# CHAPTER 2
# THEORIES

## 2.1 Economic Foundation

Price mechanism in economic term theories refers to the behavior of demand and supply optimized through prices and quantities of products. It is essential that the price mechanism work only in competitive markets. It can be described in detail by consumers' choice, producers' behavior and equilibrium point of the market. Furthermore, it is shown a theoretical effect of increasing electricity price on market in the end of this section.

### 2.1.1 Consumer Choice

The consumers will face the economic facts. They need to allocate their limited disposable income to buy goods and services [14]. In economic terms this is a budget constraint where the consumers would buy the combination of products and service within their limited budget. Figure 2.1 shows consumer utility function with a budget constraint line. The slope of budget constraint line is depicting the spending trade off of one product against the other. An amount of one product must be sacrificed in order to buy more of the other. The utility function illustrates all combinations of products that meet the same preference of consumers. Due to the law of diminishing marginal utility, the utility function has a downward trend. The consumer selects product combinations at point A to maximize utility. Economic shocks in CGE model lead to changes in consumer demand. For example, the effect of income changes lead to a change in the quantities of products and services that consumers purchases because budget constraint line move to right side and intersection with higher utility function.

Energy demand could follow this theory as well. When the price of energy increases while product prices are maintained, it shows that consumers consume less. Figure 2.2 shows the effects of the energy price increases. This will give another point on the demand curve.

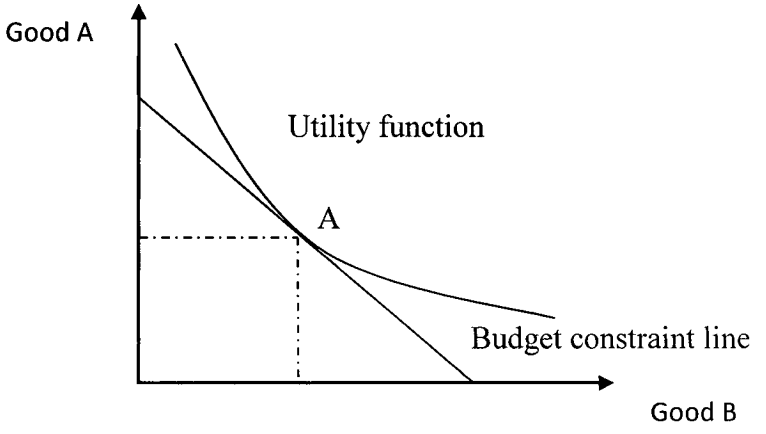


Figure 2.1 Consumer utility functions with a budget constraint

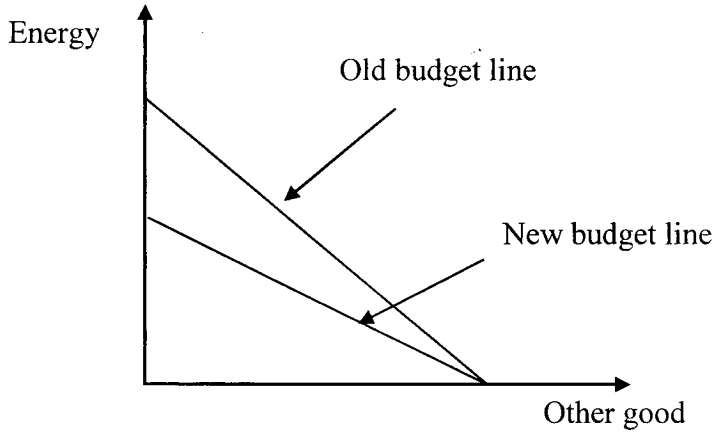


Figure 2.2 Energy price increase effect on budget line while prices of other goods are unchanged

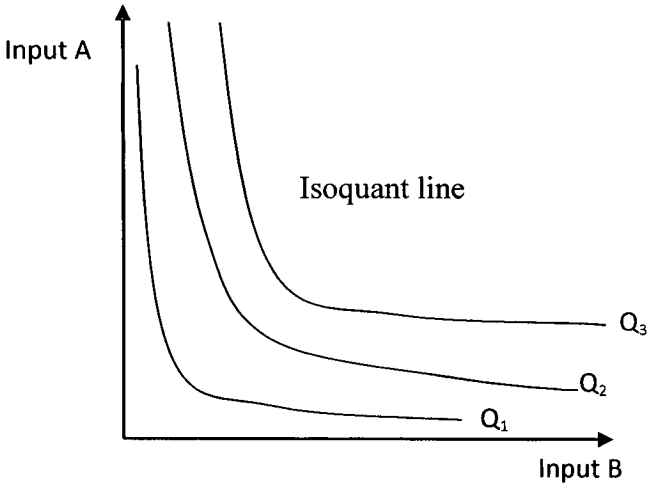


Figure 2.3 Isoquant lines for different outputs of production

### 2.1.2 Producer's behavior

Producers definitely try to earn as much profit as possible. To explain it more clearly, we must run back over the background definitions. Firstly, production is the process of combining inputs to make products and services [14]. Inputs of production includes four resources, land, labor, capital, entrepreneur, and intermediate input. Next, producers select the methods to turn input into output. Thus, producers would try to find those combinations of inputs and appropriate technology that would minimize cost of production. The least cost input mix could be achieved by graphical technique known as isoquant line. Figure 2.3 shows isoquant line with different outputs. The isoquant line depicts possible input mixes which produce the same quantity of output. Figure 2.3 illustrates that an increase in one input results in a decrease in other input to maintain production output. This is the reason the isoquant always slopes downward. The higher isoquant in the table the higher the production output using more input. The producers have limited investment costs otherwise

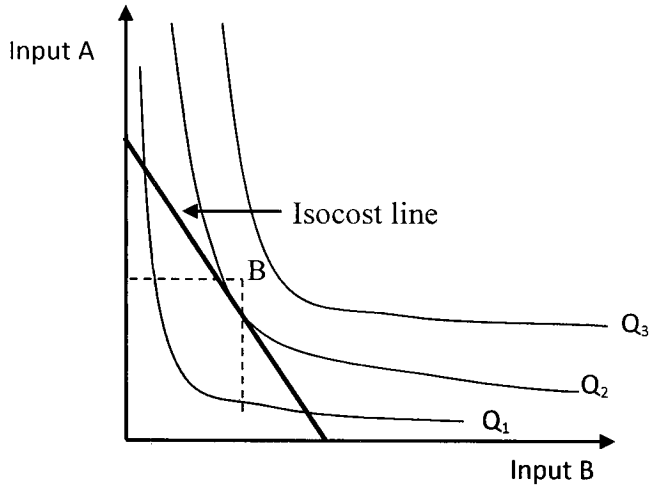


Figure 2.4 Isoquant lines with isocost line

they would make infinite profit. It is called an isocost line which is similar to the budget line in that it shows the combinations of two products that result in the same cost. According to theoretical concept, the least cost input for any level of output is the point where the isocost line is tangent to the isoquant [15] point B as shown in Figure 2.4.

### 2.1.3 Elasticity

Describe the responsiveness of supply and demand to changes in relative prices and income. In the CGE model, the types of elasticity depend on the types of production and utility function assumed in the model.

#### 2.1.3.1 Supply Elasticity Parameters

Factor Substitution Elasticity shows a relation to the demand of factors of production, such as labor and capital. It depicts the flexibility of a production technology to allow changes in the quantity ratios of factors used in the production giving a level output relative to price changes [16]. For example, producers could substitute one worker with an amount of capital or vice versa. If the parameter is zero, the factors are complements and producers must use a fixed ratio of capital and labor. To conclude, it illustrates how easy it is to substitute one input for other.

Export Transformation Elasticity shows the relation to the industry's export supply. It describes the technological ability of an industry to transfer its products between domestic and exported products. If the parameter has a low absolute value, it means the resources used in the production are relatively difficult to transform into the production of the other products.

#### 2.1.3.2 Demand Elasticity Parameter

Elasticity of substitution in consumption expresses the percentage change in the quantity ratio of product Y to product X given the percentage changes in price ratios of product X to Y. It depicts how price changes in one product could have an effect on quantity consumption of the other product. The larger this parameter the more east it is to shift to another product.

### 2.1.4 Equilibrium point

The equilibrium point of the whole economy occurs when the set of agents such as producers, consumers, workers and investors are satisfied with the quantities of goods they produce and consume, the number of hours they work, etc. When the market is in equilibrium as shown in Figure 2.5, the price and quantity of products are satisfactory to producers and consumers alike and they will remain constant unless the supply or the demand curve change.

### 2.1.5 Theoretical effects of increasing electricity prices

When the electricity price increases, the production and the supply curves will shift on the left-hand side from $S_1$ to $S_2$ curve. Where the aggregate demand curve is constant, new equilibrium price will increase from $P_1$ to $P_2$ then demand declines from $Q_1$ to $Q_2$, shown in as Figure 2.6.

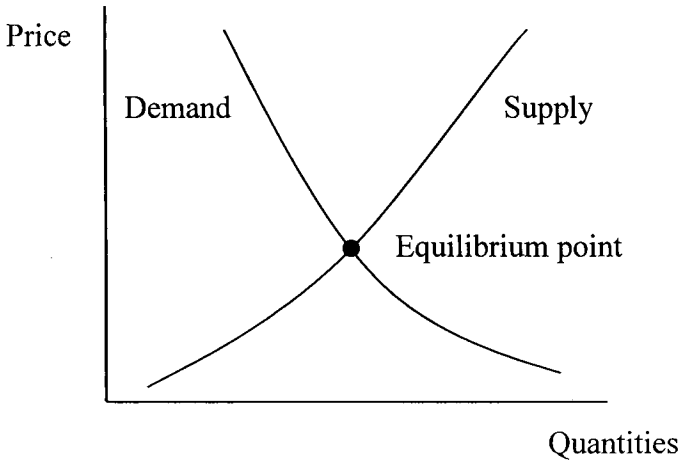


Figure 2.5 Equilibrium point

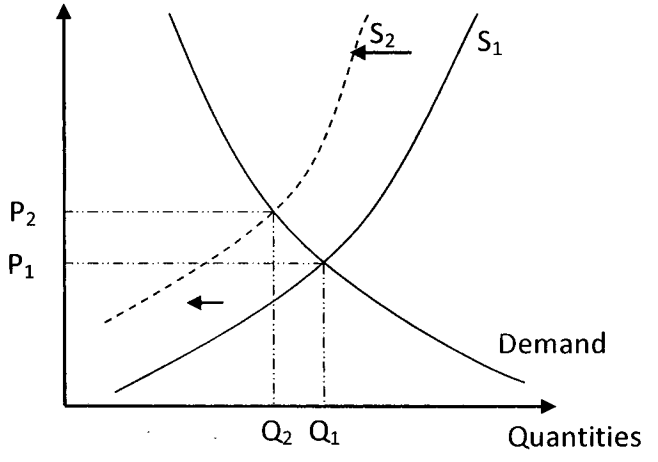


Figure 2.6 Impact of electricity price increasing on supply curve

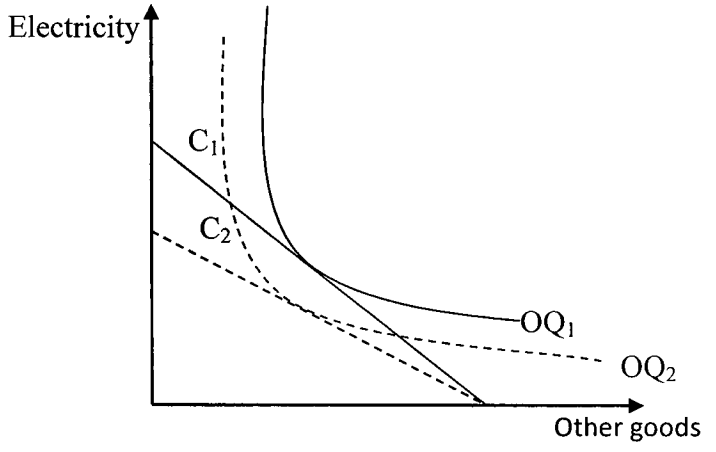


Figure 2.7 Impact increasing of electricity price on producers' behavior

On the supply side, it is assumed that production needs two types of input: electricity and other products. The initial level of output of product is $OQ_1$ under isocost ($C_1$). With increasing electricity price, isocost will be changed to $C_2$ then fewer products are produced as per $OQ_2$ in Figure 2.7.

## 2.2 Computable General Equilibrium Modeling (CGE model)

The CGE model is an economic model that depicts the market in a quantitative manner. Each term of the CGE model can be clearly described in this model. The term *computable* means this model is able to numerically calculate the effect of a shock on an economy as well as describing through theories. The term *general* means that the model covers all economic activity including production, consumption, employment, tax, savings, and trade. In this term, it is shown everything depends on everything else. The final term *equilibrium* means that the economy is in equilibrium when supply and demand are in balance with some set of prices and quantities and will remain constant unless supply and demand changes. According to the definition it can calculate a new equilibrium point in an economy when a new policy or mitigation is implemented by stimulating customers' behavior, production's behavior. Its equations describe producer and consumer behavior and impose market clearing constraints. It needs an accurate database which depicts the circular flow income and spending in a national economy during a specific time period. In the current state the CGE model is widely used by government organizations and academic institutions to analyze the effects on the economy as a result of events such as climate change, tax policies and immigration [16].

### 2.2.1 Social Accounting Matrix (SAM)

The Social Accounting Matrix (SAM) is the main database for the CGE model and it reports the values all of all transactions in the circular flow of national income and expenditures as shown in Fig 2.8.

Figure 2.8 shows the basic economic structure and financial flow. It shows the complete demand for production when firm hire factors of production such as labor, capital, wages and rent. The factor payments accrue to the private household sector as wage and capital rent income. Households spend their income on goods and services, pay tax and save. The government uses tax revenue to buy goods and services, and investors use savings to l invest in goods for use in the future production.

SAM is written in a matrix-form table. The agents in the model are represented by rows and columns. Each cell shows the payment from the account of its column to the account of its row. Therefore, the income of each agent appears along its row and its expenditures down its column. The principle of constructing SAM requests that the total amount of income equal to the total amount of expenditure. Table 2.1 shows a basic SAM structure for the CGE model. With regard to the structure of the SAM, it is consists of the following:

1. Activities
2. Commodities
3. Primary factors such as labor and capital
4. Household
5. Government
6. Enterprise
7. Saving-investment
8. Trade (rest of the world)

Normally SAM is constructed by using the official Input-Output database which is produced once every few years. The coefficients and exogenous variables are calculated by using SAM.

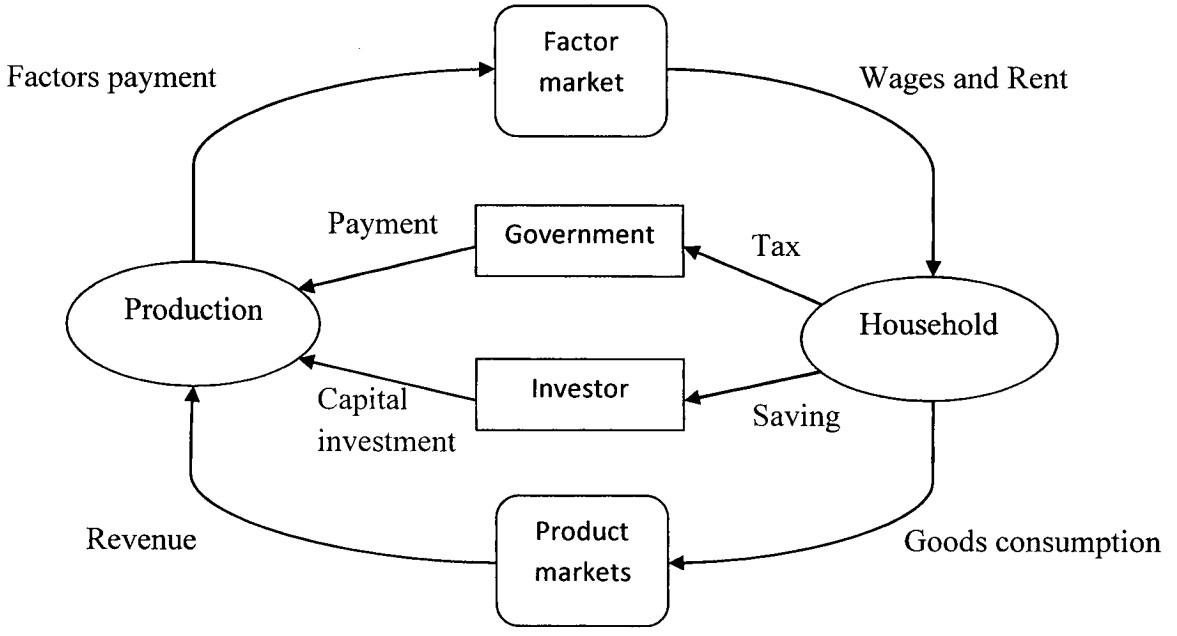


Figure 2.8 The circular flow income and expenditure

Table 2.1 Basic SAM structure for CGE model [17]

| | Expenditures | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Receipts** | **Activities** | **Commodities** | **Factors** | **Households** | **Enterprises** | **Government** | **Savings-Investment** | **Rest of the World (ROW)** | **Total** |
| Activities | | Marketed outputs | | Home-consumed outputs | | | | | Activity income (gross output) |
| Commodities | Intermediate inputs | Transaction costs | | Private consumption | | Government consumption | Investment | Exports | Demand |
| Factors | Value-added | | | | | | | Factor income from ROW | Factor income |
| Households | | | Factor income to households | Interhousehold transfers | Surplus to households | Transfers to households | | Transfers to households from ROW | Household income |
| Enterprises | | | Factor income to enterprises | | | Transfers to enterprises | | Transfers to enterprises from ROW | Enterprise income |
| Government | Producer taxes, value-added tax | Sales taxes, tariffs, export taxes | Factor income to government, factor taxes | Transfers to government, direct | Surplus to Government, direct enterprise taxes | | | Transfer to Government from ROW | Government income |
| Savings-Investment | | | | Household savings | Enterprise savings | Government savings | | Foreign savings | Savings |
| Rest of the World (ROW) | | Imports | Factor income to ROW | | Surplus to ROW | Government transfers to ROW | | | Foreign exchange outflow |
| Total | Activity | Supply expenditures | Factor expenditures | Household expenditures | Enterprise expenditures | Government expenditures | Investment | Foreign exchange inflow | |

### 2.2.2 Functions Form in the CGE model

The function form in the CGE model has the most important role in the model. It depicts how consumer demand responds to changes in income or prices. It is necessary to choose appropriate functions form and elasticity which best describe consumer preferences.

In this research, there are three function forms that use the constant elasticity of substitution utility function and the Cobb-Douglas and Leontief functions. The simplest is Cobb-Douglas utility function that elasticity of model cannot change. For all goods, the Cobb-Douglas own-price elasticity is minus 1 and elasticity of substitution and income are one. Negative own price elasticity means that change in price leads to an opposite change in quantity in an equal proportion [16]. For instance, if income increases 10 percent, the quantities demanded of all goods increase 10 percent.

The Constant Elasticity of Substitution function (CES) defines the shape of the indifference curve. All points along indifferent curve have the same value of elasticity of substitution in all income levels. This function allows the modelers to choose one values of elasticity.

Another function is the Leontief function, which is normally used for intermediate input in the CGE model. This function fixes proportions so that the process has no ability to substitute more of one intermediate input for another. It means values of elasticity are equal to zero.

### 2.2.3 Production behavior

In many standard CGE models, production is usually assumed to exhibit constant returns to scale. Thus, an increase of the same proportion in all input leads to an increase in output of the same proportions [16]. Each producer is assumed to maximize profits subject to the existing production technology. Normally, CGE model separates the function into parts. In order to describe production behavior, nested production functions must be identified. Figure 2.9 shows basic technology tree for a nested production function.

At the top level, it generally employs a Leontief production function, aggregate input substitution elasticity equal to zero between value-added nest and intermediate nest. The value added nest is normally a constant elasticity substitution (CES) function. The aggregate intermediate input is specified by a Leontief production function.

The nested production functions depend on the type of product or good. The modelers must carefully construct it as a replica of the producer's behavior. Many

researches focused on the nested production in various sectors such as Farzana Naqvi (1998) who describes the electricity supply structure in Pakistan as in Figure 2.10 which categorized by technology, high-flexibility and low-flexibility [7].

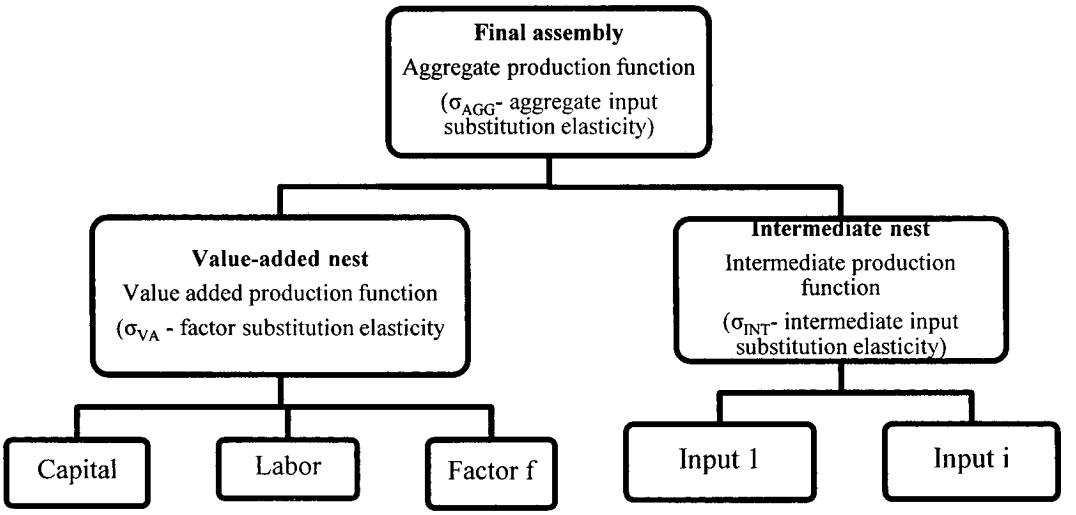


Figure 2.9 Technology tree for a nested production functions

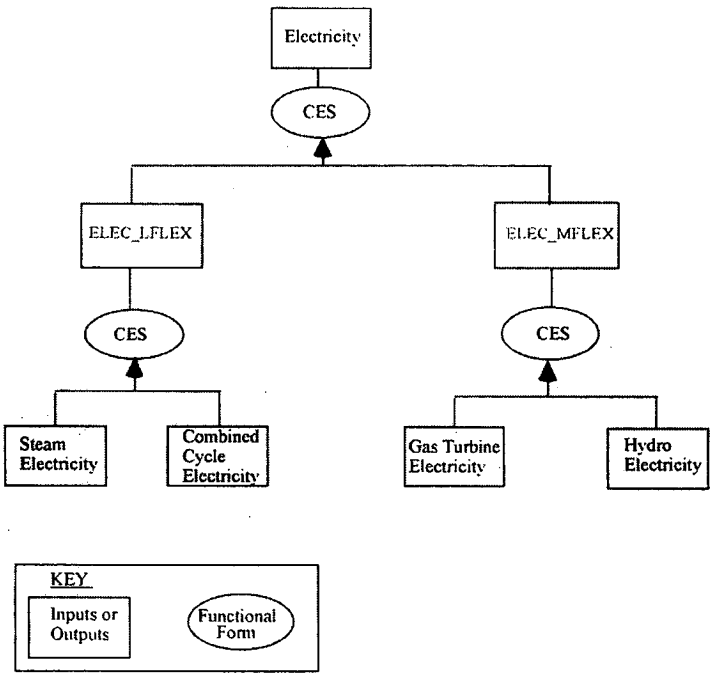


Figure 2.10 Example of electricity supply structure in Pakistan [7]

### 2.2.4 Consumer's Behavior

In the CGE model, institutions are represented by households, enterprises, the government and the rest of the world. They reflect the final demand since they the goods and services consume. They are assumed to be utility maximizers who allocate their income across commodities based on their preferences which are subject to budget and commodity prices. Figure 2.11 illustrates examples of goods and services consumption of household from General EMPAX-CGE structure.

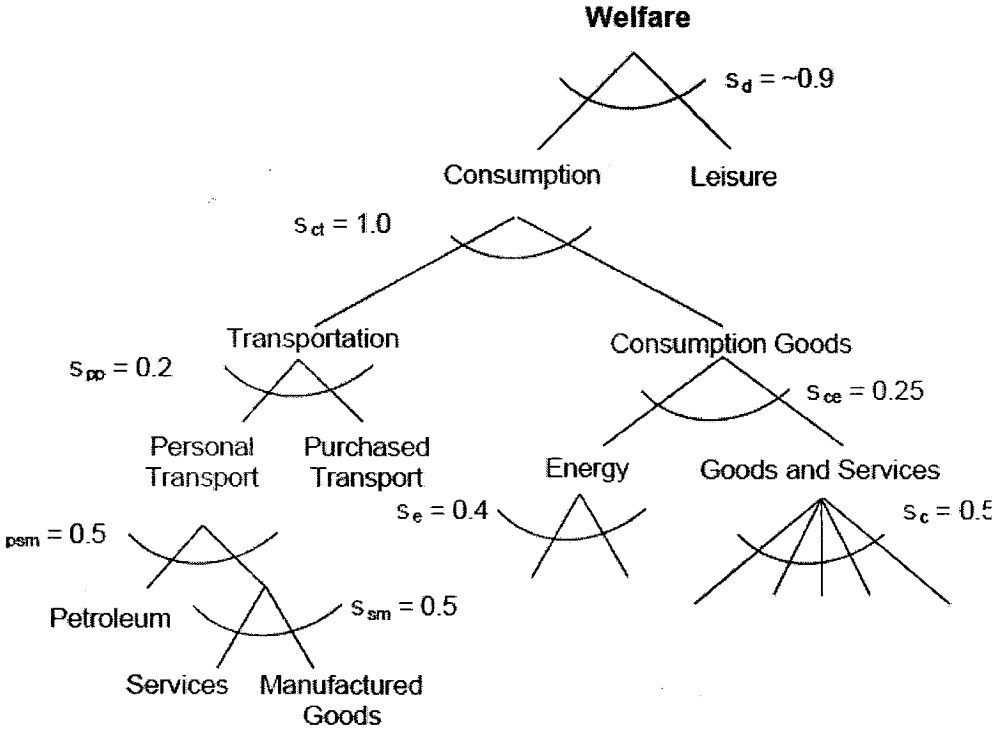


Figure 2.11 Household utility functions

### 2.2.4 Trade in the CGE model

Trade in the CGE model could be based on the Heckscher-Ohlin Theorem that economists Eli Heckscher and Bertil Ohlin developed. The model is a simple two-goods, two-factors and two-country model with the two countries differing in only their relative factor endowments. One has a larger endowment of labor relative to capital and the other has a larger endowment of capital relative to labor. The theory implies that both countries will export goods that are intensive in the factors of production and are in relatively supply abundant and import goods that are intensive in the factors of production and are in relatively scarce supply [16].

Domestic producers in each activity would provide their product to international trade subjects to revenue maximization. It depicts behavior of exported goods by export transformation function which generally assumes constant elasticity of transformation (CET) transformation to illustrate imperfect of substitution of domestic and exported product.

On the demand side, imported products describe the preference using an Armington import aggregation function subject to cost minimization.

### 2.2.5 General Equilibrium

SAM is a database which provides the initial equilibrium of an economic system. It shows the form value of SAM data in each agent in which total expenditure must equal total income. It also shows that the optimized point of each agent under market clearance condition, zero profit condition and balance in financial interaction subject to set of mathematic models such as production function, demand function of each agent, etc.

### 2.2.6 The Outstanding point and Limitations of CGE models

The main outstanding point of CGE models is the main database which is only SAM. As mentions above, SAM consists of macroeconomic data, such as IO tables, national accounts tables and trade statistics for only one year period. This strong point makes CGE models used in a wider analysis more preferable than econometrics, which requires historical data for several years to estimate parameters with sufficient degrees of freedom. For this point of view, the CGE model is more suitable for economic analysis when there is no sufficient statistical data.

The weak points of CGE models are described as follows. Firstly, according to statement above, the parameter of CGE models are determined on the basis of data from one year. This means that the reference year must be selected carefully since its effect may not lead to good empirical analysis. Secondly, CGE models mainly focus on the real side of the economy so that they can depict economics in term of relative prices, not absolute prices. But to overcome this weak point, a financial CGE model has been constructed.

### 2.2.7 Software and simulation on the PC

This study uses GAMS software to develop and solve systematic equations of CGE models, which are formulated as a system of nonlinear simultaneous equations. GAMS was originally developed for analyses of developing economies by the World Bank and it is updated and distributed commercially by GAMS Development Corporation [18].

For using GAMS on windows, the GAMS IDE software is utilized. The modeler must prepare input files to programs and the results translate into GAM code.