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Pareto Optimality and Grand Utility Possibility Frontier

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1. Introduction

An optimum allocation of resources in an economy is the one that maximizes social welfare. Italian economist Vilfredo Pareto was the first one to differ from this traditional approach. To understand the concept of Pareto Otimum it is important to distinguish between the concept of Pareto improvement and Pareto optimality.

Pareto Improvement

Pareto improvement takes place if a change is made in the distribution of goods or resources that result in at least one individual becoming better off than before the change while no other individual becomes worse off. The concept of Pareto optimum or economic efficiency states that any redistribution of economic resources that makes someone better off without harming anybody, improves social welfare**.**

Pareto Optimality

Pareto optimality describes a situation in which resources are distributed such that it is not possible to improve a single individual without also causing at least one other individual to become worse off than before the change. Another way of explaining Pareto optimality is to describe a situation as Pareto optimal when no Pareto improvement is possible and it is impossible to improve the condition of any one individual without making any other individual worse off.

First-Order Conditions (Marginal) Conditions of Pareto Optimality

Pareto stated that competition leads the society to an optimum position. But he did not specify any condition for the achievement of optimum position. Afterwards, Lerner and Hicks derived the marginal conditions that need to be fulfilled to attain Pareto optimum. These marginal conditions are based on the certain assumptions:

a) Each individual has his own ordinal utility function and possesses definite amount of each product and factor.
b) Production function of every firm and technology is given and remains constant.
c) Goods are perfectly divisible.
d) Each producer aims at producing a given output with the least-cost combination of factors.
e) Every individual wants to maximize his satisfaction.
f) Every individual purchases some quantity of all goods.
g) All factors of production are perfectly mobile.

Given these assumptions following marginal conditions (first-order conditions) are required to be fulfilled to achieve Pareto optimum or maximum social welfare:

1. Consumption efficiency
2. Production efficiency
3. Product-mix efficiency

1. Efficiency in consumption requires the distribution of available goods in such a way so that the marginal benefit of consuming an additional unit of good X for consumer A is equal to that of consumer B.

2. Efficiency in Production requires the fulfillment of three conditions viz. (a) efficient input choice for a single firm, (b) efficient input choice across firms, and (c) efficient output choice across firms. A brief description of these conditions is given below.

2a.Efficiency in production requires the allocation of available inputs between the production of two goods X and Y in such a way so that the marginal rates of technical substitution (MRTS) are equalized between the goods. That is $MRTS_X = MRTS_Y$

2b.Efficiency in production requires that input resources must be allocated across the firms so that the marginal physical product (MPP) of any input in the production of some good is the same no matter which firm produces that good. That is MPPL1 = MPPL2 and MPPK1 = MPPK2

2c. Efficiency in production requires that firms producing the same outputs must operate at those points on their respective production possibilities frontiers at which their marginal rates of product transformation (MRT) are equalized. That is MRT1 = MRT2

3. Product-mix efficiency requires that the allocation of inputs and outputs among the firms and individuals must be such that the producer's marginal rate of transformation of X for Y is equal to consumers' marginal rate of utility substitution of X for Y. That is MRT = MRUS. This Condition ties together the preferences and productive capabilities according to which the end goal of production must be the satisfaction of individual preferences.

Second Order and Total Conditions of Pareto Optimality

To attain maximum social welfare position the second-order conditions along with the marginal conditions must be satisfied. The second order conditions require that all the indifference curves must be convex to the origin and all the transformation curves are concave where the marginal conditions are satisfied.

But even the fulfillments of both the first and second order conditions do not ensure maximum welfare because even when first and second order marginal conditions are fulfilled, it may still be possible to move to another position where social welfare is greater. To attain maximum social welfare, another set of conditions stated by J.R. Hicks as 'total conditions' must also be satisfied. 'Total conditions' say in order to attain maximum welfare, it must be impossible to increase welfare by producing a product not otherwise produced or by using a factor not otherwise used.

2. Walras Law

The Walras law states that the markets are interdependent and all the individual transactors (a household, a firm, or the government) take into account their budgetary constraints when they formulate purchase and sales plans. The price at which final transaction take place would follow the price adjustment rule which say that the price should be raised if there is positive excess demand and reduced if there is negative excess demand.

According to Walras Law the value of the sum of all excess demands must equal zero whether or not the system is in equilibrium. This implies that for each individual transactor, the total value of planned supply must exactly equal the total value

of planned demand. This means that at the individual level there is neither excess demand nor excess of excess supply. It follows by simple aggregation that the aggregate market value of supply equals the aggregate market value of demand for any set of prices, not just the equilibrium set of prices. Thus Walras law refers to the aggregation of the markets for final goods and services along with the markets for raw materials, labor, and capital.

Although Walras law asserts the logical impossibility of oversupply in all markets taken together, it does not rule out the possibility of there being an oversupply in a particular market, such as the market for final goods and services, taken alone. Equilibrium in a market is a situation in which the price of the commodity is such that the supply of the commodity is equal to the demand for it. Because there can be neither excess supply nor excess demand in the aggregate, it follows that if all but one of the markets in an economy are in equilibrium, then the other market also must be in equilibrium.

The welfare properties of the Walrasian general equilibrium theory can be summarized with the help of the two well-known fundamental theorems of welfare economics. The first of these theorems states that any Walrasian allocation is a Pareto efficient allocation as well. The second theorem states that every Pareto efficient resource allocation can be attained through a competitive market mechanism, with appropriate initial redistributions.

An allocation is said to be Pareto efficient if there is no other feasible allocation where at least one individual transactor is strictly better off while nobody else is worse off. In the context of Edgeworth box economy, the first theorem implies that if the economy is in a Walrasian equilibrium, then there is no alternative feasible allocation at which every individual transactor is at least as well off and some other individual transactor is strictly better off. In other words, there is no way for the individual transactors of this economy to collectively agree to move to a different feasible allocation. If they moved from the market equilibrium, somebody would certainly be worse off.

3. Social Welfare Function and Utility Possibilities Frontier

The social welfare function provides a ranking of alternative situations in which different individuals enjoy different levels of utilities. If the economy consists of two individuals, the social welfare function could be represented by a set of social indifference curves. Each social welfare curve is the locus of points that join together different combinations of utilities of goods X and Y, which yield the same level of social welfare. Higher social welfare function represents higher level of social welfare. With such a set of social welfare functions, alternative situations in the economy can be evaluated.

4. Grand Utility Possibilities Frontier

Utility Possibilities Frontier

A utility possibilities frontier is the locus of points that join together alternative combinations of utility received by individuals A and B (i.e. U_A and U_B) when the simple economy of

the two individuals A and B is in equilibrium of exchange. By assigning utility rankings to each individual for the exchange of goods, the utility possibilities frontier UU is derived as shown in fig.1.

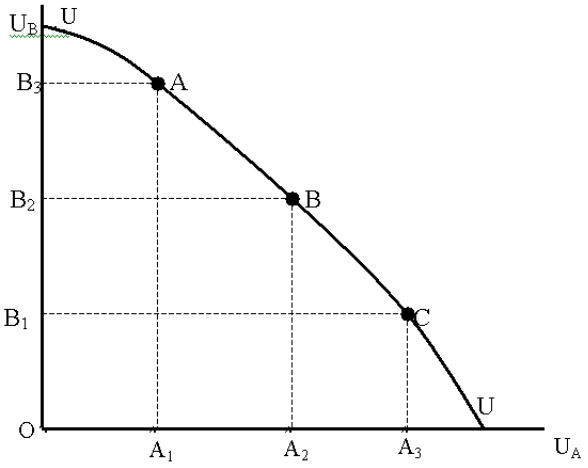

Fig.1: Utility Possibilities Frontier

Points A, B and C on fig.1 are obtained by transferring the amounts determined by the intersection of indifference curves representing General Equilibrium of Production and Exchange in the previous part (fig.4). By joining points A, B and C in fig.1 a utility possibilities frontier UU is derived.

The grand utility possibilities frontier is derived from various utility possibilities frontiers. Grand utility possibilities curve is the envelope of utility possibilities frontiers at Pareto optimum points of production and exchange. It indicates that no reorganization of production-exchange process is possible that could make someone better off, without at the same time making some one worse off. It is important to note that the utility possibilities frontier UU in fig.1 has been derived from the contract curve of

exchange drawn from Point 0_A to O_B on the production possibility frontier (TT) representing General Equilibrium of Production.

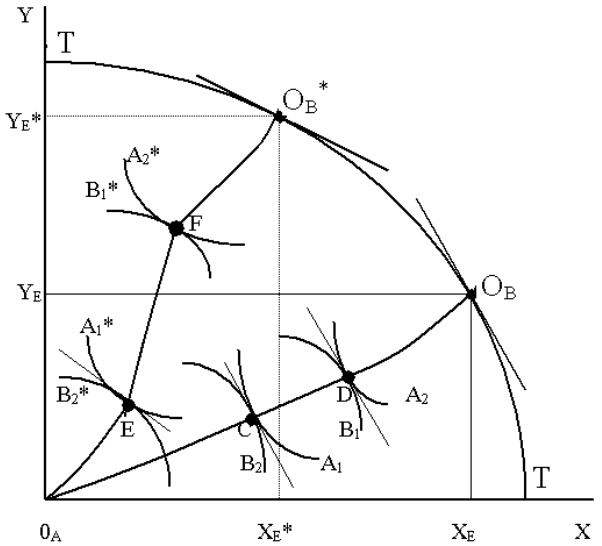

Fig.2: Derivation of Grand Utility Possibilities Frontier

If we choose another point on the production possibilities frontier in that figure we can construct another Edgeworth box diagram and get another contract curve of exchange other than O_AO_B shown by the curve from point 0_A to O_B* in fig.2. Then, we can transfer the exchange contract curve into the utility space in order to get another utility possibilities frontier.

Before we transfer the contract curves from fig.2 into fig.3, it is important to note that (I) the number of indifference curves as shown in the Edgeworth box are reduced. In fig.2 this is reproduced with slight modification (II) while the Edgeworth Box in (Fig.2) denoted by $0_AY_E*0_B*X_E*$ implies there is more of commodity Y and less of commodity X, the Edgeworth Box denoted $0_AY_E0_BX_E$ implies that there is more of commodity X and less of Y in the economy. It follows therefore that

the indifference curves on the contract curve 0_A0_B contains more of commodity X and less of commodity Y while indifference curves on the contract 0_A0_B* contain more Y and less of commodity X.

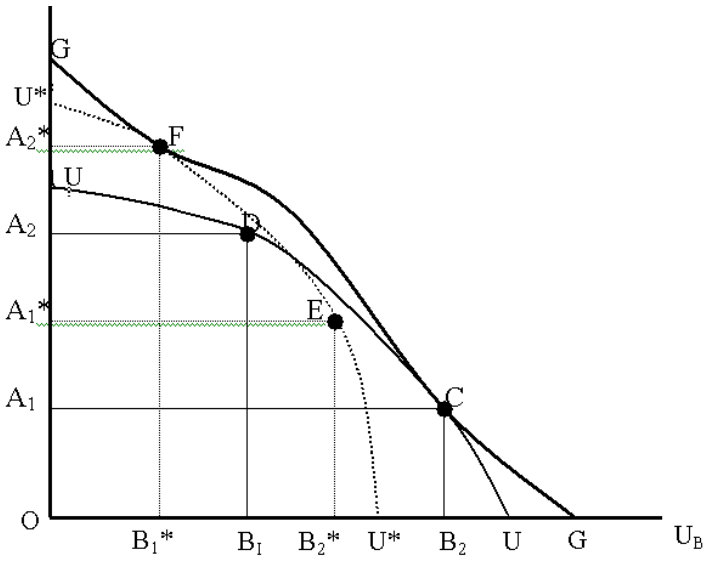

Fig. 3: Grand Utility Possibilities Frontier

Now, the Edgeworth contract curve of exchange from fig.2 can be transferred into fig.3. It is important to note that point F in fig.3 is derived by mapping the indifference curves B_1* and A_2* from fig.2 into fig.3. Similarly point E is derived by mapping indifference curves A_1* and B_2*. The utility possibilities frontier U*U* is drawn by joining points F and E from the Edgeworth box of exchange denoted by 0_AY_E*0_B*X_E*. Since there are infinite numbers of points on the Production Possibility Frontier in fig.2, there must be infinite number of utility possibility curves, each such curve for each commodity mix on the production possibility curve.

The grand utility possibilities frontier is denoted by the curve GG in the fig.3. As stated before, it is an envelope of utility

possibility frontiers at Pareto optimum points of production and exchange. It may be noted that UU is the utility possibilities curve derived from Edgeworth box of exchange denoted by $0_AY_E0_BX_E$ in Fig.2. Similarly point D is derived by mapping the indifference curves denoted by A_2 and B_1 while point C is derived by mapping indifference curves denoted by A_1 and B_2 in Fig.2.

The grand utility possibilities frontier shows all the Pareto optimal combinations of utility that the consumers may derive from the consumption of all possible combinations of goods that are produced when inputs are used in the most efficient manner possible.

5. Welfare Maximization

Social welfare is maximized at the point of tangency of the grand utility possibility frontier with the highest possible social indifference curves. This point is called 'the point of bliss' or 'constrained bliss'. In fig.4 the social indifference curve W_3 is tangent to the grand utility possibility curve UU' at point W*. Thus, point W* represents the maximum possible social welfare given the factor endowments, state of technology and preference scales of the individuals.

Point W* is called the 'point of constrained bliss' because of the constraints regarding factor endowments and the state of technology. W* is the highest possible state of social welfare which the society can attain. The two consumers will enjoy the levels of utility U^*_A U^*_B.

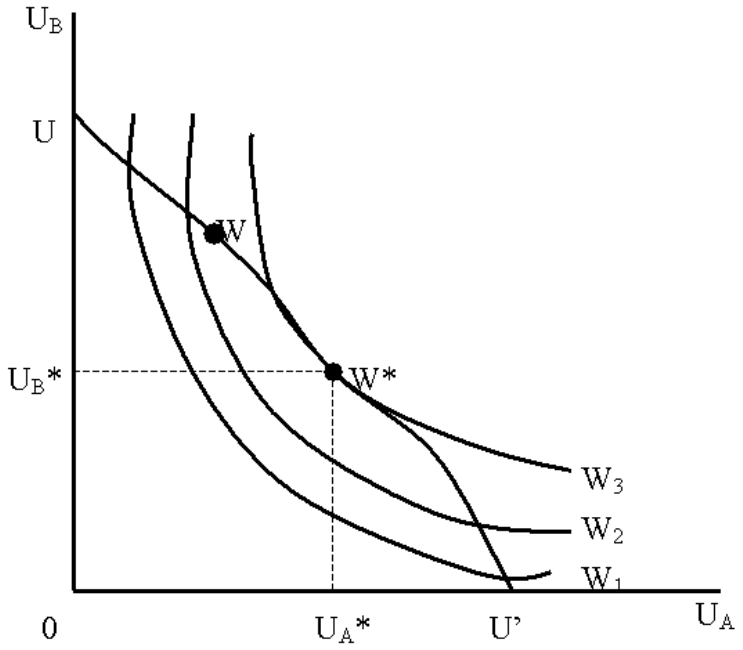

Fig.4: Maximization of Social Welfare

Fundamental Theorems of welfare economics

There are two fundamental theorems of welfare economics. The first theorem states that every competitive economy is Pareto efficient. The second theorem states that every Pareto efficient resource allocation can be attained through a competitive market mechanism, with appropriate initial redistributions.

The first theorem appears to make a case for non-intervention by the government. The theorem is often taken to be an analytical confirmation of Adam Smith's "invisible hand" hypothesis, namely that competitive markets tend to bring the efficient allocation of resources.

The second theorem states that out of many possible efficient outcomes, one can achieve any particular efficient outcome by redistribution of wealth and then letting the market take over. This appears to make the case for government intervention to achieve planned redistribution and social welfare.

Implications of First and Second Welfare Theorem

I. The First Fundamental Theorem, or Laissez-Faire Leads to the Common Good.

The First Theorem establishes that a competitive equilibrium is for the common good. The traditional definition looks to a measure of total value of goods and services produced in the economy. However, the modern interpretation of 'common good' typically involves Pareto optimality, rather than maximized gross national product (GNP). Obviously saying that a situation is Pareto optimal is not the same as saying it maximizes GNP, or that it is best in some unique sense. There are generally many Pareto optima. No one would argue that society should settle for a situation that is not optimal, because if situation A is not optimal, there exists situation B that all prefer. The first fundamental theorem is subject to some drawbacks:

(a) It ignores the preferences of consumers. The real economy is never in equilibrium, most markets are characterized by excess supply or excess demand. While the economy is dynamic as the tastes and technology are constantly changing, the model assumes they are fixed.
(b) It assumes competitive behavior, whereas the real world is full of monopolists.
(c) It assumes there are no externalities. While in an exchange economy the externalities are dominant.
(d) Laissez-faire may produce a Pareto optimal outcome, but there are many different Pareto optima, and some are fairer than others.

II. The Second Fundamental Theorem of Welfare Economics.

The Second Fundamental Theorem assumes that all the individuals and producers are price takers. Then almost any

Pareto optimal equilibrium can be achieved via the competitive mechanism, provided appropriate lump sum taxes and transfers are imposed on individuals and firms.

One version of the Second Theorem is restricted to a pure production economy, which is subject to an old debate about the feasibility of socialism. Anti-socialists like Von Mises (1937) argued that information related problems would make it impossible to coordinate production in a socialist economy. On the other hand the pro-socialists, particularly Lange, argued that the Central Planning Board would overcome those problems.

6. Summary

Welfare economics, among other things, studies the conditions under which optimal solutions to the general equilibrium model can be achieved. This requires, among other things, an optimal allocation of factors among commodities and an optimal allocation of commodities among consumers.

The achievement of Pareto optimal state in the economy required the fulfillment of some marginal conditions. Although Pareto optimality is necessary but it is not the sufficient condition for the maximization of social welfare. The social welfare function provides a ranking of alternative states in which different individuals enjoy different levels of utilities. Grand possibility utility curve is the envelope of utility possibility frontiers at Pareto optimum points of production and exchange. Social welfare is maximized at the point of tangency of the grand utility possibility with the highest possible social indifference curves.