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# A SIMPLE IN-CLASS EXPERIMENT ON THE EFFICIENT PRODUCTION OF THE PURE PUBLIC GOOD TOUCHING THE MEDIAN VOTER THEOREM

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## Abstract

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The paper show possibilities of introducing modern methods into public economy and finance teaching. We present in-class experiment which illustrates one of typical model from political economy – the median voter theorem. Students are endowed with cards that represent their preferences on different levels of the public good production. They compare benefit they can get from different levels of public good (these levels represent three candidates) and then they vote for the most preferred level. This process continues for several rounds, with a new election taking place with a different sample of students. The in-class experiment demonstrates that the simplicity of the median voter theorem, when there are more than two candidates, provides only an imprecise prediction of the collective choice.
The methodology of the experiment is enriched by the statistical analysis of experimental results from experiment cartied out by the authors in Czech Republic and Slovakia.

median voter, public choice, experiment, public good, game, free rider, efficiency

## 1 INTRODUCTION

An important part of teaching political economy is getting students to understand the intersection between politics and economics, passing through the median voter theorem (Wilson, 2005). The median voter theorem is considered as one of the basic models of political economy. Its hypotheses have spurred a fruitful research agenda not only in political economy but also in public economics and public choice, and the properties of the median voter theorem have been supported by both theoretical and empirical works (Mueller, 2006; Cullis and Jones, 1992; Brown and Jackson, 1992).

This in-class experiment is a modified version of the original model developed by Hotelling (1929) on spatial location theory. Nevertheless, this paper innovates on the existing literature because it applies an experimental method in order to test the validity of the median voter theorem's theoretical prediction. A few researches have been done employing such a classroom game approach (Hewett *et al*., 2005; Wilson, 2005; Holt, 2004, Duffy, 2011).

The main goal of the paper is to demonstrate that in a three-candidate contest the median voter theorem provide only an imprecise prediction of the collective choice. In order to run the experiment, students in the class are endowed with cards that represent their preferences on different levels of the public good production. Cards are randomly assigned among voters. Students are endowed with cards that represent their preferences on different levels of the public good production. They compare benefit they can get from different levels of public good (these levels represent three candidates) and then they vote for the most preferred level. This process continues for several rounds, with a new election taking place with a different sample of students.

The results provide an intuitive introduction to the theory of the public good and the median voter theorem, and, in turn, can lead to a useful class discussion of them.

The paper is structured as follows: section one presents the theoretical framework of the median voter theorem. Section two explains the experimental design and section three reports the main results of the experiment. Last section concludes.

## 2 MATERIALS AND METHODS

### 2.1 The theoretical framework

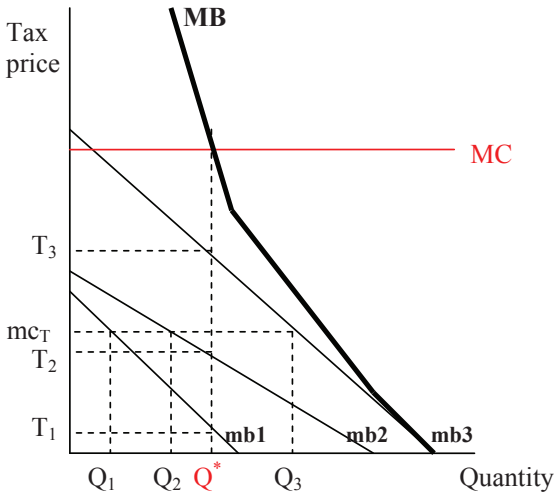
The analysis starts with taking into consideration the model of the perfectly competitive market and focuses on those situations in which the conditions necessary to achieve the market Pareto-efficiency are not fulfilled. For instance, it is generally accepted that the private provision of the pure public goods will be Pareto inefficient (Stiglitz, 1988). Given the presence of such a market failure, one possible role for the government would be to intervene in the economy and correct such inefficiency.

The traditional argument for why governments exist is to provide public goods to enhance the economic and social welfare of citizens (Mueller, 2006). Public goods and services are indispensable to the social, economic and political health of every liberal democratic state (Pollitt and Harrison, 1994). They engage the government in securing a just and equitable distribution of resources (McNutt, 1996). According to Samuelson (1954), the public good is such a good which consumption from each individual does not subtract from any other individual's consumption. Another useful definition describes the public good as a good provided in the same amount to all involved individuals although each individual could value it in a different manner (Varian, 1998). Economically speaking, the pure public good shares the properties of non-rivalry in consumption and non-excludability.

An important difference between the analysis of the private good and the public good arises in the fact that for the latter, it does not make sense to talk about the quantity that one individual consumes as separate from the quantity that another individual consumes because each of them already has at his disposal for consumption the total amount of the public good. It is more reasonable to ask how much each individual would be willing to pay for a given quantity of the good. The aggregate demand curve for the public good is obtained added vertically the individual demand curves. An important issue in public sector economics is to determine the efficient level of public good to be produced in an economy. In a partial equilibrium framework as described by Cullis and Jones (1992), the condition that must exist for ensuring the Pareto-efficient level of public good production requires the good be to produced until the sum of the individuals' marginal benefits is equal to the total marginal cost of producing an additional unit.

As further step, the analysis turns on the methods of making collective decisions. Those can be view as taking place in a range going from no-one member of the community has a vote for deciding about the outcome to all having to agree on the same outcome. The only collective decision-making rule that fulfils the Pareto-efficient condition is unanimity (McCarty and Meirowitz, 2007). Although unanimity rule has the efficiency property, it is not the common feature of democratic governments (McCain, 2004). By contrast, the majority rule is the most frequent collective decision-making method encountered in modern societies. Referring to the median voter theorem, it is generally demonstrated that under majority rule voting, with single-peaked preferences along a single policy dimension and in a binary (two-candidate) contest, it is the median voter's preference that determines the quantity of the public good to be produced in the economy and that, in the absence of individualized prices, the public production of a fixed quantity of the public good causes inefficiencies

Fig. 1 shows the aggregate and individual demand curves for a given quantity of the public good, expressed in terms of marginal benefit, as MB, mb1, mb2 and mb3, respectively. If a same tax-price ($mc_T$) equal to one-third of the total marginal cost (MC) is applied, then the quantities each individual ($I_i$) would choose if they could determine the collective choice would be $Q_1$, $Q_2$, and $Q_3$, respectively. However, in a simple majority rule as the volume of public good increases along the horizontal axis in the graph, $Q_1$ will be opposed by $I_2$ and $I_3$. Similarly, $Q_3$ will be rejected by a majority now composed by $I_1$ and $I_2$ (two of the three voters want less public goods and services than $Q_3$). Indeed, it is only at $Q_2$ that there is not a majority aiming to increase or reduce the quantity of the good provided, and, so $Q_2$, the median voter's choice, becomes the




1: *Median voter rule and the public good*
Source: Cullis and Jones, 1992

collective choice. Traditional question discussed in public choice literature is whether the efficient quantity will coincide with the median voter's choice (Mueller, 2006). As also shown in graph 1, the median voter equilibrium exists where the median voter's demand curve (mb2) equals the common tax-price ($mc_T$) and the output level that correspond to the median voter's choice ($Q_2$) is less than the efficient one (Q*). Referring to the conditions under which the two levels of output are equal $Q_2 = Q^*$, it is demonstrated that the median voter equilibrium output will be efficient only if the median voter's share of the total demand equals the median voter's share of the total marginal cost.

Given that an efficient output Q*implies $\Sigma mb_i$ = MC or, alternatively $\Sigma mb_i$/ MC = 1, and, that at the quantity $Q_2$ the condition is $mb2 = mc_T$ or, alternatively $mb2/mc_T = 1$, by combining the two equations it yields $mb2/\Sigma mb_i = mc_T$/ MC. On the left side of the equation, $mb2/\Sigma mb_i$ is the share of the median voter's demand over the total demand. On the right, $mc_T$/MC is the share of the total marginal cost of producing the public good that is paid by the median voter.

Summing up, if equal tax prices are to be charged then the median voter's quantity, as well as the collective choice, is an inefficiently too small quantity. A distribution of tax prices that does guarantee the efficient quantity under majority rule occurs when tax prices are determined as marginal benefits of each individual at the efficient quantity. At those prices each individual would vote for the same quantity of public good (Rosen, 1991). If the median voter will contribute to the public good in proportion to the amount he demands, this is the sufficient condition to be satisfied in order to produce an efficient level of public good.

Indeed, the median voter model represents a special case of the more general Lindahl model. Lindahl equilibrium meets the condition in which each individual's marginal benefit from public good consumption equals the individual's tax price. If the marginal tax price equals the marginal benefit for all individuals, then this condition must hold true for the median voter as well. Therefore, the median voter's most favourite outcome will be efficient with a Lindahl equilibrium (Lindahl, 1919).

The median voter hypothesis and its testing are ranked among the spatial voting models. There can be found two types of such voting experiments in the literature: one focusing on committee voting, and the other on the median voter model (Schram, 2002).

The overall goal of median voter experiment is to encompass the interaction between candidates and voters. The design of the experiment is based on the preposition that the voters are given an ideal point in a one dimensional policy space and their payoffs are a declining function of the distance between the chosen point and the ideal point.

Candidates, on the other hand, adopt a position in the policy space, hoping to attract voters (Collier *et al*., 1987; Williams, 1991; McKelvey and Ordeshook, 1993; Olson and Morton, 1994).

In principle, it is easily understandable that in a two-candidate contest, the median voter has a strong attractive power and the candidates will try to crowd the centre (Holt, 2007; Hewett *et al*., 2005; Wilson, 2005; Duggan, 2006).Schram (2002) summarizes the main conclusions of carried out experiments as follows:

- with complete information on ideal points and payoffs, the median voter model finds support;
- even with incomplete information, there is convergence to the median, when it exists;
- costly information on candidates' positions does not affect the rate of convergence to the median.

Schram concludes that *quite some support for theoretical predictions is observed. Moreover, stable outcome exists and convergence to the median voter even in case of incomplete information indicates that the voting mechanism can lead to even more robust results than predicted by theory*.

### 2.2 The experimental design

The environment and design of the experiment reproduces as close as possible the current reality in modern societies. It models a representative democracy form of government, where decisions are made not by individuals themselves, but by their elected representatives. Simple majority rule voting is the collective decision-making method. Needles to say, under simple majority voting, one more than half of the voters must favour a decision for it to be approved. The experiment also assumes that individual-voters have single-peaked preferences, since as they move away from their most preferred outcome in any and all directions, their utility fall. Moreover, it assumes that policy is one dimensional, since individual vote just on one single issue that is the level of the public good to be produced. Voters compare the benefit they get from the level of production proposed by the different political candidates and then they vote. However, the simplicity of the median voter theorem, when there are more then two candidates, may lead to a paradox. The in-class experiment wants to check the validity of the median voter theorem's hypotheses in the case of political elections where there are three candidates.

The players of our game are eleven individual-voters ($I_i$). The strategy of each voter is to maximize his own utility by voting for the level of public good to be produced in the economy which is the closest to his preferences. This means to vote for the political candidate representing the preferences that best suit particular voter.

In order to make our experiment as easy as possible, the candidates are assumed to belong to three different political parties (right-wind, central and left-wing), and then if elected they will propose, respectively, a small, medium or large level of the public good to be produced. These candidates are in our experiment represented by three levels of public

good provided (3, 5 and 8 units). While the payoffs of voters depend on how much is the selected level of the public good close to their preferred outcome, candidates simply aim to win the election.

The level of the public good proposed by the candidate who gets one more than half of the voters will become the collective choice. If candidates do not get the simple majority at the first round, then there is second round with the two candidates that got the most votes in the first round. In our in-class experiment, each individual-voter has a constant marginal benefit equal to one for each unit of a public good produced, up to a limit determined by the most preferred outcome and each extra unit of the public good has a total marginal cost of production equals to one. Only one type of public good can be produced in the economy. During the experiment, players are endowed with one card, with values from 0 to 10. The card is randomly assigned among voters. The number on the card determines the individual's preference over the quantity of the public good. In other words, the number on the card determines a voter's most preferred level for the public good. The worksheet in the annex explains in more detail the rules of the game. In our example, an individual-voter having the card with number X on it will have a total marginal benefit equals to the minimum level of the public good production, up to his most preferred level; otherwise the marginal net-benefit will start to decrease if extra units are produced. Hence, the individual demand curves for the public good will have slope of 1 up to the most preferred outcome of each individual-voter and a slope of – 1 above it, as shown in Fig. 2.

Each voter $i$ is endowed by the public good preferred level $g_i$. The outcome of the election can be characterised by the level of public good $G_j$ proposed by the winning candidate $j$. Payoff of the voter $I$ is than calculated as follows:

$$P = 10 - |gi - G_j|.$$

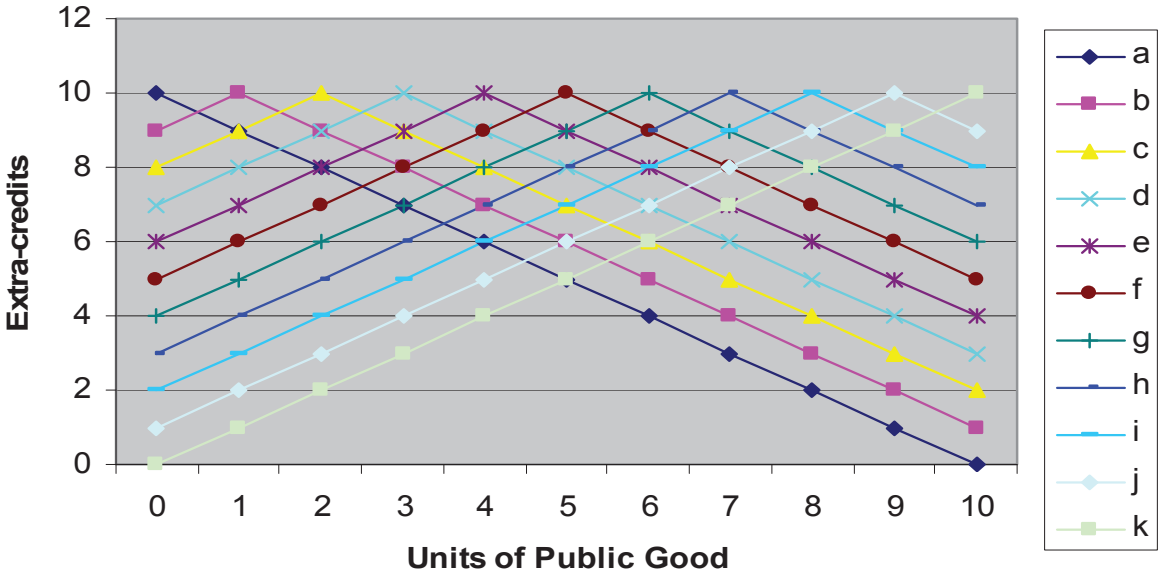
The individual's payoff $P$ is higher when his preferred level $g_i$ is close to the winning candidate's position.

## 3 RESULTS AND DISCIUSSION

Voting experiments allow instructor to study how people behave in controlled laboratory situations in order to evaluate alternative political conditions. The main idea of the in-class experiment is to let students to maximize their benefit from the public good consumption (Raguseo, 2009).

The property of the median voter's most preferred outcome is that under majority rule it becomes the collective decision even though the theoretical prediction doesn't necessarily coincide always with the experimental evidence. In the case of political elections with three candidates the outcome of our experiment demonstrates that the median voter's theorem only provides an approximate prediction of the collective choice. The result of the experiment reported here only partially validates the ideological model of the median voter.

This experiment, which was conducted with several groups of undergraduate students from selected Slovak and Czech Universities[1], demonstrates that when there are more than two



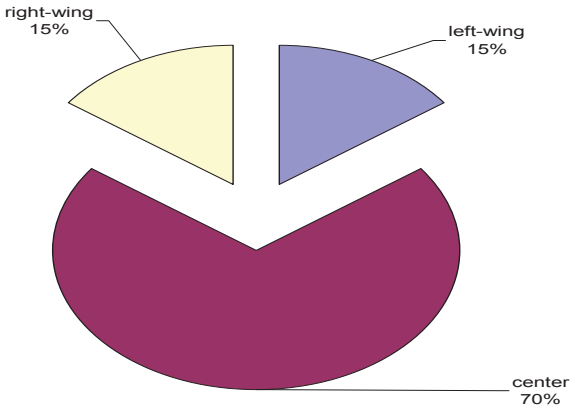

2: *Individual demand curves for the public good*
Source: Authors

1 Matej Bel University in Banska Bystrica, Masaryk University in Brno.

candidates taking positions over a single issue, convergence of voters toward the median position is less likely. Each session took place with 14 participants (11 voters and 3 candidates) and lasted five rounds. In each round subjects were endowed with one card (0–10) representing their preferences over the amount of public good. This card changed from round to round so that each subject undertook five different decision making processes.

Participants were motivated by extra points necessary to pass the final exam from the subject.[2]

The summary of the results for every group provides a clear insight about the main outcome of the experiment (see annex). The overall results show that the median voter candidate is not so dominant as the theory suggest. Over twenty elections only twice the candidate representing the median voter's most preferred outcome has been elected in the first round. In the case of the second round, the "median candidate" has been elected only in 70 per cent of the cases as shown in the figure below.




3: *Winning candidates according to their position*
Source: Authors's elaboration

In the following discussion students confirm the predictions about the motivation for their decision during the experiment. They understood the rules of the game and followed the best (predicted) strategy. Special attention we paid to the students, who have voted for the level not the closest to their preferences. As we presumed, they mention mostly error as the motivation. But some of them also mention strategic thinking as the explanation of their behavior. This result is in line with the other experiments on median voter theorem, e.g. Duffy (2011) concludes, that *uninformed voters, while not knowing the candidates, positions, can nevertheless condition on information provided in poll results as to which candidate is closer to the median position.*

## CONCLUSIONS

This in-class experiment illustrates one of typical model from political economy – the median voter theorem – and it wants to check the validity of the median voter theorem's hypotheses in the case of political elections where there are more than two candidates. Referring to the median voter theorem, it is generally demonstrated that under majority rule voting, with single-peaked preferences along a single policy dimension and in a binary (two-candidate) contest, it is the median voter's preference that determines the quantity of the public good to be produced.

Although in principle, it is easily understandable that the median voter has a strong attractive power, our in-class experiment demonstrates that the simplicity of the median voter theorem, when there are three candidates, provides only an imprecise prediction of the collective choice. The result of the experiment reported here only partially validates the theoretical model of the median voter demonstrating that when there are more than two candidates taking positions over a single issue convergence of voters toward the median position is less likely (the median voter had been chosen only in 70 % cases).

Referring to the structure of the in-class experiment, it can also be shown that, the maximum total marginal benefit would have been 80 with 5 units of public good. The result of the experiment reports that the average outcome of the whole game has been equal to the maximum benefit. It can be argued, that voter were able to maximize their utility from the consumption of a given amount of public good. Of course, in our experiment, the candidates were constrained to enact proposed positions. As suggestion for further research it would be desirable to analyze how candidates would choose their position if free to decide.

Our results are in line with the majority of the experiments to date dealing with the spatial voting models. As other studies prove (Forsythe, 1996), changing the voting rule do not necessary result in the different outcome of the election.

## SUMMARY

Experimental methods in economics belong to one of the most developing and up-to-date way economics research. But the possible benefits from using these methods do not limit only to research. Economic experiments are very useful in enriching the teaching methods used in the class. Taking

2 Each of them could win up to 10 extra-credits (10 % of the sum needed to pass the subject). The motivation follows our former experience with (not only teaching) experiments (see Šeneklová, Špalek, 2009; Špalek, Berná, 2011).

part in an experiment make a student more involved in the topic explained by the teacher. This is why an economic experiment is now a standard teaching method used at (especially western) universities. In our paper we present one experiment which can be used for purpose of introducing one of the key public choice phenomena: median voter theorem. The experiment shows that theoretical model is roughly good representation of the reality. On the other hand, however, the results of our experiments carried out in Czech Republic and Slovakia show that behaviour of subjects do not all the time follow the theoretical presumptions. In 30% of the cases students decided contrary to the predicted strategy (both by error and strategy).

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## ANNEX

### Rules of the game

You are endowed with a card that represents your preference on different levels of the public good. The number on the card determines your preference over the quantity of the public good.

As a voter you have to vote by raising your hand. You can vote for one of three candidates: One (left-wing) candidate is proposing the level of 2 units,

second one (center) is proposing 5 units, and the last (right-wing) candidate is proposing 8 units of public good to be produced in the economy.

You should vote for the candidate who proposes a quantity of the public good as close as possible to your most preferred level, so making the highest benefit.

The level of the public good proposed by the candidate who gets one more than half of the voters will become the collective choice. If candidates do not get the simple majority (50 %) at the first round, then a second round is played between the two candidates who got the most votes in the first round.

You have a marginal benefit equals to one for each unit of the public good produced, up to a limit determined by your most preferred outcome. If extra units are produced your marginal benefit will start to decrease.

For example, an individual who prefers that X units of public good are to be produced would have a total marginal benefit (MB) up to 10, if X units are produced, although the actual benefit could be less than 10 if a different level of the public good is produced in the economy.

The marginal benefit is represented by extra-credits that you can earn. Each of you can earn up to 10 extra-credits if your preferred outcome will be selected as collective choice. Otherwise, the extra-points will be calculated subtracting from 10 the absolute value of the difference between your most preferred level of public good and the level in fact produced in the economy.

**Extra-credits = 10 – |your most preferred level* – level of the public good in fact produced**|**

Name: Group:

| Election | Round | Your card* | Your chosen candidate | Winning candidate** | Extra-Credits |
|---|---|---|---|---|---|
| 1 | I | | | | |
| | II | | | | |
| 2 | I | | | | |
| | II | | | | |
| 3 | I | | | | |
| | II | | | | |

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