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Perception of Policy-Making Criteria: the Case of Vehicle Emissions Control

Jie He

Wing-tat Hung

UNIVERSITÉ DE SHERBROOKE

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Jie He[1], Wing-tat Hung[2]

Abstract

In this paper, we analyzed data addressing people's perceptions of the importance of selection criteria for vehicle-related emissions control policies and measures based on a three-round survey organized during three professional air quality control international conferences in 2006 through 2010. More than 300 participants were solicited to answer a ranking questionnaire. The results from the simple tabulation, figures and a rigorous statistical model revealed the divergence in people's perceptions of the importance of criteria guiding emissions control policies and selection of measures, and we attribute these differences in opinion to differences in people's working backgrounds and the economic and political conditions in their countries. Our multinomial logit model estimation pushed our investigation further and provided a more direct illustration of the potential determining role of each of these background factors. The estimations found that economic and political differences among countries seem to result in more divergence of opinion about the importance of the criteria. Furthermore, some criteria, particularly less classical ones such as ability to administer changes and time to reach effectiveness, showed more divergence in people's opinions than classical criteria, such as cost, effectiveness etc.

Keywords: perception, multi-criteria decision making, vehicle emission control, survey, multinomial-logit model, policy and measures

[1] Département d'Économique and GRÉDI, Université de Sherbrooke, Québec, Canada. Jie.he@usherbrooke.ca
[2] Department of Civil and Structural Engineering, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong SAR

1. Introduction and background

Decision making in environment-related policies and projects requires the consideration of trade-offs among socio-political, environmental and economic impacts. Multi-criteria decision analysis (MCDA) emerged as a formal methodology to handle available technical information and stakeholder values to support decisions and has been widely applied in many fields, such as sustainable energy (Wang et al. 2009) and transport policy (Browne and Ryan, 2011; Huang et al. 2011). Although significant developments have been made in the methodologies of using multi-criteria decision-making frameworks to treat multi-dimensional technical information(Greening and Bernow, 2004), few studies have given sufficient consideration to how to improve understanding of stakeholder values (Braunschweig et al. 2001). However, the use of various aspects of the technical information addressed in a multi-criteria decision-making framework to guide the identification of the best alternatives is highly dependent on the criteria chosen beforehand and their weighting to reflect stakeholder values. Without a clear understanding of how these criteria are chosen and weighted and how these processes are related to stakeholders' values, even the final alternatives chosen by the most efficient information-processing framework may not be "the" most pertinent alternatives for the stakeholders.

Early discussions of the importance of criteria identification and weighting can be found in studies by Yu (1990) and Zeleny (1992) and Keeney (1992), which all suggested that a good decision-making process will force decision makers to understand their preferences and allow the set of alternatives to be expanded. Henig and Buchanan (1996) further advanced this idea and criticized the MCDA method as being largely a technical one, with little emphasis on decision-making methodology. They claimed that "(in this method), all necessary components of the decision problem and any assumptions about the nature of the decision maker's preferences have been defined *a priori* and often taken for granted." As conceptually the decision making process is to compare the alternatives with the criteria, Henig and Buchanan (1996) believed the criteria should be independent of alternatives and a decision maker must already have criteria (knowingly or implicitly); therefore,the challenge is to identify or construct the aspects of the decision maker's criteria that are relevant to the decision making.

We found only four papers that directly study criteria selection and weighting among the large number of studies using MCDA approach. An interesting common conclusion of these studies is that they all reveal significant differences in the subjective preferences for criteria among people from different continents and countries with different professional backgrounds.

Ananda and Herath (2003) studied the stakeholder values in regional forest planning in Australia by using a value elicitation survey. Their study reveals that stakeholder groups do assign different importance weights to future forestry management options.

Using a questionnaire survey, Sell et al. (2006) analyzed the decision criteria of European and Latin American market actors for tropical forestry projects that provide environmental services. In addition to finding that the collected criteria cover a variety of topics that clearly go beyond the frequently applied sustainability dimensions of forestry-related decision making based on

multiple criteria, they found significant interaction between criteria weights and the provenance of participants; whereas the European sample attributed more weight to social benefits, legal compliance, sustainability, environmental benefits and stakeholder participation, the Latin American sample attributed the highest weight to expertise and capacity building, financial resources, political aspects, information management and market. The authors concluded that, in general, Latin American market actors emphasize criteria related to market and information/knowledge management, whereas European participants tend to assign importance to social and environmental benefits and sustainability. This study provides insight into the necessity of a better study of the bottom-up defined decision criteria for MCDA.

Emberger et al. (2008) discussed the transferability of the "ideal" plan-led process for urban transport planning from Europe to Southeast Asia. By applying the same questionnaire among experts of urban transport planning in Europe and in Southeast Asia, they found that people in different regions have different traditions in planning and place different weights on transport-related objectives (criteria). Apparently, many Southeast Asian cities currently focus only on economic efficiency and growth, with much less concern for the environment and equity. The authors therefore concluded that setting objectives (criteria) in Southeast Asian cities needs to be adapted to local circumstances.

Buchholz et al. (2009) also report their comparative studies on sustainability criteria for bioenergy systems, based on an expert survey that invited people to rate the relevance, practicality, reliability and importance of a pool of proposed criteria. Their study showed significant rating differences among groups for a certain number of criteria and found that the lowest consensus exists between different professions, whereas most of the differences in perceptions of social criteria were significant only between regions, suggesting potential cultural influences on these patterns.

Although the three studies described above reveal the existence of potential differences in the perceptions of people of different regions and different professions on the selection and rating of criteria that are used in different fields of decision making, their findings are based on simple comparison, such as the simple tables or figures that illustrate the differences (whether statistically significant or not) of the average weight on criteria given by people of different regions or professions. In this paper, we will go one step further to conduct formal statistical analyses by estimating a multinomial estimation model with the data that we collected through three rounds of a large-scale expert questionnaire survey (367 usable answers obtained), aiming at revealing stakeholders' preferences for various criteria that are often cited in decision making about various vehicle emissions control programs worldwide. The purpose of our study is to provide more detailed explanation, not only on which factors affect the perceptions of people on criteria importance, relevance, etc., but also on how these factors affect criteria selection and weighting and how their influences are different across aspects such as countries and professions. With the available macroeconomic, infrastructure and demographical data of the countries (regions) that the experts belong to, we also aim to deepen our understanding of the fundamental sources of the differences.

The organization of the paper is as follows. Section 2 provides a short introduction to the survey. Section 3 illustrates a general statistical description of the data. The multinomial model estimation results are presented in section 4, and we conclude in section 5.

2. Survey

The questionnaire surveys were conducted in 3 rounds during three conferences on “cleaning the air", in which the experts with similar backgrounds and interests in air quality control were solicited to complete either a paper- or internet-based self-administrated questionnaire. The first round of the survey was conducted at the Motor Vehicle Emission Control Workshop held in Hong Kong in May 2006, and the second round was conducted at the Better Air Quality Conference held in Yogyakarta, Indonesia, in December 2006. In March 2010, a third round of the survey was conducted at the Vehicle Emission Control Workshop held in Hong Kong.

After providing a short explanatory introduction about the objective of the survey, the questionnaire invited respondents to answer questions about their professional background, experiences in emissions control and the nature of their current job.After that, a brief explanation for the chosen criteria,which is followed by the preference-eliciting ordinal ranking question. Several versions of the draft survey were pre-tested on a selected group of stakeholders.

The choice of the six criteria is based on the consideration of their pertinence in the decision-making of vehicle emissions control policies and measures and on the related discussions in the literature. To avoid the potential misleading and overlapping, we just include one criterion for each aspect of the consideration.

The first criterion is the “cost of implementation,” which refers to the investments in capital, resources and technology that are required to establish measures. This criterion addresses the economic/financial impact of a measure. Costs and the potential profits of implementing alternative policies and measures are of great concern to governments in both developed and developing countries. Governments have to justify expenditures and potential gains for implementing costly vehicle emissions reduction policies and measures. Often, this aspect is addressed by a cost-benefits analysis.

The second criterion is “effectiveness.” Related to vehicle pollution control policies and measures, this criterion refers to the level of attainment in emissions control after the execution of the measures. Tzenget al. (2002) emphasized efficacy as an extension of the efficiency of alternative policies and measures in the amelioration of air quality. We often use a cost-effectiveness analysis to evaluate the efficiency of measures and policies.

We generally understand that these two dimensions are not adequate to comprehensively evaluate the performance of control strategies. Acutt and Dodgson (1997), Moavenzadeh and Liddle (1999), Molina and Molina (2004) and Rienstra et al. (1996) discussed implementation feasibility. Moavenzadeh and Liddle (1999) further advocated that the implementation feasibility was

affected by financial capability and institutional barriers coming from the government and the public. In her framework, Plaut (1998) explored efficiency and effectiveness policy assessments. She proposed that vehicle emissions abatement policy alternatives can be evaluated by examining the elements of efficiency, effectiveness, equity, costs of implementation and political feasibility. Based on these considerations, we propose another 4 dimensions of criteria.

The third criterion is the time span for the alternative policies and measures to reach their full effectiveness ("effect time"). The longer the period required for the policy measures to take effect, the greater will be the damage from air pollution. Because there is increasing concern about the adverse impacts of vehicle emissions on human health, we believe a policy measure that requires a shorter period to take effect will be preferred.

The fourth criterion is political or public acceptability, referring to the willingness of the public and the government to accept the selected policies and measures. The extent of public cooperation in implementation of a measure influences the outcome. Introduction of alternative cleaner fuel is a good example of this effect. Although the use of alternative cleaner fuels in a vehicle can reduce air pollutants efficiently, without the support and cooperation of the public, successis difficult to achieve. The Hong Kong government successfully switched the 18,000 diesel taxis to LPG versions in the period from 2000 to 2006 because the offered subsidy was acceptable to both the taxi operators and the public.

The fifth criterion is "administer-ability," i.e., the ease of administering the change. The governance capacity of the administration can directly affect the implementation and efficiency of policies and measures. This is especially true for measures and policies that involve a large number of parties. If the capacity of administer plays a relatively less important role in Western countries where political and juridical institutions function with regard to a constitution, this criterion might be much more decisive for many countries in Asia, where the historical philosophy has resulted in the effective function of the political system being highly dependent on the virtue of the political leader.

The sixth criterion is "degree of deviations from the existing system," which refers to the intensity of alterations to the community during the implementation of the measures. The higher the degree of deviation, the higher will be the uncertainties of the policies and measures. Often, additional supplements and amendments of legal acts might be needed for implementing policies and measures that deviate significantly from the existing practices.

Similar criteria have been adopted by Tzeng*et al*. (2002) in their study of air quality improvement strategies in Taipei. Their evaluation criteria were identified by environmental protection experts, government authorities, academic research groups and local residents. Except for "administer-ability," all of the other five criteria are frequently addressed in the papers cited above that directly examined such criteria, such as Emberger et al. (2008), whose list of criteria includes economic efficiency (cost), protection of the environment, livability of streets and neighborhoods (effectiveness), safety (degree of deviation from the current system), equity and social inclusion (political acceptance).

3. Statistic descriptive of the survey data[3]

In total, we obtained 327 valid returns from the three rounds of the questionnaire: 68 from the first round, 215 from the second round and 44 from the third one. The interviewees are from 35 countries or regions in Asia, Africa, Europe, North America and the Latin America and Oceania regions (Appendix 1). The participants include government officials, members of NGOs, researchers and technical workers.

Table 1 shows a more detailed summary of the interviewees' backgrounds. Although the detailed distribution of the respondents according to different classifications varies between the three rounds of the survey, the combination of the three surveys provides a relatively balanced data sample, with a good coverage of respondents with different work profiles and emissions control experience. The definition of country class according to their income level is based on the World Development Indicator (WDI). Three country classes (i.e., low, medium and high income) are defined. Approximately 46.2% of the interviewees were from high-income countries, another 21.7% were from middle-income countries and the remaining 32.1% were from low-income countries. The numbers of the respondents having no experience (0 year), some experience (0–5 years) and long experience (more than 5 years) in emissions control fields are 99, 107, 121, respectively, and each group represents approximately 30%, 32% and 37% of the total sample, respectively. Among the respondents, 116 work for government-affiliated organizations, and this represents approximately one third of the whole sample. The of jobs were distributed as follows: 102 participants work at academic jobs, 82 work in the field of research and development, 92 work at policy-making jobs and the remaining 99 work as technical personnel, corresponding to 31.2%, 25.1%, 28.1% and 30.3%, respectively, of the whole sample.

Each respondent was invited to classify the 6 criteria included in the survey from most important to least important by assigning a score of 6 to the most important criterion and a score of 1 to the least important criterion. Table 2 illustrates the average score obtained by each criterion based on the total sample and on different sub-samples, with the standard errors given in the brackets. From the total sample, an interesting finding emerges; although the effectiveness of the measure is considered as the most important criterion, with an average score of 4.12, this criterion is closely followed by political acceptability (4.01). This finding suggests that effectiveness is far from a unique criterion for the selection of emissions control policies. To our surprise, consideration of cost is ranked only third, with a much lower score of 3.43. This suggests that, in general, the cost issue is not the most critical one in the process of identifying the best policy,

[3]Economies are divided according to 2010 GNI per capita, calculated using the World Bank Atlas method. The groups are low income, $1,005–$3,975 (originally low- and lower-middle-income group; we grouped them together in our paper, given that the small number of countries included in the survey belong to the low-income group); middle income, $3,976–$12,275 (originally upper-middle income group); and high income, $12,276 or more. Here, the dollar is constant as of 2010, and the exchange rate used in currency conversion is the one based on the parity purchase power (PPP).

although it contributes to the discussion of the different policies and measures. The three remaining criteria—administer-ability, effect time and the degree of deviation from the existing system—ranked as the fourth, fifth and sixth criteria, respectively, are generally considered to be relatively less important.

Table 2 also shows the ranking results for the six criteria in different sub-groups, classified according to income level, types of job, affiliation, democratic level and past experience. An interesting finding is that if we regroup the criteria into three pairs, the importance of which varies among most important (first and second places), important (third and fourth places) and less important (fifth and sixth places), we observe an almost-perfect similarity between sub-groups in their ranking results. This finding suggests that people of different origins and different working experiences have a quite close consensus on the importance of the criteria. The significant divergence among sub-groups exists only in the choice of *the* most important criterion. Although most of the sub-groups have a consensus on the order of importance of effectiveness, some groups, such as the middle-income group, the government-affiliated group, the authoritarian regime group and the policy-making job group, instead choose public acceptability as the most important criterion. In the same sense but to a lesser extent, the middle-income group and the authoritarian regime group reverse the third and fourth places as well as fifth and sixth places for the important and less important pairs.

Figure 1 describes in more detail the rankings given by the entire sample of respondents. Following the observations from Table 2, we regroup the 6-level ranking into three levels: high importance (1st and 2nd rank), medium importance (3rd and 4th rank) and low importance (5th and 6th rank). Figure 1 shows the rankings of the entire sample. The order of appearance of the criteria in the figure from left to right follows their average ranking score, with the criterion of the highest score appearing on the far left. Of the 327 respondents, more than 50% ranked effectiveness as highly important, another 25% considered it to be of medium importance and only fewer than 25% considered it to be of low importance. The situation is completely different for the criterion "deviation from the existing system," which received a ranking of "low importance" from approximately 40% of the respondents; only a few more than 30% of respondents considered it highly important.

Figures 2 through 4 illustrate, following the same system as Figure 1, the detailed rankings for the 6 criteria given by respondents belonging to different sub-groups. Comparing the 3 panels in Figure 2, we can understand better the cause of the reversed ranking results for "effectiveness" and "political acceptability" between high- and middle-income groups. The percentages of respondents who ranked "effectiveness" and "political acceptability" as highly important are 60% and 42%, respectively, in the high-income sub-group, whereas the corresponding percentages for the respondents from middle-income countries are 42% and 60%, respective, which is the complete inverse, showing significantly different perceptions of the two criteria. The ranking details from the respondents of the low-income sub-group, although revealing a smaller difference from the high-income subgroup, are also marked by a higher importance given to

"political acceptability," with a ranking of high importance of 55% for both political acceptability and effectiveness criteria.

Figure 3 reveals the differences in criteria perceptions between respondents from countries with different levels of democracy. The democracy index (DI) used in our paper was compiled by the Economist Intelligence Unit in 2008. This index has values rangingfrom 10 to 0, with higher values indicating a higher level of democracy. Based on this index, we can further separate the countries into four groups: full democracy (10>DI>=8), flawed democracy (8>DI>=6), hybrid regime (6>DI<=4) and authoritarian regime (DI<4).[4] An interesting finding shown in this figure is that the percentage of respondents ranking the criterion "effectiveness" of high importance seems to increase with an increase in the democracy level, whereas a contrary tendency can be observed for the criterion "political acceptability," although a small fluctuation can be found in the group "hybrid regime." In other words, this finding suggests that a more democratic country gives more consideration to the effectiveness of policies and measures, whereas a less democratic country gives more consideration to the "political acceptability" of the policy. At same time, we can observe that the respondents from the less democratic countries have less consensus on the ranking of the criteria compared with their counterparts in more democratic countries

Figure 4 illustrates the differences in voting structure between people having different levels of experience on vehicle emissions control field. Comparing the three panels, we can see that the importance of the "effectiveness" criterion reduces with experience. Another finding is that people with more experience seems to have less consensus in their ranking of criteria.

Figure 5 gives the difference in the voting structures between respondents of different types of jobs. Although there seems to be a good coherence among the rankings given by respondents working in academic, R&D and technical fields, policy-makers seem to have different opinions about the importance of different criteria. Effectiveness is the most important criterion for more than 60% of the respondents working in the other three fields; for people working as policy-makers, the same percentage of respondents gave high importance to political acceptability.

4. Multinomial logit model

Until now, we have observed from simple data descriptions that people with different working experiences and from different economic and political systems seem to have different perceptions of the importance of the 6 criteria for the selection of emissions policies and measures. The separate descriptions provided by figures and by tables offer interesting insights, although they cannot resolve the potential colinearity between respondents' characteristics. For example, are people's perceptions of the importance of the criteria dependent on their personal working experience or on the general economic and political conditions of their countries? If both factors

[4] The Democracy Index measures the level of democracy in 167 countries, of which 166 are sovereign states and 165 are UN member states. This index is based on 60 indicators grouped in five categories: electoral process and pluralism, civil liberties, functioning of government, political participation and political culture. The index was first produced in 2006, with updates produced in 2008 and 2010. For more information, refer to "Democracy Index 2010: Democracy in retreat," A report from the Economist Intelligence Unit.

are involved, which factor has more impact? Do people share more common judgments of the importance of certain criteria than others? How great can the divergence be in the appreciation of the importance of criteria? To answer these questions, we use a multinomial logit model to estimate the statistical determination relationship between the different factors and the final ranking results.

Many researchers have used econometrical models in the analysis of policy decisions. For example, Nellthorp and Mackie (2000) used a hedonic model to analyze decision making on a particular scheme to enter the target program of improvements (TPI) in UK road reviews.

The multinomial logit model has been often used to explain the determination factor for an individual in the choice of occupation. In such a model, the dependent variable Y is a discrete variable, which takes an integer value ranging from 1 to N. In our criteria-ranking case, the value of this dependent variable Y corresponds to the choice of the *j*th (j=1,2,3,..,6) criterion as the most important. Based on this encoding system, we can write the ranking process of respondent *i* facing the 6 criteria as follows:

$$Prob(Y_i = j) = \frac{e^{\beta_j x_i}}{\sum_{k=1}^{6} e^{\beta_j x_i}}, \qquad j = 1, 2, \dots 6$$

Here, the subscript *j* denotes one of the 6 criteria, and *i*denotes the respondents. This equation provides a set of probabilities for each of the criteria *j* to be chosen as the most important criterion by respondent *i* with characteristics x_i (job nature, experience, country and economy characteristics, etc.). We know equally that the probabilities to be estimated for the 6 criteria sum to one, so for the 6 criteria, only 5 parameter vectors can be estimated. To proceed this estimation, we therefore need a convenient normalization that solves the problem, which is to fix one criterion as the base criterion and fix its coefficients vector $\beta_1=0$ so that the probabilities are

$$Prob(Y_i = j|x_i) = \frac{e^{\beta_j x_i}}{1 + \sum_{j=2}^{6} e^{\beta_j x_i}}$$, for j=2,3,4..,6 and $\beta'_1=0$.

The multinomial logit estimation will provide us with 5 vectors of coefficients with respect to the reference (*j*=1) and, from each of the 5 vectors, we will be able to interpret how the background of a respondent (including professional experience and country, cultural and political surroundings) can affect his or her vote on the importance of each of the 6 criteria. For a respondent *i*, if the predicted probability is for the *j*th criterion to be the highest, we know that people sharing the same characteristic as respondent *i* will choose the *j*th criterion as the most important.

Table 3 reports the variables used in the estimation. To correspond to the previous sections, we include dummies for the respondent's origin country's income and democracy level, the respondent's affiliation (governmental or not), job type (policy making or not) and working experience (no, less than 5 years or more than 5 years) as determinant variables. Considering the potential differences between the three rounds of surveys, we also include

the dummy variables to capture the non-explicable survey-specific constant in the probability determination function for each criterion.

The estimation results of the multinomial logit model are reported in Tables 4 and 7. The estimated coefficients for the same variable are listed in the same line, with the numbers included in brackets as the statistical student T value. Each column corresponds to one criterion; the coefficients listed in the same column give the explanatory power of different determinant variables for the probability to choose the criterion as the most important one. Considering the cost of implementation as a traditional determinant factor that is often used in the selection of policies and measures, we decided to define it as the base case, so its coefficient vector will be normalized to zero. Therefore, if the coefficients of the determinant factors for the other criteria are found to be larger than zero, the other criteria will have more possibility than cost to be chosen as the most important. However, if some coefficients are found to be less than zero, we can expect a smaller probability for the corresponding criterion to be more important than the cost factor.

Our estimation results confirm the statistically significant influence from the level of democracy and income level of the origin country in criteria ranking and, to a less significant extent, the influence from government affiliation, job nature and working experience. We can read the estimation result in the following way. Taking an example of a respondent coming from a low-income (mid_income=1), flawed democracy country (flawed_democracy=1) (such as India, Indonesia, Sri Lanka, Mongolia or the Philippines), working in a governmental affiliation at a policy-making job with less than 5 years of experience and surveyed at the 2nd round, the respondent's ranking as predicted by our estimation result will be as reported in Table 5. Here, all of the coefficients for the dummy variables that do not correspond to the profile of the respondent in question will be equal to zero (βX and $X=0$), and only the coefficients for the corresponding dummies will be included in the calculation. We see that this respondent will rank public acceptability as most important. From this demonstration, we know that the probability that a respondent will choose one criterion as the most important is dependent on the value of the coefficients belonging to the criterion, i.e., the higher the value of the coefficients, the higher will be the predicted probability.

Comparing the coefficients' value between variables, we also find a clear tendency toward a mutual cancellation effect between the democracy dummies, which generally report positive coefficients, and the income dummies, which, in contrast, have negative coefficients. The cross frequency of the two country profiles reported in Table 6 show in detail the interrelationship of these two country profiles, and we can easily identify 6 large groups of countries that are distinguished in their income-democracy combination: 71 respondents from high-income, full-democracy countries, 56 from high-income hybrid-regime countries, 23 from mid-income, flawed-democracy countries, 37 from mid-income, authoritarian-regime countries (only Chinese), 81 from low-income, flawed-democracy countries and 16 from low-income, hybrid-regime countries. These six groups account for 284 of the 290 respondents whose data are complet so can be used in the estimation. By using these group distinctions, we re-do the estimation of the multinomial logit model and replace the income and democracy dummy by the group dummies that identify these 6 groups. The results of this new estimation are given in Table 7.

In terms of the statistical significance and the signs of the estimated coefficients and the global explanatory power of the model, the results shown in Table 7 are similar to those shown in Table

4. The advantage of grouping the countries into 6 groups according to their combined income and democracy profile is that we can directly compare the coefficients between groups and therefore have more convenience in interpretation of the contribution of country income and democracy profile in the identification of the most important criterion.

Following, we convert the estimation results of Table 7 into rankings by comparing the values of the coefficients for different criteria belonging to the same variable. The higher the value of the coefficient for a criterion, the higher will be this criterion in importance ranking. Our first observation is that people with different working backgrounds share a higher coherence in criteria importance ranking (cf. the similar ranking numbers belonging to each criteria listed in the bottom part of Table 7). More divergence is observed in the upper part of the table, where we present the ranking predictions for the people from different countries of different income and democratic levels. Furthermore, respondents clearly have less divergence in their understanding of the importance of certain criteria such as cost, effectiveness, public acceptability and deviation from the existing system. However, for criteria such as administer- ability and effect time, rankings vary more widely among people of different origins and working backgrounds. This should reveal a more diverse understanding of people regarding their importance in selectionof emissions control policies.

5. Conclusion

In this paper, we analyzed data concerning people's perceptions on the importance of selection criteria for vehicle-related emissions control policies and measures based on a 3-round questionnaire-based survey organized during three professional air quality control international conferences in 2006 through 2009. More than 300 participants were solicited to answer the ranking questionnaire.

The results from simple tabulation, figures and rigorous statistical analysis all revealed the divergence in people's perception of the importance of criteria that guide the selection of emissions control policies and measures. We attribute these differences in opinion to the differences in people's working backgrounds and the economic and political conditions of their countries. These results are consistent with the conclusions of several previous studies, such as those by Buchholz et al. (2009), Emberger et al. (2008), Sell et al. (2006) and Ananda and Herath (2003), which found similar results with different analytical approaches. Our multinomial logit model estimation pushed our investigation further and provided more direct evidence of the potential determination role of each of these background factors. The estimation results found that countries' economic and political differences seem to result in more divergence of opinion about the importance of the criteria, and that some criteria, particularly the less classical ones such as administer-ability and effect time, also face more divergence in people's opinions than more classical ones, such as cost and effectiveness.

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Appendix 1: Country names list and income levels

Oceania		
	Australia	High
	New Zealand	High
Europe		
	Austria	high
	Belgium	High
	Denmark	High
	France	High
	Germany	High
	Great Britain	High
	Netherland	High
	Poland	High
	Sweden	High
	Switzerland	High
	Finland	High
NorthAmerica		
	Mexico	Upper-middle
	USA	High
Latin America		
	Columbia	Upper-middle
Asia		
	Bangladesh	Low
	Bhutan	Lower-middle
	China	upper-middle
	Hong Kong	High
	India	Lower-middle
	Indonesia	Lower-middle
	Japan	High
	Korea	High
	Lao People's Democratic Republic	Lower middle
	Malaysia	Upper-middle
	Mongolia	Lower-middle
	Nepal	Low
	Pakistan	Lower-middle
	Philippines	Lower-middle
	Singapore	High
	Sri Lanka	Lower-middle
	Thailand	Upper-middle
	Vietnam	Lower-middle
	Taiwan	High

Appendix 2. ranking question in survey questionnaire

6 assessment criteria have been set by considering the social, economical, political and technical judgments to evaluate the performance of the vehicle emission control measures. These performance criteria are:

A. **Effectiveness** refers to the level of attainment in emissions control after the execution of the measures.

B. **Cost of implementation** refers to the investments, including capitals, resources and technology, required to establish the measures.

C. **Administer-ability** refers to the level of involvement of different parties, such as government, automobile manufacturers, fuel producers and public transport operators, to manage the measures.

D. **Political acceptability** refers to the willingness of the government and public to accept the policy.

E. **Effect time** refers to the period of implementation when the measure could reach its full effectiveness.

F. **Degree of deviations to existing system** refers to the intensity of alterations to the community during the implementation of the measures, such as changes in vehicles and fuels used and urban planning.

1) **Please click your selection**: Criteria – Rank criterion A to F base on the importance

Criterion	Criteria Ranking					
	Most Important					Least Important
A	○1	○2	○3	○4	○5	○6
B	○1	○2	○3	○4	○5	○6
C	○1	○2	○3	○4	○5	○6
D	○1	○2	○3	○4	○5	○6
E	○1	○2	○3	○4	○5	○6
F	○1	○2	○3	○4	○5	○6

Table 1. Statistic summary of the respondents' situation

		Round 1		Round 2		Round 3		Total	
		No.	**%**	**No.**	**%**	**No.**	**%**	**No**	**%**
Total sample		68	-	215	-	44	-	327	-
Job Nature[1]	Academic	14	20.6	81	37.7	7	15.9	102	31.2
	R&D	11	16.2	65	30.2	6	13.6	82	25.1
	Policy Making	33	48.5	54	25.1	5	11.4	92	28.1
	Technical	18	26.5	51	23.7	30	68.2	99	30.3
Country income	High income	33	48.5	78	36.3	40	90.9	151	46.2
	Middle income	34	50.0	33	15.3	4	9.1	71	21.7
	Low income	1	1.5	104	48.4	0	0.0	105	32.1
Affiliation	Gov.	28	41.2	78	36.3	10	22.7	116	35.5
	Non-Gov.	40	58.8	137	63.7	34	77.3	211	64.5
Experiences on vehicle emission control	0 year	7	10.3	75	34.9	17	38.6	99	30.3
	0-5 years	22	32.4	70	32.6	15	34.1	107	32.7
	Over 5 years	39	57.4	70	32.6	12	27.3	121	37.0

Note 1. The different job nature percentage points, once added together, can be higher than 100%, this is due to the fact that some people exercise a job with multiple job natures.

Table 2. The weight of each criterion

	no. of obs.	effectiveness	acceptability	cost	Administer ability	Effect time	Deviation from existing system
Total	327	4.27	4.15	3.55	3.50	3.31	3.27
		(1.73)	(1.71)	(1.58)	(1.61)	(1.55)	(1.87)
High income	151	4.54	3.91	3.58	3.53	3.34	3.21
		(1.66	(1.74)	(1.54)	(1.64)	(1.49)	(1.93)
Middle income	71	3.82	**4.69**	3.34	**3.83**	3.49	3.65
		(1.81)	(1.35)	(1.64)	(1.56)	(1.66)	(1.91)
Low income	105	4.19	4.14	3.65	3.25	3.14	3.10
		(1.73)	(1.82)	(1.59)	(1.57)	(1.57)	(1.74)
Government	116	3.98	**4.47**	3.82	3.68	3.32	3.22
		(1.82)	(1.63)	(1.59)	(1.62)	(1.56)	(1.95)
Non-government	211	4.43	3.98	3.40	3.41	3.31	3.29
		(1.67)	(1.73)	(1.56)	(1.60)	(1.55)	(1.84)
Authoritarianregime	52	3.75	**4.71**	3.25	**3.94**	3.56	**4.19**
		(1.70)	(1.43)	(1.66)	(1.70)	(1.73)	(1.63)
Hybridregime	90	4.30	3.91	3.63	3.61	3.47	3.53
		(1.69)	(1.78)	(1.70)	(1.61)	(1.59)	(1.93)
Flaweddemocracy	107	4.17	4.07	3.76	3.19	3.22	2.87
		(1.84)	(1.78)	(1.53)	(1.51)	(1.48)	(1.73)
Full democracy	78	4.72	4.17	3.37	**3.53**	3.09	2.88
		(1.56)	(1.64)	(1.41)	(1.63)	(1.47)	(1.91)
academic	102	4.49	4.16	3.44	3.33	3.08	3.19
		(1.66)	(1.80)	(1.63)	(1.54)	(1.52)	(1.74)
R&D	82	4.26	4.30	3.41	3.41	3.23	3.09
		(1.78)	(1.55)	(1.52)	(1.59)	(1.64)	(1.81)
policymaking	92	4.08	**4.70**	3.95	3.79	3.32	3.27
		(1.76)	(1.40)	(1.49)	(1.67)	(1.53)	(2.00)
Technical	99	4.49	3.98	3.59	3.54	3.30	3.02
		(1.67)	(1.77)	(1.55)	(1.67)	(1.52)	(1.89)
experience=0	99	4.56	4.06	3.68	3.20	3.16	3.11
		(1.57)	(1.83)	(1.55)	(1.37)	(1.54)	(1.81)
experience0-5	107	4.26	4.24	3.37	3.43	3.24	3.29
		(1.80)	(1.60)	(1.63)	(1.64)	(1.66)	(1.84)
experience5	121	4.04	**4.15**	3.60	**3.82**	3.50	3.37
		(1.78)	(1.71)	(1.55)	(1.71)	(1.46)	(1.96)

Table 3. Statistical descriptive of the variables used in multinomial logit model

Variable	Definition	Obs	Mean	Std. Dev.	Min	Max
criteria	Criteria chosen as the most important, 1=effectiveness, 2=acceptability, 3=cost, 4=administer, 5=time and 6=deviation	290	2.683	1.771	1	6
high_income	Dummy: high_income country=1, other=0	290	0.448	0.498	0	1
mid_income	Dummy: mid_income country=1, other=0	290	0.207	0.406	0	1
low_income	Dummy: low_income country=1, other=0	290	0.345	0.476	0	1
full_demo	Dummy: full_democracy country=1, other=0	290	0.245	0.431	0	1
flawed_demo	Dummy: flawed_democracy=1, other=0	290	0.369	0.483	0	1
hybrid_reg~e	Dummy: hybrid_regime country=1, other=0	290	0.248	0.433	0	1
authotaria~e	Dummy: authoritarian_regime country=1, other=0	290	0.138	0.345	0	1
gov_	Dummy: governmental affiliation=1, other=0	290	0.341	0.475	0	1
policymaking	Dummy: policy making job nature=1, other=0	290	0.255	0.437	0	1
experience0	Dummy: no experience =1, other=0	290	0.321	0.468	0	1
experienc~_5	Dummy: under 5 years' experience=1, other=0	290	0.328	0.470	0	1
experience5	Dummy: over 5 years' experience=1, other=0	290	0.352	0.478	0	1
q1	Dummy: 1st round survey=1, other=0	290	0.131	0.338	0	1
q2	Dummy: 2nd round survey =1, other=0	290	0.721	0.449	0	1
q3	Dummy: 3rd round survey =1, other=0	290	0.148	0.356	0	1

Table 4.multinomiallogit model: result 1

(290 observations, cost is considered as the reference criteria, so its coefficients are equal to zero)[1]

→criteria ↓variables	Effectiveness	Public Acceptability	Administerability	Effect time	Deviationfromexisting system
high_income	5.814	5.524	6.784	6.037	7.902
	(3.71)***	(3.31)***	(3.07)***	(2.79)***	(3.85)***
mid_income	8.047	9.990	10.468	12.627	13.591
	(3.51)***	(3.84)***	(2.81)***	(3.33)***	(3.89)***
low_income	7.011	8.881	10.806	11.919	13.043
	(3.27)***	(3.59)***	(2.89)***	(3.24)***	(3.80)***
flawed_democarcy	-3.577	-5.493	-6.282	-7.640	-7.173
	(2.34)**	(3.27)***	(2.69)***	(3.24)***	(3.38)***
hybrid_regime	-3.161	-3.903	-5.695	-5.542	-5.627
	(2.43)**	(2.75)***	(3.01)***	(2.72)***	(3.08)***
authoritarian_regime	-5.464	-6.248	-8.667	-8.687	-10.515
	(2.92)***	(3.21)***	(2.73)***	(2.92)***	(3.53)***
Govermental affiliation	-0.821	-0.493	-0.517	-0.884	-1.188
	(1.41)	(0.84)	(0.70)	(1.10)	(1.72)*
Policy_making	-0.299	-0.034	-0.971	-1.282	-1.000
	(0.45)	(0.05)	(1.17)	(1.32)	(1.26)
No experience	-0.462	-0.449	-1.911	-0.943	-1.272
	(0.67)	(0.64)	(2.03)**	(1.00)	(1.62)
Experienceunder 5 years	-0.823	-0.885	-1.684	-0.608	-1.490
	(1.20)	(1.28)	(2.06)**	(0.71)	(1.94)*
q1	20.200	19.366	22.822	19.935	21.534
	(15.43)***	(15.01)***	(15.14)***	(.)	(16.01)***
q2	-1.543	-1.739	-3.495	-3.800	-4.265
	(1.56)	(1.53)	(1.91)*	(2.26)**	(2.61)***
R2 adjusted			0.2256		
LR			234.41		
Hit and miss ratio			42.7%		

Note: 1. The reduction in the number of respondents into econometrical analysis is due to the fact that we are obliged to remove 28 respondents from the database since they gave at least two criteria the 1st rank. The other 16 observations are further removed as these respondents have not identified the most important criteria, so the score of the importance starts from the number smaller than 6.
2. The disappearing of the dummies as Full-democracy and experience over 5 years is due to the identification constraint. Implicitly, the disappeared dummies can be understood as having a coefficient equal to zero.

Table 5. Interpretation of the Multinomial logit model estimation

$\beta_j * x_i$	Effectiveness	Public Acceptability	cost	Administerability	Effect time	Deviationfromexisting system
High_income	0	0	0	0	0	0
Mid_income	0	0	0	0	0	0
Low_income	**7.011**	**8.881**	**0**	**10.806**	**11.919**	**13.043**
Full_democracy	0	0	0	0	0	0
Flawed_democracy	**-3.577**	**-5.493**	**0**	**-6.282**	**-7.64**	**-7.173**
Hybridregime	0	0	0	0	0	0
Authoritarianregime	0	0	0	0	0	0
Governmental affiliation	**-0.821**	**-0.493**	**0**	**-0.517**	**-0.884**	**-1.188**
Policy_making	**-0.299**	**-0.034**	**0**	**-0.971**	**-1.282**	**-1**
No_experience	0	0	0	0	0	0
Unver 5 yearsexperience	**-0.823**	**-0.885**	**0**	**-1.684**	**-0.608**	**-1.49**
Over 5 years' experience	0	0	0	0	0	0
Q1	0	0	0	0	0	0
Q2	**-1.543**	**-1.739**	**0**	**-3.495**	**-3.8**	**-4.265**
Q3	0	0	0	0	0	0
$\beta_j x_i$	-0.052	0.237	0	-2.143	-2.295	-2.073
$e^{\beta_j x_i}$	0.949	1.267	1.000	0.117	0.101	0.126
$1+\sum_{j=2}^{6} e^{\beta_j x_i}$			3.561			
$Prob(Y_i = j \mid x_i) = \frac{e^{\beta_j x_i}}{1+\sum_{j=2}^{6} e^{\beta_j x_i}}$	0.267	**0.356**	0.281	0.033	0.028	0.035
Predicted ranking	3	1	2	5	6	4

Table 6. The democratic and income distribution of the countries of the respondents

numbers	High-income	Mid-income	Low-income	Total
Full-democracy	71	0	0	71
flawed-democracy	3	23	81	107
Hybrid-regime	56	0	16	72
Authoritarianregime	0	37	3	40
Total	130	60	100	290

Table 7.multinomiallogit model: result 2

(290 observations, cost is considered as the reference criteria, so its coefficients are equal to zero)[1]

→criteria ↓variables	Effectiveness	Public Acceptability	Administerability	Effect time	Deviationfromexisting system
Full democracy, highincome	5.498	5.152	6.815	5.779	7.643
	(3.96)***	(3.62)***	(3.42)***	(2.94)***	(4.05)***
Hybridregime, highincome	2.874	1.821	1.627	0.753	2.560
	(3.67)***	(2.21)**	(1.62)	(0.68)	(2.92)***
Flaweddemocracy, midincome	3.296	3.281	3.314	3.755	5.322
	(2.77)***	(2.69)***	(1.64)	(1.89)	(3.01)***
Authoritarianregime, midincome	3.126	4.166	2.691	4.533	3.689
	(2.20)**	(2.99)***	(1.60)	(2.69)***	(2.29)**
Flaweddemocracy, lowincome	3.323	3.193	4.833	4.229	5.812
	(3.32)***	(3.06)***	(2.66)***	(2.48)**	(3.52)***
Hybridregime, lowincome	2.393	3.641	-27.749	5.156	6.110
	(1.70)*	(2.81)***	(0.00)	(2.62)***	(3.16)***
Governmental affiliation	-0.735	-0.356	-0.437	-0.747	-1.085
	(1.23)	(0.59)	(0.59)	(0.92)	(1.54)
Policy_making	-0.365	-0.128	-1.045	-1.387	-1.087
	(0.54)	(0.19)	(1.24)	(1.43)	(1.35)
No experience	-0.429	-0.422	-1.946	-0.951	-1.281
	(0.62)	(0.60)	(2.07)**	(1.01)	(1.62)
Experienceunder 5 years	-1.066	-1.117	-1.965	-0.877	-1.747
	(1.51)	(1.58)	(2.36)**	(1.00)	(2.23)**
q1	20.190	19.383	22.433	19.828	21.409
	(16.16)***	(15.55)***	(16.29)***	(.)	(16.65)***
q2	-1.095	-1.241	-3.366	-3.390	-3.858
	(1.26)	(1.33)	(2.03)**	(2.22)**	(2.54)**
R2 adjusted			0.2313		
LR			240.26		
Hit and miss ratio			42.4%		

Note: 1. The reduction in the number of respondents into econometrical analysis is due to the fact that we are obliged to remove 28 respondents from the database since they gave at least two criteria the 1st rank. The other 16 observations are further removed as these respondents have not identified the most important criteria, so the score of the importance starts from the number smaller than 6.
2. The disappearing of the dummies as Full-democracy and experience over 5 years is due to the identification constraint. Implicitly, the disappeared dummies can be understood as having a coefficient equal to zero.

Table 8. Ranking prediction from the multinomial logit model: result 2

	Effectiveness	Public Acceptability	Cost	Administer ability	Effect time	Deviationf romexistin g system
Full democracy, highincome	4	5	6	2	3	1
Hybridregime, highincome	1	3	6	4	5	2
Flaweddemocracy, midincome	4	5	6	3	2	1
Authoritarianregime, midincome	4	2	6	5	1	3
Flaweddemocracy, lowincome	4	5	6	2	3	1
Hybridregime, lowincome	4	3	5	6	2	1
Governmental affiliation	4	2	1	3	5	6
Policy_making	3	2	1	4	6	5
No experience	3	2	1	6	4	5
Experienceunder 5 years	3	4	1	6	2	5

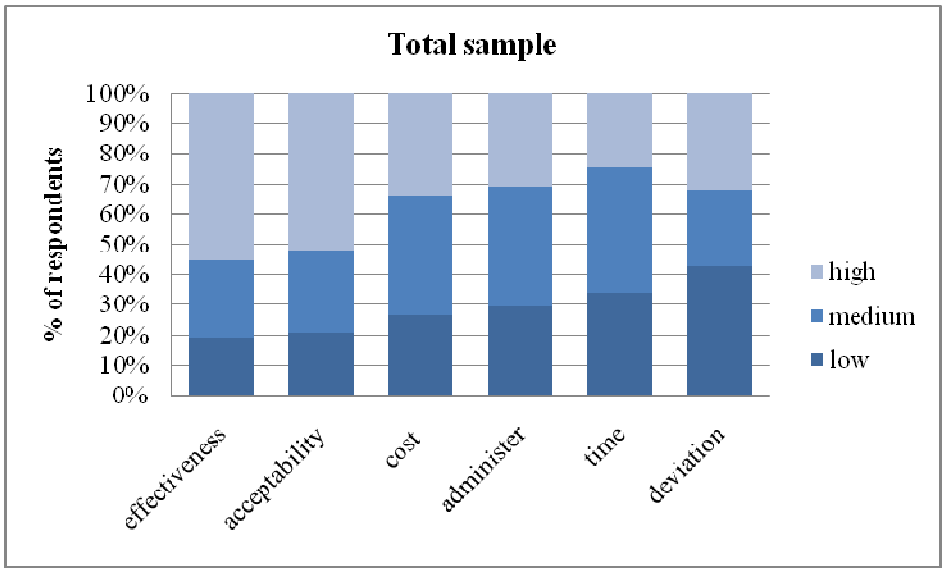


Figure 1. Details in respondents' ranking

Importance is regrouped into three level: high importance(1st and 2nd importance), medium importance (3nd and 4th importance) and low importance (ranking below the 4th place)

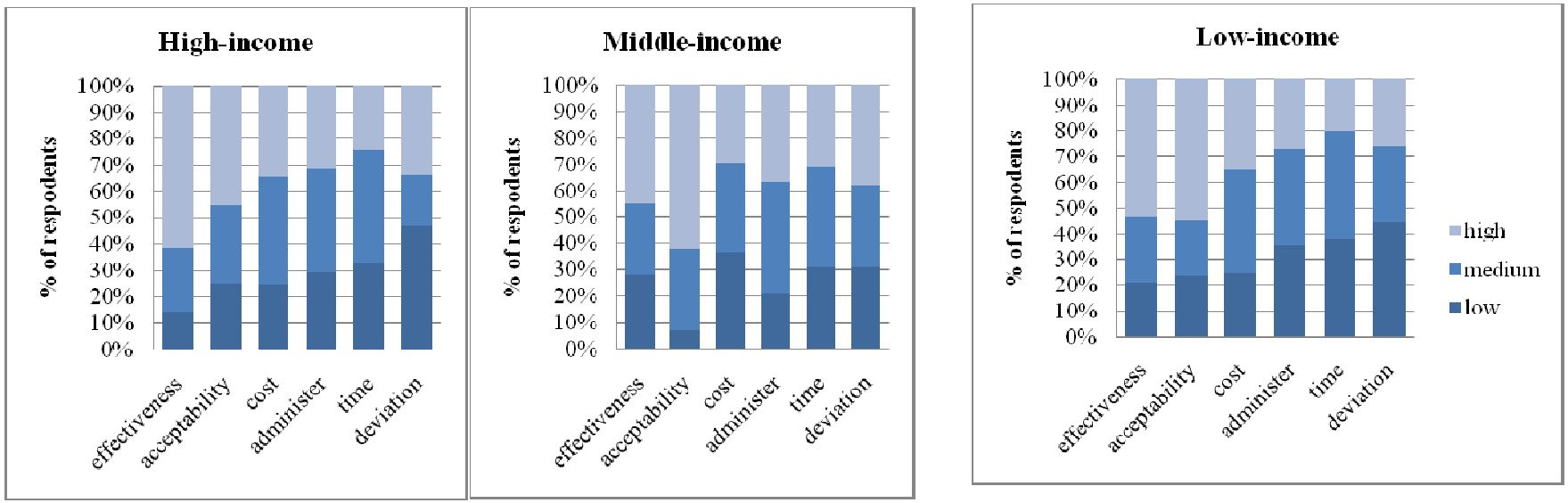


Figure 2. Difference in criteria ranking results between groups of difference income levels (Vertical axe: % of respondents)

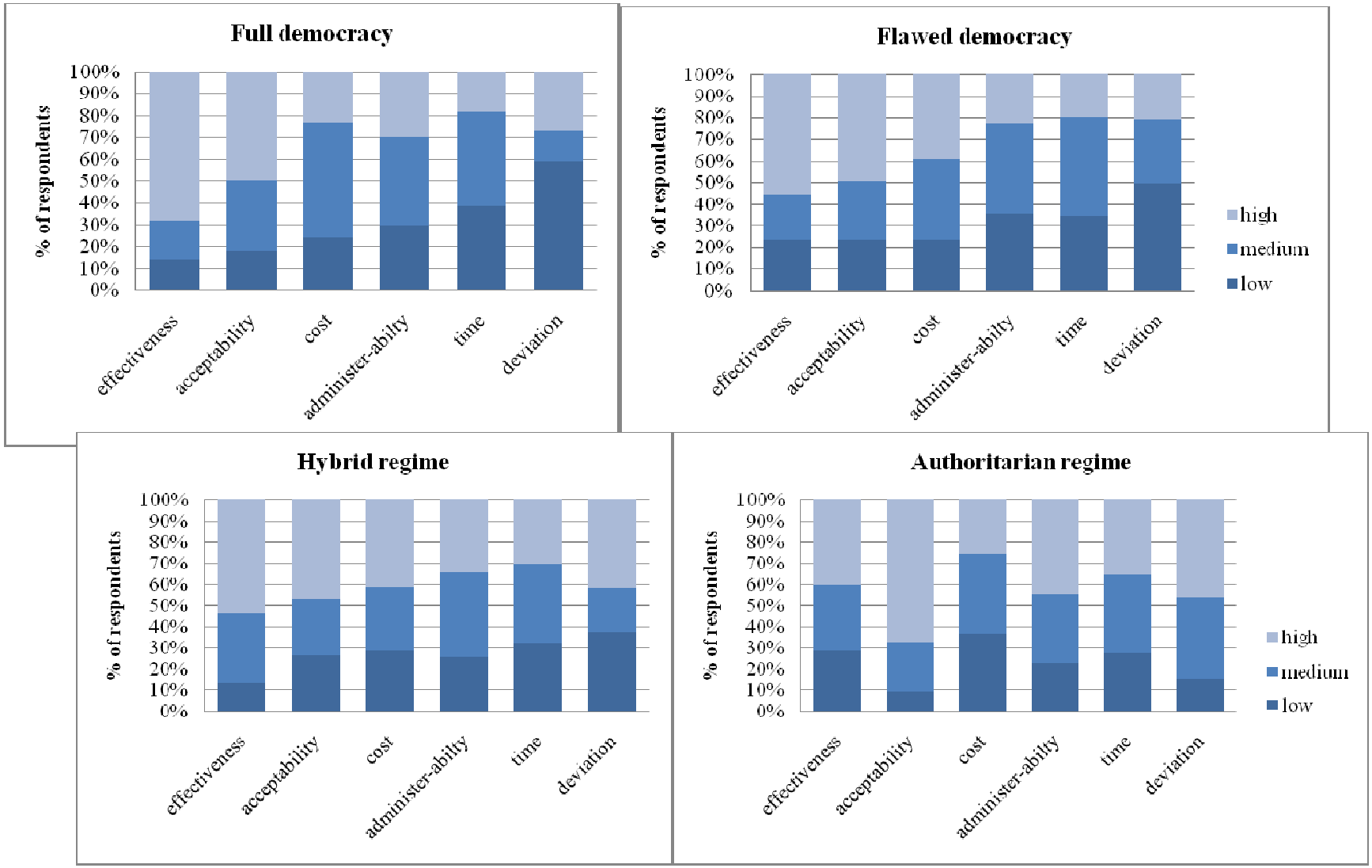
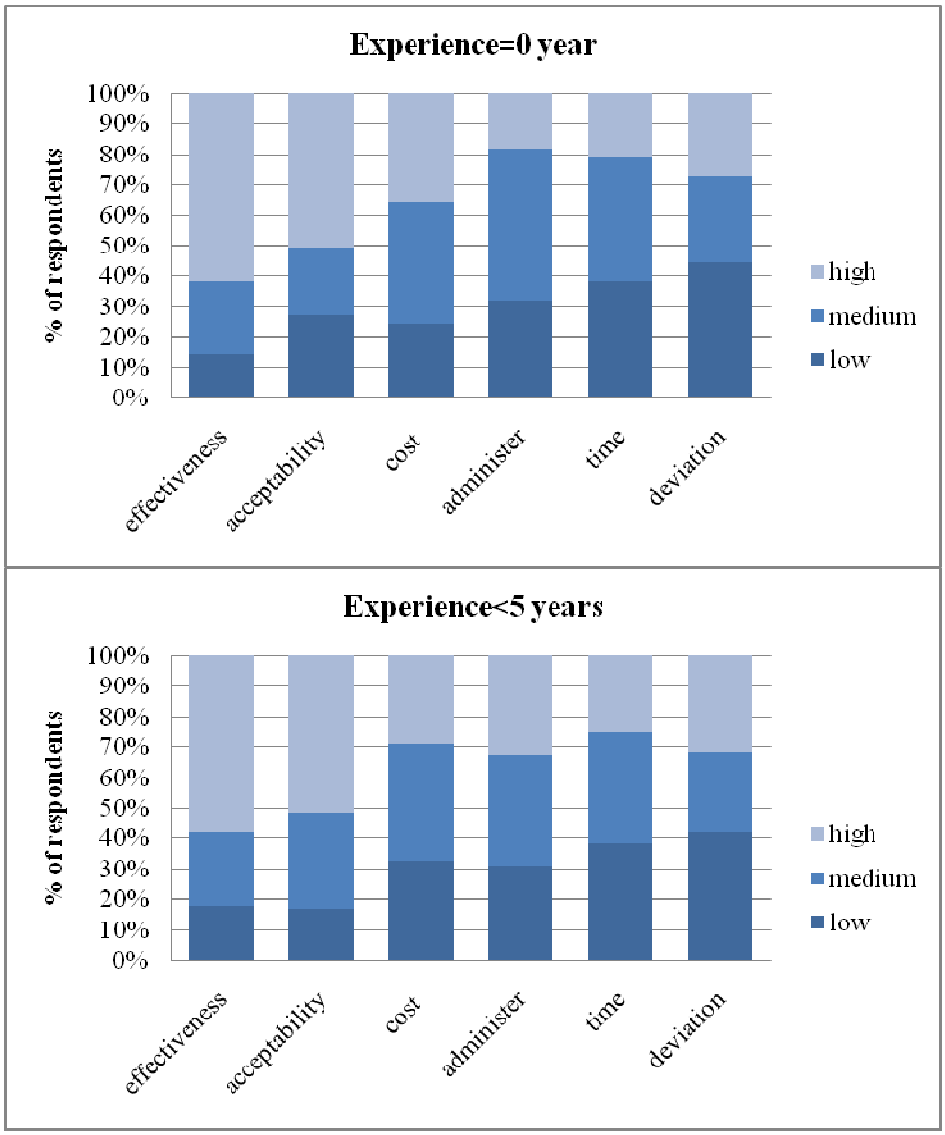


Figure 3. Differences in criteria ranking between countries of difference level of democracy



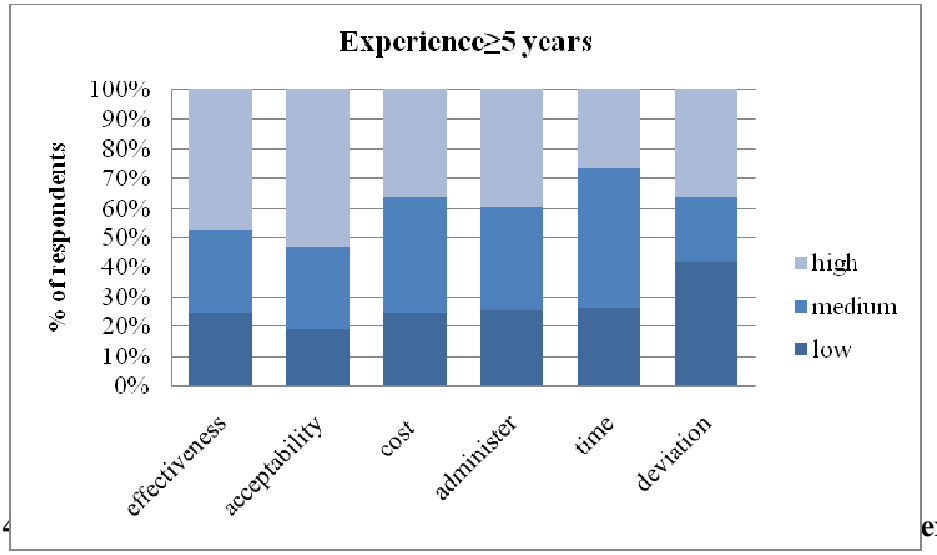
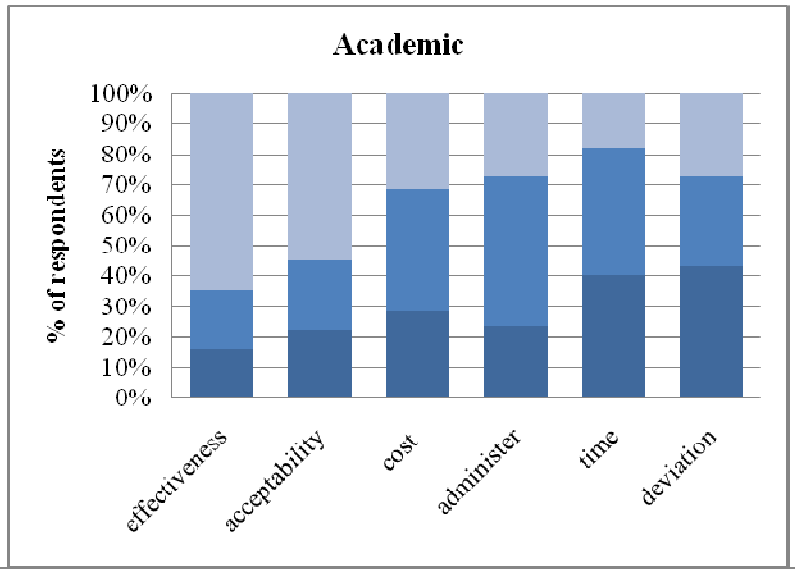
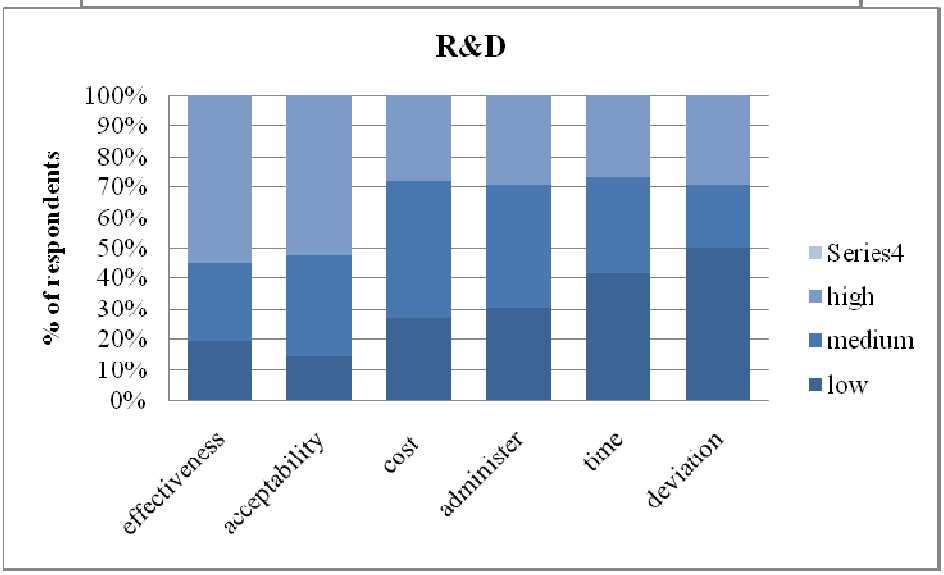
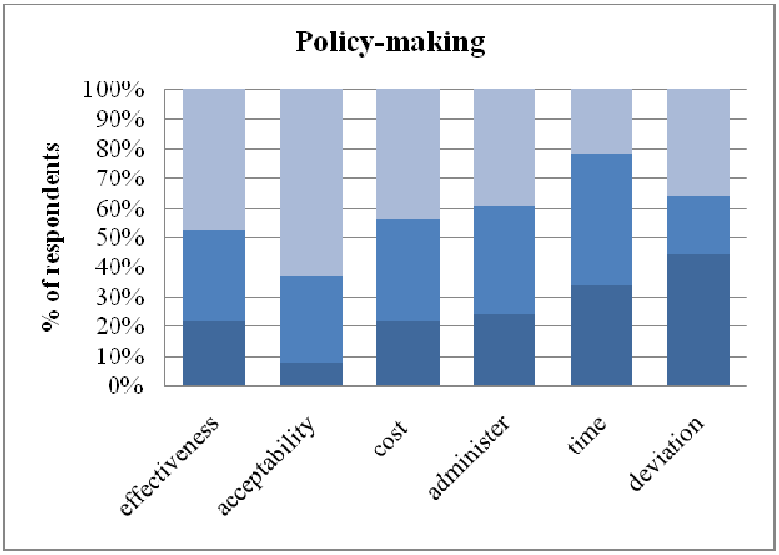


Figure 4 **experience**


Academic
% of respondents
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
effectiveness
acceptability
cost
administer
time
deviation


R&D
% of respondents
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
effectiveness
acceptability
cost
administer
time
deviation
Series4
high
medium
low


Policy-making
% of respondents
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
effectiveness
acceptability
cost
administer
time
deviation

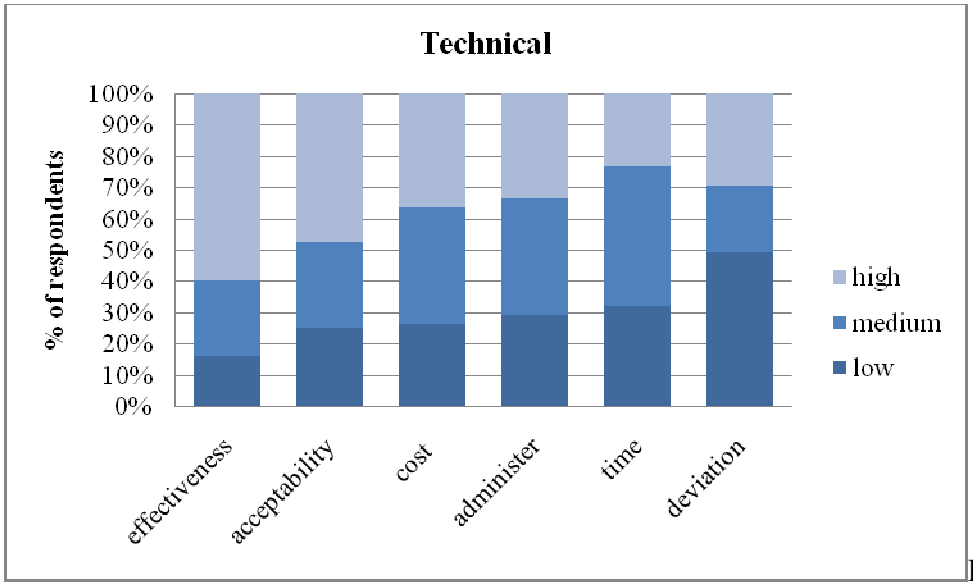


Figure 5. Difference in criteria ranking between groups of different job natures