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MODELING INFORMATION ASYMMETRY MITIGATION THROUGH FOOD TRACEABILITY SYSTEMS USING PARTIAL LEAST SQUARES

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Abstract: *Originally, food traceability is not something new; however, its added values that are enabled by information technology compose what's new about it. Food traceability was imposed on the food industry as a regulatory requirement as a response toward food incidents like the bovine spongiform encephalopathy (BSE), salmonella breakouts …etc. These events have made consumers more skeptic about the food they consume especially that a lot of information about food is only known by food producers, e.g. Genetically modified ingredients, allergic components in food…etc. This gap in information has created an information asymmetry situation in the food industry between producers and consumers, which is well reported in the literature. This study sheds the light on the role of food traceability in reducing uncertainties related to risks of food products, by helping consumers become more informed about the food they consume. This increased in knowledge is achieved through the potentials of tracing food products from farm to fork in a web-based format from the records of traceability systems provided by food producers. Through a survey research, it was found that food traceability can reduce the aforementioned information asymmetry because it reduces consumer' perceived risks toward food. This good cause of reducing information asymmetry was found to be faced with a willingness to pay price premiums for traceable products.*

Keywords: *Food traceability, information asymmetry, perceived risks.*

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1. Introduction

The progress in information technology -along with the increasingly stringent legislation have made today's agrifood industry respect ever stricter standards and increasingly rigorous quality control and monitoring procedures. However, paradoxically over the last decade there has been an increasing number of food alerts Bovine spongiform encephalopathy (BSE), dioxin, listeria, and salmonella; creating a genuine crisis of confidence among consumers. These incidents illustrate the importance of safety and quality management in food-supply chains, which is a major objective of food traceability.

Traceability has become a major concern of the food industry, especially since it became a regulatory requirement to enable and facilitate international food trade. Firms need to track where they buy their ingredients, what products they use them in? how do they store them and transport them? and which customers get those products?. Furthermore, as markets and consumers formulate the driving forces of food production, the public is pushing with more pressure on traceability. People are increasingly concerned with what they eat, for different reasons, some people are interested in identifying the sustainability of the resources of their foods, others who are concerned with environmental issues are interested in realizing whether or not their food is produced through eco-friendly methods, and whether production, transportation, and storage conditions provide assurance for food safety [23].

All the supply-chain partners can retrieve data from the traceability system, among which are the consumers who can verify how their food products were produced, from which material were manufactured, through what processes were developed and by what methods were delivered. Such information affects consumers' buying decisions. Very little research is done for addressing the added values of traceability from consumers' perspective and its mechanism in reducing consumers perceived risks toward food products. This research study aims toward assessing the food traceability system added values from the consumer's perspective within the existence of the aforementioned information asymmetry situation in the food supply chain. This information asymmetry affects consumers' bounded rationality; this rationality is limited by the available information for consumers, the cognitive limitations of consumers' minds and the finite time consumers have to take decisions, which affect the perception of risk and uncertainty to evaluate quality and safety in products. This reduction in perceived risk is motivated by a willingness to pay premiums for traceable products [18], [21].

2. Food traceability

2.1 Defining Traceability

Traceability is not an absolutely new concept, originally it was initiated as a regulatory requirement for food operators to be implemented in their plants to comply with food laws, e.g. European general food law, which came into effect in 2005 and US Bioterrorism Act, which came into effect in 2003, [18]. Traceability can be defined in several ways depending on its purposes (e.g. for regulation, food safety, supply-chain management or marketing). There are different definitions that deal with traceability, whether by ISO 8402 (1994), ISO 9000:2000, the European Food Law, and The Codex Committee on Food Import and Export Inspection and Certification System (CCFICS). However, the existence itself of so many definitions of

traceability points out that every definition is ineludibly broad. In fact, the food industry is complex due to the variety of available food products and to the wide range of inputs and ingredients. In addition, we should take into consideration the fact that traceability is a tool for achieving a number of different objectives. However, the general common understanding of different definitions implies that traceability is a system designed to track and trace products and their components through the food supply chain. Tracking is the capability to locate a product based on specific criteria at any point of the supply chain. Such a concept is important for withdrawing or recalling products when necessary, while tracing is the capability to identify the origin and characteristics of a product based on pre determined criteria at each point along the whole food supply chain. This is a critical point for firms, in order to determine the sources of products quickly and accurately especially in contingency circumstances [11], [12].
A series of procedures that include identifying, preparing, collecting, storing, and verifying data are performed through traceability. It requires implementing computer systems and databases, improved supply-chain management protocols and identification technologies such as bar codes or tags. Eventually, the traceability systems will record accumulated information about products' attributes in terms of safety and quality all through products' movement through the supply-chain [32]. Thus traceability can reduce anonymity by mitigating suboptimal results due to asymmetric information among consumers and suppliers [30].

2.2 Traceability in the food supply chain

Tracking food products forward and tracing them backward through traceability records throughout the whole supply chain has its potentials in decreasing risks adjacent to food, especially with the ability to deploy efficient recalls [20],[4],[29]. The role of food traceability as a mean of food safety and consumer trust is argued from different point of views all of them accumulate over the enhancement of consumers' safety, [9], [13], [21], [23], [28], [35], [38].
Furthermore, quality wise traceability value is embedded in the ability of enhancing food quality through labeling of experience and credence food attributes. Experience attributes can only be evaluated after consumption, while credence attributes refer to characteristics that consumers cannot discern even after consuming the product [3], [7], [15], [25].
The basic characteristic of traceability systems (i.e. identification, information and the links between) are common in all systems, independently of the type of product, production, and control systems that are served. The early applications of traceability systems were paper based, then the level of technology increased as systems developed. However, a good traceability system does not necessarily include complicated advanced technological solutions. Advancements in information technology (IT) have had an essential role in enhancing the effectiveness of record keeping of activities, not to mention the increased efficiency, effectiveness and security of IT-enabled system's adoption throughout the food supply chain, [22], [5]. Implementation of traceability systems requires standards that can organize the process, especially for storing the necessary information. For this purpose, global standards are developed like the GS1, allowing item identification for global tracking and tracing of food products [5].

2.3 Consumers' perception of food traceability systems:

As for consumers' perception of traceability systems, while understanding the role of the "ability-to-trace" in consumer decision-making process with respect to food, it was found out that consumers' perception of food traceability is likely to be driven by signaling route not a screening one[19]. Signaling refers to the activities of the suppliers (as better informed side)

offering quality indicators to consumers. Screening on the other side refers to the consumers (as a less informed side) gathering information actively and thus assessing product attributes by own inspection and observation [14]. However, consumers perceive both safety and quality as related to traceability, within this sense it is argued that consumers don't easily understand what traceability systems are, but clearly express what benefits they're willing to take from them [14].
It is necessary, to take consumers' background into account when relating consumers' perception to traceability systems. Different consumers may have different concerns regarding traceability, depending on individual differences or on a socio- demographic basis e.g. cultural background, [36].
[36] indicate that "When studying how traceability can positively influence confidence, we need to study consumer perceptions of traceability systems, together with the impact of information that comes available to consumers through these systems. It is therefore, unlikely that emphasizing the technical aspects only of traceability is going to boost consumer confidence. Thus it is important to investigate what benefits people will derive from traceability systems and whether these benefits will lead to improved confidence" which is a promising contribution this study is willing to provide.

2.4 Traceability informativeness within information asymmetry:

Traceability as an informative system for consumers tends to increase knowledge or dissipate ignorance toward food and all what is related to it. Information when directed towards consumers usually has a low distorting level on the market and the main function of the information is to educate the consumer choice [31]. Furthermore, mandatory traceability as a food safety tool has the ability to raise the information flow to make it available to all the different actors along the food chain. It also has the capability of facilitating the risk management when damage is present, through its tracing and tracking potentials. It is essential to realize that the effectiveness of traceability strictly depends on the interaction among different social actors: i.e. firms, consumers and policy makers, [31].
The difficulty in recognizing credence attributes by consumers paves the way for verifying these attributes through traceability bookkeeping records that establish their creation and preservation. For example, tuna caught with dolphin-safe nets can only be distinguished - from tuna caught using other methods - through the bookkeeping system that ties the dolphin-safe tuna to the observer on the boat from which the tuna was caught. Without traceability as evidence of value, no viable market could exist for dolphin-safe tuna; fair-trade coffee, non-biotech corn oil, or any other process credence attribute, [8].

3. Research model and hypotheses development

This study introduces food traceability as a tool to extend the knowledge of consumers within the existence of an information asymmetry situation. This information asymmetry affects on consumers perceived risks toward food products; because perceived risks are consequences from uncertainty resulting from the shortage in knowledge that affects the outcome of consumption acts [17]. Furthermore, two characteristics are assigned to perceived risks of consumers, and they are uncertainty and negative consequences [2]. Thus this study focuses on reducing consumers' perceived risks through increasing their knowledge. The question of the study was how food

traceability will decrease consumers' perceived risks and subsequently affects their buying decisions. This change in behavior would be evident by expressing willingness to pay a price premium for traceable products. At the same time it is related to technology acceptance and reasoned actions theories in which consumers' purchase intentions are based on attitudes; because of the fact that consumer wise traceability is presented as a new source of information in a web-based format.

To represent the previous relations and test them, a structural equation modeling approach has been followed, in which a structural model with latent variables was built, to identify the relations and the hypothesized relations in Figure 1.

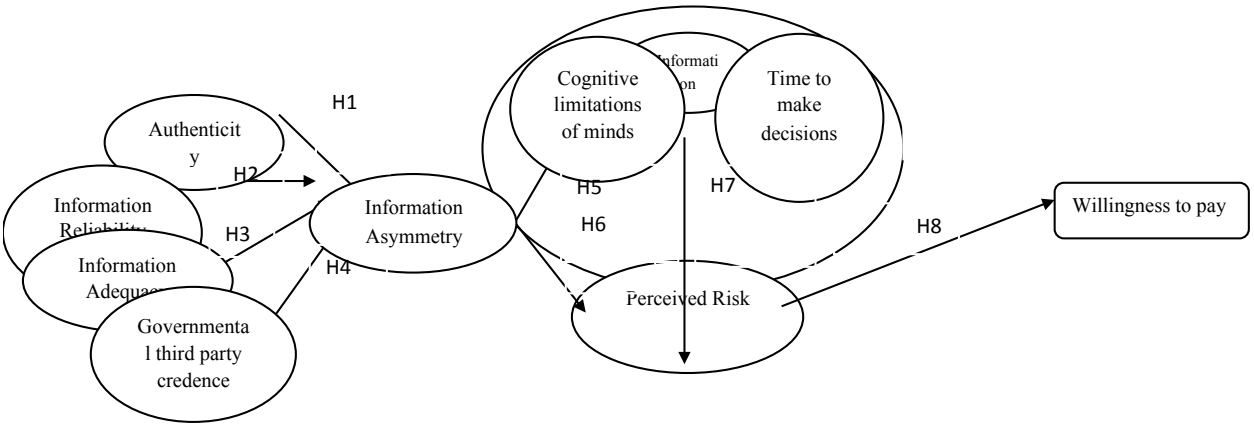

Figure1. Model of the research and hypothesized relations.

According to [1], the costs of measuring relevant information are a major cause of transaction costs. Some product attributes are easily measured, like weight and color, not implying significant transaction costs. However, some attributes are difficult or impossible to measure, requiring additional and costly arrangements in order to transmit this relevant information. As a consequence, for example, the competitiveness of a meat exporter depends heavily on its capacity to provide the relevant information in a credible way, with, an adequate traceability system [39].

3.1 Authenticity

Food authenticity is a term basically referring to whether the food purchased by the consumer matches its description. Misdescription can occur in many forms, from the undeclared addition of water or other cheaper materials, to the wrong declaration of amounts of particular ingredients. It includes making false statements about the source of ingredients, i.e. their geographic, plant or animal origin. There are research programs applying novel technology where possible to develop methods that can be used to check that foods are correctly described and labeled to ensure that consumers are not receiving misleading information about food to reduce food fraud [10], [24].

There are special research agencies that help companies throughout the food supply chain by using powerful bio technical tools to support the authenticity of products such as DNA and protein analysis. Also to protect product integrity and monitor compliance with labeling requirements and consequently avoid and disable misdescription, counterfeiting or even hiding

information like using genetically modified ingredients. Authenticity in food has a lot of bioscience details, for example DNA analysis, studying protein population in biological systems, chemical and molecular testing methods to confirm authenticity and provenance of foods, along with other food authentication issues, which indicate the huge amount of credence attributes that need to become searchable for consumers. Based on the results of [26], it was found that supporting the authenticity of bottled wine is perceived by consumers to influence the performance risk they perceive while buying the product. Bottles of wine with labels perceived as authentic by young consumers were considered to be less risky to buy.
Based on the literature review, the first hypotheses associated with food authenticity and information asymmetry was developed.
H1: product authenticity reduces Information asymmetry.

3.2 Information reliability

It refers to how much one can depend on the information according to ones needs and requirements. [15] address that business wise for supply-chain management purposes, establishing traceability systems is characterized by the breadth, depth and precision of such systems, in which various objectives help to drive differences in them. Such variables have an effect on the practice of offering traceability information to consumers, to help them screen out safety and quality in food products. Depth refers to how far back or forward the system tracks the relevant information which affects the information reliability latent variable introduced in the previous model. At the same time precision which refers to the degree of accuracy with which the tracing system can pinpoint a particular product's movement or characteristic also affects the reliability of the information provided by the system [15] [16]. When there is no reliable information to be provided by the system to consumers, the information asymmetry increases, within this sense and in relation to information asymmetry, the second hypothesis was developed:
H2: Information reliability reduces information asymmetry.

3.3 Information adequacy

It refers to how sufficient the information is to satisfy consumers' requirements or meet their needs. This latent variable is related to the breadth of the system which relates to the amount of information collected by the system. However, the breadth of the system varies according to the nature of the product, farm practices or other food chain operations, customer specifications and legal or codes of practice requirements. The importance of the type of information to be provided by the system may vary among consumers according to types of products and consumers' interests. It is essential to realize that providing information at each point along the supply chain involves high costs and high information technology infrastructure. Providing less or insufficient information to consumers increases the gap between them and the food producer, within this sense the third hypothesis was developed:
H3: Information adequacy reduces information asymmetry.

3.4 Governmental third party credence

A certification label has a strong positive meaning to the consumer in regard to food safety, and that itself is a signal to all partners involved in the food supply chain, be it growers or manufacturers or retailers, Extra assurances such as a certification authority to enhance credibility and reliability of the product information provided is considered necessary [5];

because different health, safety and quality characteristics are difficult to be detected by consumers without the existence of a third party credence [21]. Within this sense, the fourth hypothesis was developed:
H4: Governmental third party credence reduces information asymmetry.

3.5 Bounded rationality of consumers

The shopping process of consumers is affected by time, which is evident even in comparing and differentiating products during shopping. On the other hand, it is affected by the information that is available to consumers, and because of the information overload and the increasing time pressure many decisions have to be made directly at the point of sale. According to [33] the main cost of information is time, which is also a constraint of bounded rationality. Bounded rationality is a concept based on the fact that rationality of individuals is constrained by three limitations: the information available for them, the cognitive limitations of their minds, and the finite amount of time available to take decisions. Other factors contribute also to explain consumers' reluctance towards information processing and rational decision-making like facing irrelevant or useless information that doesn't fit their needs and the limited human cognitive capacity. Even though in some cases, it may be completely rational for consumers to remain with incomplete information [37] which refers to the 'rationally ignorant' consumer hypothesis [27] i.e. even when information is free, consumers may refrain from acquiring more information because the price of information processing is too high compared to the marginal expected benefits from information, hence constraining people's motivation to process information [36]. In other words, if consumers are provided with an overload of information, this overload will become a cost because it will get consumers to the starting point of the constraint of time, which is a major cost to process the overload of information. This is why consumers tend to use their emotions or feelings as heuristics to make faster effective decisions in complex or uncertain situations. This can take place especially with the absence of adequate and reliable information. Therefore, reducing the information gap between consumers and producers has positive effects on the constraints of available information, cognitive limitations of minds and time to take decisions, which consequently, affects consumers' perception of risks. The reduction in risk perception is a good cause for which consumers are willing to pay price premiums; within these relations the following hypotheses were developed:

H5: Reducing Information asymmetry positively affects the constraints of consumers' bounded rationality.
H6: Positively affected bounded rationality reduces consumers' perceived risks.
H7: Reducing Information asymmetry positively affects consumers' perceived risks.
H8: Reducing consumers perceived risks positively affects their willingness to pay (WTP) a price premium for traceable products.

4. Data collection and analysis

4.1 Data collection

The theorized model of this research, and the eight (8) hypotheses developed to test the relations between constructs were empirically tested in a survey research. An online questionnaire was built; the questionnaire consisted of the following:

- A section related to the general information of respondents, for describing the characteristics of the sample population /society of the study, questions of this section were in the form of multiple choice and a few polar questions.
- A section related to consumers' perception and expectations from traceability systems for assessing the measurement and the structural model of the research model as well as the hypothetical relations inside it.

Questions of this section were in the form of Likert scale, in each question respondents specified their level of agreement to a statement according to the scale of; strongly agree/ agree/ neither agree nor disagree/ disagree/strongly disagree/don't know.

The questionnaire composed of measures based on literature review to operationalize the latent variables introduced in the model. The questionnaire items for the first and second sections are provided in Appendix A and B respectively.

Data were collected from students from two universities in Jordan and Italy. The link to the online questionnaire was sent to students. 321 students participated in the survey. A variance-based technique represented by partial least squares (PLS) path modeling inside structural equation modeling was used. PLS is less conservative in terms of sample size requirements [41]. All of the participating students were in the class of age that is between 20-30 years of old, which makes them belonging to generation Y and Z in terms of generations (net generations).

The newness of food traceability systems as a subject under discussion, especially with the dimension that focuses on the idea of disclosing traceability information in a web-based format, by using, barcodes data, made it logical to target generation Z and generation Y, who are described as consumers of tomorrow and the Net generation respectively to represent the population for this research study. They can be early adopters of such a practice. The online survey collected 321 responses. Respondents disclosed their per week spending on meat, fruits and vegetables, milk and grain derivatives. They also addressed their shopping frequencies and responsibilities. Despite that respondents' knowledge of traceability was not very high because only 39.6% of the respondents had a general awareness of food traceability; still their perception of traceability was feasible to be tested, because from one side the questionnaire items for testing this perception were not only based on respondents' beliefs but also on their expectations from traceability systems. And from another side, as the following section will show the assessment of the measurement model implied that individual item loadings and internal consistency reliabilities have indicated reliability of the presented model. The targeted sample of respondents had more females (53.6%) than males (46.4%). Also the Jordanian respondents (63.2%) in the sample were more than the Italians (36.8%). The general ignorance of traceability overpassed the awareness of the respondents toward food traceability, since that 60.4% of the respondents didn't know about traceability while 39.6 % had a general awareness of traceability, at the same time the awareness of the ability to trace food products online by using, for example, products barcodes was 37.3% while 62.6% didn't know about it. The general awareness of traceability seemed to be coming mainly from the internet (66.1%) and advertisements on media (23.6%). For major factors affecting food purchasing process, 40.2% of respondents choose product features in terms of safety, quality, taste, freshness, and nutritional needs. While 38.9% choose the option that combines all the factors, including products' features, processes on products, price and environmental issues.

Table 1 shows a brief frequency distribution of respondents.

Table 1. Frequency distribution of respondents.

Item	***Criteria***	***Frequency***	***Percent %***
Gender	*Male* *Female*	149 172	46.4 53.6
Nationality	*Jordanian* *Italian*	203 118	63.2 36.8
General Awareness of food traceability	*Yes*	127	39.6
	No	194	60.4
Total		321	100
Source of knowledge about traceability	*Internet*	84	66.1
	Newspapers	10	7.8
	Advertisements on media	30	23.6
	Other: friends	3	2.3
Major factors affecting food purchasing process	*Product features in terms of safety, quality, taste, freshness, nutritional needs*	129	40.2
	Processes related to the product, in terms of production methods, transportation, storing conditions.	10	3.1
	Environmental issues and animal welfare	7	2.2
	Price	50	15.6
	all of the above	125	38.9
Willingness to pay	*0%*	115	35.8
	1 – 10 %	157	48.9
	11 – 20 %	44	13.7
	> 20 %	5	1

4.2 Data analysis

Data analysis was performed using smart PLS and Minitab softwares, to apply partial least squares method as a variance-based technique of path modeling for testing a measurement model as well as a structural model.

The empirical model and the eight hypotheses described in section three were empirically tested through survey research. This study was cross-sectional via an online questionnaire composed of measures based on literature review. The latent variables presented in the research model were operationalized to assess the measurement model to test reliability and validity of the model. The measurement model was assessed through quality criteria in terms of average variance extracted (AVE) and composite reliability for each construct. It is provided in Table 2.

As a measure of reliability the average variance extracted (AVE), quantifies the amount of variance that a construct captures from its manifest variables or indicators relative to the amount due to measurement error [40]. AVE values should be greater than 0.50. This means that 50% or more of the indicator variance should be accounted for [42].

The Average Variance Extracted AVE for each latent variable was higher than 0.60 except for the information asymmetry it was 0.49 and the composite reliability for each latent variable was higher than 0.80. The results of both the AVE and the composite reliability suggest a strong convergent validity of the measurement model which indicates that the assessment is related to what it should theoretically be related to [40].

Table 2. Average Variance Extracted and Composite reliability.

	AVE	***Composite Reliability***
Authenticity	0.743	0.932
Bounded Rationality	0.756	0.924
Governmental third party credence	1.000	1.000
Information Adequacy	0.663	0.884
Information Asymmetry	0.495	0.850
Information Reliability	0.661	0.916
Perceived Risks	0.680	0.935
Willingness to pay	1.000	1.000

The AVE-value can be used again. The average shared variance of a construct and its indicators should exceed the shared variance with every other construct of the model. Therefore, the square root of AVE should surpass the correlation coefficient of the construct with every other construct of the model, [40], [42]. Table 3 examines correlations of the latent variables and the square root of AVE.

The cross loading matrix of the latent variables was explored. It is provided in Table 4. It shows that each observable manifest variable had higher loads on its own latent variable, indicating a good convergent and discriminant validity as well.

Table 3. correlations of the latent variables and the square root of AVE.

	Authenticity	***Bounded Rationality***	***Governmental third party credence***	***Information Adequacy***	***Information Asymmetry***	***Information Reliability***	***Perceived Risks***	***Willingness to pay***
Authenticity	1	0.862						
Bounded Rationality	0.415	1	0.869					
Governmental third party credence	0.295	0.723	1	1				
Information Adequacy	0.542	0.496	0.258	1	0.814			
Information Asymmetry	0.615	0.564	0.306	0.772	1	0.676		
Information Reliability	0.876	0.463	0.337	0.529	0.645	1	0.813	
Perceived Risks	0.769	0.594	0.358	0.579	0.65	0.751	1	0.825

Table 4. Cross loading matrix.

	Authenticity	Bounded Rationality	Governmental third party credence	Information Adequacy	Information Asymmetry	Information Reliability	Perceived Risks	Willingness to pay
A1	0.661	0.605	0.499	0.347	0.408	0.627	0.485	0.278
A2	0.890	0.450	0.336	0.483	0.522	0.802	0.708	0.292
A3	0.755	0.429	0.322	0.429	0.448	0.518	0.603	0.392
A4	0.684	-0.057	-0.105	0.429	0.530	0.520	0.280	0.260
A5	1.203	0.429	0.289	0.600	0.684	1.162	1.098	0.488
BR1	0.289	0.694	0.297	0.677	0.718	0.327	0.274	0.153
BR2	0.282	0.851	0.535	0.274	0.338	0.353	0.364	0.150
BR3	0.403	0.990	1.369	0.353	0.419	0.461	0.491	0.406
BR4	0.424	0.914	0.391	0.376	0.441	0.440	0.802	0.400
GC1	0.403	0.990	1.369	0.353	0.419	0.461	0.491	0.406
I.Ad1	0.289	0.694	0.297	0.677	0.718	0.327	0.274	0.153
I.Ad2	0.488	0.358	0.354	0.731	0.420	0.591	0.476	0.282
I.Ad3	0.472	0.149	0.030	1.040	0.789	0.374	0.416	0.329
I.Ad4	0.622	0.456	0.267	0.759	0.429	0.578	0.929	0.517
I.As1	0.237	0.528	0.291	0.394	0.607	0.306	0.282	0.148
I.As2	0.289	0.694	0.297	0.677	0.718	0.327	0.274	0.153
I.As3	0.346	0.333	0.243	0.185	0.410	0.353	0.371	0.198
I.As4	0.472	0.149	0.030	1.040	0.789	0.374	0.416	0.329
I.As5	0.461	0.423	0.285	0.370	0.666	0.426	0.469	0.274
I.As6	0.570	0.058	-0.025	0.395	0.657	0.819	0.387	0.235
I.As7	0.540	0.441	0.316	0.424	0.803	0.521	0.802	0.294
IR1	0.321	0.441	0.477	0.223	0.272	0.476	0.321	0.288
IR2	0.511	0.621	0.560	0.392	0.378	0.719	0.457	0.371
IR3	0.534	0.502	0.308	0.409	0.478	0.746	0.520	0.211
IR4	0.890	0.451	0.336	0.483	0.522	0.802	0.708	0.292
IR5	0.570	0.058	-0.025	0.395	0.657	0.819	0.387	0.235
IR6	1.203	0.429	0.289	0.600	0.684	1.162	1.098	0.488
PR1	0.386	0.398	0.360	0.293	0.340	0.435	0.543	0.235
PR2	0.541	0.191	0.084	0.476	0.499	0.529	0.631	0.225
PR3	0.618	0.443	0.324	0.382	0.469	0.577	0.845	0.249
PR4	0.540	0.441	0.316	0.424	0.803	0.521	0.802	0.294
PR5	1.203	0.429	0.289	0.600	0.684	1.162	1.098	0.488
PR6	0.425	0.914	0.391	0.376	0.441	0.440	0.802	0.400
PR7	0.622	0.456	0.267	0.759	0.429	0.578	0.929	0.517
WTP1	0.469	0.360	0.307	0.423	0.341	0.447	0.486	1.123
WTP2	0.370	0.348	0.314	0.336	0.390	0.345	0.415	0.956

5. Results and Discussion

The result of the model testing is shown in Figure 2. The structural model is assessed in terms of how much of the variation in the model is explained by its latent variables to which R square is used and also by establishing the significance of all path coefficients' estimates (Beta's).

From Figure 2, in the first-order latent variables, 67.6% of the variance of respondents' information asymmetry was accounted for by authenticity (*B=0.015),* information reliability *(B=0.302),* information adequacy *(B=0.592)* and governmental third party credence *(B=.047).* All path coefficients were significant at the level of 0.05 except for the paths from authenticity to

information asymmetry and from governmental third party credence to information asymmetry. we can conclude that among the four hypotheses of the first-order latent variables, two were supported (H2 and H3) and two were not (H1 and H4).

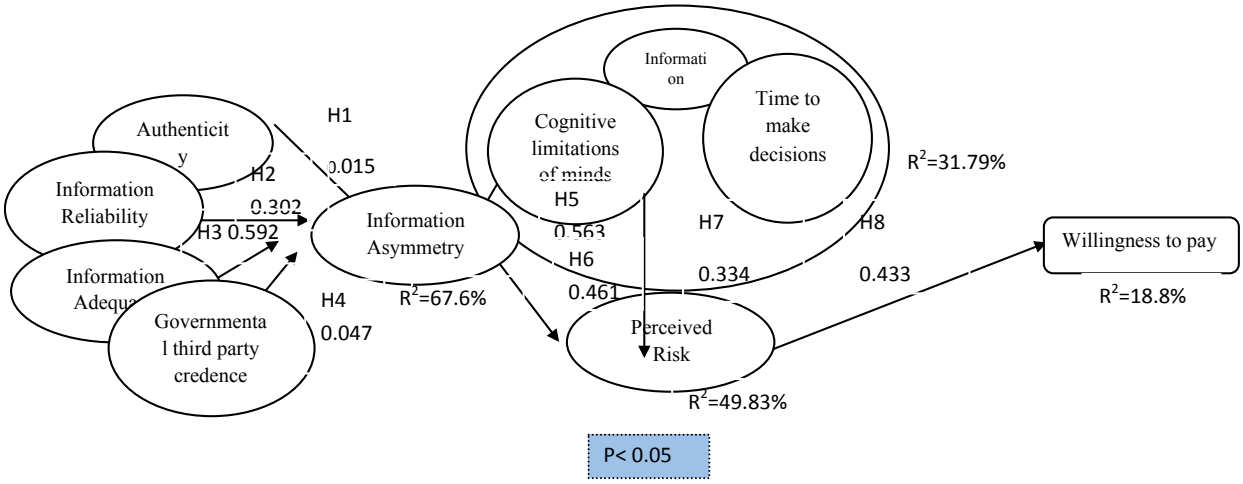

Figure 2. Results of the model testing.

As for the supported hypotheses relating to the latent variables of information reliability and information adequacy, the information adequacy had a stronger impact on mitigating information asymmetry over information reliability. The result of H4 being not supported was unexpected; especially that it is reported in the literature that governmental certification labels have strong positive meaning to the consumer, the reason behind this result could be the cumulative food incidents that took place recently, which in the eyes of consumers especially in Jordan is always connected to control leakages over food products.

Beta path coefficients were significant at the level of 0.05; accordingly, both of H5 and H6 were supported. However, the decreased information asymmetry had a stronger effect on respondents bounded rationality (*B*=0.563) than on their perceived risk (*B*=0.461)

Path coefficients between respondents bounded rationality and their perceived risk (*B*=0.334) as well as between their perceived risk and their willingness to pay (*B*=0.433) were significant at the level of 0.05. Therefore, hypotheses H7 and H8 were supported.

The R square values show that 49.83% of the variance in respondents' perceived risk was explained by information asymmetry (*B*=.461) and bounded rationality (*B*=.334). Also 31.79% of the variance in respondents' bounded rationality was explained by information asymmetry (*B*=.563). Finally 18.8 % of the variance in respondents' willingness to pay price premiums for traceable products was explained by their perceived risks of food products (*B*=.433).

6. Conclusions and limitations

Food traceability new developed practices are still emerging especially on the consumer level. Food traceability added values for consumers are vital; because it can work as a quality and safety control tool in their hands, through this tool, they have the chance to become better

informed about the food consumed in a way that affects their perceived risks toward food incidents.

This research has introduced food traceability as a tool that can reduce the information asymmetry situation taking place between consumers' and producer along the supply chain. This reduction in information asymmetry was found to be significantly affected by information reliability and information adequacy as characteristics of the system. This reduction of information asymmetry had significant positive effects upon both consumers' bounded rationality and perceived risks, which positively affected consumers' willingness to pay a price premium for traceable products.

The results support what was concluded by [6], that many consumers from (Canada and USA) were willing to pay premiums for food products characterized by traceability, transparency and quality assurance characteristics, which can help in verifying safety.

The research results also support the survey study of [43], regarding the perception of food safety and willingness to pay for certified traceable food products among the citizens of Jiangsu Province; especially after the melamine outbreak in China that occurred in 2008, which had dramatically affected consumers' perceptions of food. Their results affirmed that despite the fact that only 37% of the respondents have heard of food traceability systems, 68% of respondents were willing to bear the extra cost for traceable food.

The tests' results of this research confirm the importance of food traceability even though the level of knowledge about food traceability and the recent initiatives by food producers to permit tracking food traceability was not very high. However, respondents' perceptions, expectations and beliefs regarding food traceability systems allowed testing the model presented in the research. Results confirm that food traceability systems can play a role, in giving consumers the chance to make better informed decisions regarding the food they consume. It showed that, as consumers become better informed about food products in terms of safety and quality, (whether we are talking about information related to taste, freshness, nutritional needs or processes during production, transportation methods and circumstances, or even the storing conditions), their bounded rationality is positively affected in a way, that gets the gap between consumers' and food producers to be reduced. Once this gap is reduced consumers' perception of intrinsic risks in food is decreased especially with the existence of credence attributes in food.

This study had several limitations; first, the sample selected could not represent all food consumers; especially that the respondents were young university students with somehow low shopping responsibilities. However, targeting this group of consumers was essential because of two concerns:

- As consumers, compared to younger people, the elderly are shown to be the last to adopt a product, service, or emerging innovative ideas [34]; for that it seemed impractical to target older consumers in a subject that is framed by IT practices.
- Younger generations have been reported to be making more decisions in a way that is influencing more family decisions concerning food [34].

It was difficult to target larger groups of consumers at this point of time with different age classes, unless the practice of online food tracking spread over among older people.

The fact that the study has targeted two nationalities might have affected the model presented and because of two reasons:

- There are somehow different social and cultural backgrounds between Italians and Jordanians regarding food.
- Different food incidents took place at the time of study in Jordan have affected consumers' trust in authorities responsible for food.

This study while exploring traceability as a tool for safety and quality assurance by consumers, has introduced four latent variables to reduce the reported information asymmetry situation, nevertheless, there are other aspects and elements could be affecting the traceability system while reducing the information asymmetry situation and eventually the perceived risks.
Further approaches to applying other theoretical models are needed to investigate traceability on the consumer level, especially if it can use consumers' real-time data from the records of a food producing company that offers its consumers' traceability information in a web-based format.

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***Appendix A**: Questionnaire items for section one*

* Age:
a) 20-30
b) 30-40
c) 40-50

* Gender:
a) Male
b) Female

* Nationality
a) Jordanian
b) Italian

*Are you aware of food traceability systems in general?
a) yes
b) no

* If yes, your knowledge of food traceability systems is coming from (how did you know about food traceability systems):
a) Internet
b) Advertisements on media
c) Newspapers
d) Other, specify please ……

*Did you know that there are food producers offering on their websites Information about their products by having you as a consumer entering the barcode of these products?
a) Yes
b) No

*The major factors in terms of information that influence your choice when buying food products are:
a) Product features in terms of safety, quality, taste, freshness, nutritional needs
b) Processes related to the product, in terms of production methods, transportation, storing conditions.
c) Environmental issues and animal welfare
d) Price
e) all of the above
f) Other please specify……..

What is the percentage (out of the price) that you would pay as a price premium for traceable products?
……%

***Appendix B**: Questionnaire items for section two*

A: Authenticity, BR: Bounded rationality, GC: Governmental credence, I.Ad: Information adequacy, I.As: Information asymmetry, I.R: Information reliability, P.R: Perceived Risk.

A1	*You believe that being able to trace food products will help determining products authenticity, meaning that, tracing products will clarify whether "the product is what it is claiming to be" or not*
A2	*You assume that using a food traceability system indicates a high level of transparency and disclosure*
A3	*You believe that as a consumer being able to trace food products can help you feel whether what the producers say about their products is true or not.*
A4	*You don't think that tracing food products will provide you with a real feel of agro products*
A5	*You believe that producers of food products applying traceability systems will not counterfeit any information that might cause harm, because of the accountability element that is embedded in traceability systems*
BR1	*You intend to read all the information provided on a food product*
BR2	*You think that having the chance to trace food products will be worthwhile because it can affect your buying decision in terms of useful information available on products, and time saving as well, for future buying decisions*
BR3	*Having credence confirmation from a government authority on food products coming through a traceability system facilitates your decision of buying safe, authentic food*
BR4	*You believe that purchasing traceable food products will decrease the possible level of uncertainty associated with your buying decision especially with quality attributes*
GC	*Having credence confirmation from a government authority on food products coming through a traceability system facilitates buying safe, authentic food*
I.Ad1	*Having credence confirmation from a government authority on food products coming through a traceability system facilitates buying safe, authentic food*
I.Ad2	*You expect when tracing food products to be able to trace (back and forward) more than one stage/step along the supply chain*
I.Ad3	*You think of a food traceability system as a useful tool for companies to communicate only credence attributes to consumers (Credence attributes are ones that are difficult to verify even after use e.g.. containing genetically engineered (GE) ingredients, environmental practices used on the farm).*
I.Ad4	*You believe that using traceability systems will ensure transparency that will reduce any possible illegal practices that might affect you as a consumer or the environment, or animal welfare, by any supply chain actor.*
I.As1	*You know and understand the information provided on the labels of food products.*
I.As2	*You intend to read all the information provided on a food product*
I.As3	*You believe that the more you become (as a consumer) better informed about food products, the easier your buying decisions will be*
I.As4	*You think of a food traceability system as a useful tool for companies to communicate only credence attributes to consumers (Credence attributes are ones that are difficult to verify even after use e.g. containing genetically engineered (GE) ingredients, environmental practices used on the farm)*
I.As5	*You believe that producers are better informed actors than consumers regarding food products characteristics nevertheless consumers will be also sufficiently informed about their food if they are able to trace adequate, reliable information about it*
I.As6	*You don't think that food traceability systems are efficient tools in changing credence*

	attributes of food products into trustworthy and reliable information in the shape of searchable attributes
I.As7	*You expect traceability systems to provide you with objective information that would reduce the information gap between producers and consumers regarding food quality*
IR1	*Your information requirements on food products will change according to the country it is coming from*
IR2	*Having the ability to trace food indicates the existence of an embedded quality and food safety management system.*
IR3	*You believe that the element of accountability in a traceability system will ensure providing reliable information to help consumers in their judgment about food products.*
IR4	*You assume that using a food traceability system indicates a high level of transparency and disclosure.*
IR5	*You don't think that food traceability systems are efficient tools in changing credence attributes of food products into trustworthy and reliable information in the shape of searchable attributes*
IR6	*You believe that producers of food products applying traceability systems will not counterfeit any information that might cause harm, because of the accountability element that is embedded in traceability systems.*
PR1	*You think that tracing food products will decrease your perceived risks related to food products*
PR2	*Your expectations regarding food safety and quality will not increase with a food traceability system in action as long as there are quality and safety management systems in hand (without a traceability system) such as HACCP, ISO 22000…..etc.*
PR3	*You expect food traceability systems to reduce consumers' complaints on contaminated food.*
PR4	*You expect traceability systems to provide you with objective information that would reduce the information gap between producers and consumers regarding food quality.*
PR5	*You believe that producers of food products applying traceability systems will not counterfeit any information that might cause harm, because of the accountability element that is embedded in traceability systems.*
PR6	*You believe that purchasing traceable food products will decrease the possible level of uncertainty associated with your buying decision especially with quality attributes.*
PR7	*You believe that using traceability systems will ensure transparency that will reduce any possible illegal practices that might affect you as a consumer or the environment, or animal welfare, by any supply chain actor.*
WTP1	*You prefer to purchase traceable products over non traceable ones for a price premium.*
WTP2	*You prefer to purchase traceable products over non traceable ones but without paying additional money.*