where p^0 and p^1 are the initial and final price vectors over which the integral is taken. The areas to the left of Hicksian demand functions therefore represent changes in expenditure holding utility constant; these areas indicate the amount a consumer would be willing to pay (or have to be paid) to willingly accept some change in property rights, for example, a change in the purchase price of some good.

The area to the left of the Marshallian demand function, however, has no such easy interpretation, because unlike the Hicksian demands, the Marshallian demand functions are *not* in general the partial derivatives of some integral function; therefore the integrals of the Marshallian demands are not expressible in terms of changes in some well defined function of the initial and final prices and income levels. From Roy's equality, the Marshallian demands are the first partials of the indirect utility function *divided by the marginal utility of income*. Thus

$$-\int x_i^M \, dp_i = -\int (1/\lambda^M)(\lambda^M x_i^M) \, dp_i$$

$$= \int (1/\lambda^M)(\partial U^*/\partial p_i) \, dp_i.$$

However, if the marginal utility of money term is 'constant', that is, independent of prices, it can be moved in front of the integral sign; only then can this expression be integrated to yield a function of the endpoint prices (and money income):

$$-\int x_i^M \, dp_i = (1/\lambda^M) \int (\partial U^*/\partial p_i) \, dp_i$$

$$= (1/\lambda^M)[U(p^1) - U(p^0)].$$

Thus, in this case, the area to the left of the Marshallian demand function equals a change in utility divided by the marginal utility of money, thus converting that change in utility into units of money. Marshall's claim that the area to the left of a demand curve may be interpreted as a change in utility under the assumption of constant marginal utility of money is thus technically correct for the demand functions derived from utility maximization, though how much of the above discussion he had in mind can easily be debated.

The issue now becomes one of analysing the meaning of 'constancy' of λ^M, the marginal utility of money. Samuelson (1942) showed that λ^M cannot literally be a 'constant'. Since $\lambda^M = U_i/p_i$ and a proportionate change in prices and income leaves the goods consumed and hence the numerator of this expression unchanged, it follows that $\lambda^M(p_1, \ldots, p_n, M)$ must be homogeneous of degree -1. Therefore, λ^M can be independent of at most n of its arguments. It can, for example, be independent of all prices, but not income also, or it can be independent of $n-1$ prices and income.

Since $\partial U^*/\partial p_i = -\lambda^M x_i^M$ and $\partial U^*/\partial M = \lambda^M$, applying Young's theorem on invariance of partial derivatives to the order of differentiation yields (omitting superscripts)

$$-[\lambda \partial x_i/\partial M + x_i \partial \lambda/\partial M] = \partial \lambda/\partial p_i.$$

Suppose

$$\partial \lambda^M/\partial p_i = 0, \quad i = 1, \ldots, n.$$

Then

$$(M/x_i)(\partial x_i/\partial M) = -(M/\lambda)(\partial \lambda/\partial M) \quad \text{for} \quad i = 1, \ldots, n,$$

i.e. the income elasticities are all equal (necessarily to unity, from the budget constraint); thus the utility function must be homothetic. Denoting the Marshallian area CS, we have

$$CS = (1/\lambda^M)[U^*(p^1, M) - U^*(p^0, M)].$$

Thus for homothetic utility functions, where the indifference curves are all radial blow-ups of each other, the Marshallian area represents the unique monetary equivalent of a change in utility; the coefficient which converts utiles to money income is invariant over the price change.

Suppose now that λ^M is a function of one price only, say p_n. Then from the above equation, $\partial x_i^M/\partial M = 0$, $i = 1, \ldots, n-1$. Since there is no income effect for goods 1 to $n-1$, the Marshallian demand functions for those goods coincide with the Hicksian demands. This is the famous case of 'vertically parallel' indifference curves. Therefore the interpretation of the area to the left of any of these Marshallian demand curves is identical to the case of the Hicksian demands, that is, the willingness to pay to face the lower price.

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See also CONSUMERS' SURPLUS; GIFFEN PARADOX; INDIRECT UTILITY FUNCTION; MARSHALL, ALFRED.

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market clearing. *See* MONETARY DISEQUILIBRIUM AND MARKET CLEARING.

market failure. The best way to understand market failure is first to understand market success, the ability of a collection of idealized competitive markets to achieve an equilibrium allocation of resources which is Pareto optimal. This characteristic of markets, which was loosely conjectured by Adam Smith, has received its clearest expression in the theorems of modern welfare economics. For our purposes, the first of these, named the First Fundamental Theorem of welfare economics, is of most interest. Simply stated it reads: (1) if there are enough markets, (2) if all consumers and producers behave competitively, and (3) if an equilibrium exists, then the allocation of resources in that equilibrium will be Pareto optimal. (See Arrow, 1951, or Debreu, 1959.) Market failure is said to occur when the conclusion of this theorem is false; that is, when the allocations achieved with markets are not efficient.

Market failure is often the justification for political intervention in the marketplace (for one view, see Bator, 1958, section V). The standard argument is that if market allocations are inefficient, everyone can and should be made better off. To understand the feasibility and desirability of such Pareto-improving interventions, we must achieve a deeper understanding of the sources of market failure. Since each must be due to the failure of at least one of the three conditions of the First Theorem, we will consider those conditions one at a time.

The first condition requires there to be enough markets. Although there are no definitive guidelines as to what constitutes 'enough', the general principle is that if any actor in the economy cares about something that also involves an interaction with at least one other actor, then there should be a market for that something; it should have a price (Arrow,

1969). This is true whether the something is consumption of bread, consumption of the smoke from a factory, or the amount of national defence. The first of these examples is a standard private good, the second is an externality, and the third is a public good. All need to be priced if we are to achieve a Pareto-optimal allocation of resources; without these markets, actors may be unable to inform others about mutually beneficial trades which can leave both better off.

The informational role of markets is clearly highlighted by a classic example of market failure analysed by Scitovsky (1954). In this example, a steel industry, which must decide now whether to operate, will be profitable if and only if a railroad industry will begin operations within five years. The railroad industry will be profitable if and only if the steel industry is operating when the railroad industry begins its own operations. Clearly each cares about the other and it is efficient for each to operate; the steel industry begins today and the railroad industry begins later. Nevertheless, if there are only spot markets for steel, the railroad industry cannot easily inform the steel industry of its interests through the market place. This inability to communicate desirable interactions and to coordinate timing is an example of market failure and has been used as a justification for public involvement in development efforts; a justification for national planning. However, if we correctly recognize that there are simply too few markets, we can easily find another solution by creating a futures market for steel. If the railroad industry is able to pay today for delivery of steel at some specified date in the future then both steel and railroad industries are able to make the other aware of their interests through the marketplace. It is easy to show that as long as agents behave competitively and equilibrium exists the addition of futures markets will solve this type of market failure.

A completely different example of the informational role of markets arises when actors in the marketplace are asymmetrically informed about the true state of an uncertain world. The classic example involves securities markets where insiders may know something that outsiders do not. Even if it is important and potentially profitable for the uninformed actor to know the information held by the informed actor, there may not be enough markets to generate an efficient allocation of resources. To see this most clearly, suppose there are only two possible states of the world. Further suppose there are two consumers, one of whom knows the true state and one of whom thinks each state is equally likely. If the only markets that exist are markets for physical commodities then the equilibrium allocation will not in general be Pareto optimal. One solution is to create a contingent claims market. An 'insurance' contract can be created in which delivery and acceptance of a specified amount of the commodity is contingent on the true state of the world. Assuming both parties can, *ex post*, mutually verify which is indeed the true state of the world, if both behave competitively and an equilibrium allocation exists, it will be Pareto optimal, given the information structure. A more general and precise version of this theorem can be found in Radner (1968).

Analysing this example further we note that in equilibrium the prices of commodities in the state which is not true will be close to or equal to zero, since at positive prices the informed actor will always be willing to supply an infinite amount contingent on the false state, knowing delivery will be unnecessary. If the uninformed actor is clever and realizes that prices will behave this way in equilibrium then he can become informed simply by observing which contingency prices are zero. If he then uses this information which has been freely provided by the market, the equilibrium will be Pareto optimal under full information. In a very simple form, this is the idea behind rational expectations (see Muth, 1961). With clever competitive actors, it may not be necessary to create all markets in order to achieve a Pareto-efficient equilibrium allocation.

Completing markets seems to be an easy technique to correct market failure. The suggestions that taxes and subsidies (Pigou, 1932) or property rights reassignments (Coase, 1960) can cure market failure follow directly from this observation. However, an unintended consequence can sometimes occur after the creation of these markets. In some cases, adding more markets may cause conditions (2) and (3) of the First Theorem to be false. Curing one form of market failure can lead to another. To understand how this happens and how the second condition requiring competitive behaviour can be affected, consider the informed consumer in our previous example. If he realizes that the uninformed consumer is going to make inferences based indirectly on his actions then he should not behave competitively because he could do better by pretending to be uninformed. He can, by strategically limiting the supply of information of which he is the monopoly holder, do better than if he behaved competitively. It is only his willingness to supply infinite amounts of the commodity in the false state that gives away his knowledge. Supplying only a little commodity contingent on that (false) state in return for a small payment today would not allow the uninformed agent to infer anything and would allow the informed agent to make a profit from his monopoly position. This is not very different from the standard example of a violation of condition (2), monopoly supply of a commodity.

A different example of this phenomenon of unintended outcomes arises when markets are created to allocate public goods. It is now well known that the introduction of personal, Lindahl prices to price individual demands for a public good does indeed lead to Pareto-optimal allocations if consumers behave competitively (see Foley, 1970). However, under this scheme, each agent becomes a monopsonist in one of the created markets and, therefore, has an incentive to understate demand and not to take prices as given. This is the phenomenon of 'free riding', often alluded to as the reason why the creation of markets may not be a viable solution to market failure. To understand why, let us now examine the second condition of the First Theorem in more detail.

The second condition of the First Theorem about market success is that all actors in the marketplace behave competitively. This means that each must act as if they cannot affect prices and, given prices, as if they follow optimizing behaviour. Consumers maximize preferences subject to budget constraints and producers maximize profits, each taking prices as fixed parameters. This condition will be violated when actors can affect the values that equilibrium prices take and in so doing be better off. The standard example of market failure due to a violation of this condition is monopoly in which one actor is the sole supplier of an output. By artificially restricting supply, this actor can cause higher prices and make himself better off even though the resulting equilibrium allocation will be inefficient.

Can we correct market failure due to non-competitive behaviour? To find an answer let us first isolate those conditions under which agents find it in their interests to follow competitive behaviour. The work of Roberts and Postlewaite (1976) has established that if each agent holds only a small amount of resources relative to the aggregate available, then they will usually be unable to manipulate prices in any significant way and will act as price takers. It is the depth of the market that is important. This is also true when the

commodity is information. If each agent is informationally small, in the sense that he either knows very little or what he does know is of little importance to others, then he loses little by behaving competitively (see Postlewaite and Schmeidler, 1986). On the other hand, if he is informationally important, as in the earlier example, he may have an incentive to behave non-competitively. The key is the size of the agent's resources, both real and informational, relative to the market.

The solution to market failure from non-competitive behaviour then seems to be to ensure that all agents are both resource and informationally small. Of course this must be accomplished through direct intervention as in the anti-trust laws and the securities market regulations of the United States and may not be feasible. For example, it may not be possible to correct this type of market failure by simply telling agents to behave competitively. In such an attempt, one would try to enforce a public policy that all firms must charge prices equal to the marginal cost of output. But, unless the costs and production technology of the firm can be directly monitored, a monopolist can easily act as if he were setting price equal to marginal cost while using a false cost curve. It would be impossible for an outside observer to distinguish this non-competitive behaviour from competitive behaviour without directly monitoring the cost curve. If the monopolist were a consumer whose preferences were unobservable, then even monitoring would not help. In general, market failure from non-competitive behaviour is difficult to correct while still retaining markets. We will hint at some alternatives below.

Expansion of the number of markets can also lead to violations of the third condition of the First Theorem. For illustration we consider three examples. The first and simplest of these is the case of increasing returns to scale in production. The classic case is a product which requires a fixed set-up cost and a constant marginal cost to produce. (More generally we could consider non-convex production possibilities sets.) If the firm acts competitively in this industry and if the price is above marginal cost the firm will supply an infinite amount. If the price is at or below marginal cost the firm will produce nothing. If the consumers' quantity demand is positive and finite at a price equal to marginal cost, then there is no price such that supply equals demand. Equilibrium does not exist. The real implication of this situation is not that markets do not equilibrate or that trade does not take place, it is that a natural monopoly exists. There is room for at most one efficient firm in this industry. Again it is the assumption of competitive behaviour which is ultimately violated.

The next example, due to Starrett (1972), involves an external diseconomy. Suppose there is an upstream firm that pollutes the water and a downstream firm that requires clean water as an input into its production process. It is easy to show that if such a diseconomy exists and if the downstream firm always has the option of inaction (i.e. it can use no inputs to produce no outputs at zero cost), then the aggregate production possibilities set of the economy when expanded to allow enough markets cannot be convex. (See Ledyard, 1976 for a formal proof.) If the production possibilities set of the economy is non-convex then, as in the last example, it is possible that a competitive equilibrium will not exist. Expansion of the number of markets to solve the inefficiencies due to external diseconomies can lead to a situation in which there is no competitive equilibrium.

The last example, first observed by Green (1977) and Kreps (1977), arises in situations of asymmetric information. Recall the earlier example in which one agent was fully informed about the state of the world while the other thought each state was equally likely. Suppose preferences and endowments in each state are such that if both know the state then the equilibrium prices in each state are the same. Further, suppose that if the uninformed agent makes no inferences about the state from the other's behaviour then there will be different prices in each state. Then no (rational expectations) equilibrium will exist. If the informed agent tries to make inferences the prices will not inform him, and if the uninformed agent does not try to make inferences the prices will inform him. Further, it is fairly easy to show that if a market for information could be created (ignoring incentives to hide information) the resulting possibilities set is in general non-convex. In either case there is no equilibrium.

Most examples of non-existence of equilibrium seem to lead inevitably to non-competitive behaviour. In our example of non-existence due to informational asymmetries, it is natural for the informed agent to behave as a monopolist with respect to that information. In the example of the diseconomy, if a market is created between the upstream and the downstream firm, each becomes a monopoly. If there is a single polluter and many pollutees, the polluter holds a position similar to a monopsony. The non-existence problem due to the fundamental non-convexity caused by the use of markets to eliminate external diseconomies is simply finessed by one or more of the participants assuming non-competitive behaviour. An outcome occurs but it is not competitive and, therefore, not efficient.

Market failure, the inefficient allocation of resources with markets, can occur if there are too few markets, non-competitive behaviour, or non-existence problems. Many suggested solutions for market failure, such as tax-subsidy schemes, property rights assignments, and special pricing arrangements, are simply devices for the creation of more markets. If this can be done in a way that avoids non-convexities and ensures depth of participation, then the remedy can be beneficial and the new allocation should be efficient. On the other hand, if the addition of markets creates either non-convexities or shallow participation, then attempts to cure market failure from too few markets will simply lead to market failure from monopolistic behaviour. Market failure in this latter situation is fundamental. Examples are natural monopolies, external diseconomies, public goods, and informational monopolies. If one wants to achieve efficient allocations of resources in the presence of such fundamental failures one must accept self-interested behaviour and explore non-market alternatives. A literature using this approach, sometimes called implementation theory and sometimes called mechanism design theory, was initiated by Hurwicz (1972) and is surveyed in Groves and Ledyard (1986).

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See also COASE THEOREM; ECONOMIC ORGANIZATION AND TRANSACTIONS COSTS; EXTERNALITY; INCENTIVE COMPATIBILITY; INCOMPLETE CONTRACTS; INCOMPLETE MARKETS; LAW AND ECONOMICS; ORGANIZATION THEORY; PARETO OPTIMALITY; PROPERTY RIGHTS; REVELATION OF PREFERENCES; STRATEGY-PROOF ALLOCATION MECHANISMS; WELFARE ECONOMICS.

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marketing boards. With trivial exceptions, marketing boards for agricultural products fall into two distinct categories: first, boards endowed by government with monopoly power in the sale of controlled products; second, marketing boards similarly endowed with monopsony power in the purchase of controlled products. The former function mainly in advanced countries, the latter in certain poor countries.

I. To be effective, monopolistic action in a particular country requires official support and enforcement because of the multiplicity of producers of standardized commodities and the availability of imports. Without such support, agricultural markets approximate the model of perfect competition of the textbooks.

Concerted action to raise farm prices was often tried during the interwar period, and occasionally even earlier. These attempts failed because of incomplete market control. In the early 1930s, farm prices declined sharply, partly as a result of the expansion of capacity, and partly as a result of the depression. Under the influence of political pressure and because of social considerations, many governments wished to arrest the decline of farm prices and incomes. In many instances fiscal considerations were thought to preclude direct subsidies. Again, prohibition or control of competing imports was of no avail to producers of some important perishable commodities such as liquid milk and main crop potatoes. State supported or organized monopolies, termed marketing boards, were among the instruments introduced for maintaining or raising farm prices and incomes in a politically and administratively practicable and politically painless manner. The boards set up under the British Agricultural Marketing Acts of 1931 and 1933 are examples of marketing boards effectively controlled by producer representatives (Astor and Rowntree, 1938; Bauer, 1948; Warley, 1967).

The methods used by marketing boards to raise returns to producers include the following: acreage restriction (as with hops and potatoes); direct or indirect restriction of the amounts producers may market (as with potatoes); and the exercise of discriminating monopoly power, with higher prices in sheltered markets and lower prices in exposed markets (in milk, the liquid market and the market for processed products respectively).

The raising of prices and farm incomes are the objectives and principal effects of these marketing boards. Some other features of these boards and their operations may be of greater interest than this banal result. (a) The acreage restrictions under the potato and hops schemes conferred windfall profits on the owners of land that had quotas attached to it. (b) The boards encouraged and supported cartels of processors and distributors, and also minimum resale and retail prices for the controlled commodities. These arrangements, an example that monopoly breeds monopoly, were *prima facie* surprising since they reduced the share of the prices paid by consumers that went to the farmers. The reasons behind them may have been a wish to placate distributors and processors, or to benefit the minority of producers who were also retailers. But it appears that the Milk and Potato Boards, at any rate, were also misled by inappropriate analogy with those manufacturers of branded goods who were practising resale price maintenance. (c) The boards, established to assist farmers at the time of a sharp fall in prices and incomes, were retained, and new ones created, in radically different postwar conditions – an example of the self-perpetuating character of organizations established by governments. (d) The system involved decisions at two levels, namely the boards and the individual producers. The former were faced with sloping demand curves. In the absence of production or marketing quotas, the individual producer faced a horizontal demand curve. With such quotas, the producer faced a demand curve which was horizontal up to the assigned quota and then became vertical (or nearly so).

II. Marketing boards of the second type by statute have the sole rights to buy the designated produce for exports. During World War II, marketing boards of this type were set up in the former British West African colonies for cocoa, palm oil, palm kernels and groundnuts, and subsequently for cotton. The produce was bought for the boards by merchants as their agents. During the war and early postwar years these agents bought the controlled produce for export on the basis of official quotas calculated accounting to their prewar performance. Agents who exceeded their quotas paid large penalties to those who had underbought, the settlement being effected through the boards. The declared purpose of these arrangements was to prevent a collapse in the local price of coca (feared because of shortage of shipping and the closure of major outlets, notably Germany), and to encourage the exports of the other crops (required by the loss of Far Eastern supplies).

These arrangements were anomalous. The British Government in any case had undertaken to purchase the entire exportable output at seasonally fixed prices, so that the market available to local producers was unlimited at those prices. Monopsony of export and the imposition of buying quotas were unnecessary to maintain the local price of cocoa, and deterred the production and exports of the other crops. The statutory monopsony *cum* quota system had been proposed in 1939 by a trade association of the major West African merchants. The quota system in effect provided statutory enforcement for their restrictive prewar marketing sharing agreements, which had limited success both because of