_1}{w_2} \tag{5.40}$$

From the other side, the utility function of the consumer has a quasilinear form:

$$U = x_1 x_2 + x_3 \tag{5.41}$$

where x_1 is the electricity that is consumed by the individual, x_2 is the leisure time, and x_3 is consumer's rights on clean air. Suppose that initially, consumer has an endowment of L units of total time and A units of clean air (it isn't out of place to assume that L and A are normalized to unit). He supplies an amount $(L - x_2)$ of labor to firm, and $(A - x_3)$ units of clean air to firm at prices (p_1, w_1, w_2). These units of clean air are used from firm to release its smoke. The consumer is also the owner of the firm. So, the total amount he can spend on the consumption good is his labor earnings $w_1(L-x_2)$ plus earnings from selling air $w_2(A-x_3)$ plus the profit distribution from the firm $\pi(p_1,w_1,w_2)$. Thus the budget constraint is:

$$p_1\, x_1 = w_1(L-x_2)+w_2(A-x_3)+\pi(p_1,w_1,w_2) \tag{5.42}$$

Consumer's problem given prices (p_1,w_1,w_2) is:

$$\max_{x_1,x_2,x_3} U = x_1x_2+x_3 \tag{5.43}$$

$$\text{subject to: } p_1\,x_1+w_1x_2+w_2x_3 = w_1L+w_2A+\pi(p_1,w_1,w_2)$$

So, the Langragian would be:

$$Lan = x_1x_2+x_3+\lambda\left(w_1L+w_2A+\pi(p_1,w_1,w_2)-p_1x_1-w_1x_2-w_2x_3\right), \tag{5.44}$$

and, the first order conditions are:

$$\begin{aligned}
&\text{(a)} \quad \frac{\partial Lan}{\partial x_1}=0 \Rightarrow x_2-\lambda p_1=0\\
&\text{(b)} \quad \frac{\partial Lan}{\partial x_2}=0 \Rightarrow x_1-\lambda w_1=0\\
&\text{(c)} \quad \frac{\partial Lan}{\partial x_3}=0 \Rightarrow 1-\lambda w_2=0\\
&\text{(d)} \quad \frac{\partial Lan}{\partial \lambda}=0 \Rightarrow \; w_1L+w_2A+\pi(p_1,w_1,w_2)-p_1x_1-w_1x_2-w_2x_3=0
\end{aligned} \tag{5.45}$$

Given prices (p_1,w_1,w_2) consumer's optimal choices is:

$$x_1^* = \frac{w_1}{w_2}, \qquad x_2^* = \frac{p_1}{w_2}, \tag{5.46}$$

$$x_3^* = \frac{Aw_2^2+Lw_1w_2-2p_1w_1+\pi(p_1,w_1,w_2)}{w_2^2}$$

A Walrasian equilibrium in this economy involves a price vector (p_1^*,w_1^*,w_2^*) at which the consumption, labor, and air markets clear; that is, at which:

$$\begin{aligned} x_1^* &= f(z_1^*) && \text{(consumption market)} \\ z_1^* &= L - x_2^* && \text{(labor market)} \\ z_2(z_1^*) &= A - x_3^* && \text{(air market)} \end{aligned} \tag{5.47}$$

If we normalize labor price to unit, i.e. $w_1=1$, then from equations (5.35)-(5.37), (5.40) and (5.46)-(5.47) we can determine the price vector (p_1^*, w_1^*, w_2^*):

$$\left(p_1^*, w_1^*, w_2^*\right) = \left(2, 1, \frac{3}{L}\right) \tag{5.48}$$

Thus, consumer's and firm's optimal choice is (from equation (5.40), (5.46), (5.48)):

$$\left(x_1^*, x_2^*, x_3^*\right) = \left(\frac{L}{3}, \frac{2}{3}L, A - \frac{L^2}{18}\right), \tag{5.49}$$

$$z_1^* = \frac{L}{3} \tag{5.50}$$

Now, from equations (5.35)-(5.37), (5.41), and (5.49)-(5.50) we can calculate consumer's maximum utility and firm's maximum profit:

$$U^* = A + \frac{L(4-L)}{18} \tag{5.51}$$

$$\pi^* = \frac{L}{6} \tag{5.52}$$

As in the previous section, consumer's utility and firm's profit at equilibrium depends on the initial endowments. With the introduction of property rights over externality and the existence of limit, market failure is avoided.

The results from this model are that consumer's choice of consumption and utility, as well firm's choice and profit, in equilibrium depends only from the initial endowments. These results justify our claim that the unboundedness of externality rights in Starret's approach is the reason of market failure. Total quantity of rights to pollute is bounded either by nature or statute. Not only should this bound be taken into account, but an explicit rights market must be established which efficiently allocates these rights between the two competing uses: pollution and pollution abatement (unused rights retained by the public). To do so, abatement could be traded as a form of public good (in our examples with one consumer, rights of clean air used by consumer could be seen as a form of pollution abatement).

5.4 BOYD AND CONLEY MODEL

Boyd and Conley (1997) deal with the introduction of property rights into a general equilibrium framework when externalities are present. They argue that failure is due to the structure of the Arrovian markets that Starrett uses and not to the presence of externalities as such. They provide an extension of a general equilibrium model in which property rights are explicitly traded. The result from this model is similar to our results in previous paragraphs. In this context they suggest a notion of Coasion equilibrium for this economy and show first and second welfare theorems. In this paragraph I shall revise Boyd and Conley solution to the problem of externalities.

Let an economic model with I individual/consumers and F firms. Let also, $\mathfrak{I}$ to be consumer's set, i.e. $\mathfrak{I} \equiv \{1, \ldots, I\}$ and $\mathcal{F}$ firm's set, $\mathcal{F} \equiv \{1, \ldots, F\}$. There are N^c private consumer goods, N^d directed externalities[2], N^g public goods, and N^r public externality rights, for a total of $N = N^c + N^d + N^g + N^r$ goods. We are most interested in the public externality rights market. These rights may be put to two uses. First, the public can buy rights and use them up in the form of a public good we can think of as abatement of externalities. All consumers experience the same level of this public good. Second, the individual firms can buy rights and use them up by generating public bads. The purpose of the externality market described below is to divide the total endowment of externality rights between these two competing uses.

A typical consumption bundle for the agent i will be written $x_i = \left(x_i^c, x_i^d, x_i^g, x_i^r\right)$, where x_i^c denote bundles of private goods, x_i^d private bads, x_i^g public goods, and x_i^r externality rights (abatement of public bads) respectively. Each agent i is characterized by an endowment $\omega_i = \left(\omega_i^c, 0, 0, \omega_i^r\right)$ and a preference relation $\succcurlyeq_i$ over a consumption set $X_i \subset \Re_+^N$. The aggregate endowment is $\omega = \sum_i \omega_i$.

Suppose the following concepts on preferences for all $i \in \mathfrak{I}$:

(A1) $\succcurlyeq_i$ is complete and transitive.

(A2) $\succcurlyeq_i$ is continuous.

(A3) If $x_i \succcurlyeq_i \tilde{x}_i$, then for all $\lambda \in [0,1]$, $\lambda x_i + (1-\lambda)\tilde{x}_i \succcurlyeq_i \tilde{x}_i$ (weak convexity).

[2] Directed externalities are a type of private bad (garbage, for example). The only reason to separate them from other private goods is to highlight their production technology.

(A4) For all $x_i \in X_i$, and for all $\varepsilon \geq 0$ there exists $\widetilde{x}_i \in X_i$ such that $\|x_i - \widetilde{x}_i\| \leq \varepsilon$ and $\widetilde{x}_i \succ_i x_i$ (local nonsatiation).

Each firm f $\mathcal{F}$ is represented by a production set $Y_f \subset \Re^N$. A typical production plan will be written $y_f = \left(y_f^c, y_f^d, y_f^g, y_f^r\right)$ where these represent net outputs vectors of private and public commodities. In particular, firms which generate externalities must consume externality rights, and so y_f^r will be negative in these cases. Firms also have endowments of property rights, $n_f = \left(0,0,0,n_f^r\right)$ and $n = \sum_f n_f$, although property rights are not necessary for the system to work. The externalities in this system are all generated by firms and experienced by consumers. This is done in the interest of simplifying notation. There should be no technical difficulty in extending the model. For all the production sets we assume:

(B1) Y_f is a nonempty, closed set.

(B2) For all $y_f, \widetilde{y}_f \in Y_f$ and all $\lambda \in [0,1]$, $\lambda y_i + (1-\lambda)\widetilde{y}_i \succcurlyeq_i \widetilde{y}_i$ (weak convexity).

(B3) The global production set $Y \equiv \{ y \in \Re^N \mid y = \sum_f y_f \text{ and } \forall f \in \mathcal{F}, y_f \in Y_f \}$ is closed (Y inherits convexity from the individual Y_f sets).

The set of feasible allocations A consists of all allocations $a = \left(x_1, \dots, x_I, y_1, \dots, y_F\right)$ such that:

1. For all $i \in \mathfrak{I}$, $x_i \in X_i$.
2. For all $f \in \mathcal{F}$, $y_f \in Y_f$.
3. $\sum_i x_i^c = \sum_i \omega_i^c + \sum_f y_f^c$.
4. $\sum_i x_i^d = \sum_f y_f^d$.
5. For all $i \in \mathfrak{I}$, $x_i^g = \sum_f y_f^g$.
6. For all $i \in \mathfrak{I}$, $x_i^r = \sum_f n_f^r + \sum_i \omega_i^r + \sum_f y_f^r$.

Conditions 1 and 2 require that the allocation be feasible for each consumer and producer. Condition 3 requires that the net production of private goods equals the consumption. Condition 4 requires that the production and consumption of directed externalities be equal. Condition 5 requires that each consumer consumes the total amount of public goods produced by firms. Finally, condition 6 requires that the total endowment of property rights be divided between externality and abatement uses, and that each consumer experiences the total level of externality generated by all the firms.

The set of Pareto efficient allocations is defined as:

$$PE \equiv \{\alpha \in A \;/ \text{there is no } \hat{\alpha} \in A \text{ with } \hat{x}_i \succcurlyeq_i x_i \text{ for all } i \in \mathfrak{I} \text{ and } \hat{x}_j \succ_j x_j \text{ for some } j\}.$$

The price space is:

$$\Pi \equiv \{\mathbf{p} \equiv (p^c, p^d, p^g, p^r) \in \Re^{N^c+N^d+IN^g+IN^r} \;/ \mathbf{p} \neq 0\}.$$

The prices faced by individual i are $p_i \equiv (p^c, p^d, p_i^g, p_i^r)$ and the prices faced by the firms are $p \equiv (p^c, p^d, \sum_i p_i^g, \sum_i p_i^r)$. The profits of firm f are $\pi_f(y_f, p) = p(y_f + n_f)$.

We denote also a profit share system for a private ownership economy by $\theta = (\theta_1, \ldots, \theta_I) \equiv \Theta$, where θ_{if} is interpreted as consumer i's share of the profits of firm f.

The budget set of agent i depends on the endowment of goods and firm shares, profits, and prices. Omitting the arguments in the profit function, this is given by:

$$B_i(\omega_i, \theta_i, \pi, p) \equiv \{x_i \in X_i \;/ p_i x_i \leq p\omega_i + \sum_f \theta_{if}\pi_f\}.$$

A feasible allocation and price vector $(\alpha, \mathbf{p}) \in A \times \Pi$ is said to be a *Coasian equilibrium relative to endowments ω and n, and profit shares $\theta \in \Theta$* if and only if:

a. For all $i \in \mathfrak{I}$, $x_i \in B_i(\omega_i, \theta_i, \pi, \mathbf{p})$ and $x_i \succcurlyeq_i \hat{x}_i$ for every $\hat{x}_i \in B_i(\omega_i, \theta_i, \pi, \mathbf{p})$ where $\pi = \pi(\alpha, \mathbf{p})$.
b. $py_f \geq p\hat{y}_f$ for all $f \in \mathcal{F}$ and all $\hat{y}_f \in Y_f$.
c. For all $f \in \mathcal{F}$, $\pi_f = p(y_f + n_f)$.

We state now the first welfare theorem:

THEOREM 1. *If $(\alpha, \mathbf{p})$ is a Coasian equilibrium, then $\alpha \in PE$.*

Theorem 1 is essentially a Coase Theorem for convex economies. Given the structure of this general equilibrium economy, transactions costs are zero. Thus, we can rephrase the first theorem as saying:

'When transactions costs are zero, any endowment of property rights (including private goods endowments and profit shares) leads to Pareto efficient outcomes through market exchanges'.

If we drop convexity, a form of the Coase Theorem very different from Theorem 1 is still true. Coase did not necessarily require that property rights be traded on markets through linear price systems. Trade could also take place through bundled offers of the form: a payment of x dollars in exchange for a total of y rights to pollute. If transactions costs are zero and there are gains from trade, then of course the trades will take place. Since Pareto optimality means that there are no further gains from trade, we get the Coase Theorem.

Next we give the second welfare theorem:

THEOREM 2. *Suppose that* $\alpha \in PE$, *and for all* $i \in \Im$, $x_i \in$ *interior*(X_i). *Then there exists a set of endowments* $(\hat{\omega}, \hat{n})$ *such that* $\sum_i \hat{\omega}_i + \sum_f \hat{n}_f = \sum_i \omega_i + \sum_f n_f$, *a set of profit shares,* $\hat{\theta} \in \Theta$, *and prices,* $\mathbf{p} \in \Pi$, *such that* $(\alpha, \mathbf{p})$ *is a Coasian equilibrium relative to* $\hat{\omega}$, $\hat{n}$, *and* $\hat{\theta}$.

The second welfare theorem says that every Pareto Efficient allocation not on the boundary of the agent's consumption sets can be achieved as an equilibrium. This directly puts to rest Starrett's concern that some efficient allocations will not be supportable by prices in economies with externalities.

The model above has several simplifications in the interest of clarity. The most important is that only consumer, and not firms, are affected by public externalities. Generalizing this would require that the production sets of firms be expanded to include the abatement level, and that a set of individualized Lindahl prices for these public goods be defined for firms. But, although these simplifications, Boyd and Conley provide a general equilibrium model and a definition of Coasian equilibrium which address the problem of the Arrow model that misses many important institutional structures.

5.5 CONCLUSION

Starrett argues that the presence of externalities implies fundamental non-convexities, which cause Arrow markets to fail. But, I argue that this failure should be attributed to the structure of the Arrovian markets that Starrett uses, and not to the presence of externalities as such. For example, the existence of smoke generates externality conditions and according to Starrett it causes the market failure. But, by introducing rights over the use of clean air, and these rights are explicitly traded, the non-convexities cease being fundamental. Additionally, if there is a limit and initial endowments of rights, then market failure is avoided. Clean air could be traded as any other traditional good.

Someone could be wondering: *is it possible to set a limit to clean air?* The answer is rather simple: the atmosphere can absorb only a limited amount of pollution. It is feasible to find this amount of pollution for each geographic region; knowing this limit, the authorities could set a maximum pollution level, smaller or equal to this limit; this maximum pollution level implies automatically a limited amount of possible traded rights on clean air in the specific geographic region. The problem now is shifted to the following questions:

What would be the criteria by which authorities should set the maximum pollution level? Under which legal system or institutions the trade of clean air will take place?

In this framework the non-convexities are not fundamental. In fact there aren't any non-convexities. The only non-convexities, that might be present, are due to non-convex technologies (for example, a production technology with setup cost) or consumer's preferences, because externality conditions don't affect directly the agents. There is a market with well establishment rights in which the influence takes place.

Of course, sometimes it isn't feasible to set up markets for externality effects. Some reasons have to do with the nature of goods like air, land or water and their social values, as I have discussed in last section of Chapter 4. Another reason could be the cost of setting up such markets. In Chapter 6 I am going to follow Yang and Wills (1990), in setting up a model, which takes into account the costs of establishing property rights and cost of trade for all goods. The purpose of this model is to show that the existence of a potential market depends on these costs. If the costs for a market are high enough then this market will not be created.

6. Transactions Costs, Property Rights and Existence of Markets

6.1 Introduction

In the previous paragraphs I assumed that the property rights are well defined. The main idea was that if there are well defined rights then externality conditions must be overcome. The market failure is prevented by the existence of a well-formed market for the externality. But, before the assumption of well-established rights there is an additional step: *is it efficient to specify and enforce such property rights for a market to exist?* This question is closely connected with two many concepts. The first concept is this of transaction costs. The second is associated with the basic values of a society that limit the range of possibilities in which property rights may be defined (as we discussed in Chapter 4).

In previous chapters I gave a first hint about transaction costs, externality conditions and market failure. Now, I am going to revise Yank and Wills (1990) to show the significance between the costs of establishing property rights over some resources or activities and the existence of markets for those resources or activities. I am also going to refer to the distinction between the trade of property rights[1] and the trade of goods that carry properties.

Yank and Wills present a model formalizing the economics of property rights. The model formalizes a tradeoff between the gains from trade based on increasing returns to specialization and the costs involved in specifying and enforcing property rights. They end up with the following proposition:

'The level of efficiency in specifying and enforcing property rights affects the number of markets in existence. There is no market for a particular good if the level of efficiency in specifying and enforcing property rights to that good is sufficiently low.'

The above proposition differs from the conventional wisdom of market failure which does not explain why the markets for some commodities, for example, clean air, do not exist. Their existence is a matter of the degree of vagueness in specifying and enforcing property rights.

6.2 A Model Formalizing the Tradeoff between Economies of Specialization and the Efficient Number of Markets

6.2.1 The Model

Yank and Wills' model is about an economy with M consumers/producers, and m consumer goods. The number of consumer goods equals the population size, $M = m$, an assumption that simplifies the algebra. The self provided amount of good i is x_i. The amount of good i sold in the markets is x_i^s. The amount of good i purchased in the market is x_i^d. The transportation cost coefficient is k. A fraction of a shipment disappears in transportation. Thus, $(1-k)x_i^d$ is the amount an individual obtains when he buys x_i^d.

The output level of good i is $x_i + x_i^s$. By assumption all consumers/producers have an identical system of production functions given by:

$$x_i + x_i^s = L_i^a \qquad i = 1,\ldots..,m \quad a \succ 1 \tag{6.1}$$

An individual allocates a fraction L_i of his total available hours to the production of good i. As $\alpha > 1$, the production function exhibits increasing returns to specialization.

The utility function is identical for all individuals:

$$U = \prod_{i=1}^{m}\left[x_i + (1-k)x_i^d\right] \tag{6.2}$$

where $x_i + (1-k)x_i^d$ is the amount of good i consumed. The quantity of each and every good consumed must be positive for utility to be positive.

Let' denote by q_r a coefficient associated with the specification and enforcing property rights. Well specificated and enforced property rights lead to a more efficiently use of the commodity. The coefficient q_r is associated with vagueness in specifying and enforcing property rights in purchase contracts, that may lead to misunderstanding about the category, quality of goods to be delivered, about delivery times, and so on. The consequence of such a failure is that the buyer does not receive the good that he expects. Small q_r is associated with little vagueness of a contract.

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[1] In the previous paragraph, the trade of property rights was the only way by which I have handled externality conditions. But, this is not the only way. Which way will be used depends also from the legal system and/or the institutions that shall be defined.

Suppose that there are N_r individuals selling traded good r and a buyer can immediately shift to other producers if a producer fails to deliver the goods ordered by the buyer. Hence, for a single buyer, there are N_r parallel producers who supply good r. The probability that N_r independent sellers fail to deliver the good to the buyer is $q_r^{N_r}$. The probability that a buyer actually receives the good he buys is:

$$1 - q_r^{N_r} \tag{6.3}$$

If P is the probability that an individual receives all goods bought by him, then:

$$P = \prod_{r \in R} \left(1 - q_r^{N_r}\right) \tag{6.4}$$

where R is a set of all goods bought by an individual. As individual will enjoy full U if he receives all goods bought by him it is supposing that his preference is represented by a risk neutral Von Neumann-Morgenstern utility function:

$$V = PU \tag{6.5}$$

An additional assumption is that the more labor is used in stipulating and enforcing a contract, the less vaguely the property rights are specified and enforced, and the lower the probability that the buyer does not receive the expected goods. The share of an individual's labor endowment required to ensure that a buyer receives a good from a single seller with probability $1 - q_r$ is:

$$c\left(1 - q_r\right) \tag{6.6}$$

where c is a constant coefficient and $1/c$ is a measure of efficiency in specifying and enforcing property rights. If r is an environmental resource, like clean air, then c depends on the way that property rights are defined. We are expecting a more efficiency use of these resource, if property rights are well defined and enforced (we are not take care here about the explicit definition of these property rights).

Assume now that q_r is the same across all sellers of a traded good. When an individual buys good r, he has to spend the additional labor cost $c\left(1 - q_r\right)$. If the first seller will fail to deliver at probability q_r, byer faces a conditional probability q_r when he asks second seller to deliver the good. The labor cost in this state is again $c\left(1 - q_r\right)$. In general, the conditional probability that the buyer has to ask for a delivery from the next seller and incur a cost $c(1-q_r)$ when the first t sellers fail to deliver is q_r^t. Therefore, the expected labor cost in a transaction that involves N_r potential sellers is:

$$c(1-q_r)(1+q_r+q_r^2+...+q_r^{N_r}) = c(1-q_r^{N_r}) \tag{6.7}$$

The expected labor cost for all purchases of a consumer/producer is:

$$c\sum_{r\in R}(1-q_r^{N_r}). \tag{6.8}$$

The endowment constraint for a consumer/producer endowment with a unit of labor is:

$$c\sum_{e\in R}(1-q_r^{N_r}) + \sum_{i=1}^{m} L_i = 1 \qquad 0 \le L_{i,} \quad q_r \le 1. \tag{6.9}$$

This model formalizes several important tradeoffs. First, there is a tradeoff between economies of specialization and the labor costs involved in specifying and enforcing property rights for increasing numbers of purchase contracts, given individual preferences for diverse consumption. Second, there is a similar tradeoff between economies of specialization and transportation costs for increasing numbers of purchase contracts. Third, given a certain level of vagueness in specifying and enforcing property rights, there is tradeoff between economies of specialization and the reliability of exchange coordination across all transactions which indirectly affects individuals' expected utilities. Finally and more interesting for us, there is a tradeoff between economies of specialization and the use of labor to reduce vagueness in specifying and enforcing property rights.

In this model the number of producers of each traded good and thereby the market structure are endogenously determined. As Yang and Wills show, the equilibrium number of producers of each traded good is a decreasing function of transaction efficiency. Thus, for sufficiently great transaction efficiency, only one individual produces each good in equilibrium, while the number of consumers of each good always equals the population size because of the preference for diverse consumption. The specification of production functions allows free entry for all consumers/producers into the production of each good. Nobody has monopoly powers even if only one individual produces a good in equilibrium, due to the absence of the perceived downward sloping aggregate demand curve. Prices of traded goods in the model are determined by aggregate supply and aggregate demand, which are in turn determined by the numbers of individuals who sell and buy different goods. Individuals make decisions about which goods they sell and buy. Consequently, the impersonal market determines the numbers of individuals selling and buying different goods, which, in turn, determines the price of traded goods.

Yang and Wills next define individual's decisions according to the model. They apply the Kuhn-Tucker theorem and prove:

PROPOSITION 1.

Each individual sells only one good (if any) and does not buy and produce the same good.

Also, they prove that utility maximizers' decisions are corner solutions in the model. Thus, there are 2^{3m} possible corner solutions for an individual consuming m goods. But, by employing the proposition 1, many corner solutions can be ruled out from the list of candidates for an individual's optimum decision. Without loss of generality, Yang and Wills assume that goods $1,2,...,i,...n$ are traded and goods $n+1,n+2,...,m$ $(0 \leq n \leq m)$ are not traded by individuals selling good i. According to Proposition 1, this assumption implies that $x_r^s = x_r = 0$ for $r = 1,...,n$ expect i and $x_j^d = x_j^s = 0$ for $j = n+1,...,m$.

Each individual receives full payment for goods sold by him and pays for goods which he buys and may fail to receive because of a risk of defining property rights to goods purchased. Hence, the individual's budget constraint involves expenditure uncertainties but no income uncertainties. A buyer for the good r has to pay $p_r x_r^d$ to the seller he contacts first. If the first seller fails to deliver the good, the buyer has to pay another $p_r x_r^d$ to the second seller with probability q_r. Similarly, he has to pay $p_r x_r^d$ to the $(t+1)$th seller with probability q_r^t when the first t sellers fail to deliver. Thus the budget constraint of an individual selling good i is:

$$p_i x_i^s = \sum_{r=1, r\neq i}^{n} p_r x_r^d \left(1 + q_r + q_r^2 + ... + q_r^{N_r}\right). \qquad (6.10)$$

According to the above, the labor cost in production becomes:

$$\sum_{i=1}^{m} L_i = L_i + \sum_{j=n+1}^{m} L_j. \qquad (6.11)$$

The individual consumer/producer maximizes expected utility subject to the production functions, the endowment constraint and the budget constraint. Thus, the decision problem for an individual selling good i is stated as:

$$\text{Max: } V_i = U_i P_i = x_i \prod_{r=1, r\neq 1}^{n} \left[(1-k) x_{ri}^{d} \right] \left[\prod_{j=n+1}^{m} x_j \right] P_i, \tag{6.12}$$

s.t. $x_i + x_i^s = L_i^a$, $\quad x_j = L_j^a$,

for $j = n+1, \ldots\ldots, m$ (production constraint)

$$L_i + \sum_{j=n+1}^{m} L_j + c \sum_{r=1, r\neq 1}^{n} \left(1 - q_r^{N_r}\right) = 1 \qquad \text{(endowment constraint)}$$

$$p_i x_i^s = \sum_{r=1, r\neq 1} p_r x_{ri}^{d} \left(1 + q_r + q_r^2 + \ldots + q_r^{N_r}\right) \qquad \text{(budget constraint)},$$

where $P_i = \prod_{r=1, r\neq i}^{n} \left(1 - q_r^{N_r}\right)$. Variables n and q_r may differ across individuals who sell different goods. For simplicity the subscript i is omitted. The decision variables are x_i, x_i^s, x_{ri}^d, L_i, x_j, L_j, q_r, and n. Because of complete symmetry of the model, an individual's optimum trade composition is indeterminate. Hence, the selection of which goods are traded has no effect on the utility level. Only the number of traded goods n matters. Solutions to the problem give individual demand and supply functions. Using the first order conditions for the problem, the maximization problem can be written:

$$\underset{n, q_r}{Max}: \quad V_i = n^{(a-1)n} \left[(1-k)(1-q_r) \right]^{n-1} \left(p_i^n \Big/ \prod_{r=1}^{n} p_r \right) (A/m)^{am} P_i \tag{6.13}$$

where $A = 1 - c \sum_{r=1, r\neq i}^{n} \left(1 - q_r^{N_r}\right)$. Solving this maximization problem we have:

$$n = n\left(p_i / p_t, N_i / N_t, t = 1, \ldots, n\right) \tag{6.14}$$

$$q_r = q_r\left(p_i / p_t, N_i / N_t, t = 1, \ldots, n\right), \quad r = 1, \ldots, n \quad r \neq i \tag{6.15}$$

Thus, we have n indirect utility functions:

$$V_i = V_i(p_i/p_t, N_i/N_t, t = 1,\ldots,n) \qquad i = 1,\ldots,n \tag{6.16}$$

and individual's demand and supply functions are:

$$x_{ri}^d = p_i(nA/m)^a / p_r, \qquad i = 1,\ldots,n \quad r = 1,\ldots,n \ r \neq i \tag{6.17}$$

$$x_i^s = (n-1)(nA/m)^a / n \qquad i = 1,\ldots,n. \tag{6.18}$$

The equations of n, q_r, x_{ri}^d and x_i^s are symmetric over i and r.

The utility equalization conditions are:

$$V_1(p_i/p_t, N_i/N_t, t = 1,\ldots,n) = V_2(p_i/p_t, N_i/N_t, t = 1,\ldots,n)$$
$$= \ldots = V_n(p_i/p_t, N_i/N_t, t = 1,\ldots,n) \tag{6.19}$$

Here, there are $n-1$ equations. Because of the uncertainty of single purchases, total demand in uncertain. Assume that the quantity of good i demanded by a person selling good r is x_{ri}^d. Initially he will demand x_{ri}^d from the first seller. He will demand another x_{ri}^d with probability q_r when the first seller fails to deliver, a third x_{ri}^d with probability q_r^2 when the first two sellers fail to deliver, and so on. Hence the expected demand for good i by a person selling good r is:

$$x_{ir}^d(1 + q_r + q_r^2 + \ldots + q_r^{N_r-1}) = x_{ri}^d(1 - q_r^{N_r})/(1 - q_r) \tag{6.20}$$

Since the decision problems for individuals who sell the same type of good are the same and there are no supply uncertainties, the aggregate supply of good i can be obtained by multiplying x_i^s with N_i and the expected demand with N_r and by summing up the right hand side of the above equation over subscript r. N_i (or N_r) is the number of individuals selling good i (or r). Let aggregate supply equal expected aggregate demand; there are $n-1$ independent market clearing conditions in the rational expectation equilibrium:

$$N_i x_i^s = \sum_{r=1, r\neq 1}^{n} N_r x_{ri}^d \frac{1 - q_r^{N_r}}{1 - q_r}, \qquad i = 2,\ldots,n \tag{6.21}$$

Since trade compositions is indeterminate, we assume that all individuals trade the same bundle of goods $1, \ldots, n$. The symmetry of the utility equalization conditions and the market clearing conditions implies that the prices of all traded goods are equal, N_i is the same for $i = 1, ..., n$, n is the same for all individuals, and q_r is the same for all traded goods and all individuals. Thus:

$$
\begin{aligned}
&n \text{ is the same for all individuals,} && \text{(a)} \\
&N_i = N = m/n \text{ for } i = 1,\dots,n, && \text{(b)} \\
&p_i = p \text{ for } i = 1,\dots,n, && \text{(c)} \qquad (6.22) \\
&q_r = q \text{ for all individuals and for } r = 1,\dots,n, && \text{(d)} \\
&P_i = P \equiv \left(1-q^N\right)^{n-1} \text{ for } i = 1,\dots,n \text{ (for all individuals).} && \text{(e)}
\end{aligned}
$$

So, individual's demand and supply functions become:

$$x_{ir}^d = \left\{n\left[1-c(n-1)\left(1-q^N\right)\right]/m\right\}^{\alpha}/n, \text{ for all } i \text{ and } r \qquad (6.23)$$

$$x_i^s = (n-1)\left\{n\left[1-c(n-1)\left(1-q^N\right)\right]/m\right\}^{\alpha}/n, \text{ for all } I \qquad (6.24)$$

where $m = M$ is the population size as well as the number of goods and $N = m/n$. Using the above relationships the utility maximization problem become:

$$\underset{n,q}{Max:} \quad V_i = V \equiv n^{n(\alpha-1)}\left[k(1-q)\right]^{n-1} \times \left\{\left[1-c(n-1)\left(1-q^N\right)\right]/m\right\}^{\alpha m} \qquad (6.25)$$

where $i = 1,\dots,n$, $N = m/n$. The first order conditions for the above maximization problem are:

$$(\partial V/\partial n)/V = (\alpha-1)(\log n + 1) + \log k(1-q) \qquad (6.26)$$
$$-\alpha mc\left[1-q^N + N(n-1)q^N \log q/n\right]/\left[1-c(n-1)\left(1-q^N\right)\right] = 0$$

$$(\partial V/\partial q)/V = \qquad (6.27)$$
$$\left\{\alpha mc(n-1)Nq^{N-1}/\left[1-c(n-1)\left(1-q^N\right)\right] - (n-1)/(1-q)\right\} = 0$$

The above equations together with $N = m/n$ gives the equilibrium n and q as functions of α, c, k, and m. Note that V converges to 0 as k tends to 0 and c tends to 1. Also, $\partial V/\partial q \prec 0$ for any q if $c = 0$. This means equilibrium $q = 0$ if $c = 0$. For $q = 0$,

$\partial V/\partial n$ is positive for any $n \le m$ if k and/or c are sufficiently close to 0 and/or α is sufficiently great. This implies:

(6.28): *The equilibrium value of n is 1 (its minimum) if α, k, and/or 1/c are sufficiently small;*
(6.29): *The equilibrium value of n is m (its maximum) if α, k and 1/c are sufficiently great.*

Differentiating again the above equations, we find that the second order conditions for interior equilibrium values of n and q are satisfied if α, k and $1/c$ are neither too great nor too small. Therefore:

(6.30): *The equilibrium value of n is between 1 and m if α, k, and 1/c are neither too great nor too small.*

The equilibrium solved in this section determines the level of division of labor, n, the degree of vagueness in specifying and enforcing property rights in a contract, q, each individual's cost of specifying and enforcing property rights, $c(n-1)(1-q^N)$, and the number of producers of each traded good, $N = m/n$.

6.2.2 Comparative Static

In this paragraph we are going to explore the effects of changes in the values of the parameters on the equilibrium. Differentiating (6.26)-(6.27) and taking account of (6.28)-(6.30), yields that if α, c, and k are neither too small nor too great:

$$\begin{array}{lll} V_{ir} \equiv \partial^2 V/\partial i \partial r, & i,r = n,q,\alpha,k,c & \\ V_{nn} \prec 0, & V_{nq} = V_{qn} \succ 0 & \\ V_{qq} \prec 0, & V_{\alpha n} \succ 0, & V_{cn} \prec 0 \\ V_{kn} \prec 0, & V_{\alpha q} \succ 0, & V_{kq} = 0 \\ V_{cq} \prec 0, & \Delta \equiv V_{nn}V_{qq} - V_{nq}^2 \succ 0 & \end{array} \quad (6.31)$$

Using (6.31) and (6.26)-(6.27) the comparative statics of the equilibrium can be derived:

$$
\begin{aligned}
dn^*/dc &= \left(V_{cq}V_{nq} - V_{qq}V_{cn}\right)/\Delta \prec 0, \\
dn^*/dk &= \left(V_{kq}V_{nq} - V_{qq}V_{kn}\right)/\Delta \succ 0, \\
dn^*/d\alpha &= \left(V_{\alpha q}V_{nq} - V_{qq}V_{\alpha n}\right)/\Delta \succ 0
\end{aligned}
\tag{6.32a}
$$

and

$$
\begin{aligned}
dq^*/dc &= \left(V_{cn}V_{nq} - V_{nn}V_{cq}\right)/\Delta \text{ is ambiguous,} \\
dq^*/dk &= \left(V_{kn}V_{nq} - V_{nn}V_{kq}\right)/\Delta \succ 0, \\
dq^*/d\alpha &= \left(V_{\alpha n}V_{nq} - V_{nn}V_{\alpha q}\right)/\Delta \succ 0.
\end{aligned}
\tag{6.32b}
$$

Since $N = m/n$ and $P = \left(1 - q^{m/n}\right)^{n-1}$ we can show:

$$
\begin{aligned}
dN^*/dc &= \left(dN/dc\right)\left(dn^*/dc\right) \succ 0, \\
dN^*/dk &= \left(dN/dn\right)\left(dn^*/dk\right) \prec 0, \\
dN^*/d\alpha &= \left(dN/dn\right)\left(dn^*/d\alpha\right) \prec 0
\end{aligned}
\tag{6.33a}
$$

and

$$
\begin{aligned}
dP^*/dc &= \left(\partial P/\partial n\right)\left(dn^*/dc\right) + \left(\partial P/\partial q\right)\left(dq^*/dc\right) \prec 0 \\
&\qquad \text{if } \left(\partial P/\partial n\right)\left(dn^*/dc\right) \prec \left|\left(\partial P/\partial q\right)\left(dq^*/dc\right)\right|, \\
dP^*/dk &= \left(\partial P/\partial n\right)\left(dn^*/dk\right) + \left(\partial P/\partial q\right)\left(dq^*/dk\right) \prec 0 \\
&\qquad \text{if } \left(\partial P/\partial n\right)\left(dn^*/dk\right) \prec \left|\left(\partial P/\partial q\right)\left(dq^*/dk\right)\right|, \\
dP^*/d\alpha &= \left(\partial P/\partial n\right)\left(dn^*/d\alpha\right) + \left(\partial P/\partial q\right)\left(dq^*/d\alpha\right) \prec 0
\end{aligned}
\tag{6.33b}
$$

where $\partial P/\partial n \prec 0$ and $\partial P/\partial q \prec 0$.

Applying the envelope theorem to (6.25) yields:

$$
\begin{aligned}
dV^*/dc &= \partial V/\partial c \prec 0 \qquad \text{(a)} \\
dV^*/dk &= \partial V/\partial k \succ 0, \qquad \text{(b)}
\end{aligned}
\tag{6.34}
$$

where V^* is the equilibrium expected real productivity in terms of utility (per capita real income), which is a function of parameters α, c, and k, and n^* and q^* which are also functions of α, c, and k. The last relationships lead us to:

PROPOSITION 2.

Increases in transportation efficiency (k) and/or efficiency in specifying and enforcing property rights (1/c) will raise the equilibrium level of division of labor (n), thereby improving productivity and decreasing the number of producers of each traded good. Their effects on the equilibrium probability that property rights are perfectly specified and enforced in all transactions (P) are ambiguous. Increased transportation efficiency will increase the equilibrium degree of vagueness of property rights in a transaction (q); the effect of increased efficiency in specifying and enforcing property rights on the equilibrium degree of vagueness is ambiguous. An increase in the degree of economics of specialization will raise the equilibrium level of division of labor and the equilibrium degree of vagueness of property rights in a transaction, and lower the equilibrium number of producers of each traded good and the equilibrium probability that property rights are perfectly specified and enforced in all transactions.

Additionally, if transaction efficiency in specifying and enforcing property rights, $1/c$, differs across goods but the degree of economies of specialization, α, and transportation efficiency, k, are identical for all goods, then both the number of traded goods and the composition of trade are important to determining equilibrium. Assume that the number of traded goods is given; (6.34) implies that per capita real income increases with $1/c$. With the assumption of fixed α and k, this means that the per capita real income in a market that trades goods with higher $1/c$ is greater that that in a market that trades the same number of different goods with lower $1/c$. Using the multiple-step approach proposed from Yang and NG (1993), we can show that in equilibrium those goods with greater $1/c$ will be traded if not all goods are traded. In other words, the development of exchange for a certain good depends crucially on the efficiency in specifying and enforcing property rights to this good. This result is summarized in the following proposition:

PROPOSITION 3

The level of efficiency in specifying and enforcing property rights affects the number of markets in existence. There is no market for a particular good if the level of efficiency in specifying and enforcing property rights to that good is sufficiently low.

6.2.3 On Proposition 2

An example may provide the intuition behind proposition 2. The institution of the university can be used to improve efficiency in specifying and enforcing rights ro knowledge. Teaching staff members' rights to the knowledge, which is sold to students is specified and enforced via wage contracts between a university and the staff members and the tuition payment to the university from students. Transaction efficiency is lower when teachers collect payment from students through the university. An improvement in efficiency of specifying and enforcing rights to knowledge which is associated with the emergence of a university will promote the division of labor between producers of knowledge (faculty members) and future producers of other goods (students) and between different specialist teachers. However, monthly-wage contracts are more common between universities and teaching staffs than between students and private tutors who usually charge a hourly-fee. If property rights are more vaguely specified and enforced in a monthly-wage contract than in a hourly-fee contract, the above example implies that an increase in the division of labor is associated with a more vague specification and enforcement of property rights as long as benefits from the higher level of division of labor outweigh utility loss caused by the higher level of vagueness of contracts.

Further, the emergence of the institution of university promotes the division of labor between the professional management of books (library) and the users of books (teachers and students). The emergence of professional libraries increases the vagueness in specifying and enforcing rights to knowledge generated by books. Before professional libraries were established, an individual had to buy a book if he wanted to utilize the knowledge in that book since it was not easy to borrow many different books from other individuals. He can more easily borrow a book without any payment to the author of the book since libraries emerged. Even if students' tuition includes a payment for using a university library, the payment is not proportional to the frequency of the books used. This implies that rights to authors' knowledge are more vaguely specified and enforced in a library system than in a book market without the institution of the library. However, the system with libraries will be the equilibrium as long as the benefits generated by the division of labor between professional libraries and other sectors outweigh the utility loss generated bu the higher level of vagueness in specifying and enforcing the rights to intellectual property.

Nevertheless, a new institutional arrangement that charges for each use of a book in a library may be combined with copyright laws to increase the level of the division of labor and decrease the level of vagueness in specifying and enforcing rights to intellectual property at the same time if magnetic cards and a computer system are effectively employed to monitor and collect the required payments. This new institution emerged in some North European countries in 1980s. In this case, an improvement in the efficiency of specifying and enforcing property rights that is associated with a system which charges for each use of a book simultaneously increases the level of division of labor and decreases the degree of vagueness in specifying and enforcing property rights. Intuitively, a slight improvement in transaction efficiency due to the emerge of professional libraries increases the equilibrium level of division of labor and the equilibrium degree of vagueness in specifying and enforcing property rights because this slight improvement cannot afford both the increase in the level of division of labor and the decrease in vagueness at the same time. The emergence of a system that charges for each use of a book, together with copyright laws, magnetic cards, and the computer system, will significantly improve transaction efficiency in specifying and enforcing authors' rights to knowledge in books, so that the level of division of labor increases and the degree of vagueness in specifying and enforcing property rights decreases, resulting in a significant increase in productivity and welfare.

If the CES utility or production function is introduced, the evolution in the division of labor will be associated with the emergence of new goods and related new technology. As new technology emerges from the evolution of division of labor, rights to use, to transfer, and to appropriate earnings from a property may be separable from the materials that carry the property. For instance, knowledge in a book is a property that can be separated from the book. An individual can use the property without paying for the knowledge if he borrows this book. Misic in a tape is a property that can be separated from the tape. An individual can use and transfer the property without paying for it if he copies the tape from his friend. As new technology that can separate a property from the materials that carry it develops, trade of the rights to use, to transfer, and to appropriate is more important that trade of the related materials.

As defined to Furubotn (1974), the economics of property rights is to study the trade of property rights rather than the trade of goods which carry properties. The property rights approach would be similar to the traditional approach if a property could not be separated from the materials that carry it since the trade of property rights is the same as the trade of the materials in this case. If the separation is possible, then the property rights approach will be substantially different from the traditional one. Traditional economics considers this kind of problem as externalities resulting from non-exclusivity. But or the economics of property rights, the degree of "externalities" is not exogenous as in traditional economics, but rather is endogenously determined in an economic system. For instance, there were many "externalities" in activities that generated inventions prior to the introduction of patent laws. These laws have substantially reduced such "externalities". The extent of "externalities" is determined by property rights and related contractual arrangements, which can be chosen by individuals. There is a tradeoff between the distortions generated by "externalities" and the costs of reducing them, so that eliminating all "externalities" are not efficient even though individuals can choose a level of "externality" or of vagueness of property rights.

6.2.4 Proposition 3 and the Efficient Extent of Externalities

Proposition 3 differs from the conventional wisdom of market failure which does not explain why the markets from some commodities, for example, clean air and intangible information, do not exist. The model formalizes the argument that the determination of contractual forms is a matter of the degree of vagueness in specifying and enforcing property rights, or, in less illuminating words, the degree of externality. The difference between the externalities in buying a pound of oranges and buying clean air is a difference of degree rather than difference of substance. When people buy oranges, there are externalities resulting from vagueness in weighing oranges and in estimating their quality. However, the equilibrium degree of vagueness in specifying and enforcing rights to oranges is much lower than to clean air because of much greater efficiency in specifying and enforcing property rights to oranges than to clean air.

The model also formalizes the idea that a decentralized market based on a private property system will find an efficient extent of externality. For some economic activities, the costs of specifying and enforcing property rights ar extremely high, so that the property rights cannot be delimited. Hence, no markets for such activities exist. The benefits and costs of such activities, not registered in markets, are commonly termed externalities. However, eliminating all such externalities is not efficient because of the costs of specifying and enforcing exclusive rights to property. The efficient extent of externality will balance the tradeoff between the welfare loss caused by the absence of markets and the costs of specifying and enforcing the property rights required for markets. Alternatively, a government may determine the appropriate tradeoff between the welfare losses resulting from externality and the costs of reducing it by a tax/subsidy scheme or by direct regulation. A positive economic analysis may compare the efficiencies of alternative economic systems in balancing this tradeoff. Nevertheless, a comparison between alternative institutional arrangements should include an analysis of the dynamic effects. For instance, a government post system may more efficiently balance a tradeoff between ex post transaction costs related to network externalities and ex ante transaction costs in specifying and enforcing rights to benefits arising from network effects in the short-run. However, a monopolized government post system will paralyse the function of a decentralized market in searching for efficient contractual arrangements to balance this tradeoff, so that the costs of a government post system may be much larger than its benefits in the long-run compared with a private post system. The government posy system prevents sophisticated contractual arrangements, such as some private post chain offices, from emerging. Such sophisticated contractual arrangements may more efficiently balance the above tradeoff in the long-run and will be more effective in exploiting new opportunities for better contractual arrangements created by new technology and new institutions than a government post system. This property rights approach to the problem of externalities is much more insightful than the theory of market failure, which attributes externalities to the inefficiency of the market.

Efficiency in specifying and enforcing property rights is determined by both the legal system and technical conditions. For example, low efficiency in specifying and enforcing property rights in pre-reform China can be attributed to a legal system that restrained free trade in labor, land, and capital, while low efficiency in specifying and enforcing property rights to clean air is due to the high cost of technology used to measure pollution.

6.3 Ending Up

In first part I presented the traditional approaches to the externality problem. Traditionally, externality conditions are associated with non-convexities and market failure. In Chapter 4, I gave a first hint about an alternative approach to externality problems, the property rights' approach. I argued that if property rights were adequately defined, the optimal allocation would be reached.

In the second part I completed this argument. I showed that with this approach, the economic system does not fail. Externality conditions do not induce fundamental non-convexities that lead market to failure. Externality conditions are transformed to a traditional interaction between agents through a market system. If there are some non-convexities in the economic system, these are due to non-convex firm's technologies or consumer's preferences. The main points in this approach are:

(a) Property rights are well-established and enforced,
(b) there are markets for these rights,
(c) there are explicit limits to rights and initial endowments to agents.

The existence of the market seems to depend on the existence of limits and initial endowments. Futhermore, the existence of initially endowments requires adequately defined rights. In Chapter 6 I proved that there is no market for a particular good if the level of efficiency in specifying and enforcing property rights to that good is sufficiently low. If we assume that it is feasible to adequately define property rights, then the problem of externality is shifted to the following problems:

(a) the problem of defining the legal system or institutions under which rights would be traded,
(b) the problem of determining the optimum limits of these rights.

In the end of Chapter 5 I gave a hint about these two problems. But, it isn't always feasible to define property rights. There are two main reasons. Firstly, since the basic values of a society limit the range of possibilities in which property rights may be defined. And secondly, because of the costs of defining rights and creating a market for them may be prohibitive.

The second reason is closely associated with the concepts of technology and information. Alternative technologies and complete information may reduce the costs of rights definition. And about the second reason, we cannot exclude the change of values over time, so the property rights approach remains an interesting counterposition.

Someone could charge me with having a sterile technical point of view. But, the historical process is the evidence of the opposite opinion. By looking at human development, we realize that the increasing scarcity of resources required the definition of property rights. Let me recall the discussion in Chapter 4. When land was in ample supply, property titles for land were not necessary. When people competed for the scarce good "land", property rights became relevant. Similarly, water once was a free good, but today property titles for water are well accepted. The evidence is the existed market for water. The continuing endangering wildlife species or fish induces institutional arrangements for conserving these resources. Thus, the property rights approach will remain interesting counterposition in the future.

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