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COMPARISON OF NANOTECHNOLOGY ACCEPTANCE IN TURKEY AND SWITZERLAND

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The aim of this paper is to replicate the study of Siegrist *et al.* [2007] and to present a comparison of nanotechnology acceptance in Turkey and Switzerland. The participants in our survey acknowledge the benefits of nanotechnology in achieving a preferred future (significance on the country's economy and on wealth creation, as well as quality of life) while reserving some sceptism on the institutions' responsibility in utilizing nanotechnology in the food domain.

The most beneficial application in our study is viewed as nanotechnology-used bread compared to food packaging of Swiss study. The most *risky* application is seen as the application for tomatoes, the most *affect* is observed again for the tomatoes and *willingness to buy* (*WTB*) choice is more for juice application than any other applications analyzed in this study. Perceived *benefits* and perceived *risks* are found to have influence on the *WTB* nanotechnology applications in the food domain. Results did not support any evidence suggesting that the nanoinside applications are perceived as less acceptable than nanooutside application as stated in the Swiss study. *Affect* evoked by the information existing in environment about the nanotechnology products have significant relation with *benefits* and *risks* of this emerging technology. The relation between *affect* and *risk* in our model is positive whereas it is negative

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in Siegrist *et al.* [2007]. The effect of *social trust* on *affect* is found to be insignificant in our study which was an assumption of Siegrist *et al.* [2007] and found to be significant in their research.

This paper attempts to help the managers to understand the youth and young adults' perception of nanotechnology in Turkey and to consider the importance of those perceptions for the realization of technological advances in improving their products and developing new ones.

Keywords: Youth foresight; nanotechnology; Turkey; Switzerland.

1. Introduction

Nanotechnology, as the study of manipulating matter on atomic and molecule scale is increasingly employed in a vast range of areas such as medicine, electronics, biomaterials and energy production. The word "nanotechnology" encompasses many other technologies inside, since the developments in this area are strongly related with other areas of science and technology. In past, when nanotechnology was the issue what is understood was just a single concept. However, at the beginning of the 21st century, the majority accepts the fact that nanotechnology is the sum of the variety of different technologies that have been integrated and differentiated from others due to the uniqueness of operating in the nanoscale [Hullmann (2006)]. Some researchers also indicate that the word "nanotechnologies" is used instead of "nanotechnology" to reinforce this difference [Munshi *et al.* (2007)]. It is very likely that public perception of nanotechnology will be crucial for the realization of technological advances [Macoubrie (2006); Royal Society (2004)] cited in Siegrist *et al.* [2007] since there are health and environmental concerns on the impact and future implications of nanotechnologies.

The nanomaterials that are incorporated into consumer products are, for the most part, relatively inactive. It is expected that succeeding generations of nano-based products will have far greater and more profound societal implications. The numbers from different sources may give some clue about the vitality of the concept that we are dealing. National Science Foundation (NSF) of USA has projected that the world market of nanotechnological products will reach to one trillion USD in 2015 while, Lux Research has estimated of 2.6 trillion USD world market of nanotechnology for the year 2014, in a study completed in 2004 [Hulmann (2004)]. In some studies even if the nanotechnology use of the product is limited and is just an input, the researchers take the whole value of the end product as a nanotechnological product, and in some others, they only consider the nanotechnology-used part. Hence, it is hard to assess the real economic potential of nanotechnology [Malanowski and Zweck (2007)].

As being one of the sub areas, the impact of nanotechnology to the food industry has been very strong. Nanotechnology techniques or tools are used during cultivation, production, processing or packaging of the food [Joseph and Morrison (2011)]. Companies like Nestle, Kraft, Heinz and Unilever have scientific research programs or support certain ones to be in the front line. However, the concerns associated with nanotechnology are in-line with concerns for the management of emerging technologies in general. A variety of studies have identified a common theme, namely, that the public is wary of the potentially negative, unintended, inadvertent and long-term

consequences of new technologies [Michelson and Rejeski (2011)]. As the first wave of nano-based products — including cosmetics, dietary supplements, food additives and consumer products — enter the market, society is expected to ask questions about the health, environmental and safety implications of these materials [Michelson and Rejeski (2011)].

Nanotechnology has been described as the new industrial revolution and both developed and developing countries are investing in this technology to secure a market share [Joseph and Morrison (2011)]. The Turkish government assessed nanotechnology as one of the eight essential technologies in 2005 and the research centers along with the graduate programs at some of the universities were established [TUBITAK (2011)]. However, according to 2011−2016 National Science, Technology and Innovation report, the enthusiasm seems to be vanishing [NanoTürkiye (2011)].

In this paper, we aim to replicate the study of Siegrist *et al.* [2007] on the acceptance of nanotechnology foods and food packaging in Turkey. Considering nanotechnology on food domain and its relationship with safety, the acceptance of such technology use certainly deserve a better understanding of a fit between the concerns, hopes and opinions of the youth and young adults and the corporations, of which helps creating certain futures. This paper attempts to help the policy makers to understand the concerns, hopes and opinions of the youth and young adults on the aspects of future role of nanotechnologies. It may help to set a ground to generate a dialogue between some segments of the population and the policy makers.

This is the first study to:

(1) Explore the acceptance of the use of nanotechnology among youth and young adults in Turkey.
(2) Compare the data from Switzerland and Turkey on nanotechnological issues; how people perceive nanotechnology foods and nanotechnology food packaging and factors that influence willingness to buy these products.
(3) Provide a set of assessment tools which may bring different approaches, perspectives and priorities to foresight studies.

The next section discusses the issues of perception and acceptance of nanotechnology with a concentration on foods and food technologies. Section 2 gives methodology including the questionnaire developed for the measurement of the research. Collected data and the results of the study are also given and discussed in the very same section. Section 3 is the conclusion where the possible application fields, limitations of the study, as well as future research recommendations are discussed.

1.1. *Issues of perception and acceptance of nanotechnology*

It is widely accepted that the nanotechnology will deeply affect the life of the ordinary people in the years ahead. Despite the huge economic potential, studies reflect the fact that public knowledge of the nanotechnology is still low [Cobb and Macoubrie (2004); Lee *et al.* (2005)].

The acceptance of the nanotechnology in general, the public perception, the influence of risk, benefit and trust are the major topics that need to be covered for

understanding the issue. There are quite a number of studies that elaborates those issues such as the studies on; the public attitudes and risk versus benefit perception towards nanotechnology in nanomedicine compared to conventional treatments [Nerlich *et al.* (2007)], Americans' risk perception of nanotechnologies [Smith *et al.* (2008)], public perception and risk assessment on oversight of emerging nanotechnologies [Michelson and Rejeski (2006)], expert opinion on nanotechnology [Besley *et al.* (2008)], effects of cognition and affect on public attitudes toward nanotechnology [Lee *et al.* (2005)], and specifically on the public acceptance of nanotechnology food and food packaging [Siegrist *et al.* (2007)], perceived risks and benefits [Siegrist *et al.* (2008)], the influence of carrier, benefit and trust on consumers' willingness to buy functional foods [Siegrist *et al.* (2008)], and also on the role of views on science, technology and nature on public understanding of nanotechnology food domain [Vandermoere *et al.* (2009)], the relation of familiarity with foods and the perception of risks and benefit [Fischer and Frewer (2009)], and finally on the construction and validation of a scale to measure the consumers' views on novel food technologies [Cox and Evans (2008)].

There are still concerns on the views of the public especially when the nanofood is the subject. Hailu *et al.* [2009] examined the functional foods, [Siegrist *et al.* (2007, 2008)] tried to illustrate the effects of benefit, risk, affect and trust, Vandermoere *et al.* [2009] viewed a broader look of public to science and technology, Fischer and Frewer [2009] tried to observe the effect of familiarity associated with risk and benefit. All these studies in fact searched for the causes of those concerns related with nanotechnology in food domain. Nevertheless, the nanotechnology is expected to grow in multiple sectors and products and the impacts of this emerging technology may be difficult to predict beforehand [Michelson and Rejeski (2006)] Macoubrie [2004] found in her study that 50% of the respondents stated that they had not much faith or trust in government to effectively manage the hazards occurring from the use of the nanotechnology. Lee *et al.* [2005] studied the public attitudes towards nanotechnology as an emerging technology. They have sought for the possible impacts of knowledge and affect. The results suggests that affective variables such as trust in scientists and negative emotions toward nanotechnology serve as important heuristics in shaping the perception of risks versus benefits of nanotechnology and of general attitudes towards nanotechnology regardless of people's levels of knowledge about science in general or about nanotechnology. The issue of trust is also elaborated in a study done by Siegrist *et al.* [2008] where the respondents with high levels of trust perceived more benefits associated with the nanotechnology applications compared with respondents with low levels of trust.

If there are indicators for strong public concerns and/or high potential for social amplification of risk and social controversy and conflict, a more refined and detailed assessment of possible social implications should be conducted [Dreyer *et al.* (2009)]. We will face those implications especially the nanobased products continue to emerge in the world's nanotechnology, biotechnology and information technology converges [Michelson and Rejeski (2006)].

1.2. *Perception and acceptance of nanotechnology in food domain*

The applications of nanotechnology in the food industry is quite an important topic and has drawn a significant amount of attention in academia due to recent works on; nanocomposites for food packaging applications, [De Azeredo (2009)]; bioactive packaging, [Lopez-Rubio *et al.* (2009)]; food and nutritional implications, [Nickols-Richardson (2007)]; active and intelligent packaging, [Dainelli *et al.* (2008)]; familiarity with functional foods, [Hailu *et al.* (2009)]. There are numerous studies done by universities, research institutes, public and private institutions on nanotechnology and nanotechnological applications in various areas [Miyazaki and Islam (2007)]. The examples of these applications include smart packaging, on demand preservatives, interactive foods and some other applications such as nanosensors, nanotubes and nanomaterials [Nickols-Richardson (2007); Sozer and Kokini (2008); Dainelli *et al.* (2008)]. The nanosensors are able to respond to environmental changes such as temperature or humidity, and to microbial contamination.

Nanotechnology has the potential to revolutionize the agricultural and food industry with new tools for the molecular treatment of diseases, rapid disease detection and enhancing the ability of plants to absorb nutrients, etc. [Joseph and Morrison (2006)]. The impact of nanotechnology in the food industry has become more evident with the type of applications such as smart packaging, on demand preservatives and interactive foods will gain attention by consumers. Governmental agencies and industry are investing significant resources toward the application of nanotechnology in the domains of food processing, food packaging, food safety and agricultural production [Kuzma and Verhage (2006); cited in Siegrist *et al.* (2008)].

As with any new technology, there is a significant challenge to create awareness and gain acceptance of the use of nanotechnology in the food industry [Sanguansri and Augustin (2006)]. The acceptance of the nanotechnological foods and food packaging is an important issue. It is also the main problem of this article. Vandermoere *et al.* [2009] distinguished the nanooutside applications from the nanoinside applications and explored the effects of the views on science, technology and nature on public perceptions of benefit and risk for nanofood and nanotechnology food packaging. According to their study, support for nanotechnology food packaging is positively related to attitudes toward science and technology and negatively related to views on nature and as far as the support for nanofood is concerned, it seems that social factors are much more important than cognitive variables.

Another study done on the consumer perception of risks and benefits, seeks for the effects of familiarity on consumers' decisions [Fischer and Frewer (2009)]. The findings suggest that benefit perception is best predicted by familiarity or personal experience with a particular food; while risk information has an important role in risk perception. Order of presentation of information is more relevant for unfamiliar, as opposed to familiar foods. They also propose a proactive risk-benefit communication rather than reactive since, once they have been established, attitudes are less conformable to be modified by new information. As far as the nanotechnology packaging is concerned, active and intelligent packaging materials and articles were

first introduced in the market of Japan in the mid 70s, but only in the mid 90s they raised the attention of the industry in Europe and in the USA [Dainelli *et al.* (2008)]. Given that most food products reach the consumer with some sort of packaging technology, packaging has become a major partner in food chain [Lopez-Rubio *et al.* (2006)]. Bioactive packaging is a novel set of technologies designed to give response to a number of issues related to the feasibility, stability and bioactivity of functional ingredients for the food industry [Priest (1995)]. Cox and Evans [2008] construct a food technology neophobia scale to measure consumer's fears of novel food technologies by utilizing some other scales used such as food neophobia scale [FNS; Pliner and Hobden (1992)], general neophobia scale [GNS; Pliner and Hobden (1992)] and trust in science scale [TISS; Bak (2001)].

Siegrist *et al.* [2007] has utilized a causal model to examine the consumers' attitudes towards nanotechnology foods and food packaging and its effect on buying habits of such products. Siegrist *et al.* [2008] have studied the effects of perceived risks and perceived benefits of different nanotechnology foods and nanotechnology food packaging. 19 applications are assessed in terms of perceived benefits and risks. Results suggest that the public perceives various nanotechnology applications differently. The industry should carefully examine consumer acceptance of these products. Another important finding was that nanotechnology packaging is viewed as less problematic in the public view. Consumers may be more likely to accept innovations of packaging than the innovations of food. Moreover, naturalness is a key factor affecting the acceptance of nanotechnology foods. Specifically in this model the concept of affect heuristic, the influence of affect on perceived risks and benefits in processing information, when an individual have to form judgments on the risks of an emerging technology, is utilized as a determining factor for willingness to buy [Finucane *et al.* (2000)]. Studies in the literature also explore the effects of knowledge and affect that help us to understand the factors shaping the public attitudes for an emerging technology [Lee *et al.* (2005)].

Attitudes toward food innovations will be influenced not only by the innovation itself but also by the surrounding social, economic and political environments [Henson (1995); cited in Siegrist *et al.* (2008)]. The transparency of health, safety and environmental impacts should be at the forefront when dealing with the development of nanotechnology in food systems [Sanguansri and Augustin (2006)]. Therefore, the measures to increase the trust in the food industry may be important for increasing public acceptance of novel food technologies [Siegrist *et al.* (2008)]. The impact of trust has been searched in many studies as a factor influencing other factors such as affect in determining the acceptance [Siegrist *et al.* (2007)] and as a factor influencing the perceived risk of nanotechnological food and food packaging [Siegrist *et al.* (2008)]. It also has been explored in a number of studies for its role in general oversight [Michelson and Rejeski (2006)] and in shaping the general support and perceived benefit and risk of Nanotechnology [Lee *et al.* (2005)]. Therefore, the role of trust in influencing the willingness to buy the nanotechnological food and food packaging products are also sought in this model. With all the information that has been indicated, we believe that the above model will be helpful in understanding the concept of public acceptance of an emerging technology.

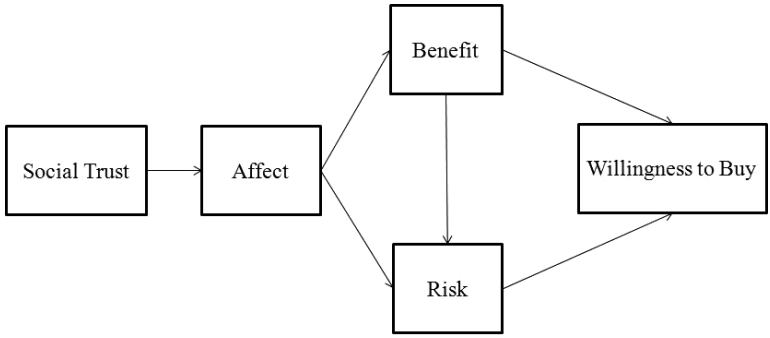

Fig. 1. Proposed model explaining willingness to buy nanotechnology foods [Siegrist *et al.* (2007)].

As our study is the replication of the study done by Siegrist *et al.* [2007], we use their model to compare differences in the findings. It is assumed that perceived benefits and perceived risks influence willingness to buy nanotechnology foods [Siegrist (2000); Siegrist *et al.* (2007)] and this hypothesized model is presented in Fig. 1. It is also assumed that the perceived benefits negatively influence the perceived risks [Siegrist (2000)].

2. Methodology

2.1. *Participants*

Data were collected by means of a web survey in Turkey in April 2009. Tables 1–3 give us the characteristics of the Turkish participants.

Participants were selected from a diverse panel of Internet users. Combining all the information, Siegrist [2000] have formed the causal model given in (Fig. 1). We have used the same causal relations. In this study, we have examined mainly the Turkish young adults that include the university youth — the Undergraduate, MBA and PhD students of Yeditepe University — and adults aged above 40 (Table 1). A convenience sample of 324 respondents participated in our survey. 99 fully completed surveys were used in the analysis. We have a 30.5% response rate for this particular survey. Out of 99 respondents of our survey, 78.5% is younger than age of 40. There existed 30 female and 68 male respondents with one respondent missing. As far as the main sector of activity is concerned, 9.1% of the sample are from government (public) institutions, 51.02% comes from private for profit,

Table 1. Age–gender distribution of the participants ($N = 98$, missing = 1).

	Age					
Gender	<20	20–29	30–39	40–49	50–59	60+
Female	2	18	7	2	1	0
Male	0	28	22	9	7	2
Total	2	46	29	11	8	2

Table 2. Main sector of activity−degree of expertise on nanotechnology distribution of the participants ($N = 99$).

	Degree of expertise on nanotechnology				
Main sector of activity	1 = Unfamiliar	2 = Casually acquainted	3 = Familiar	4 = Knowledgeable	5 = Expert
Government/Public	0	2	4	2	1
Private for Profit	4	34	11	1	1
Third Sector	0	1	3	0	0
University	5	16	10	3	1
Total	9	53	28	6	3

4.0% from third sector (foundations, associations) and finally 35.7% from university. The self assessment of expertise section of our questionnaire indicates that 28.2% of our sample is familiar, 53.5% is casually acquainted and 7.0% is knowledgeable and 3.0% is expert in terms of the concept of nanotechnology.

2.2. *Questionnaire*

Degree of expertise on nanotechnology among participants was measured by asking the participants if they were unfamiliar, casually acquainted, familiar, knowledgeable or an expert on the subject matter. The participants were asked to assess the impact of development and exploitation of nanotechnology on wealth creation and quality of life in Turkey — giving one of the responses of "*harmful*", "*neutral*", "*beneficial*" or "*highly beneficial*". This part of the research gives us the extra information and differentiates our study from the Swiss study.

In the present research, four different food products that are or might be produced utilizing nanotechnology as suggested in Siegrist *et al.* [2007] are: food packaging,

Table 3. Cross tabulation results of the Turkish participants.

	Gender		Age					
Main sector of activity	Female	Male	<20	20−29	30−39	40−49	50−59	60+
Government/Public	2	7	0	3	3	2	1	0
Private for Profit	11	39	0	23	21	4	2	0
Third Sector (Associations, Foundations)	0	4	0	2	0	0	2	0
University	17	18	1	18	5	5	3	2
Total	30	68	1	46	29	11	8	2
Degree of expertise on nanotechnology								
1 = Unfamiliar	3	6	0	6	2	1	0	0
2 = Casually acquainted	16	35	0	28	16	4	2	1
3 = Familiar	8	20	1	12	9	0	6	0
4 = Knowledgeable	2	5	0	0	1	4	0	1
5 = Expert	1	2	0	0	1	2	0	0
Total	30	68	1	46	29	11	8	2

tomatoes, bread and juice. Each nanotechnology application was described in detail with advantages and disadvantages being listed. The same information that the Siegrist *et al.* [2007] have used are given to the participants in order to make meaningful comparison of Turkish and Swiss data. Different from their study our participants instead of rating the first five associations they mentioned after reading the information material about nanotechnology, directly have rated the *affects*, *benefits*, *risks* and *willingness to buy* (WTB) on a six-point Likert scale ranging from very low (1) to very high (6) Since, the data from Siegrist *et al.* [2007] questionnaire used a five-point Likert scale, we have transformed our data to convert from one Likert scale to another. The original values of the means and standard deviations for affect, *benefit*, *risk* and *WTB* of Turkey data are given in Appendix A.

Social trust was conceptualized as trust in institutions utilizing a certain food technology [Siegrist (2000)]. *Social trust* (Table 4) was measured utilizing the following question: "*How much trust do you have in the following institutions regarding their responsibility in utilizing nanotechnology in the food domain*?" The institutions were food industry firms, science/research organizations, and pharmaceutical firms. Participants rated trust on a six-point scale ranging from 1 (*no trust*) to 6 (*very high trust*). We have the Cronbach's alpha $\alpha = 0.67$ which is an acceptable level and therefore we can conclude that the *social trust* scale is internally consistent. Siegrist *et al.* [2007] had a value of 0.69 which is very close to our result.

2.3. *Results*

The means and standard deviations of *affect*, *perceived benefit*, *perceived risk* and *WTB*, which were associated with the four nanotechnology applications of the previous research [Siegrist *et al.* (2007)] are shown in Tables 5 and 6.

Table 5(B) illustrates the means and standard deviations of *affect*, perceived *risk* and *benefit* and *willingness to buy* related to the four chosen nanotechnology applications after transforming the data to a common scale.

One way repeated measurement analysis of variance yielded no significant effects for benefit $F(3, 88) = 1.036$ (not significant) and for affect $F(3, 88) = 1.325$. Same analysis yielded significant results for perceived *risk* $F(3, 89) = 4.611$, $p < 0.05$ and the pair wise comparisons suggested that the respondents perceive more risk in the nanotechnology application used in tomatoes compared to other nanotechnology applications such as in bread and juice significantly and in food packaging very close

Table 4. The means and the standard deviations of the variable *Trust*.

	M	SD
Trust in Inst. — Food Industry Firms	2,05	1,10
Trust in Inst. — Science/Research Organizations	3,51	1,20
Trust in Inst. — Pharmaceutical Industry Firms	2,74	1,30
Social Trust	2,77	1,00

Note: The original values of the *Trust in Institutions* variable are according to 1–6 Likert scale and are shown in the Appendix B.

Table 5. (A) Means and standard deviations for *affect*, *benefit*, *risk* and *WTB* of Siegrist *et al.* [2007] — (scale 1–5) versus (B) Means and standard deviations for *affect*, *benefit*, *risk* and *WTB* of Turkey — (*after data conversion*).

	Bread		Juice		Tomatoes		Packaging	
	M	SD	M	SD	M	SD	M	SD
(A)								
Affect	3.35	1.03	3.40	1.09	3.38	1.04	3.22	1.00
Benefit	2.96	1.18	2.96	1.14	2.92	1.12	3.68	1.09
Risk	3.05	1.06	3.03	1.03	3.16	1.04	3.13	0.98
WTB	2.47	1.38	2.59	1.27	2.42	1.27	2.88	1.27
(B)								
Affect	3.14	1.34	3.13	1.38	3.27	1.42	3.13	1.33
Benefit	3.01	1.31	2.92	1.28	2.80	1.35	2.97	1.35
Risk	3.43	1.31	3.35	1.29	3.74	1.22	3.61	1.22
WTB	2.46	1.32	2.56	1.43	2.24	1.35	2.42	1.36

Note: (a) Siegrist *et al.* [1]: $N = 153$ (except for juice, $N = 152$). Values of the items ranged between 1 and 5. Higher values mean a more positive evaluation of the applications.
(b) Present study: Valid N (listwise) $= 91$ for bread and juice, $N = 92$ for tomatoes and $N = 93$ for food packaging. The original values of the items ranged between 1 and 6. The converted data values range between 1 and 5. Higher values mean a more positive evaluation of the applications.

to significant levels. Our analysis also yielded significant results for *WTB* F (3, 87) $= 3.231$, $p < 0.05$. The related pair-wise comparisons show that the respondents are more "willing to buy" juice than all the other nanotechnology applications.

Table 7 shows us the differences of the means of the groups in variables age, gender, main sector of activity and main function. According to the table, as far as the groups of categorical variables are concerned, there exists significant difference between the means in the levels of main sector of activity for the variable food

Table 6. (A) Percentage wise illustrations of means and standard deviations for *affect*, *benefit*, *risk* and *WTB* of Siegrist *et al.* [2007] — (scale 1–5) versus (B) Percentagewise illustrations of means and standard deviations for *affect*, *benefit*, *risk* and *WTB* of Turkey — (*after data conversion*).

	Bread		Juice		Tomatoes		Packaging	
	M (%)	SD (%)	M (%)	SD (%)	M (%)	SD (%)	M (%)	SD (%)
(A)								
Affect	67	21	68	22	68	21	64	20
Benefit	59	24	59	23	58	22	74	22
Risk	61	21	61	21	63	21	63	20
WTB	49	28	52	25	48	25	58	25
(B)								
Affect	63	27	63	28	65	28	63	27
Benefit	60	26	58	26	56	27	59	27
Risk	69	26	67	26	75	24	72	24
WTB	49	26	51	29	45	27	48	27

Table 7. The mean differences nanotechnology bread, tomatoes, juice and food packaging in terms of the variables *affect*, *benefit*, *risk* and *WTB* for groups of age, gender, main sector of activity and main function.

Constructs	Age	Gender	Main sector of activity	Main function
Bread				
Affect	No difference*	No difference	No difference	No difference
Benefit	—	—	—	—
Risk	—	—	—	—
WTB	—	—	—	—
Tomatoes				
Affect	No difference	No difference	No difference	No difference
Benefit	—	—	—	—
Risk	—	—	—	—
WTB	—	—	—	—
Juice				
Affect	No difference	No difference	No difference	No difference
Benefit	—	—	—	—
Risk	—	—	—	—
WTB	—	—	—	—
Food packaging				
Affect	No difference	No difference	Significant difference**	No difference
Benefit	—	—	No difference	—
Risk	—	—	No difference	—
WTB	—	—	No difference	—
Trust in institutions				
Food Ind. Firms	No difference	No difference	No difference	No difference
Sci./Res. Org.	—	—	—	—
Pharma. Ind. Firms	—	—	—	—

*No significant difference BTW groups of AGE in terms of *affect*, *benefit*, *risk* and *WTB* of nanotechnology used bread.
**Government/Public group have a higher affect for food packaging than the Private for Profit group.

packaging *affect*. The very same table indicates that there is no difference in groups of the categorical variables as far as the *affect*, *benefit*, *risk* and *WTB* is concerned for bread, tomatoes, juice, food packaging and trust in institutions.

We have utilized the AMOS program and searched for the causal relationships using the same proposed model that Siegrist *et al.* [2007] had used (Fig. 1).

In this study however, we not only focused the final models that our research has suggested to us, but also we analyzed the country-wise comparisons of the results. Evaluations of the final models are done to certain criteria. AMOS program has a very broad range of alternative statistical methods and test statistics. Amongst these Siegrist *et al.* [2007] have used Bayesian information criterion (BIC) which has a greater tendency to pick parsimonious models with values close to zero and thus having the highest posterior probability and comparative fit index (CFI) which has a value ranging from 0 to 1 where values close to 1 indicates a better fit.

We have analyzed and compared four different causal models and tried to explore the differences and similarities of the willingness to buy decisions with the models suggested by Siegrist *et al.* [2007]. Figures 2–5 illustrate those comparisons and relationships.

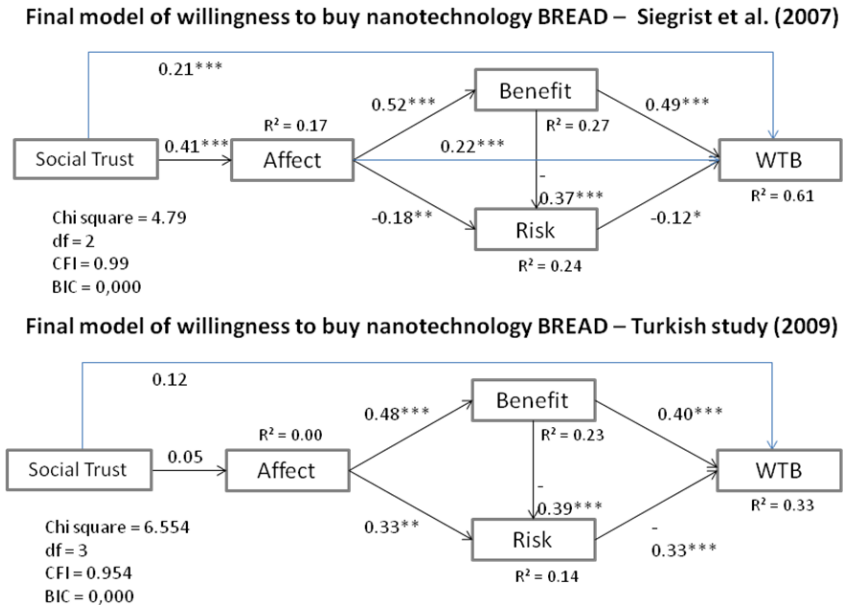

Fig. 2. Comparison of bread results of Switzerland and Turkey.

Path Analysis — Bread

Our model explains only the 33% of the variance of the variable *WTB* whereas the model suggested by the Siegrist *et al.* [2007] has a figure of 61% which is clearly a better statistic. Looking at the two models the major difference comes from the relationship stemming directly from *affect* to *WTB*. The BIC figures of the two

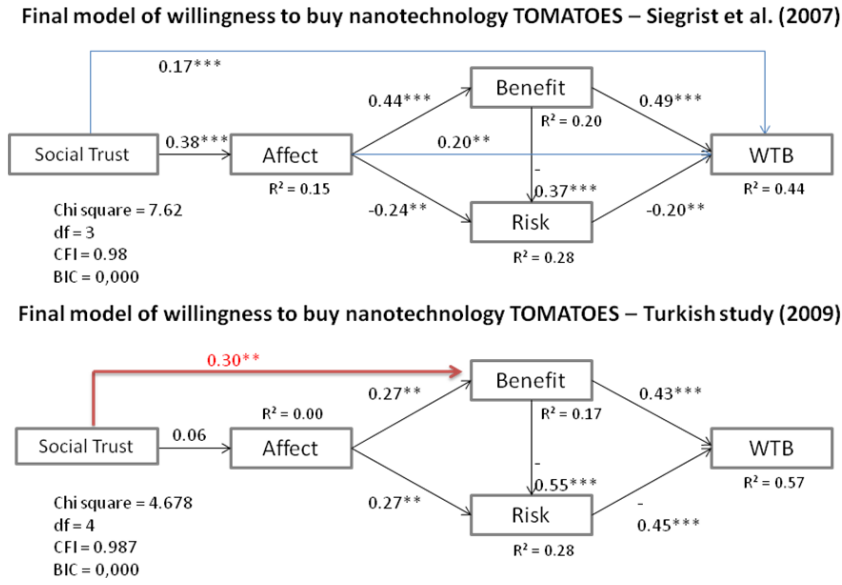

Fig. 3. Comparison of tomatoes results of Switzerland and Turkey.

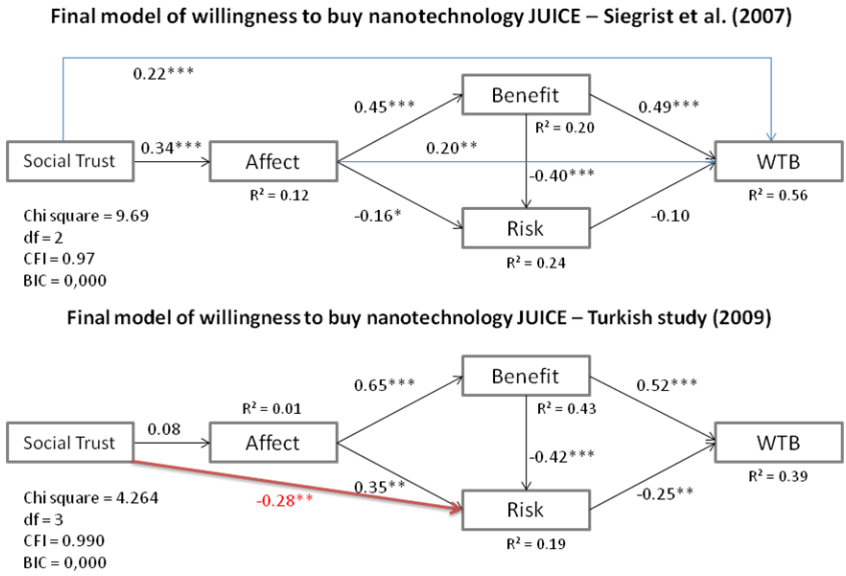

Fig. 4. Comparison of juice results of Switzerland and Turkey.

models are same and there is only a slight difference between CFI's with Siegrist *et al.* [2007] having a value of 0.99 and our model 0.95. The relationship from *affect* to *WTB* in Siegrist *et al.* [2007] has decreased the degrees of freedom by 1 compared to our model and finally both models have significant χ^2 values.

If we seek for the differences between the models, we see that the effect of *social trust* in explaining the *affect* is very low in our model (0.05) whereas the same relation is significant in Siegrist *et al.* [2007] (0.41***).[a] There is also a significant relation (0.21***) between the *social trust* and *WTB* in the model offered by Siegrist *et al.* [2007] however in our model same significant relation does not exist (0.12). Besides the difference in *R*-squared values of *WTB* of both models, the most important finding to cite here is that, the relation between *affect* and *risk* in our model is positive whereas it is negative in Siegrist *et al.* [2007]. In Turkey data the magnitude of the path from *affect* to *risk* and *risk* to *WTB* is greater than the Swiss data. There is no relation from *affect* to *WTB* in Turkey data.

Path Analysis — Tomatoes

According to Fig. 3 it is clear that our model does a better job in explaining the variance of the variable *WTB* by 57% compared to 44% of Siegrist *et al.* [2007]. There are three differences between the models. One is the relation from *affect* to *WTB* does not occur in our *WTB* nanotechnology tomatoes model as in our bread model and secondly there exists a significant relation (0.30) from *social trust* to *benefit*. Finally, there is no direct relation between the *social trust* and *WTB*. The

[a]*Correlation is significant at the 0.05 level (two-tailed). **Correlation is significant at the 0.01 level (two-tailed). ***Correlation is significant at the 0.001 level (two-tailed).

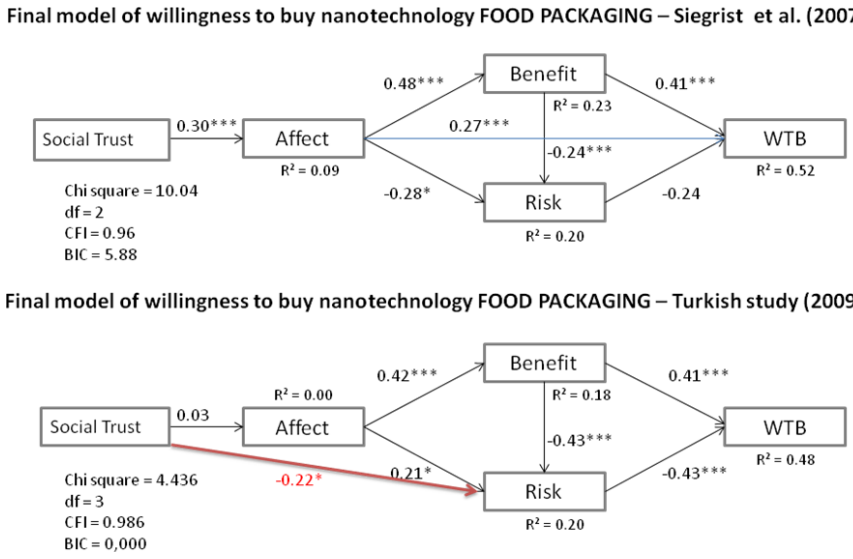

Fig. 5. Comparison of food packaging results of Switzerland and Turkey.

BIC and CFI figures are same having values of 0.00 and 0.98 respectively. Both models have significant χ^2 values.

The effect of *social trust* in explaining the *affect* is low in our model (0.06) whereas the same relation is significant in Siegrist *et al.* [2007] (0.38***) as it was in bread model. There is a significant relation (0.17***) between the *social trust* and *WTB* in the model offered Siegrist *et al.* [2007] which does not exist in our model. The relation between *affect* and *risk* in our model is again positive whereas it is negative in Siegrist *et al.* [2007] as in the case of bread model. In Turkey data the effect of *affect* to *risk* and *benefit* are both positive and equal. The relation from *benefit* to *risk* and *risk* to *WTB* is significant and strong compared to Swiss study. There is no relation in Turkey data from *affect* to *WTB*.

Path Analysis — Juice

The comparison of the models for *WTB* nanotechnology juice models of both study have the same differences as cited in previous models since there exists no direct relation from *social trust* and *affect* to *WTB* in our model as illustrated in Fig. 4. Nevertheless, we realize that there is a significant negative relation (−0.28**) between *social trust* and *risk* which did not appear in previous models. Siegrist *et al.* [2007] has a better model in explaining variance of the variable *WTB* 56% compared to our model 39%. The path from *risk* to *WTB* is not significant in Siegrist *et al.* [2007] with a value −0.10. The same path is significant in our model (−0.25**).

The BIC and CFI figures are acceptable for both models that also have significant χ^2 values. All other relations are identical compared to our previous comparisons of the two models for *WTB* for nanotechnology bread and tomatoes as shown in the figure.

Path Analysis — Food Packaging

According to Fig. 5, the explained variance of variable *WTB* in Siegrist *et al.* [2007] is very close to our model with values 52% and 48%, respectively. The same path from *social trust* to *risk* that appeared in our juice model also exists in this food packaging model of Turkey data (−0.22*). The relation from *affect* to *WTB* does not occur. There is no direct path from the *social trust* to *WTB*, this time however in both models. The path from *risk* to *WTB* is not significant in Siegrist *et al.* [2007] (−0.24) as compared to our significant and negative relationship (−0.43***). The BIC figure of our model indicates a better posterior probability (0.00) compared to (5.88) of Siegrist *et al.* [2007] and CFI figures are close values 0.96 and 0.98. Models have significant χ^2 values.

The relation between *affect* and *risk* in our model is positive whereas it is negative in Siegrist *et al.* [2007] as in the case of all previous models. The significant relation between *social trust* and *affect* (0.30***) of Swiss study again does not exist in our model, the fact which is also same for all our previous models. The direct relation from *affect* to *WTB* which existed for all models of Swiss study again does not exist for this food packaging model as in all previous models of our study.

3. Conclusion

In this study, we tried to replicate the study done by Siegrist *et al.* [2007] for the Turkey data in order to understand to a certain extent what the Turkish public thinks for this important emerging technology. Public attitudes seem to have great importance and should be given importance at an early stage of technology development [Renn and Roco (2006)]. This study enabled us not only to compare two different cultures on a common point, development of an emerging technology, but also enhanced our analysis of the thoughts and perceptions of *affect*, *risk*, *benefit*, *social trust* on *WTB* habits of Turkish individuals. Hence, we could be able to observe thoughts of the public at this early stage of development of nanotechnology where the initial products are already started to being marketed.

The present study compared two casual models of two different countries on the variable *WTB* of four different nanotechnology applications which are bread, juice, tomatoes and food packaging. As far as the applications are concerned, the most beneficial application in our study is viewed as bread compared to food packaging of Swiss study. The most risky application is seen as the application for tomatoes, the most affect is observed again for the tomatoes application and willingness to buy choice is more for juice application than other applications analyzed in this study. The correspondent results were tomatoes, juice and food packaging for the Swiss study, respectively.

If we delve into the results we realize that, as in Swiss study participants had similar *affect* toward each application in this present research. Nevertheless, results do not support any evidence suggesting that the nano-inside applications are perceived as less acceptable than nano-outside application. The causal models also reveal us some interesting results. It is argued that perceived benefits and perceived

risks are shaped by the affect associated with a technology [Finucane *et al.* (2000)]. The Swiss study approves this relationship with all four models having a significant and positive affect to benefit path and significant and negative affect to risk path. The Turkish study however suggests that, the affect to benefit path is same as in the Swiss study but Turkish public believes a positive and significant relation between affect and risk. All four models confirmed this issue.

This finding is important because benefit and risk are by nature opposite concepts. It is normally accepted that if a variable has a positive relation with one of them will have a negative with the other. However, it can be inferred from this result that, the concept *affect* is either not well understood by the participants, since the survey is made in English, or is seen as an issue that can be regarded as both a benefit and a risk. We believe that the latter is more probable. This mode of thinking is parallel to the SWOT analyses where an issue can be treated as both an opportunity and a threat at the same time. It is possible that the affect occurring for nanotechnology applications can have positive relation both with benefit and risk.

The concept affect heuristics proposed by Slovic *et al.* [2004] distinguishes two modes of thinking, experiential and analytical, and argues that elements of experiential system such as images, metaphors and narratives helps us quickly decide on an issue and perceived benefit and risks are shaped according to it [Finucane *et al.* (2000)]. The Swiss study argues that an increase in affect lowers the risk and increases the benefit. Our study, however, suggests that an increase in affect both increases the risk and benefit. One explanation to this might be the relation of *social trust* and *affect*. *Social trust* in institutions producing nanotechnology foods is an important factor with a direct influence on affect created by these new products and WTB [Siegrist *et al.* (2007)]. In all four models of the Swiss study there exists a positive and significant path from *social trust* to *affect*. Siegrist *et al.* [2007] further argues that an event with a negative consequence could have a huge negative impact which will reduce the trust to industry. The low trust on industry will also make it harder for the acceptance of nanotechnology applications. The trust in institutions who will determine the needed regulations that is important for the responsible development and trust in the industry that will make the corrective auto-control for socially responsible management of this emerging technology is of utmost importance. Studies show that public trust in the management of technology-related risks can be more important than beliefs in the technology itself [Priest (1995); Robbins (2001); Lee *et al.* (2005)]. Revealing all the information about nano-based products and informing the public with correct information about potential risks associated with them, are the measures that can increase the trust of the public.

The Swiss model with high values for the path from *social trust* to *affect* indicates that the variable affect is significantly affected by the *social trust* of public which in turn effects perceived *benefit* positively and perceived *risks* negatively. In other words, be it negative or positive the information coming from the institutions about these nanotechnological applications are taken into consideration and create images, beliefs and ideas. Affect heuristic suggests that those information influence perceived benefit positively because of the belief in potential benefits of this technology and

influence the perceived risk negatively since the information is viewed as trustworthy and the public is aware of all the potential risks. Studies confirms that people who trusted in institutions involved in using or regulating gene technology, which can also be viewed as important emerging technology, attributed more benefits and fewer risks to this technology [Siegrist (1999, 2000); Tanaka (2004); cited in Siegrist *et al.* (2007)].

The Turkish model has low and insignificant values for the path from *social trust to affect* indicating a low relation between them. The path from affect to benefit and to risk is significant though. This picture can suggest that alternative information sources shape the variable affect which in turn affects the perceived benefit and perceived risk. However, since those information sources are not institutionally valid they can at the same time influence the benefit and risk positively. In other words those sources can present the benefits of the nano-applications, which increases the perceived benefits and present the potential risks and the regulations and measures taken by institutions to overcome it which in our case **do not** reduce the perceived risks. This may be because of the insignificant effect of *social trust* in shaping the variable affect. Therefore, an application of nanotechnology can both be viewed as beneficial and risky at the same time. Finally in the food packaging model and juice model we see direct path from *social trust* and *risk* and in tomatoes model we see direct path from *social trust* to *benefit*. The relations confirm that increase in *social trust* increases perceived *benefit* and decrease the perceived *risks*.

One of the limitations of the study is the use of non-probability sampling which is useful in exploratory studies, yet lacking the complete identification of the population being studied. The findings of this study should be viewed within the cultural analysis of the two countries which is one of the limitations of this study. The Swiss data that Siegrist *et al.* [2007] have used and our Turkish data may have different societal and cultural backgrounds. However, the findings still can give us important results and ideas about the stance of the Turkish public to this newly emerging technology. This study analyzed the comparisons of the nanotechnology applications in the food domain. It is possible that there may occur different outcomes and findings for other areas of nanotechnology. Other factors such as perceived naturalness cited in Siegrist *et al.* [2007], the degree of expertise on nanotechnology, future expectations of individuals and their attitudes towards scientific innovations in general can also be amongst the factors that influences nanotechnology applications in the food domain.

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Appendix

Appendix A.1. Means and standard deviations for *affect*, *benefit*, *risk* and *WTB* of Turkey — current study (scale 1−6).

	Bread		Juice		Tomatoes		Packaging	
	M	SD	M	SD	M	SD	M	SD
Affect	3.67	1.43	3.66	1.48	3.84	1.52	3.66	1.41
Benefit	3.51	1.39	3.40	1.35	3.25	1.44	3.46	1.44
Risk	4.04	1.39	3.94	1.36	4.43	1.27	4.26	1.27
WTB	2.83	1.40	2.95	1.54	2.55	1.44	2.78	1.45

Note: Valid *N* (listwise) is 91 for bread and juice, 92 for tomatoes and 93 for food packaging. Values of the items ranged between 1 and 6. Higher values mean a more positive evaluation of the applications.

Appendix B.1. The scale conversion of values of the variable *Trust in Institutions*.

	1−5 Likert scale		1−6 Likert scale	
	M	SD	M	SD
Trust in Inst. — Food Industry Firms	2,05	1,10	2,31	1,12
Trust in Inst. — Science/Research Organizations	3,51	1,20	4,14	1,25
Trust in Inst. — Pharmaceutical Industry Firms	2,74	1,30	3,18	1,38
Social Trust	2,77	1,00	3,21	1,00

Note: Originally the survey had been conducted according to the 1−6 Likert scale. In order to make the comparisons of the Swiss and Turkish Data the values are converted to 1−5 Likert scale.

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