DEPARTMENT OF INTERNATIONAL AND EUROPEAN ECONOMIC STUDIES

"Optimal Taxation & Provision of Public Goods"

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Abstract

This inquiry presents the optimal way of financing a public good through taxes with the construction of three alternative simple models of optimal taxation and public good provision. In the first model, the public good affects only the household's utility. In the second model, the public good affects only the firm's production. In the third model, the public good affects both the household's utility and the firm's production. My target is to solve for the optimal income tax levels in the three models. Also, I tried to find an established relation between the tax levels and the importance which have the public good for the households and the firms. A bibliographic research shows the theory of public goods, the classification of the goods in general and the significance which have nowadays via global public goods. Furthermore, this paper explains the connection of the public goods with all the theories of political economy during the history. It represents some basic first best solutions (without taxes) such as Samuelson and Lindhal solutions. In addition, it illustrates the free riding problem and potential solutions of it. In the end, I describe and analyze some useful conclusions about the optimal taxation and provision of public goods.

Keywords: Public Goods, Free Riding, Optimal Taxation, First Best Solutions, Second Best Solutions, Public Provision

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Contents

“The noblest motive is the public good”

-Virgil (70 BC–19 BC)

Chapter 1: *Introduction*

Virgil, the ancient Roman poet said that "The noblest motive is the public good".
It is true that the main purpose of a state is to ensure and to provide some types of public goods for their citizens. For this reason, despite the different approaches which have the theories of organizing and managing the state. The role of public goods is significant to all of them and in the core of public policy.

In the capitalistic system, goods and services are provided either through a market mechanism or through the government (Filiz Kartal, 2010).
The idea of classic liberalism and welfare economics is that all the individuals have self-interested behavior, that leads to the right level of production and demand through the mechanism of prices in a social optimal spot and the economy in a general equilibrium. This process in a multi-actor society faces various problems. One of the most important problems is the production and provision of public goods. The nature of those goods might be one of the basic reasons why people organized in societies. In the market mechanism, the theory assumes that the property rights for the good are well-defined, the marginal cost to provide the good to one more costumer is not zero and the agents have perfect information. Typically, public goods could not have satisfied none of these prerequisites. For these reasons, most of the times, markets are unable to provide and cost them. Hence, public goods refer as one of the basic market failures.

Assuming that we take Amartya Sen’s definition of human well-being in terms of the freedom that people have reason to choose and value (Sen, 1999), or if we take Martha Nussbaum’s list of central human capabilities (Nussbaum, 2000), it is obvious that humans life would not be secured without the existence of public goods. So, every society choose which of the public goods are crucial for their citizens and their levels. The freedoms, like the freedom to be healthy or to be educated are secured through the existence of basic infrastructure such as hospital, a good quality piped system or at least a basic level of schools.

Furthermore, public goods have a major role in the theories of social justice. John Rawls (1971) in his book “A theory of Justice” described the primary goods. Primary goods are of two categories. First, the natural primary goods like health, intelligence etc. Second, the social primary goods like a system of liberties, civil and political rights, self-esteem etc. They are goods which are required to have individuals as free people and members of the society and also, they are related with the basic moral capacities of citizens (Rawls, 1996).

The need of a public authority (institution) and a government which provides some types of goods and maintains an organizational system is required. Public goods

as national defense, legal system and many types of infrastructure had been essential for individuals and the growth of the societies during the modern history of the states. The provision and the funding of a public good is an object of research that fights against different theories of the modern state. Also, due to the fact of asymmetric information, societies do not know the optimal level of provision for public goods and usually exist under-provision of public goods.

Moreover, modern fields of economic science such as Behavioral Economics suggests that individuals might have other motivations apart from the money. In many cases individuals could contribute without expecting to receive anything. For example, in a national disaster or in an environmental plan they could contribute simply for the sense of duty, civic pride, altruism or just a peer pressure. Although, other people possibly decide not to contribute, despite that they have benefitted from the positive impact, that is the famous free-riding problem which we will analyze more specifically later on. Thus, every society faces the two normative questions:

(1) How much of the different public goods should be supplied?

(2) How should the public goods be financed?

In a 1954 article, Paul Samuelson introduced the two essential characteristics that diversify 'pure' public good from a private good (Samuelson, Paul A., 1954).

1.Non-excludability: This occurs when it is either impossible or prohibitively costly to exclude those who do not pay for the good when consuming it. Once the good has been produced, its benefits or harm has impact to all. For example, if a citizen contributes to national defense, he protects everyone in the area, whether they contributed or not for defense. In some cases, goods are non-excludable by their nature. For instance, the services of a lighthouse are excludable. However, sometimes goods are non-excludable by choice or design, like the enforcement of rule of a law. A producer can classify a good non-excludable by setting the price of to zero (Jodi Beggs, The 4 Different Types of Goods, 2019).

2.Non-rivalry: this implies to any person's consumption of the public good but it doesn't reduce the available amount for others. For example, the air, where everyone could breath as much as he wants, without any effects on diminishing the available resources to others in contrast with a private good like consumption of food. For example, a park has a low rivalry in consumption, because one person benefits from the park and doesn't infringe on another person's ability to benefit from the same park. For production perspective, non-rivalry implies that the marginal cost of serving one more customer is virtually zero (Musgrave 1969, p. 128, Samuelson 1969, p. 22).

Chapter 2: *The view of public goods inside the history*

The discussion about public goods is usually related with the role of the state. The role of the state is shaped from the different political and economic conditions in every situation across the history. The provision of the public goods through the state is a modern situation.

In the past, a variety of public goods has been provided through charities, voluntary organizations and the church. However, the idea of establishing hospitals, breadlines and poor accommodation, it was not derived only from pure compassion about charity or humanitarian purposes. But also, for the need of decreasing epidemics, famines, infections, illnesses and social unrest (Desai, 2003). Hence, the existence of provision to some kinds of public goods and the public expenditures began with the rise of the nature of a modern nation-state, after the American and French Revolution in 18th century. Before this period, the main political system was feudalism. The main public expenditure was the public security, that means the defense of the state. The real reason was the protection of the feudal lord and their lands. Also, the same system was in pre-modern states during the ancient period, where the king funding came from the king treasury for military purposes in order to protect for expansion of the kingdom.

By the end of 18th century, when the structure of the modern state emerged. The capitalistic system started to provide some public goods (basic infrastructure e.g. roads, water etc.), in order to heal the inequalities, which come from the market and update individuals' lives.

Public goods played a main role in the Liberalism. Although, the support of a small and effective state and the minimal government's intervention in the market. The creation of a basic safety net was crucial for social justice and a basic level of welfare which every state desires for their population. The classic economic theory, from Adam Smith, David Ricardo and John Stuart Mill supports the public provision of some basic public goods. Adam Smith in 1774 in his magnum opus supported the idea that the prosperity of the individuals depends upon the degree of freedom and justice which they enjoy (An Inquiry into the Nature and Causes of the Wealth of Nations, 1776). Also, Smith in his other major book (Theory of Moral Sentiments, 1761) described the idea that if every individual try to achieve their own interest, then the general welfare of the society will be achieved as it is the sum of the individual's welfare levels. The free market could maximize the welfare through the powers of demand and supply. However, even with this background he supported that the state's duties were to maintain security and justice, and to provide a sum of public goods such as education and infrastructure as harbors, roads bridges etc.

The Great Depression of 1930s has lead in a different way of thinking and the decline of the pure liberalism which was established till then. The supremacy of free market stopped to be the pioneer target. John Maynard Keynes proposed a more active role of the state. Simultaneously, the idea of the welfare state was gaining ground, because the life expectancy had started increasing. The main targets of

Keynes theory were full employment, government intervention to correct market failures and redistributive policies through tax system.

Furthermore, the middle of 20th century was characterized as "the golden age of welfare state". The public expenditures were increased, services such as health insurances, retirement systems, educational system and many others had been provided by the government. The welfare state especially in Scandinavian countries provided almost every required public good and service. In the middle of 60s Samuelson proposed the modern theory of public good. Since, public goods became an indispensable part of the theory of public policy and public finance as it is known today.

However, the oil crisis in the 70s led on the impeachment of Keynesian theory and government intervention. The New Right movement propose again the minimal state and the reduced role of the government. New Right thinkers support that the state should be responsible for a limited number of public goods. Such as the enforcement of rule of law, the protection and the security of the citizens' prosperity (Friedrich von Hayek, 1960). Thus, the next 2 decades were affected by this movement. Politicians as Margaret Thatcher in Great Britain and Ronald Regan in United States imply these policies and. reduced effectively the role of the state. So, the public provision of public goods remained only in a limited number of categories. Today and after the great crisis of 2008, the experience of overcoming the crisis indicated the necessity of the state. The significant role which is required to have in the provision of some basic public goods and in the creation of a modern-effective welfare state, which will be capable to provide a basic safety net for all their citizens and to protect social mobility and prosperity.

Chapter 3: *Examples of public goods*

The bibliography illustrates as a classic example of public good the lighthouse (Ronald H. Coase, 1974, "The lighthouse in economics"). It is a pure public good which satisfies to a high degree the two axioms, simultaneously, the weakness of provision from the private sector shed light the example of lighthouses called as "the failure of market failure," (Zerbe and McCurdy,1999, The Failure of Market Failure).

Other examples are the national defense. If a country wants to be protected, then it must invest in national defense. this is beneficial to everyone who lives in the country's territory. Police service which protects the community and has to be fair must not discriminate against the citizens. Street lighting, if a public road has light, no none can reduce the available amount for the others. Flood defenses, building infrastructure in order to protect a region can be beneficial for the citizens regardless of their contributions, if any contribute in the payment of such public goods

Additionally, in modern democratic states law and order are public goods with compulsory enforcement to all inhabitants. Many different examples of public good can be classified as public education, public health system or electricity distribution companies, scientific knowledge - ideas, public TV and positive or negative externalities.

However, it is worth mentioning that in public goods are also classified goods with negative impact. Public bads are the other side of the same public goods coin. For instance, the pollution in an area which has landfill structures is a negative implication for the environment and it has direct and/or indirect consequences to the community.

Chapter 4: *Classification scenarios of goods*

Paul A. Samuelson made a conceptual distinction between those goods which are purely public and those which are purely private goods (Buchanan, 1968). Although, due to the fact that public goods have not well-defined property rights and the difference in the two previous mentioned characteristics, they can incur four different types of goods: (Jodi Beggs, 2017). The first approach is goods with characteristics of "non-rivalness in consumption" and "non-price exclusiveness" (Head, 1962; Peston, 1972). These goods could have either one or both of these two characteristics. Thus, they could be non-rivalness in consumption and non-excludable like public goods, or they could be non-rivalness in consumption but excludable, or rival but non-excludable, or like private good which could be both rival and excludable. The second approach about classification of goods is concentrated in "degree of indivisibility" and the number of people which consume the good (Buchanan, 1968).

4.1 Private Goods

This type of good is both excludable and rival in consumption. Private goods behave normally in the laws of demand and supply. Examples are most consumer goods like beer, food, cloths etc.

4.2 Public Goods

They all have the above mentioned characteristics (Non-excludability, Non-rivalry). Also, the marginal cost in offering the good to individuals is essentially zero. So, it is socially optimal to provide the good at a zero price. Although, why someone pays at first in order to produce the good. Unfortunately, aborting the basic operation of the market and it established public goods leads to a typical market failure.

4.3 Common Goods

The third category is Common Goods. These goods exhibit high excludability but low rivalry in consumption. Hence, they can be natural or human made resource systems. For instance, a fishing ground or an irrigation system. The size and the characteristics of these goods make them costly in order to exclude the potential users from the benefits. Also, the common pool resources due to difficult excludability, they may have the inherent problem of overuse. A common problem in this type of goods is known as the "tragedy of commons". This phenomenon observed in common pool resources system, where individuals act based on their own self-interest can result in harming the resource through the collective action (Lloyd, William Forster, 1833). In this situation users exploit resources for short-term gains without to think the long-term repercussions. Usually, the resource could collapse due to conjunction and overuse like the phenomenon of overfishing or deforestation.

The solution in this type of good is the creation of institutions, where the access in common goods can be restricted the situation of the tragedy of commons is prevented. The common goods which are under this institutional arrangement is called as common-pool resources. (Ostrom, Elinor, 1990).

A good example of common goods are wild fish. They are non-excludable, because no one can prevent the other from fishing up. However, population of wild fish is rivalrous.

4.4 Club Goods

The fourth type of goods is called a club good. These goods exhibit high excludability but low rivalry in consumption. Typically, those goods are shared by more people than usually share a private good, but fewer people than typically share a public good (James M. Buchanan, 1965). Because of the characteristic of low-rivalry, club goods have zero marginal cost, so the cost of provision in one or more individuals is zero. Generally, this category of good is provided by natural monopolies (Jodi Beggs, 2017).

A classic example in order to understand the nature of those goods is the example of a swimming pool facility: one or more individuals are allowed to use a facility of a specific size, but after a point and further the benefit which derives from the use will diminish. Of course, this will increase the total welfare of the citizens, because more people will use the facility. Although, from one point towards congestion will be enforced and the utility of the good will decline. (James M. Buchanan, 1965). Other examples of club goods are cinemas, private parks, satellite television etc.

Thus, with the exception of the private goods all other types of goods are caused from market failures, due to the lack of well-defined property right between the individuals.

A table which illustrates these four categories based on the two axioms

Table 1.1. The characteristics and typology of public goods

Benefits	Rival	Partia lly rival	Non-rival
Excludable	**Pure private goods** Food Cars, fuel	**Club goods** Intelsat International Space Station Canals, waterways	Weather-monitoring stations
Non-excludable	**Common goods** Free access pasture Open pathways Hunting grounds Air corridors	**Impure public goods** Ocean fisheries Pest control	**Pure public goods** Pollution-control Disease-eradication programs Strategic weapons Sound financial practices Basic research
Partially excludable	**Impure public goods** Information dissemination Extension services		

Source: Adapted from Sandler 2002: 86; Kaul, Grunberg and Stern 1999: 5.

- Rival and excludable goods: private consumption goods like food cars, and houses etc.
- Rival and non-excludable goods: common resources,
  e.g. red tuna in the sea etc.
- Non-rival and excludable goods: pay-tv, computer software, patented knowledge etc.
- Non-rival and non-excludable goods: pure public goods, e.g. national defense, lighthouses etc.

4.5 Characteristics of Quasi-Public Goods

As is a special category of public goods are the Quasi-Public Goods. It is a hybrid type of good. They are goods and services that satisfied the two characteristics of being non-rivalrous and non-excludable, but, they are not pure public goods (Hillman, A. L., 2003). A typical example is public beaches and roads. All the infrastructure facilities are built in order to benefit the public. However, in a rush hour, it creates traffic, and many people have difficult to enter in the road so, the good is not pure non-rivalrous, because the use of the public good by an individual can be difficult for the other to use it.

Chapter 5: *The Technological Effect*

It is usual for changes in technology to alter the nature of a public good. For example, in the past, television signal could be classified as pure public good, since, no technology could scramble the signal. After the invention of this technology that exclude the signal, private sector was able to provide the good, and charged a price ensuring a normal return rate on the investment. Of course, there are situations where exclusion is possible but morally and socially inappropriate, e.g. primary education. Although, sometimes is financial possible for private sector to provide a public good. For example, in the previous case, a channel could be free of charge for the audience by financing its needs through advertising or government like public service broadcaster.

Chapter 6: *Global Public Good*

Another modern discussion in the theory of public policy is global public goods. For economists, it is difficult to find a consensus in the theory of public goods. Thus, when these goods are classified in local, national or global categories, the consensus is even harder (Reisen et al, 2004, p. 12). Global public goods are public goods with impact which spread around the globe (Nordhaus, 2005). Nowadays, with the penetration of globalization in people's lives, as global public goods could be considered even local goods. For example, a plant which grows only in one area, but it has medical power. If it is transformed into medicine then it can potentially save millions of lives in an upcoming pandemic (Berg, 2014, p. 22). So, the motivation of saving this plant is a global and not only a local issue. Many international organizations had tried to recognize some categories of global public goods with significant value for the world.

For instance, environmental resources (water, climate, ecosystems like Amazon rainforest) tend to be recognized as global public goods. The ecosystems are common heritage of humankind. When situations like "tragedy of the commons" happened. They harm humankind. The full cost of the environmental destruction could not depict in market prices. Where indirect costs of market failure reach high levels, as in climate change. Public policies should focus on market change and transformations. In other fields, public action is required to maintain and increase a global public good.

Modern global organizations have set as their main duty to achieve the provision of some of these international goods. But, the problems are very complicated and require global consensus in both political and economic level for finding potential solutions.

The next table shows the classification of the global or international public goods. They are divided between intragenerational-intergenerational level and through 3 space levels (Cross-borders, Regional, Global).

Table 1.4. International public goods classification

Spillover range	Pure public	Impure public	Club	Joint products
Intragenerational				
Cross-border	Forest fire prevention Groundwater pollution cleanup	Waterways Rivers Highways Local parks	Electric grid Information networks Peacekeeping	Medical aid Technical assistance Internet connectivity
Regional	Animal disease control Flood control Weather forecasts	Regional parks Treatment of endemic disease	Free-trade zone Common market Monetary area	Regional peacekeeping Military forces
Global	Ocean pollution cleanup Monitoring station World Court	Electromagnetic spectrum allocation Satellite transmissions Postal service Disease control	Air corridors Internet Shipping lanes Financial stability	Foreign aid Disaster relief Drug interdiction
Intergenerational				
Cross-border	Wetland preservation Lake cleanup Toxic waste cleanup	Acid rain reduction Fisheries protection	National parks Irrigation system Lakes	Natural disaster prevention
Regional	Lead emissions reduction Forest conservation	Reduction in emissions of volatile organic compounds Agricultural research	Transnational parks Barrier reefs	Cultural norms Bioprospecting
Global	Ozone shield protection Global warming prevention Disease eradication Knowledge generation	Overuse of antibiotics Ocean fisheries Antarctica protection Revolution making	Geostationary orbits Polar orbits	Tropical forest preservation Space colonies United Nations Poverty alleviation

Source: Sandler (1999: 24–25).

Chapter 7: *First best provision of a pure public good: "The solutions without taxes"*

7.1The Samuelson rule

The Samuelson rule was the first effort to define the two basic axioms and to make quantitative analysis in the theory of public goods.

Efficient Provision of a Pure Public Good (Samuelson Condition)

We have an economy with N consumers, n private goods, and one pure public good

$K=(K_1,\dots,K_n)$	the endowment vector of the n private goods
$P=(P_1,\dots,P_n)$	the production vector of private goods
$D=(D_1,\dots,D_n)$	the vector of demand for private goods
$E^\lambda=(E_1^\lambda,\dots,E_n^\lambda)$	the vector of agent λ's endowment
$x^\lambda=(x_1^\lambda,\dots,x_n^\lambda)$	the consumption vector
$U^\lambda(x^\lambda,G)$	the utility function of Consumer λ's preferences (twice continuously differentiable and monotone)
G	the public good
$F(P,G)=0$	the aggregate technology
$K_j+P_j=D_j=U^\lambda(x^\lambda,G)$ for $j=1,\dots,n$	the budget constraints

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The Social Planner has to decide the levels of consumption and production in order to maximize the social welfare function $\sum_\lambda t^\lambda U^\lambda(x^\lambda,G)$, with respect to the technology constraint, F(P, G) = 0, and the budget constraints, where $\{t^1,\dots,t^N\}$ is a set of social weights.

The FOC is : $\sum_\lambda (U_G^\lambda/U_1^\lambda)=F_G/F_1$, (1.1a)

$$U_h^\lambda/U_j^\lambda=F_h/F_j \quad \text{for } j=1,\dots,n, \text{ and } h=1,\dots,N, \qquad (1.1b)$$

$$t^\lambda U_j^\lambda=t^h U_j^h \quad \text{for } j=1,\dots,n, \text{ and } h=1,\dots,N, \qquad (1.1c)$$

where

$U_i^\lambda=\partial U^\lambda/\partial x_i^\lambda$ is the marginal utility of good i and $F_i=\partial F/\partial P_i$

The solution (P^*, D^*, G^*) satisfies the FOCs and the constraints.
The functions $U^{\lambda}(\ )$ and $F(\ )$ have unique solution hts to the programming problem for a given set of weights, due to their characteristic (concave functions).

Equation (1.1a)
It is the known function as the Samuelson's rule for providing a pure public good.
The rule implies that the quantity of the public good should be selected, in order the sum of the marginal rates of substitution between the public good and a private good, say x_1 , $\sum_{\lambda}(U_G^{\lambda}/U_1^{\lambda})$ to be equal with the marginal rate of transformation between the two goods, F_G/F_1.
Since $m^{\lambda} = U_G^{\lambda}/U_1^{\lambda}$ is agent λ's Willingness to Pay for the public good in units of the first private good.
The F_G/F_1 is equivalent to the marginal production cost of the public good in units of the first private good, Also, the rule could be written as the sum of the Willingness to Pay which is equal to the marginal production cost.

Equation (1.1b)
Is the condition for two private goods? Where the marginal rate
of substitution between the two-private goods h and j is equal to the marginal rate of transformation for each consumer.

Equation (1.1c)
Illustrating the social value of the marginal utility of the j^{th} private good for consumers for any given private good.

For instance, there are two individuals (a and b), two private goods and one public good. The economy has an endowment of W units of a single resource which can be used to produce either private goods or the public good at a constant marginal cost (linear production).

The budget constraint is $W = D_1 + D_2 + qG$
Where the marginal production requirements for the three outputs are (1, p, q),
The utility function is $U= \alpha^{\lambda} \ln(x_1^{\lambda}) + (1-\alpha^{\lambda})\ln(x_2^{\lambda})+\beta\ln(G)$, where tastes differ by α.
Let $\kappa^a = \kappa$ and $\kappa^b = 1 - k$.
The Samuelson condition is $\beta(x_1^a a^a G + x_1^b / a^b G) = q$,

The solution to the social planner's problem :

$$(x_1^a, x_2^a, x_1^b, x_2^b, G) = (\Phi a^a D, \frac{\varphi(1-a^a)D}{p}, (1-\varphi)a^b D, \frac{(1-\varphi)(1-a^b)D}{p}, \frac{\beta D}{q})$$

where $D = \frac{E}{1+\beta}$.

The individuals are identical, so
$a^h = a, \varphi = 1 - \varphi = 1/2,$ and the solution is unique

$(x_1^a, x_2^a, x_1^b, x_2^b, G)$ = (aD/2, (1-α) D/2p, aD/2, (1-α) D/2p, βD/c).

The diversity of a pure public good can be illustrated geometrically in the next graph. The rule of create the aggregate demand curve of a private good is after picking a price to sum horizontally all the different individual's quantities in this price.
For a pure public good the rule implies that the sum of the willingness to pay in all the individuals which consume public good will be done vertically instead.
This is presented in figure 2.1

C shows the marginal cost of a pure public good. The individual a has a sloping demand for public good. The individual b has a perfect elastic demand. The depiction of the aggregate demand of public good in this economy is the vertical sum of the two individual's demand curves. Thus, the optimum level of production of the public good is where aggregate demand meets the aggregate supply at G*.

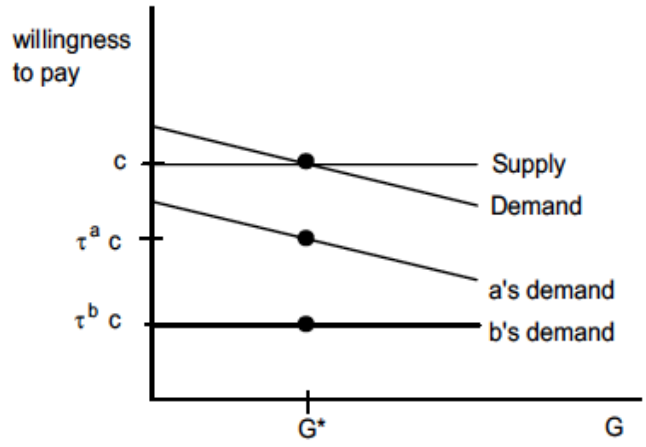


Fig. 2.1. Determining the Optimal Amount of a Pure Public Good

(Source: R. G. Batina,T. Ihori, 2005)

The question which rises is how to finance the optimal level of the public good in a competitive economy?

7.2 Lindhal Solution

Another mechanism of financing public goods without taxes is Lindhal solution. Under this mechanism each agent pays for the public good according to their marginal benefit. Hence, according to the Figure 2.1 under Lindhal solution the A agent pays $t^a c$ and the B agent pays $t^b c$. The sum of $t^a c + t^b c$ is enough to cover the financing of the public good.

The A agent pays tax equal to the area of the rectangle with height $t^a c$ and base in the G axis. The B agent pays the area of the rectangle with height $t^b c$ and base in the G axis until the G*.

The use of Lindhal solution has as prerequisite the division of population into small groups. Which is more possible the estimation of every individual's demand for the good.

For example, consider that the healthcare system is a public good. The hospital is the institution that produce this public good. The population can be segmented into two groups, the young and the old people. Of course, the demand for health services is different among these groups. The Lindahl solution estimates the willingness to pay every group for this good and it can charge differently based on this willingness.

With symbols, let t^kbe the tax share of k's person. This is Lindahl price. The agent k choose their demand $D^k = (D_1^K, \dots, D_n^K)$ in order to maximize the utility function $U^k(D^k, G)$ under the budget constraint $\sum_i P_i \ E_i^K - t^k cG = \sum_i P_i \ D_i^K$, where p is the price of the public good in the market and the $\sum_i P_i \ E_i^K$ is k's agent income.

Assuming perfect competition, thus, the profits equal to zero. If we take FOC implies that $U_G^k / U_i^k = t^k c / P_i$.

The sum of all individuals in the economy is $\sum_i (U_G^k / U_i^k) = (c/P_i) \sum_k t^k = c/P_i$, because, the total of tax shares is 1. Under the condition of perfect competition in the market, c/P_i = Marginal rate of transformation (MRT) between the public and private good.

The Lindahl equilibrium is a policy (G, $t^1, \dots, t^k$) with prices ($P_1, \dots, P_n$) agents optimize their utilities, the markets clear, tax shares sum to 1 ($\sum_k t^k$=1). the allocation of the resource and the Samuelson rule ($\sum_k MB = MC$) in in action.

However, the Lindahl solution mechanism has many problems in the reality. Among the many problems, the four basic are highlighted here.

The diversification of population into different groups based on the willingness to pay might be too expensive and inefficient. For example, a country that encounters problems with its neighboring countries like Israel. The population which lives close to the Gaza zone could have higher willingness to contribute in national defense, instead of the population in the central region. So, it is very difficult to define this willingness to pay and to diversify the population. However, if individuals were literally unified then each one could be charged with different price.

The second problem with Lindhal mechanism is the possibility that some people could mask their type and change group. For example, in Figure 2.1, the B agent could try to pretend A agent in order to pay lower tax. The only solution is extra

conditions and personal data for better classification in groups, which forces extra cost and a complicated tax system which means inefficiency.

The third problem appears when the public goods could be resold. Of course, this concerns only the impure public goods. Because the pure public goods could not have the ability to resold. So, a group may take a good in a low price and after to resell the good or the service in another group and charge a higher price. These goods can be food stamps, rent vouchers etc.

The fourth problem comes by categorizing in groups. This might be affected some social norms like horizontal equity and fairness, due to the different treatment by the Lindahl mechanism. For example, the extra charge in elderly people for medical treatment leads to doubt about the morality and the social justice of this treatment. Nevertheless, that this group of the population has greater willingness to pay for medical treatment.

In general, by setting lower prices some groups of populations may subsidize other groups. For instance, if a state follows the proportional tax system and all the agents pay the same percent of tax, the agents with higher willingness to pay for the public good will be subsidized by people with lower willingness to pay. Hence, some may undermine the pricing rule and as a result equilibrium is away from the socially optimal.

Chapter 8: *The Free Riding Problem*

The free riding problem is a situation where those who benefit from resources, public goods or services pay less or nothing from the fair share of the cost. In addition, free riding could be observed when individuals consume more than their fair share. As a result, it has the under-provision of the public good or the exploitation without restrictions (Baumol, William, 1952).

It can be observed as market failure, because the market is not able to restrict and to distribute the public good through the price mechanism. Furthermore, free riding might be consistent of undefined and imposed property rights (Pasour, Jr., 2014).

As Paul Samuelson refers to his paper, people have motive to hide their true willingness to pay. In order to pay lower for the funding of a public good. (Samuelson, Paul A., 1954). Thus, free riding lead to under-provision or over-provision of public goods. It is an economic inefficiency of the markets.

Furthermore, if more and more people start to mask their true willingness to pay and participate in the free riding, every system or service could not cover their costs and will lead to under-provision. On the other hand, the overproduction of some goods which are not covered by extra cost could provoke environmental consequences.

8.1 NATO as an Example of Free Riding

The North Atlantic Treaty Organization(NATO) with the form which has nowadays is an example of free riding. NATO defense allies have as a compulsory burden to invest 3% of their national GDP in military expenditures, which is required so that the members of the organization have a minimum level of defense. Also, this type of alliance can create economies of scale, through the exchange of military technology, resources allocation, common trainings and facilities. However, from 29 member states only United States satisfied the financial burden and invest more than 3% (Financial and Economic Data Relating to NATO Defence, 2015). Thus, 29 members receive security services and potential support in emergency and only USA contributes the required amount. Of course, USA has more purposes and remain in this ally. But, the benefits are spread though the sum of the allies.

8.2 The Solutions of Free Riding Problem

The most common solution is through taxation. We will analyze it further in chapter with second best solutions of public goods. So, now we will discuss about a different variety of economic and political solutions (Cornes, Richard; Sandler, Todd, 1986).

8.2.1 Assurance Contracts

All the agents are committed to contribute, in order to produce or built a public good. By this type of contracts, every entrepreneur, when the public good is provided, then receive an extra amount, otherwise, it is compulsory for the public to pay according to

the unhatched terms and conditions. Hence, the best choice for every participant is to contribute and fulfill their commitments about the public goods.

8.2.2 Coasion Solution

Ronald Coase in his paper presented a solution of free riding without government intervention. He proposed that all the beneficiaries, by the use of the public good, could classified according to their willingness to pay. Supposing that the transaction cost between the beneficiaries of the public good is close to zero (Coase Ronald,1960). It would be easy to find each other and create a party, in order to organize and allocate their sources in an optimal way for potential production of the public good. Although, the "Coase Theorem" is a simplified model of the reality, because it is impossible for an economic system to have zero transaction costs. Some different types of the use of this solution are the internet crowdfunding or the street performer. For example, especially in the goods which are related with information, it is possible for a producer to set a threshold in order to release an extra part of their work. For instance, the writer Stephen King published a book via his site in separate chapters for free. But, he set a specific amount of money which was required to be raised, in order to publish the next chapter.

8.2.3 The Government Provision

It is a solution which is closely related to taxes. So, briefly the most effective way to overcome the problem of free riding is the enforcement of a tax system. Also, the problem of overproduction of some demerit goods or negative externalities for the society, it could be decreased by an effective tax system. For example, the negative externalities from the production of a factory which produces electricity in a lake could affect fish and the environment. So, a tax will decrease the negative impact and it will lead the economic system closer to the social optimum equilibrium. Thus, the responsibility of the government is to protect the individuals and the environment through the provision of public goods (as it does with the enforcement of catalytic converter in the cars) (Thompson Donald, 2015).

8.2.4 Subsidies and Joint Products

A government can provide public goods through private sector. So, it can subsidize the public provision with the private provision. Usually, this action decreases the cost and it is possible to lead to the creation of a type of competitive market structure.

Although, it is a political decision, if it is socially optimum to provide a good through private sector and might exclude some citizens from the use. In some cases, subsidies lose their positive effect. Because, depending on the nature of the public good and the subsidy, the problems of principal-agent may rise.

Subsidies could have not been used in fields with non-individual benefits but with social benefits. For example, government creates a local sewage treatment

system. and demands from the local citizens to contribute a percentage to its cost through municipality taxes. In the same way, the type of joint products represents the associate result of joining a public with a private good. For instance, a tax decrease (private good) could be achieved from an individual by donating a percentage of their income in a charity (public good).

The prerequisite for the provision of a public good which can be increased through the collaboration with a private good, is to provide the private good by a monopoly. Alternatively, in different market structures, the private good will be produced by many competitors and the connection with the public goods and the potential benefits will be almost impossible.

8.2.5 Privileged Groups

The theory of collective action shows that multiple individuals would all benefit from a certain action. However, it has an associated cost for any individual to undertake it and solve it privately. The one who pay the cost of production could have intrinsic motivation to produce or business models based on complement goods. A group that has this type of behavior is called privileged group.

Evidence could be for example, a business in the center of a city which can have a 24 hour light operated. With purpose to attract customers, with the projection that the potential benefits would cover the costs.

Some examples in solving the free riding problem can be Linux community, where everyone has the ability to contribute to the update of this software and could be beneficial, personally and publicly, to all the other users by the free version. Another example is the music which is composed by some musicians for free, just for personal enjoyment. But the whole audience could enjoy freely the songs.

8.2.6 Exclusion Mechanism and Club Goods

An alternative solution of free riding is to use the mechanism which change the nature of goods from public to club goods. These mechanisms could be patents, laws and copyright. These laws enforce the property rights. However, these laws that overcome the free riding problem, they lead to monopolies and they are not socially optimal. For example, in the pharmaceutical industry, the companies have motivation to invest in the research and development of a new drug. Because they know that the benefits of a potential new drug will be higher, without having the obstacle of free riding problem. So, these types of goods have at the beginning high cost and after, where large number of people use the good the marginal cost drops or approaches to zero.

The excess profits which derives from patents and copyrights could attract more and more companies to invest in the sector. A part of the bibliography considers that the new companies will lead to technological innovations, and breaking the already established monopolies. For example, assuming that Microsoft increases its

prices, iOS and Linux software could take advantage of this and target to a higher market share.

8.2.7 Altruistic Solutions

Apart of the economic and political solution, the other category of free riding's solutions are the **altruistic solutions**. However, it is a longstanding debate, because, the economic science supports that the individuals are self-interest and try to achieve at first their interests. On the other hand, sociology supports that the view of cooperation, altruism and evolution of social norms in the societies.

Altruistic solutions of the free riding problem could be the **voluntary organizations** like Red Cross, private non-profit foundations, fire departments with volunteers or volunteers who secure the boarders. They could provide services with altruistic ways. That means, only a small part of population pay for the cost, but, the benefits is free for anyone who wants to take the advantage of it. Other examples are Wikipedia, free mass media, open software etc.

Moreover, altruistic behavior can exist in **religion or ideological field.** The values and moral code about justice or fair which tend to maintain a part of Christianity in their lives or the altruistic behavior like philanthropy. Also, karma in Buddhism which implies that our present actions determine our future. Furthermore, in the ideological field patriotism implies to people in defending their country without expecting something in return. Also, the volunteers in political campaigns help candidates and parties to be elected without a salary. Based only in their ideology and the benefits of the potential election will be spread out in all people with the same ideology or political and economic background.

Another solution is **punishment**. Vis à Vis whether or without government intervention the free riding could be overcome through punishment (Elinor Ostrom; James Walker; Roy Gardner ,1992). It is observed that individuals prefer to punish someone even if they have personal cost. Rather than avoiding the cost and do not punishing the individuals who do not contribute to the cost of public goods (Fehr, E., & S. Gächter, 2000).

Last but not least, the. **social norms**, people feel that is mandatory to contribute toward the public goods, because other people have already contributed. Inside the interaction of individuals tend to observe this phenomenon. For example, if they see their neighbor to contribute for the creation of a green park area close to the neighborhood, they feel that they must contribute too and avoid the thinking of the free riding mechanism.

Chapter 9: *Externalities*

In economic science, an externality can be defined as the cost or the benefit that affects an agent who did not select to incur that benefit or cost (Buchanan, James; Wm. Craig Stubblebine, 1962). Externalities exists when a product or a service cost a price which does not reflect the true social costs or benefits that the society receives from this product or service. Externalities can have either positive or negative effects for the society. The weakness of the markets to set a right price and eliminate the externalities lead to characterization of the externalities as another type of market failure.

Example of a negative externality could be a factory which process as aluminum close to a rive and pollutes the waters. The negative externality of this production has an impact in the social welfare and the natural environment. It could be reduced with the adaption of a Pigou tax which may decrease the production in a more optimal level for the social welfare (Pigou, A. C., 1920). A positive externality could be the educational system. The student take education with a specific fee either as public good or as private. The private and public benefits and the premium in their salary after education process, it is not reflected in the fee of education.

In the free market the existence of externalities lead to the under-provision or the over-provision of some goods. Markets tend to over-produce goods with negative externalities like the above mentioned factory, and under-produce goods with positive externalities like the educational system which most of the times is under the required level by the society.

Externalities are closely related with public goods. For instance, the education could be taken as private good or as public good. However, their externalities such as knowledge and information are both non-rival and non-excludable. For these reasons, education tends to consider as a responsibility of public sector. Thus, positive externalities can be crucial for the progress and the prosperity of human kind.
For example, the research at an educational institution, the cultural heritage and the different civilizations, the training of human capital, and the education of responsible and knowledgeable citizens-voters (Jones, P. R., & Cullis, J. G., 1993).

Chapter 10: *Second-Best Public Provision of Pure Public Goods*

The first best public provision is based upon the personal preference of every agent to contribute or not in the provision of public goods. The second best public provision of pure public goods is based on the tax system. It becomes compulsory for the agent of an area or the consumers of a good or a service to contribute thought taxes.

The main idea when distorting taxes is required to finance spending comes from Pigou (1928, 1947). The crucial considerations of a tax must be (1) the " efficiency " considerations, (2) distributive considerations and (3) administrative problems (Stiglitz, J. E., & Dasgupta, P. ; 1971). The rule is that the social marginal cost of a public good is raised, due to the use of taxes. The result is the deadweight loss. The key for social policy is that the deadweight loss raised the social cost of providing the public good. This becomes optimal due to the lower provision of the public good. The importance of this rule is usually underestimated by governments, which impose taxes and distort economic activity, the agent's behavior and decision making. Thus, misallocating resources and distort decisions of public projects.

For example, a gasoline tax may bring a higher loss in the consumption of gasoline than the government's revenue. Also, it may reduce the sales of SUVs and bears down public transportation or decrease revenue from tolls that is important in funding infrastructure. Another example could be the entry fee in a public park. This fee may decrease the visitors of the park, with effect both in the funding for the maintenance of the park, but also, in the real purpose of their existence, if only a few citizens enjoy the park. An increase in tuition fees for university courses could have future negative effects in the human capital or the lower number of enrollments may affect the funding for university's new buildings.

Moreover, recent research in Pigou's statements have found that is valuable not only in theoretical level. The public provision of public goods may affect tax commodities which results to indirect affects and raised the social cost of the public goods (Diamond and Mirrlees, 1971). (Stiglitz and Dasgupta, 1971) presented the basic equations for the second best provision of public goods. After, (Atkinson and Stern, 1974) illustrated that Pigou argument have two categories. First, the rule issue and second the level issue. They tried to test the social marginal cost of funds (MCF) in the second-best equilibrium into two effects. Although, Wildasin (1984) shew that the estimates of (MCF) were fragile. Furthermore, a conclusion of the Pigou's rule is affected by efforts of equity in the societies (King,1986 and Batina, 1990b).

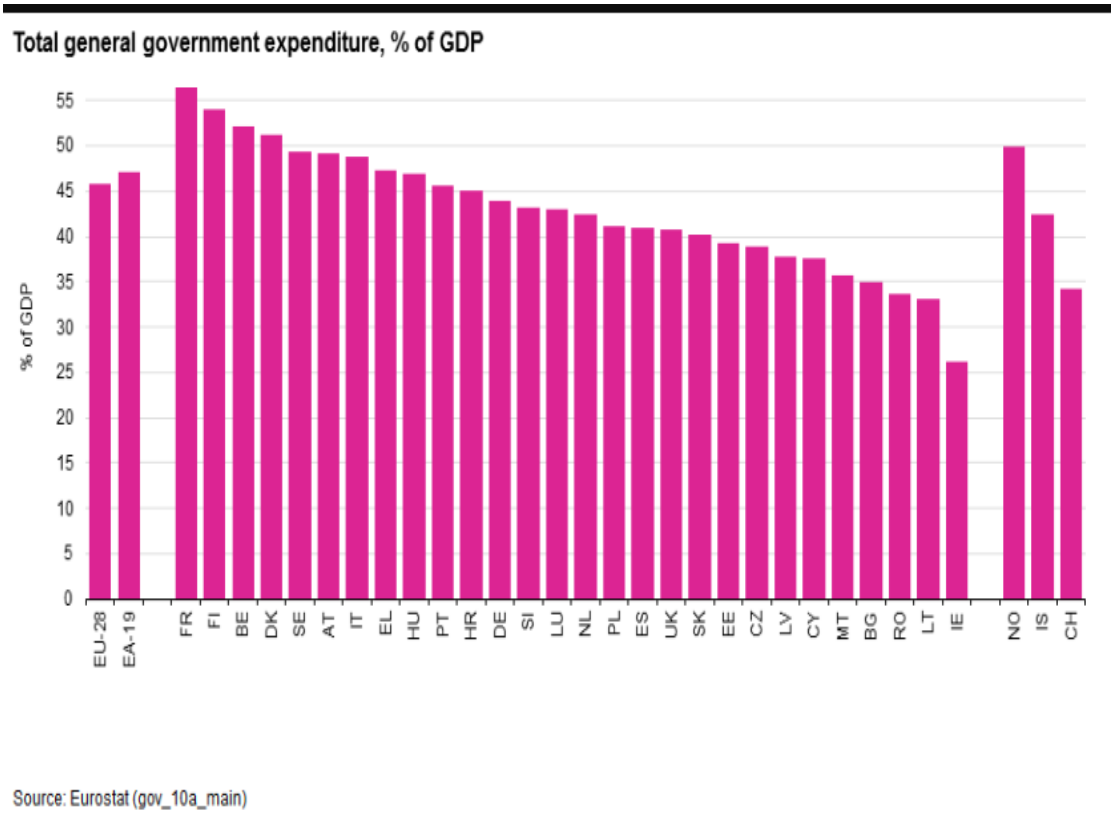
Chapter 11: *Expenditures and Economic Growth*

Public expenditures are closely related with economic growth. Public investments in infrastructure support the growth of the private sector and create the structure for capital accumulation. Also, in merit goods such as education and health facilities, the public investments contribute in human capital accumulation.

While the relationship between public expenditure and economic growth was assumed as theoretical belief. Empirical studies based on public expenditure data have found a weak link between public investment and economic growth. A statistical significant relationship was found by using cross-country data (Barrow, 1991). Other research focused on public investment in health, education and housing have found a positive effect of public expenditure on economic growth (Diamond, 1989). Other inquiries examine the productivity levels, the unemployment and the private capital spending under different percentages of public expenditures in the United States and they have found positive effects. Also, it is significant that the categories of public expenditure which are normally considered productive could become unproductive if there is an excessive spending (Devarajan, S., Swaroop, V., & Zou, H. F., 1996). Although, the problem that is derived from public investments was the existence of crowding out effect in private investments (Aschauer, 1989a,1989b), (Munnell, 1990), (Holtz-Eakin, 1992).

The results were unclear in developing countries. It was difficult to found robust results between public investment and growth due to misallocation of the resources (Levine & Renelt, 1992). So, the only link which is accepted from all the researches for indicating positive effects with economic growth is the investment in education (Psacharopoulos,1993), (World Bank, 1993b).

The general public expenditure in the European Union have a major role in the GDP. The average is 45.8 % of EU GDP in 2017 and at 46.2 % of GDP in 2016, using the latest available aggregated data (Eurostat, 2019). Hence, the public expenditures through the public goods provided counted almost the half GDP per year. The conclusion is that European citizens estimate very high the role of public goods. The state participates actively in the funding and the provision of public goods, especially in Scandinavia. Although, this trend requires high taxes in order to operate smoothly, without creating debts. For this reason, the member states with big welfare state have a high percentage in taxes (direct and indirect).



As shown in the graph above in 2017, the highest levels of government expenditure were in France (56.5 % of GDP) followed by Finland (54.0 % of GDP), Belgium (52.2 % of GDP), Denmark (51.2 % of GDP), and Sweden (49.3 % of GDP). On the contrary at the bottom, can be found Ireland (26.3 %), Lithuania (33.1 % of GDP), Romania (33.7 % of GDP) and Bulgaria (35.1 % of GDP), (Eurostat, 2019). Furthermore, during the crisis in 2008 the general government expenditure remains steadily, something which implies that countries decided to use the public expenditure as a tool to overcome the financial crisis and the recession. The evidence seems that it had increased from 44.6% of GDP in 2007 to 50.0% in 2009. But the main reason was the lower GDP. So, the amount had not high fluctuations. (Eurostat, 2019).

Chapter 12: *A simple model of optimal taxation and public good provision*

In this chapter, I present a dynamic general equilibrium tax model with public goods in a decentralized economy. That means the private agents (households and firms) make their decision based on the maximization of their own interests and trade through the market mechanism. The government tries to maximize the utility of the private agents via the funding of public good. The government sets only one direct tax, the income tax (Ty).

In this model, due to the fact that existing market failures such as public goods, the solution is not the first best allocation, and the market mechanism could not allocate the resources optimally. So, a distorted tax is required for funding the public good.

The Model is dynamic and it has two periods. For simplicity, I assume that the public good and the production take place only in the second period. In the first period, the households have only the consumption through the exogenous endowment wealth.

The Models are distinguished in 3 different types. The Model A has a "non-productive" public good which directly enhances the households' utility. The Model B has a "productive" public good which works as a positive externality to firms and enhances the production. This type of public good consists the engine of long-term growth (Angelopoulos, K., Economides, G., & Kammas, P., 2007). The Model C has both "productive" and "non-productive" public good and the government allocates the tax revenues among these two categories which depend on an exogenous parameter.

The analysis has as a core the Simple Model of Endogeneous Growth (Barro, Robert J. 1990) followed by the model of Baier and Glomm (2001). The main difference is that here I use the public good. Thus, one more policy instrument exists, where the preferences of the government allocate the total tax revenues between production sector or consumption sector and assuming discrete time and perfect foresight.

In the decentralized or market economy, the households consume, work, and make savings in physical capital. The firms use physical capital and labor as the two resources and they produce one same product. If the firms have profits, these are allocated through dividends in the households, which are the owners of the firms. Also, assuming that the households are the same, thus, the representative household and the representative firm will be used (allocation issues of income and inequality levels do not exist).

12.1 Model A

A dynamic model with two-period economy. At the first period the economy has only the endowment wealth (e_1) which is divided into the consumption (C_1) and the capital's reward (k_1).

12.1.1 The representative household

The household acts competitively by choosing the paths of consumption C_1, C_2 between the two periods and it tries to maximize their utility function. The parameter $0<\beta<1$ is the time preference or discount rate and shows the interest of the household about the future. For simplicity, the utility function U(.) is additively separable and logarithmic:

$$U^h (C_1, C_2, g_2) = \log C_1 + \beta [\log C_2 + \mu_2 \log g_2] \quad (1)$$

where $0 \leq \mu_2 \leq 1$ is the weight given to public relative to private consumption.

In the first period, the household rents its predetermined capital k_1 to the firm and receives $r_2 k_1$ in the second period, where r_2 is the return to capital. It also supplies inelastically one unit of labor services per time period so that labor income is w_2. Further, it receives profits made by firms throw d_2 only in the second period.

The household's budget constraint of the 1st period is:

$$\text{s.t.} \quad C_1 + k_1 = e_1 \quad (2a)$$

The household's budget constraint of the 2st period is:

$$\text{s.t.} \quad C_2 = (1 - t^y)(r_2 k_1 + w_2 + d_2) \quad (2b)$$

where $0< t^y <1$ is the income tax rate. For simplicity, we assume full capital depreciation. Setting k_2 is zero, and assuming that households offer one unit of labor

After taking the First Order Condition (FOC) of $U^h (C_1, C_2, g_2)$ with respect to k_1 :

$$C_2 = \beta (1 - t^y) r_2 C_1 \quad (3)$$

The (3) is the Euler function and gives the intemporal rate of consumption's substitution between the first and the second period, or better the best way of saving between the two periods.

12.1.2 The representative firm

The firm has production only in the 2nd period. I also assume that technology at the firm's level takes a Cobb–Douglas form like (4b). Where $A>0$ and $0<\alpha<1$. So, it has

fixed economies of scale. The representative firm maximizes the usual profit by choosing k_1 and l_2.

$$\Pi_2 = y_2 - r_2 k_1 - w_2 l_2 \quad (4a)$$

$$\text{s.t. } y_2 = A\, k_1^a\, l_2^{1-a} \quad (4b)$$

The FOC of Π_2 wrt k_1 is:

$$r_2 = a\, A\, k_1^a\, l_2^{1-\alpha} \quad (5a)$$

The FOC of Π_2 wrt l_2 is:

$$W_2 = (1-\alpha) A\, k_1^a\, l_2^{1-a} \quad (5b)$$

when I subsidize the (5a) ,(5b) in (4) I will take the

$$\Pi_2 = 0 \quad (5c)$$

Which says that the firm acts competitively, it is price taker and the usual profit are zero.

12.1.3 The Government budget constraint

The government runs a balanced budget by taxing the household's income at a rate $0< t^y <1$. Thus,

$$g_2 = t^y (r_2 k_1 + w_2 + d_2) .\ ^1 \quad (6)$$

12.1.4 Competitive decentralized equilibrium (for given economic policy)

Given the paths of the policy instrument t^y, a competitive decentralized equilibrium (CDE) is defined to be a sequence of allocations C_1, C_2, y_2, k_1 and prices r_2, w_2 such that: (i) households maximize utility and firms maximize profits by taking prices, policy and public services as given; (ii) all budget constraints are satisfied; (iii) all markets clear. [2] As is shown in Appendix A, this CDE is summarized by the following equations that give the paths of output, private consumption and private capital accumulation:

$$l_2 = 1 \quad (7a)$$

$$\Pi_2 = d_2 = 0 \quad (7b)$$

$$k_1 = \frac{a\,\beta\, e_1}{1+a\,\beta} \quad (8)$$

$$C_2 = (1-t^y)\, A\left[\frac{a\,\beta\, e_1}{1+a\,\beta}\right] \quad (9a)$$

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[1] For simplicity, there is no public debt in the model since adding one more state variable would not change our main results (see

[2] In the labor market, the market-clearing condition is $l_2 = 1$.

$$g_2 = t^y A\left[\frac{a\,\beta\,e_1}{1+a\,\beta}\right] \quad (9b)$$

Optimal Taxation

max log C_1+ β log $[(1- t^y)\ A\ [\frac{a\,\beta\,e_1}{1+a\,\beta}]^a]$+ β μ_2 log $[t^y\ A[\frac{a\,\beta\,e_1}{1+a\,\beta}]^a\ ]$

After taking the FOC of U^h (C_1, C_2, g_2) wrt t^y:

$$t^y = \frac{\boldsymbol{\mu_2}}{\mathbf{1+\mu_2}} \quad (10)$$

$$\frac{\partial\, T^y}{\partial\, \mu_2} = \frac{1+\mu_2-\mu}{(1+\mu_2)^2} = \frac{1}{(1+\mu_2)^2} > 0$$

12.1.5 Conclusions

The equation (10) shows that the optimal tax t^y depends on μ_2 which is the importance of the public good for the household's utility. So, it is clear the establishment of a sustainable positive relationship between t^y and μ_2. When μ_2 increases the t^y should increases too. The households give higher importance to the public good g_2 for their utility. The t^y should be positive and less than 1, the (10) equation certifies this. When the μ_2 is zero then the tax t^y should be zero, due to the fact that the positive effect of the public good is zero {If $\mu_2 = 0 \Rightarrow t^y = 0$ }.

12.2 Model B

As in the literature introduced by Barro (1990), I assume in Model B that the public good provides production externalities to private firms.

12.2.1 The representative Household

The household acts competitively by choosing the paths of C_1, C_2 between the two periods and it tries to maximize their utility function, but without to have the contribution of the public good g.

$$U^h\,(C_1, C_2) = \log C_1 + \beta \log C_2 \quad (11)$$

The budget constraint of the 1st period is

$$\text{s.t.} \quad C_1 + k_1 = e_1 \quad (11a)$$

The budget constraint of the 2nd period is

$$\text{s.t.} \quad \Rightarrow C_2 = (1-t^y)(r_2 k_1 + w_2 + d_2) \tag{11b}$$

The FOC of U^h (C_1, C_2) wrt k_1 is :

$$C_2 = \beta\,(1-t^y)\,r_2\,C_1 \tag{12}$$

The (12) is the Euler function and gives the intertemporal rate of consumption's substitution between the first and the second period.

12.2.2 The representative firm

The firm has production only in the 2nd period, as production function I will use a Cobb-Douglas function with public goods (13b), the A>0 and 0<a<1 so, it has fixed economies of scale. The firm tries to maximize their profits. The is modeled as in Barro and Sala-i-Martin (2004, chapter 4)

The firm's profits function is:

$$\Pi_2 = y_2 - r_2 k_1 - w_2 l_2 \tag{13a}$$

$$\text{s.t.} \quad y_2 = A\,k_1^{\alpha}\,l_2^{b} g_2^{1-\alpha-b} \tag{13b}$$

where y_2 is output at 2nd period, l_2 is the labor input at 2nd period, g_2 is public production services. The firm chooses k_1 and l_2. In doing so, it acts competitively by taking prices and public services as given.

The FOC of Π_2 wrt k_1 is

$$r_2 = A a\, k^{a-1} l_2^{b} g_2^{1-\alpha-b} \tag{14a}$$

The FOC of Π_2 wrt l_2 is

$$w_2 = (1-\alpha) A\, k_1^{a}\, l_2^{b-1} g_2^{1-\alpha-b} \tag{14b}$$

12.2.3 The Government budget constraint

The government runs a balanced budget by taxing the household's income at a rate $0< t^y <1$.

$$g_2 = t^y\,(r_2 k_1 + w_2 + d_2) \tag{15}$$

12.2.4 Competitive decentralized equilibrium (for given economic policy)

Given the paths of the policy instrument t^y, a competitive decentralized equilibrium (CDE) is defined to be a sequence of allocations C_1, C_2, y_2, k_1 and prices r_2, w_2 such that: (i) households maximize utility and firms maximize profits by taking prices, policy and public services as given; (ii) all budget constraints are satisfied; (iii) all markets clear. As is shown in Appendix B, this CDE is summarized by the following equations that give the paths of output, private consumption and private capital accumulation:

$$l_2 = 1 \tag{16}$$

$$\Pi_2 = d_2 = 0 \tag{17}$$

$$k_1 = \frac{a\,\beta\,e_1}{1 + a\,\beta} \tag{18a}$$

$$y_2 = A^{\frac{1}{\alpha+b}}\, k_1^{\frac{\alpha}{\alpha+b}}\, t\, y^{\frac{1-\alpha-b}{\alpha+b}} \tag{18b}$$

$$g_2 = A^{\frac{1}{\alpha+b}}\, k_1^{\frac{\alpha}{\alpha+b}}\, t\, y^{\frac{1}{\alpha+b}} \tag{19}$$

$$C_1 = 1 + \alpha\beta - \alpha\beta e_1 \tag{20}$$

$$C_2 = (1 - t^y)\, A^{\frac{1}{\alpha+b}}\, k_1^{-\frac{b}{\alpha+b}}\, t\, y^{\frac{1-\alpha-b}{\alpha+b}} \tag{21}$$

Optimal Taxation

$$\max U^h (C_1, C_2) = \log C_1 + \beta \log C_2 \tag{10}$$

I will take FOC in (10) wrt t^y:

(The analytical solution is in Appendix B)

$$\boldsymbol{t^y = 1 - \alpha - b} \tag{22}$$

12.2.5 Conclusions

The public good enhances the production of the firm. So, the higher it is the share which contributes the public good in the production function, then it is socially optimal a higher tax percent. The α and b are the variables which presents how allocated the production resources. The $\{t^y = 1 - \alpha - b\}$ is the part which contributes to the public good. In other words, (22) is the marginal production. Thus, when the contribution of g_2 increased, the tax t^y should also increase. If the production resources divided only into l and the k the tax is zero, because the public good has not a positive effect in the production.

12.3 Model C

In Model C, I assume that the public goods are provided simultaneously as production externalities to private firms and as public consumption services to the households.

12.3.1 The representative Household

The household acts competitively by choosing the paths of C_1, C_2 between the two periods and it tries to maximize their utility function.

$$U^h (C_1, C_2, h_2) = \log C_1 + + \beta [\log C_2 + \mu \log h_2] \quad (23)$$

Same as before:
The budget constraint of the 1st period is

$$\text{s.t.} \quad C_1 + k_1 = e_1 \quad (24a)$$

The budget constraint of the 2nd period is

$$\text{s.t.} \quad C_2 = (1 - t^y)(r_2 k_1 + w_2 + d_2) \quad (24b)$$

The FOC of $U^h (C_1, C_2, h_2)$ wrt k_1 is

$$C_2 = \beta (1 - t^y) r_2 C_1 \quad (25)$$

The (25) is the Euler function and gives the intertemporal rate of consumption's substitution between the first and the second period.

12.3.2 The representative firm

The firm has production only in the 2nd period, as production function I will use a Cobb-Douglas function with public good like (30b), the A>0 and 0<a<1 so, it has fixed economies of scale. The firm tries to maximize their profits

$$\Pi_2 = y_2 - r_2 k_1 - w_2 l_2 \quad (26a)$$

$$\text{s.t.} \quad y_2 = A\, k_1^{a}\, l_2^{\beta}\, g_1^{1-\alpha-\beta} \quad (26b)$$

The FOC of Π_2 wrt k_1 is

$$r_2 = a\, A\, k_1^{a-1}\, l_2^{\beta}\, g_1^{1-\alpha-\beta} \quad (27a)$$

The FOC of Π_2 wrt l_2 is

$$W_2 = (1 - \alpha) A\, k_1^{a}\, l_2^{\beta-1}\, g_1^{1-\alpha-\beta} \quad (27b)$$

when I subsidize the (27a) ,(27b) in (26a) I will take the

$$\Pi_2 = 0 \quad (28)$$

This says that due to the perfect competition the profits are zero

12.3.3 The Government budget constraint

The government runs a balanced budget by taxing the household's income at a rate $0 < t^y < 1$. Where 0<b<1 financing the public good in consumption g_2 and the rest $0<(1-b)<1$ financing the public good in production h_2.

$$g_2 + h_2 = t^y (r_2 k_1 + w_2 + d_2) \quad (29a)$$

Without loss of generality, I assume that a share 0<b<1 of total tax revenues finances public production services ($g_{2)}$ and the rest 0<(1-b)<1 finances public consumption services (h_2). Thus, the Equation (32a) is decomposed into:

$$g_2 = b\, t^y (\, r_2\, k_1 + w_2 + d_2) \tag{29b}$$

$$h_2 = (1-b) t^y\, (r_2\, k_1 + w_2 + d_2) \tag{29c}$$

12.3.4 Competitive decentralize Equilibrium (for given economic policy)

Given the paths of the policy instrument t^y, a competitive decentralized equilibrium (CDE) is defined to be a sequence of allocations C_1, $C_{2,}$ $y_{2,}$ k_1 and prices $r_{2,}$ w_2 such that: (i) households maximize utility and firms maximize profits by taking prices, policy and public services as given; (ii) all budget constraints are satisfied; (iii) all markets clear. As is shown in Appendix C, this CDE is summarized by the following equations that give the paths of output, private consumption and private capital accumulation:

$$l_2 = 1 \tag{30a}$$

$$\Pi_2 = d_2 = 0 \tag{30b}$$

$$y_2 = A^{\frac{1}{\alpha+\beta}} k_1^{-\frac{\alpha}{\alpha+\beta}} (b\, t^y)^{\frac{1-\alpha-\beta}{\alpha+\beta}} \tag{31}$$

$$k_1 = \frac{\alpha\beta}{1+\alpha\beta} e_1 \tag{32}$$

$$g_2 = A^{\frac{1}{\alpha+\beta}} k_1^{\frac{\alpha}{\alpha+\beta}} (b\, t^y)^{\frac{1}{\alpha+\beta}} \tag{33}$$

$$C_1 = \frac{1}{1+\alpha\beta} e_1 \tag{34a}$$

$$C_2 = \beta\,(1-t^y)\alpha\, A^{\frac{1}{\alpha+\beta}} k_1^{-\frac{\beta}{\alpha+\beta}} (b\, t^y)^{\frac{1-\alpha-\beta}{\alpha+\beta}} (e_1 - k_1) \tag{34b}$$

(The analytical solution is in Appendix C)

Optimal Taxation

$$\max U^h (C_1, C_2, h_2) = \log C_1 + \beta\, [\, \log C_2 + \mu \log h_2] \tag{23}$$

FOC wrt t^y:

$$\Rightarrow \frac{1}{c_2}\frac{\partial c_2}{\partial t^y} + \frac{\mu}{h_2}\frac{\partial h_2}{\partial t^y} = 0 \tag{35a}$$

FOC wrt b:

$$\Rightarrow \frac{1}{c_2}\frac{\partial c_2}{\partial b} + \frac{\mu}{h_2}\frac{\partial h_2}{\partial b} = 0 \quad (35b)$$

I will create the equation $\frac{\partial c_2/\partial t^y}{\partial c_2/\partial b} = \frac{\partial h_2/\partial t^y}{\partial h_2/\partial b}$

$$\boldsymbol{b} = \frac{(\boldsymbol{1-\alpha-\beta})(\boldsymbol{1+\mu})}{\boldsymbol{1-\alpha-\beta+\mu}} \quad (36)$$

$$\boldsymbol{t^y} = \frac{\boldsymbol{1-\alpha-\beta+\mu}}{\boldsymbol{1+\mu}} \quad (37)$$

12.3.5 Conclusions

The b is the share of the tax revenues which leads to finance the public good in the firm's production. As in the model B, when $\{1-\alpha-\beta\}$ increases also the t^y increases. Because, the share of public good in the production increases, it is more productive to finance there a higher level of public good. So, b increases too.

When μ (the importance of public good for the consumers) increases, then t^y and b decreases. The government choose to finance more the public good h_2 which is in the consumer's utility.

Case 1 $\{1-\alpha-\beta\uparrow \Rightarrow t^y\uparrow, b\uparrow\}$

Case 2 $\{\mu\uparrow \Rightarrow t^y\uparrow, b\downarrow\}$

Furthermore, another interesting case is when $\{\mu\downarrow$ and $b\uparrow \Rightarrow t^y\downarrow\}$. Thus, μ has greater impact in the tax, than the b. Because, despite that b increases the tax rate drops.

$$b = \frac{(1-\alpha-\beta)(1+\mu)}{1-\alpha-\beta+\mu}\ \begin{matrix}>0\\<1\end{matrix}\ ,\ t^y = \frac{1-\alpha-\beta+\mu}{1+\mu}\ \begin{matrix}>0\\<1\end{matrix}\ ,\ \frac{\partial t^y}{\partial \mu} = \frac{1+\mu-(1-\alpha-\beta+\mu)}{(1+\mu)^2} = \frac{\alpha+\beta}{(1+\mu)^2} > 0$$

Chapter 13: *Conclusions*

In these models, the government aims to maximize the utility of the private agent. It tries to solve for the socially optimal tax, in order to finance the public good which provides. In the Model C the solution has except for objective role, an ethical role. The government has to choose the level of b (allocation of tax revenues). Of course, the households are the owners of the firms. However, the government needs to recognize the most socially profitable. It means that if it is better to finance more the public good which contributes in production or to turn the tax revenues to finance the public good in the consumers' utility. This process of finding or better guess the preferences of the private agents by the government and the resource allocation efforts could consider as a matter of research and debate.

The core problem with which both Musgrave and Samuelson deal concerns the mechanism by which consumer-voters register their preferences for public goods.

Many theories of public goods like C.M. Tiebout, (1956) support that the provision for public good is better decentralized. In recent years, some examples and the problems in the provision which have some categories of public goods lead to the conclusion, that this is a correct choice for some goods. The decentralization has as a main purpose to satisfy more personally the need of every group of people about the quantities and to estimate the willingness to pay for public goods. Of course, may rise problems such as that in poor neighborhoods the quality and the quantity of the public goods could be lower. Although, the central government could provide a solution by central funding in these situations. The decentralized managements are more capable to find a better approach of the importance which is given by the people to the public good (μ) in a specific area. The local authority is more informed and efficient in order to recognize the preferences, the emergency and the quantities of the local population for a public good. That means, a more flexible and affordable package of tax and level of public goods.

Many examples which have followed the strategy of the decentralization are successful. A major example could be the managements of the educational system in the Finland, if we characterized as impure public good the education. It considers as the best educational system in the worlds, as it is first in PISA test and simultaneously is the most decentralized. Every school follows a basic national curriculum, and after the rest of the program adapts special lessons and knowledge depending the students' needs of every area.

In addition, in the cases which the socially optimal and the most productive is the public good which enhances the production of the firms, only in the sectors which the country has comparative advantage. For example, Greece to support firms which produce in the secondary sector of the economy or specific services upon tourism, or specific categories of agriculture products. With these actions the efficiency of the public good could have the highest impact in the production.

However, the categories like global public goods, big infrastructure facilities or military equipment required central action. Thus, categories of public goods which need large amount of funding or could create economies of scale, it is optimal the

central funding and provision. For the rest of the categories, the decentralization offers higher benefits and lower costs. But, the most appropriate stage of decentralization for every category of public good needs further research and classification.

Appendix A

The solution at the Model A

First Order Condition (FOC) of U^h (C_1, C_2, g_2) with respect (wrt) to k_1 is

$$-\frac{1}{c_1}+\frac{1}{c_2}(1-t^y)\, r_2=0 \Rightarrow \quad C_2=\beta\,(1-t^y)\, r_2\, C_1 \tag{3}$$

I have two forms for C_2:

$$C_2=(1-t^y)\, A\, k_1^a \tag{8b}$$

$$C_2=\beta\,(1-t^y)\, A\, k_1^{a-1} C_1 \tag{8c}$$

Dividing (8b)/(8c) I will take $k_1=\frac{a\,\beta\,e_1}{1+a\,\beta}$

Optimal Taxation

The FOC of U^h (C_1, C_2, g_2) wrt T^y is

$$\frac{1}{c_1}\left[-A\left[\frac{a\,\beta\,e_1}{1+a\,\beta}\right]^a\right]+\frac{\mu_2}{g_2}\, A\left[\frac{a\,\beta\,e_1}{1+a\,\beta}\right]^a=0 \Rightarrow g_2=\mu_2\, C_2 \Rightarrow$$

$$\Rightarrow t^y\, A\left[\frac{a\,\beta\,e_1}{1+a\,\beta}\right]^a=\mu_2(1-t^y)\, A\left[\frac{a\,\beta\,e_1}{1+a\,\beta}\right]^a \Rightarrow t^y=\mu_2(1-t^y)$$

$$\Rightarrow t^y=\frac{\mu_2}{1+\mu_2} \tag{10}$$

Appendix B

The FOC of U^h (C_1, C_2) wrt k_1 is $\quad -\frac{1}{c_1}+\frac{1}{c_2}(1-t^y)\, r_2=0$

$$\Rightarrow C_2=\beta\,(1-t^y)\, r_2\, C_1 \tag{12}$$

$$r_2=a\, A^{\frac{1}{\alpha+b}}\, k_1^{-\frac{b}{\alpha+b}}\, t^{y\,\frac{1-\alpha-b}{\alpha+b}} \tag{20}$$

$$w_2=(1-\alpha)\, A^{\frac{1}{\alpha+b}}\, k_1^{\frac{\alpha}{\alpha+b}}\, t^{y\,\frac{1-\alpha-b}{\alpha+b}} \tag{21}$$

$$g_2=t^y[Aa\, k^{a-1} g_2^{1-\alpha-b} k_1+(1-\alpha)A\, k_1^a\, g_2^{1-\alpha-b}+d_2]$$

For k_1, I have also two forms for C_2:

I divide (11b) / (12)

$$\Rightarrow 1 = \frac{k_1}{\alpha\beta(e_1 - k_1)} \Rightarrow k_1 = \frac{\alpha\beta e_1}{1+\alpha\beta} \quad (18a)$$

Optimal Taxation

$$\max U^h(C_1, C_2) = \log C_1 + \beta \log C_2 \quad (11)$$

$$\Rightarrow \log(1 + \alpha\beta - \alpha\beta e_1) + \beta \log(1 - t^y)\, A^{\frac{1}{\alpha+b}} k_1^{-\frac{b}{\alpha+b}} t^{y\,\frac{1-\alpha-b}{\alpha+\beta}}$$

After taking FOC in (10) wrt t^y:

$$\Rightarrow \frac{b}{c_2}\left[-A^{\frac{1}{\alpha+b}} k_1^{-\frac{b}{\alpha+b}} t^{y\,\frac{1-\alpha-b}{\alpha+b}} + \frac{1-\alpha-b}{\alpha+b}(1-t^y)\, A^{\frac{1}{\alpha+b}} k_1^{\frac{\alpha}{\alpha+b}} t^{y\,\frac{1-2\alpha-2b}{\alpha+b}}\right] = 0$$

$$\Rightarrow \left[-1 + \frac{1-\alpha-b}{\alpha+b}(1-t^y) t^{y^{-1}}\right] = 0$$

$$\Rightarrow \frac{1-\alpha-b}{\alpha+b}\,\frac{(1-t^y)}{t^y} = 1 \Rightarrow (1-\alpha-b)(1-t^y) = (\alpha+b)\, t^y$$

$$\Rightarrow 1 - \alpha - b - t^y + (\alpha+b)\, t^y = (\alpha+b)\, t^y$$

$$\Rightarrow \quad t^y = 1 - \alpha - b \quad (22)$$

Appendix C

Optimal Taxation

$$U^h(C_1, C_2, h_2) = \log C_1 + \beta\,[\log C_2 + \mu \log h_2]$$

FOC wrt t^y:

$$\Rightarrow \frac{1}{c_2}\frac{\partial c_2}{\partial t^y} + \frac{\mu}{h_2}\frac{\partial h_2}{\partial t^y} = 0$$

FOC wrt b:

$$\Rightarrow \frac{1}{c_2}\frac{\partial c_2}{\partial b} + \frac{\mu}{h_2}\frac{\partial h_2}{\partial b} = 0$$

I will create the equation $\frac{\partial c_2/\partial t^y}{\partial c_2/\partial b} = \frac{\partial h_2/\partial t^y}{\partial h_2/\partial b}$ after substitutions

$$\Rightarrow b = \frac{1-\alpha-\beta}{t^y},\ t^y = \frac{1-\alpha-\beta+\mu}{1+\mu},\ b = \frac{(1-\alpha-\beta)(1+\mu)}{1-\alpha-\beta+\mu}$$

Chapter 14: *References*

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