Factors influencing nanotechnology acceptance: benefits, potential risk, government support and attitude

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Abstract. The aim of this study was to examine issues of benefits (B), potential risks (PR), government support (GS) and attitude (AT) that influence the acceptance (AC) of nanotechnology in Malaysia. Respondent were selected based on purposive sampling and generally they represent the various social groups in the country (n=1207). The findings of the study provide a strong support of the relationships, which theorizes for the roles played by each determinant, either positively or negatively. Almost equal results were obtained to determine nanotechnology acceptance between benefits, potential risks and government support.

1. Introduction
The capability of nanotechnology in producing new manufacturing processes and products in vastly varied sectors from agriculture to medicine could create changes in society as a whole. Previous research has reported that nanotechnology is an emerging technology which has made a significant economic impact in various sectors including food, semiconductor manufacturing, catalysts, medicine, agriculture, energy production [1], [2], [3].

Previous research on attitudes toward nanotechnology has mainly focused on cognitive and emotional processes [4]. With regard to the cognitive, descriptive results on the public understanding of nanotechnology have shown that about half of the population is not aware of the existence of nanotechnology and that people’s knowledge about nanotechnology is low to very low [5], [6], [7], [8].

A national survey conducted by Peter Hart Research Associates found that although a large majority of respondents reported having heard “little” or “nothing at all” about nanotechnology before being polled, a majority still had a position on whether its risks would outweigh its benefits. This shows many persons without significant knowledge about nanotechnology would nevertheless have an opinion about how dangerous it is [9].

Additionally, research done by Valerie and Bellucci [10] reveal that respondent was quite concerned when they heard about the risks nanotechnology might imply. In the study also show that respondents feared that nanoparticles might enter the human body and cross the blood-brain barrier, and they were worried that nanoparticles might accumulate in the environment or might be harmful when being integrated into food. However, Macoubrie [11] said that there is a changes attitude of respondents that shows attitudes of respondent from neutral to a more positive view of nanotechnologies. It is important to understand what factor that leads to nanotechnology acceptance because it associated to the government roles to promote the benefits of nanotechnology to the consumers.
In order to encourage people acceptance and lead to purchases of nanotechnology products, there are four determinants (benefit, potential risk, government role and attitude) was identify to investigate in this study. Thus, the main aim of the study was to examine the relationships between benefits, potential risks, government support, attitude and then the acceptance of nanotechnology.

2. Methodology

2.1. Participants and procedure
The study used a quantitative survey method as the data collection procedure in order to achieve the objectives. The respondents were selected based on purposive sampling and generally they represent the various social groups in the country. This study managed to obtain 1207 respondents to participate in the study. Prior to the actual data collection, a pilot test was performed to ensure the observational categories themselves are appropriate, exhaustive, discrete, unambiguous and effectively operationalize the purpose of the research [12].

2.2. Instruments
The questionnaire comprised of items measuring benefits of nanotechnology, potential risk perception of nanotechnology, government involvement and nanotechnology acceptance. All items were adopted from previous study [13]. To ensure all factors and items in scale are valid and reliable for subsequent analysis, data reduction process using Factor Analysis with principle component and varimax rotation techniques were used. As recommended by Field [14], all items with factor loading of less than 0.40 were omitted. The procedure continues with the performance of reliability tests using Cronbach Alpha score value of greater than 0.70.

3. Result and Discussion

3.1. Participants demographic profile
Sixty five percent of the respondents were female and the 39% were male. Majority of the respondents aged between 20 to 29 years old (860 respondents; 71%). Other group range are less than 20 years old (139 respondents; 12%), 30 to 39 years old (140 respondents; 12%), between 40 and 49 years old (44 respondents; 4%) and more than 50 years old (24 respondents; 2%). More than 67% of the respondents possess bachelor degree academic qualification, and the remaining 33% from other education qualification (i.e. 6% with Master degree, 0.2% with PhD qualification and 26% with others).

3.2. Descriptive analysis of respondent awareness on nanotechnology
The first question was on respondents’ attitude towards new technology. Four items were used to measure on whether the respondents feel new technology makes life more comfortable, is necessary for survival, scientific progress implies social welfare and technology has improved the quality of life. The results are shown in table 1.

Although the results imply the respondents feel new technology have contributed significantly to the world, the degree of how they believe differs. For instance, 31.6% of them strongly believe technology has improved the quality of life. Yet, only 16.3% of them strongly believe scientific progress implies social welfare.

Furthermore, deductively, the results seem to pair all measures into two distinct perspectives. One is the common believe that technology makes life more comfortable (85.3%) and technology has improved the quality of life (81.4%).

Second is the belief shared on both technology is necessary for the survival of an increasing world population (76.5%) and that scientific progress implies social welfare (71.6%). In sum, all of the respondents perceive new technology has significant benefits to the world and their lives.
Table 1. Attitudes towards new technology.

| Attitude toward technology | Strongly disagree | Disagree | Uncertain | Agree | Strongly Agree |
|----------------------------|-------------------|---------|-----------|-------|---------------|
| Technology makes life more comfortable. | 2.8 | 2.1 | 9.9 | 55.5 | 29.8 |
| Technology is necessary for the survival of an increasing world population. | 2.4 | 4.0 | 17.0 | 55.6 | 20.9 |
| Scientific progress implies social welfare. | 1.8 | 4.0 | 22.6 | 55.3 | 16.3 |
| Technology has improved the quality of life. | 3.1 | 3.4 | 12.1 | 49.8 | 31.6 |

The respondents were also asked on what they think the term nanotechnology means. Figure 1 depicts the results. Majority feels nanotechnology is associated with science and technology (50%). Associating nanotechnology to green technology, weapon, pharmacy, cosmetics, communication technology and weapons and military are not perceived as high. This may indicate a very low awareness of what nanotechnology could be used for in various applications.

Figure 1. Associating nanotechnology to various applications.

The respondents were also asked about the sources of information about nanotechnology and the result is shown in figure 2. More than 50% mentioned the Internet as the source of information, followed by television/radio (31%), magazines/journals (24%) and press/newspaper (22%). It is not surprising for the Internet to be the main source of information as it depicts the availability of the Internet of Things (IoT).
3.3. Measurement and structural model

In fulfilling the factor analysis requirements, considerations were given by Field [14]. These are eigenvalues greater than 1, the Keiser-Meyer Olkin measure (KMO) that assesses sampling adequacy of items should be 0.6 or above and Bartlette’s sphericity test should be less than the alpha value to indicate that the items are correlated. In addition, Hair suggested important factor loadings are: +/.30 is considered acceptable, +/.50 is moderately important and +/.70 is very important. In determining the validity of the instrument as a whole, all items were entered simultaneously by using the principal axis factoring method with varimax rotation.

The results indicate all items were loaded into the respective components that explained 60.40% of the variations in the items. The measure of sampling adequacy (MSA) was greater than 0.50, indicating all items should be included in the factor analysis. The KMO value was 0.925 implying factor analysis was appropriate and the Bartlette’s test was significant, suggesting items are correlated. Items with factor loading of less than 0.40 were omitted from the conceptualized factors. After the omission, attitude remains with three items, Benefits is left with five items, Potential Risks with eight items, Government Support with five items and finally, Acceptance with seven items.

The reliability coefficient tests resulted in cronbach alpha is more than 0.70 for each variable. Thus, it depicts the existence of consistency and the items represent the respective concepts accordingly. The overall items descriptive analyses as depicted in the mean and standard deviation columns of table 2 indicate respondents’ concern on the potential risks is focused on greater implications to the social welfare, rather than on individual consequence, in addition to the roles played by the government agencies in disseminating information and regulating the policies. The results on what respondents perceive on the benefits of nanotechnology are not adequately impressive. Except for new and better ways of treating and detecting diseases with a mean score of 4.04, the remaining items were rated fairly.
Table 2. Descriptive analysis and factor loadings.

| Attitude                             | Mean  | SD   | EFA   | Structural Loading |
|--------------------------------------|-------|------|-------|--------------------|
| Nanotechnology is good               | 3.861 | 0.654| 0.729 | 0.867              |
| Nanotechnology is wise               | 3.829 | 0.678| 0.664 | 0.826              |
| Support for nanotechnology           | 3.863 | 0.722| 0.709 | 0.813              |
| Benefits                             |       |      |       |                    |
| Increase industrial competitive advantages | 3.902 | 0.707| 0.603 | 0.746              |
| Lead to new and better ways to treat and detect human diseases | 4.046 | 0.754| 0.675 | 0.842              |
| Lead to new and better ways to clean up the environment | 3.956 | 0.772| 0.707 | 0.792              |
| Develop increased national security and defensive capabilities | 3.825 | 0.777| 0.637 | 0.704              |
| Ability to improve human physical and mental abilities | 3.839 | 0.799| 0.621 | 0.706              |
| Potential Risks                      |       |      |       |                    |
| Nanotechnology weapon falls into the wrong hands | 4.067 | 0.852| 0.591 | 0.711              |
| Harming human health                 | 4.039 | 0.871| 0.795 | 0.929              |
| Harming the environment              | 4.049 | 0.840| 0.656 | 0.855              |
| Breathing tiny nano-sized particles  | 3.890 | 0.866| 0.718 | 0.684              |
| Getting in touch with tiny nano-sized particles | 3.739 | 0.865| 0.801 | 0.848              |
| Eating in touch with tiny nano-sized particles | 3.736 | 0.879| 0.848 | 0.857              |
| Uncontrollable spread of very tiny self-replicating robots | 3.776 | 0.868| 0.761 | 0.787              |
| Loss of personal privacy because of tiny surveillance devices | 3.844 | 0.913| 0.663 | 0.671              |
| Government Support                   |       |      |       |                    |
| Provide information to the public    | 4.001 | 0.766| 0.637 | 0.671              |
| Regulate and monitor the Nanotechnology industry | 4.039 | 0.784| 0.665 | 0.458              |
| Provide funds to public institutions | 3.946 | 0.774| 0.744 | 0.801              |
| Provide funds to private enterprises | 3.834 | 0.824| 0.668 | 0.751              |
| Design and Implement Nanotechnology policy | 3.958 | 0.777| 0.725 | 0.793              |
| Facilitate the development of Nanotechnology infrastructure | 3.981 | 0.770| 0.734 | 0.808              |
| Nanotechnology Acceptance            |       |      |       |                    |
| Like electronic devices produced from Nanotechnology | 3.656 | 0.720| 0.697 | 0.722              |
| Like to use Nanotechnology based products | 3.650 | 0.719| 0.774 | 0.811              |
| Intend to use more Nanotechnology based products in the future | 3.684 | 0.724| 0.708 | 0.776              |
| Nanotechnology benefits my life in many ways | 3.662 | 0.742| 0.674 | 0.713              |
| Young generation should be made compulsory to learn Nanotechnology | 3.787 | 0.789| 0.523 | 0.707              |
| Local universities must provide courses about Nanotechnology | 3.891 | 0.750| 0.461 | 0.817              |
| Our country should produce many engineers and scientists who master Nanotechnology | 3.973 | 0.751| .474 | 0.844              |

A two-step approach was conducted for the model analysis. First, is the confirmatory factor analysis procedure (CFA) in the attempt to assess the construct validity. Second is the structural equation model to test the structural relationships among the latent constructs. Construct validity serves as an evidence that items measures taken from a sample represent the actual true score that exists in the population [15].
In addition, the adequacy of the measurement model was evaluated for the model fit. Previous study [16] suggested for a minimum index that should be reported and interpreted in assessing the model fit which are the discrepancy value of Chi-square $\chi^2$ value must be <3, the fit function of Goodness-of-fit index (GFI) must be close to 1, parsimony-adjusted value of Adjusted Goodness-of-fit index (AGFI) is close to 1, the Comparative-fit-index (CFI) and also known as the Bentler Comparative Fit Index should be equal to or greater than 0.90 indicating 90% of the covariation in the data can be reproduced by the given model and the Root mean square error of approximation (RMSEA) value is less than 0.80.

The results of the convergent validity, composite reliability and internal consistency were shown in table 3. The discriminant validity of all variables is larger than the square of the correlation. Thus, there are evidences that the constructs are valid. The measurement model fulfills all the fit requirements, hence verify the model is acceptable (chi-square/df< 3, all the fit indices > 0.9, RMSEA < 0.08). CFA test yields the results of correlations between constructs as shown in table 3. All correlations are within the acceptable area and the associations are significant at 0.01 level. The strongest correlation is between attitude and acceptance, indicating a good support for nanotechnology and the positive perception of nanotechnology is associated with the likelihood of using nanotechnology products. As predicted, there are negative correlations between potential risks and other constructs, which explains the assumptions that nanotechnology brings dangers to human life and the ecosystem are related to the avoidance of using any related nanotechnology products.

| Alpha | AVE | CR | B | PR | GR | AT | AC |
|-------|-----|----|---|----|----|----|----|
| B     | .870| 0.577| 0.872| 1  |
| PR    | .896| 0.662| 0.939| -.549| 1  |
| GR    | .892| 0.525| 0.865| .602| -.500| 1  |
| AT    | .873| 0.698| 0.874| .594| -.239| .447| 1  |
| AC    | .871| 0.596| 0.911| .647| -.321| .617| .763| 1  |

A structural relationship was then performed on all constructs. Following [16], the overall fit statistics indicate an acceptable fit for the proposed model (chi-square/df = 2.898, GFI = 0.924, AGFI = 0.909 CFI = 0.958, RMSEA = 0.044). The results of the structural analysis are depicted in figure 3. All of the paths are significant with a p-value less than 0.05, implying for supported hypotheses. Overall, the base model accounted for 71.8% of the variance in nanotechnology acceptance. Thus, the overall fit model is good.
4. Conclusion
The main aim of the study was to examine the relationships between benefits, potential risks, government support, attitude and the acceptance of nanotechnology. The result indicates benefits, potential risks and government support have an influence towards the acceptance of nanotechnology among respondent. Therefore, the government or policy makers consider taking initiative to increase public awareness about nanotechnology. This initiative will also increase acceptance of nanotechnology among public.

This study also have discovered attitude respondent towards new technology which majority of respondent (85.3%) agreed that technology make life more comfortable and (81.4%) believed that new technology improved quality of life. This indicates that respondent certainly agreed the advantages of new technology have contributed in their life.

Next this study has analyzed the understanding of respondent towards the term of nanotechnology. Majority agreed that nanotechnology was associated with science and technology. This shows respondents have low awareness of nanotechnology because supposedly nanotechnology could be used for in various application such as communication, cosmetic, medical, computer and etc. not only in science and technology. Similarly, recent study [17] done among Malaysian students also indicate low awareness which 6.12% respondent only understand very well the term nanotechnology.

Next analysis reveals that source of information about nanotechnology was from internet which means that majority of respondent (50%) acquire nanotechnology information from internet.

However, this study has some limitations. First, it only captured the opinions and acceptance of nanotechnology from the general society through a cross sectional data. Therefore, the fundamental reasons of why and how they perceive the nanotechnology acceptance are missing. Future efforts shall be placed on getting a thorough understanding via a qualitative focus group discussion or interview session.

Second, the group of participants was limited to few cohorts. Therefore, to address the robustness of the acceptance, involvement of the policy makers and related agencies shall be considered. Detail understanding of government supports and how they create awareness of the benefits and potential dangers of nanotechnology should be discussed in more detail.

Third, as the variance of acceptance is about 71% explained by benefits, potential risks, government support and attitude, future study shall explore other possible antecedents for nanotechnology acceptance. In conclusion, the findings of the study provide a strong support of the relationships, which suggests for the roles played by each determinant, either positively or negatively. Almost equal results were obtained to determine nanotechnology acceptance between benefits, potential risks and government support.
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