Asymmetric Information in Agriculture Supply Chain Management: A Literature Review

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Abstract **— Food markets have been in a state of upheaval for some time now. Due to the current trend of numerous consumers favouring sustainable nutrition, the organic food market has proven to be an important market for both consumers and producers. This development enables consumers to continue to afford sustainable food in the future. Due to the complexity and non-transparency of value chains (especially in the organic food market) as well as the insufficient labelling of organic food, there is a lack of information in the organic food market. This often results in market failure. The aim of this research is to understand the problems caused by asymmetric information in the food supply chain and to present the principal-agent theory to detect and describe asymmetric information and as an economic model for understanding asymmetric information in the food supply chain. The principal-agent theory is most frequently used to explain and describe asymmetric information. The imperfection of principal-agent theory is due to the lack of and insufficient application of theories from related disciplines such as transaction theory and game theory. Furthermore, the theory assumes the existence of an informed agent and an uninformed principal. Finally, the analysis of information asymmetry is based on the existence of only principal and agent and neglects the information asymmetries in multi-level network-value chains. This paper presents a structured literature review that provides an overview of the current literature on the subject of asymmetric information in multi-level network-value chains. The identified studies are classified, and gaps are identified for future research.**

Keywords— *Agri-Supply Chain; Asymmetric information; Labelling; Principal-Agent Theory; Organic Food*

1. Introduction

In the current era of globalization and an ever-growing population, new customer-related markets are emerging [1] [69], especially within the food industry, which represents one of the markets which have discovered the trend of healthy living for itself [2]. More than 100 years ago, the issue of sustainable food was already present under the concept of organic food. At the beginning of the 20th century (around 1924), the subject of organic food was considered to be a specialty which did not receive too much popularity. In the following years, numerous farmers began to produce organic food, as there was a trend and a growing demand for it. In the early 1990s a new understanding of organic food and sustainability emerged [3]. Thus, from that time on the trend of organic food began, and it continues to this day along with a steady increase in popularity [4]. Supermarkets as well as discounters in a country cannot ignore this increasingly important trend, not least because of the associated economic aspect [5]. The intention behind the creation of special departments for organic foods is to indicate the exclusivity of the goods and to separate them from conventional foods. In these times of increasingly advanced digitalization and the associated entry of this into our private and professional daily lives, food can also be ordered via the Internet from a wide variety of suppliers [6]. Nowadays, such orders of sensitive products can be delivered to the desired address on the same day or can even picked up ready packed at the respective supermarket or discount store [7]. Payment can be made through numerous digital payment systems. This trend of increased consumption of organic food can be seen not only in industrialized countries, but also across the globe. The Asian region follows this trend and tries to make it possible through its numerous agricultural areas [8]. One could think that the development of organic food has only come about because of the current demand, but in fact, Asian farmers have been practicing traditional food cultivation for several centuries [9] [10]. However, in the current era of globalization and the ever-increasing growth of the organic food market, farmers have converted their agricultural management with the latest technology so that higher yields can be achieved. This is also done because the production standards of organic food have been set by

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legislators, retailers, and consumers [11]. In order to promote compliance with the requirements for organic certified food, the EU organic seal was created in the German market in 2001, and this has enormously increased the market confidence of customers [12]. However, along with this trend it also became apparent that consumer confidence in these foods has been damaged by the increasing numbers of negative reports that were published [13]. Even though consumers nowadays are more and more often able to pay a high price for such foods, they do not feel sufficiently informed by the numerous certifications that can be found on the products [14]. This insufficient information regarding the sustainability of the food products creates an information deficit (asymmetric information) on the consumer side [15] [16] [17]. The emergence of this information asymmetry can lead to opportunistic behaviour on the part of producers and retailers; this illustrates the current problem: namely, trust in organic food [18] [19]. A transparent design of the food supply chain (FSC) is required, especially when the problem of information asymmetry is prevalent in the organic food market. This is because the FSC is one of the most important and essential types of logistics and is highly significant due to ever-increasing globalization and the import and export between numerous countries [20]. Thus, concrete consideration of the food value chain and the possible information asymmetries is required. An analysis of the respective actors in the FSC should reveal some information about the information asymmetry. Thus, the purpose of this paper is to present the current state of research on information asymmetries using the agri-supply chain as an example, to address the issue of asymmetric information in value chains, and to point out possible gaps in the literatures. To undertake a structured investigation, it is necessary to consider the following:

- Current methods for conception of asymmetric information
  - Principal-agent theory
  - Game theory
  - Price approach theory
- Main literature problems related to the current scientific state of the art of information asymmetries and research gaps
- Requirements for a model to describe, explain and measure information asymmetries

2. Methodology

In order to properly document the topic and the possible existing research gap, the analysis of scientific publications is required. For this purpose, a structured literature review was conducted [21] [22]. To conduct a targeted literature review of the topic under review, a structured approach was followed, as shown in Figure 1.

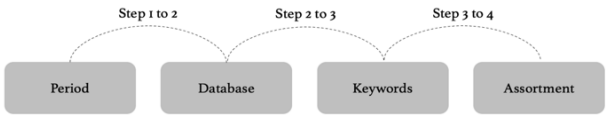

Figure 1. The Four Phases for Selecting Targeted Literature

Step 1. The Period of Time: The narrowing down of the time frame for the selection of the appropriate literature occurred in two phases. Here, the literature from 1976 onwards is of importance, as at this point in time the principal-agent theory was conceived [23] and the concept of supply chain management was considered for the first time by Landis and Gyr in 1981 [24]. Thus, the period spans from 1976 to the present. This is because only after the beginning of the 1980s could the principal-agent theory find its application in supply chain management.

Step 2. The Database: In order to identify the appropriate literature, it was necessary to select the appropriate databases; this is presented in the introduction to the methodology. Above all, the databases of the Scopus, Taylor & Francis, SpringerLink, JSTOR and Emerald Insight, Collection proved to very useful because of the high number of hit ratios for the topic under investigation. Especially the Scopus database turned out to be essential, due to its high-quality papers of numerous scientists. Some literatures, which were important through Scopus database (Table 2, No. 1-17), also contained important information about scientific publications, which made it necessary to search in databases of Taylor & Francis, SpringerLink, JSTOR and Emerald Insight.

Step 3. The Keywords: In order to achieve a high and target-oriented hit rate for the literature selection and the subsequent analysis, a syntax of necessary keywords was created, which was ultimately useful for the database query. Table 1 presents the results of the data query for each keyword (Code) and the literature used for the further selection.

Table 1. Syntax of the structured analysis

No.	Date	Syntax	Result	Exploitation
1.	02.02.22	ALL (principal AND agent AND theory AND supply AND chain AND food) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SUBJAREA , "busi") ORLIMIT-TO (SUBJAREA , "agri")) AND (LIMIT-TO (EXACTKEYWORD , "supply chains")) AND (LIMIT-TO (LANGUAGE , "english")) AND (LIMIT-TO (SRCTYPE , "j"))	12	8
2.	02.02.22	ALL (the AND willingness AND to AND consume AND organic AND food: AND a AND review) AND (LIMIT-TO (PUBSTAGE, "final“)) AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "english")) AND (LIMIT-TO (SRCTYPE , "j"))	320	143
3.	02.02.22	Edit ALL (akerlof AND asymmetric AND information) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (OA, "all")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SUBJAREA , "econ") OR LIMIT-TO (SUBJAREA ,"busi")) AND (LIMIT-TO (EXACTKEYWORD , "asymmetric information") OR LIMIT-TO (EXACTKEYWORD ,"information asymmetry")) AND (LIMIT-TO (LANGUAGE , "english")) AND (LIMIT-TO (SRCTYPE , "j"))	109	54
4.	05.02.22	ALL (organic AND food AND information AND principal AND agent) AND (LIMIT-TO (SUBJAREA, "busi“) OR LIMIT-TO (SUBJAREA , "econ")) AND (LIMIT-TO (LANGUAGE , "english")) AND (LIMIT-TO (SRCTYPE ,"j"))	100	30
5.	05.02.22	ALL (pricing AND asymmetric AND information) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SUBJAREA , "econ") OR LIMIT-TO (SUBJAREA , "busi")) AND (LIMIT-TO(EXACTKEYWORD , "supply chains") OR LIMIT-TO (EXACTKEYWORD , "game theory") OR LIMIT-TO (EXACTKEYWORD , "asymmetric information")) AND (LIMIT-TO (LANGUAGE , "english")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (OA , "all"))	339	132
6.	08.02.22	ALL (principal AND agent AND asymmetric AND information) AND (LIMIT-TO (PUBSTAGE, "final “)) AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SUBJAREA , "econ") OR LIMIT-TO (SUBJAREA , "busi")) AND (LIMIT-TO (EXACTKEYWORD , "asymmetric information")) AND (LIMIT-TO (LANGUAGE , "english")) AND (LIMIT-TO (SRCTYPE , "j"))	120	76
7.	13.02.22	Edit TITLE-ABS KEY (classification AND of AND asymmetric AND information) AND (LIMIT-TO (PUBSTAGE,"final “)) AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SUBJAREA ,"econ")) AND (LIMIT-TO (LANGUAGE , "english")) AND (LIMIT-TO (SRCTYPE , "j"))	18	11
8.	16.02.22	TITLE-ABS-KEY (food AND labeling AND asymmetric AND information)	21	9
9.	19.02.22	Edit ALL (adverse AND selection AND moral AND hazards) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SUBJAREA , "econ") OR LIMIT-TO (SUBJAREA , "busi")) AND (LIMIT-TO (EXACTKEYWORD , "moral hazard") OR LIMIT-TO (EXACTKEYWORD, "adverse selection") OR LIMIT-TO (EXACTKEYWORD , "asymmetric information")) AND (LIMIT-TO (LANGUAGE , "english")) AND (LIMIT-TO (SRCTYPE , "j"))	249	130
10.	23.02.22	ALL (uninformed AND principal AND an AND informed AND agent)	128	65
11.	23.02.22	ALL (information AND asymmetry AND food AND supply AND chain) AND (LIMIT-TO (PUBSTAGE , "final"))AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SUBJAREA , "busi") ORLIMIT-TO (SUBJAREA , "econ")) AND (LIMIT-TO (EXACTKEYWORD , "supply chains") OR LIMIT-TO (EXACTKEYWORD , "supply chain management") OR LIMIT-TO (EXACTKEYWORD , "information asymmetry")) AND (LIMIT-TO (LANGUAGE , "english")) AND (LIMIT-TO (SRCTYPE , "j"))	55	18

12.	01.02.22	ALL (food AND supply AND chain AND asymmetric AND information) AND (LIMIT-TO (PUBSTAGE , "final"))AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SUBJAREA , "busi") ORLIMIT-TO (SUBJAREA , "econ")) AND (LIMIT-TO (EXACTKEYWORD , "supply chains") OR LIMIT-TO (EXACTKEYWORD , "supply chain management")) AND (LIMIT-TO (LANGUAGE , "english")) AND (LIMIT-TO(SRCTYPE , "j"))	47	20
13.	27.02.22	ALL (food AND labeling AND asymmetric AND information) AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SUBJAREA , "econ")) AND (LIMIT-TO (LANGUAGE , "english")) AND (LIMIT-TO (SRCTYPE , "j"))	82	32

When entering the Syntax of Keywords, 1600 references were found. By carrying out a rough title analysis of the 1600 literatures, numerous literatures could be selected, which do not correspond to the topic of the information asymmetry in food conveyor chains. Furthermore, duplications of literatures were eliminated. Finally, 728 literatures could be used for the further selection.

This literature dealt with different topics, and it was necessary to classify it, as shown in Figure 2.

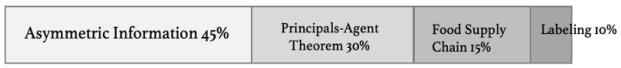

Figure 2. Number of papers according to topics

Most papers referred to the subject of asymmetric information (45%), 30% referred to the principal-agent theory, followed by Food Supply Chains with 15% and Labelling with 10%.

The subject of asymmetric information covers a wide range of topics and should therefore be considered in detail, as shown in Figure 3.

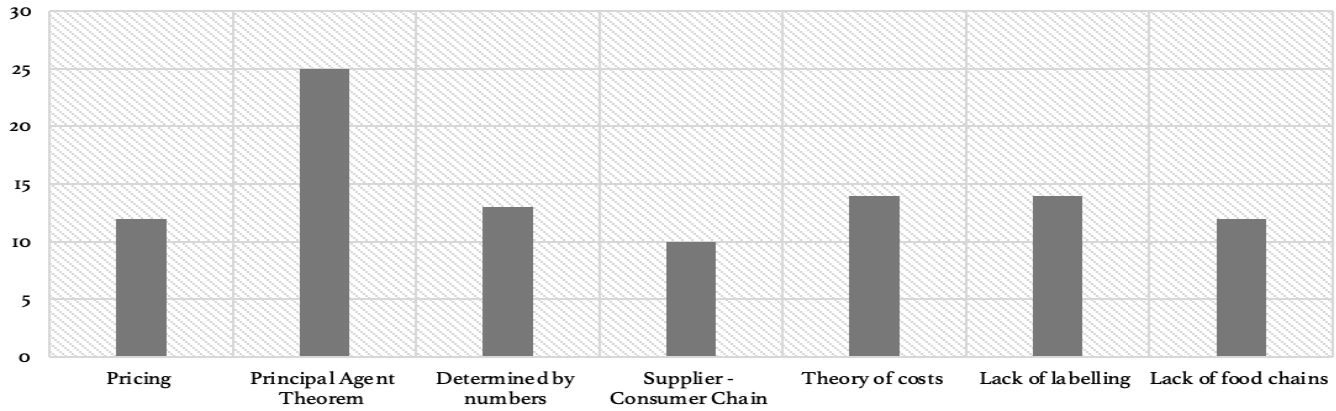

Figure 3. Topic spectrum of food asymmetric information expressed in %

Step 4. **The Assortments**: The sorting of the numerous literature examples from the databases required a more exact classification and examination regarding the correctness of the comprehension of the topic. As a result, the following can be reported about the selection of the literature from the databases. In total, 728 papers were selected with the input of the syntax of keywords, which related to the topic of the supply chain management.

Subsequently, it was determined that 80% of the literature required a further sorting so that the quality of the literature could be ascertained. Thus, only 142 papers could be used for further analysis. The 142 papers were analysed again by using a more detailed content analysis, so that finally 27 papers (Table 2) were shortlisted. Papers that had an extensive literature review on the topic of information asymmetry and principal-agent theory were of highest interest.

Table 2. Literature used for the analysis

No.	Headings
1. Scopus	Ambrose, E., Marshall, D. and Lynch, D. (2010). "Buyer supplier perspectives on supply chain relationships", *International Journal of Operations and Production Management*, vol. 30, pp. 269-1290.
2. Scopus	Arcelus, F.J., Satyendra, K. and Srinivasan, G. (2008). "Pricing and rebate policies in the two-echelon supply chain with asymmetric information under-price-dependent, stochastic demand," *International Journal of Production Economics,* vol.113, pp. 598-618.
3. Scopus	Auler, D., Teixeira, R. and Nardi, V. (2016). "Food safety as a field in supply chain management studies: A systematic literature review," *International Food and Agribusiness Management Review*, vol. 20, pp. 1-14.
4. Scopus	Bonroy, O. and Constantatos, C. (2015). "On the economics of labels: How their introduction affects the functioning of markets and the welfare of all participants", *American Journal of Agricultural Economics,* vol. 97, pp. 239-259.
5. Scopus	Canidio, A. and Gall, T. (2019). "Rewarding idleness", Journal of Public Economic Theory, vol. 21, pp. 433-459.
6. Scopus	Dosis, A. (2018). "On signalling and screening in markets with asymmetric information", *Journal of Mathematical Economics*", vol. 75, pp. 140-149.
7. Scopus	Ehmke, M.D., Bonanno, A., Boys, K. and Smith, T.G. (2019). "Food fraud: economic insights into the dark side of incentives", *Australian Journal of Agricultural and Resource Economics*, vol. 63, pp. 685-700.
8. Scopus	Golan, E., Kuchler, F., Mitchell, L., Greene, C. and Jessup, A. (2001). "Economies of Food Labeling", Journal of Consumer Policy, vol. 24, pp. 117-184.
9. Scopus	He, J., Zheng, X., Rejesus, R.M. and Yorobe, J.M. (2019). "Moral hazard and adverse selection effects of cost-of-production crop insurance: evidence from the Philippines", *Australian Journal of Agricultural and Resource Economics,* vol. 63, pp. 166-197.
10. Scopus	Huang, S. and Yang, J. (2016). "Information acquisition and transparency in a supply chain with asymmetric production cost information," *International Journal of Production Economics,* vol. 182, pp. 449-464.
11. Scopus	Huffman, W. and McCluskey, J. (2017). "Food labels, information, and trade in GMOs", *Journal of Agricultural and Food Industrial Organization*", vol. 15, pp. 1-9.
12. Scopus	McFadden, J. R. and Huffman, Wallace, E. (2017). „Willingness-to-pay for natural, organic, and conventional foods: The effects of information and meaningful labels", *Food Policy*, vol. 68, pp. 214-232.
13. Scopus	Müller, M. and Gaudig, S. (2011). „An empirical investigation of antecedents to information exchange in supply chains", *International Journal of Production Research*, vol. 49, pp. 1531-1555.
14. Scopus	Nistor, C. and Selove, M. (2020). "Pricing and quality provision in a supply relationship: A model of efficient relational contracts", *Marketing Science,* vol. 39, pp. 939-955.
15. Scopus	Pourmohammad-Zia, N., Karimi, B. and Rezaei, J. (2021). „Food supply chain coordination for growing items: A trade-off between market coverage and cost-efficiency*", International Journal of Production Economics*, vol. 242, pp. 1-20.
16. Scopus	Trivic, N. and Todic, B. (2022). "Models of Wages and incentives contracts in the conditions of Information asymmetry on the Labor Market", *Economic Horizons*, vol. 24, pp. 17-32.
17. Scopus	Zhang, J., Xiong, Q., Xu, W. and Zheng, P. (2021). „Relationship Between Supply Chain Contract, Supply Chain Behavior and Agricultural Supply Chain Performance", *Lecture Notes on Data Engineering and Communications Technologies*, vol. 79, pp. 489-507.
18. SpringerLink	Brusset, X. (2009). "Multi Period Contracts in Transport under Asymmetric Information and Prior Investments", *Logistik Management,* Physica Editor, pp. 37-54.
19. Taylor & Francis	Eyinade, G., Mushunje, A. and Yusuf, F. (2021). "The willingness to consume organic food: A review", *Food and Agricultural Immunology*, vol. 32, pp. 78-104.

20. JSTOR	Bergen, M., Shantanu, D. and Orville C., W.Jr. (1992). "Agency relationships in marketing: A review of the implications and applications of agency and related theories," *Journal of marketing*, vol. 56, pp. 1-24.
21. JSTOR	Eisenhardt, K. M. (1989). "Agency Theory: An Assessment and Review", *The Academy of Management Review*, vol. 14, pp. 57-74.
22. Emerald Insight	Fayezi, S., O'Loughlin, A. and Zutshi, A. (2012). "Agency theory and supply chain management: A structured literature review," *Supply Chain Management,* vol. 17, pp. 556-570.
23. Emerald Insight	Man Mohan, S., Gunjan, S., Rakesh, J., Milind, S. and Vinod, Y. (2017). "Agri-fresh food supply chain quality (AFSCQ): a literature review," *Industrial Management & Data Systems,* vol. 117, pp. 2015-2044.
24. Divers	Minarelli, F., Galioto, F., Raggi, M. and Viaggi, D. (2016). "Asymmetric information along the food supply chain: a review of the literature", *Proceedings. International Farming Systems Association (IFSA) Europe,* Bologna, Italy, pp. 1-14.
25. Divers	Ross, S. (1973). "The Economic Theory of Agency: The Principal's Problem," *American Economic Review,* vol. 63, pp. 134-39.
26. Divers	Teniwut, W., Betaubun, K., Marimin, M. and Djatna, T. (2018). "Asymmetric Information Mitigation in Supply Chain: A Systematic Literature Review," *Journal of Supply Chain Management,* vol. 7, pp. 183-194.
27. Divers	Zhang, J., Tang, W., Feng, L. and Hu, M. (2014). "A principal-agent model in a supplier-led supply chain under asymmetric information," *IMA Journal of Management Mathematics,* vol. 25, pp. 185-201.

3. Results

3.1 Current methods for conception of asymmetric information

Ref. [25] laid in 1970 the foundation of the topic of information asymmetry with his paper "The Market of Lemons" in which different approaches used in the numerous prevailing types of information asymmetries were be identified and counteracted [26]. Ref. [25] determined that essentially two main information asymmetries prevail, namely adverse selection (information asymmetry before contracting/hidden characteristics) and moral hazard (information asymmetry after contracting/hidden information) [27] [28] [29] [30] [31] [32]. Ref. [25] however, in order to reduce information asymmetries, presented two main approaches to counteract them, namely signalling (agent/seller creates trust with the customer by making his information about the product transparent) and screening (principal/buyer signals his intentions and obtains the necessary accessible information in this regard) [33] [34]. The classification of information asymmetries as well as the related solution approaches enabled the identification of broad applications of these principles in numerous other literature types, including the presented structured literature selection of, where information asymmetry in the food value chain was analysed, as shown in Table 3 [35].

Table 3. Information asymmetries along food supply chains using adverse selection and moral hazard [35]

PROBLEM	ASYMMETRY TYPE	PROPOSED SOLUTION	ATTRIBUTE	MODEL	SECTOR	ACTORS	REFERENCE	MAIN CONTENTS	FINDINGS	REFERENCE
Safety	Adverse selection	Contract	Credence	Principal agent defines the bid price in order to segregate unsafe and safe producers	Agri-Food	Producer-Processor	Starbird 2007	2 types of producers: one with low contamination rate (safe producers) one with high contamination rate (unsafe producers) itis safeifmeetgov. Standard Producers' capacity exceeds the processor's finite demand so demand can be satisfied by safe producers or unsafe producers.	Regulators: to act on cost failure. Processors: to help design contract that segregate unsafe and safe suppliers Producers: to determine if processor contract is appealing or not	journal of agricultural and food industrial organization
Safety and quality	Moral hazard	Traceability	Credence & Experience	GameTree model of ex ante quality verification system post traceability system to demonstrate different function of incentive	Agri-Food	Agri-food chain	Hobbs 2004	ex post traceability to trackback contamination problem ex post traceability used to test allocation liability ex ante traceability to detect experience attribute	Ex-ante traceability system with private market incentive is sufficient as quality verification function. Food Safety attributes require ex-post traceability system with government enforcement.	Agribusiness

Even though the topic of information asymmetry has experienced immense progress during the last decades, including the discovery of some factors which favour information asymmetries as well as suitable solutions (Figure 3 & Table 3), so far only three leading methods which are able to describe the topic and finally explain it have been established. These three methods are the price theory approach [36] [37], the game theory approach [38]

and the principal-agent theory [39] [70]. The price theory approach model will be considered first. Since measurement of the asymmetric information level is an immense challenge, economic modelling approaches such as pricing in the value chain are applied in order to discover the respective asymmetries in the information. Thus, the theory of pricing is implemented within the supply chain so that changes can be brought to light. By continuously changing and adjusting the prices, the researchers were able to identify possible reasons and at what price the information asymmetry may occur in the supply chain under consideration [37] [40]. Not only price theory, but also the whole topic of pricing has been noted as a current trend in models that are designed to detect information asymmetry, as well as game theory approach, which is under the rubric of probability theory. Here, researchers attempted to apply targeted experimental external influence to a supply chain according to the game theory approach; changes in the information asymmetry between the actors could be seen depending on the action [41] [42]. However, one of the most hopeful models that science has produced is the principal agent theory[1] [43]. The theory has proven to be an essential tool for describing and explaining information asymmetries in the core [44] [45]. The theory considers in detail the relationship between two actors (principal and agent). The principal represents the side of the market that places the required order with the agent, because without this, fulfilment of the order would not be possible. Accordingly, the principal represents the market side which has an information deficit vis-à-vis the agents [46]. The agent, on the other hand, represents the side of the market which accepts the principal's order to perform a service, Figure 4.

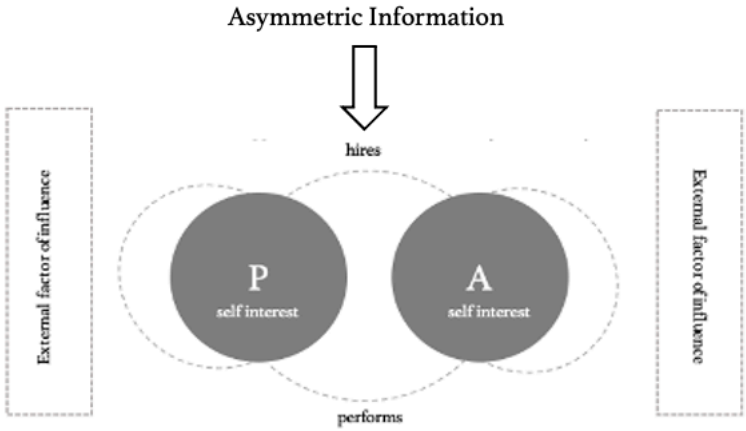

Figure 4. Principal-Agent Theory Information Asymmetry

However, the agent has an information advantage and as a result tends to maximize its utility at the expense of the principal [47]. Due to the principal's information deficit vis-à-vis the agent, the principal tends to adopt opportunistic behaviours, which results in a welfare loss and the emergence of an imperfect market [48] [49]. Thus, the theory is an essential model that enables the description of information asymmetries. Ultimately, the theorem makes it possible to address the characteristics of the two actors (principal and agent) and whether they have an information deficit or information advantage. Since the theory represents a structured model with which information asymmetries can be described and explained, and in which the effect of solution approaches can ultimately be determined, it can be used extensively in numerous areas, including supply chain management. For example, many researchers have used the theory to gain insight into the actions between suppliers and retailers [21] and to gain knowledge about

> "the development of inter- and intra-organizational relationships; the maintenance of complex relationships between suppliers and customers (e.g., vendors and third-party logistics providers); the dynamics of risk sharing, capital outlay, power and conflict between channel intermediaries; and, identifying the costs and benefits of SC integration" [50].

For this purpose, theoretical experiments were conducted by researchers, with the two actors and their behaviour simulated using the principal-agent theory. In order to keep

[1] The principal-agent theory was developed in 1976 by the scientist and William Meckling and Michael Jensen to describe information asymmetry in contracts [68].

the complexity within specific limits, pairs of actors were used and the principal agent theory was applied; Figure 5 [51] [52].

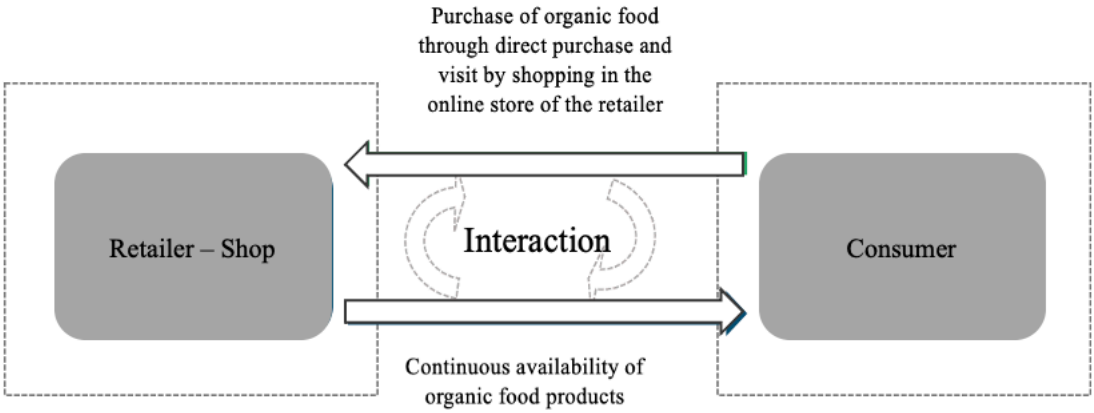

Figure 5. Principal agent theory at the level of a one-stage pair of actors

Complex structures of network supply chains (multi-level value chains) which correspond to reality have only been explored using the principal-agent theory [53] [54] [55]. Thus, researchers, have been able to state the limitations of the theory [21]. For example, the theory focuses only on the economic view of actors and neglects the social view, which results in a significant impact on information asymmetry [56]. Furthermore, the model considers the actors in the form of an uninformed principal and an informed agent, which, however, does not correspond to reality. How can the information advantage or information deficit be explained when a principal in a supply chain subsequently becomes the agent, or an agent simultaneously represents a principal? Figure 6 [57] [58].

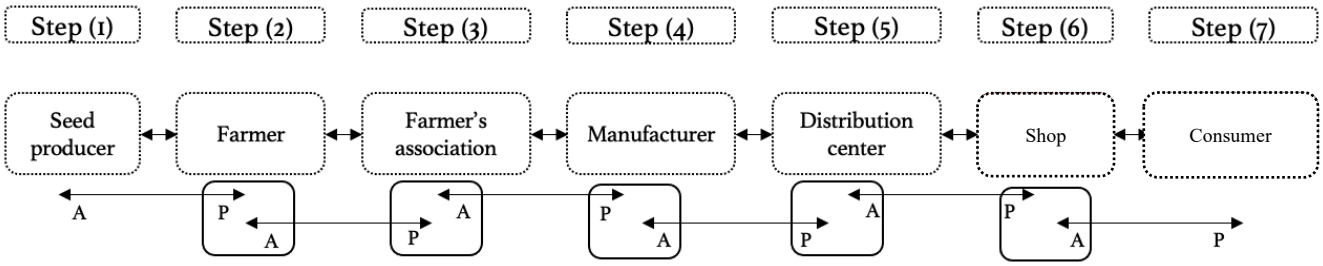

Figure 6. Actors in a multi-stage value chain using the principal agent theorem

Researchers also noted further insights into the capabilities of the principal-agent theory. Information distribution between the different actors within a supply chain, (principal and agent) are represented in a simplified way. In addition, the issue of information is not considered in more detail. How do the actors define their view of information? The theory does not allow for a clear classification/weighting of information and assumes that all information is represented in the same way [59]. Another weakness is the uniform view of the actors.

This is because not every principal and agent in a supply chain has the same characteristics, because some actors have a higher status than others and can therefore have higher information asymmetries than other actors in the supply chain who have a lower level of information. The theory thus neglects the principle of inequality (complexity of multi-level value chain) of actors, which would be necessary for a purposeful description, explanation, and representation of information asymmetries.

3.2 State of the art of information asymmetries in the agri-supply chain: key issues and research gaps

Since the scientific community has been dealing with the issue of asymmetric information for several decades, important advances have been documented that enable the understanding of asymmetric information and its reduction. Even though scientific progress has brought to light numerous models that can describe and explain information asymmetry, these models are imperfect [21]. Numerous features such as personal interest, information weighting, the importance of some actors over others in the supply chain, etc., do not receive any attention in the models. Up until now, the basic literature has been able to establish the existence of the following problems which

completely hinder perfect understanding of information asymmetries, especially in organic food supply chain:

a. Numerous papers show a very detailed elaboration of the issue of asymmetric information within a supply chain, but for simplification of the issue the focus is on only two actors and the analysis of their information asymmetries. What is ignored entirely, or at least to a not very detailed extent, is the analysis of information asymmetries in complex multi-level value chains and network value chains [60].

b. Even though numerous papers provide a very high level of detail and the use unique methodology (for example the principal-agent theory is able to recognize, describe, explain, and possibly reduce information asymmetries), the implementation is based only on the theoretical proposition. A practical application in the form of an empirical elaboration in a real laboratory and the resulting change in information asymmetries has not yet been undertaken in any significant paper [35].

c. The principal-agent theory is used as a model to explain and describe asymmetrical information. However, the theory neglects to invoke transaction cost theory and assumes the ideal state of the informed agent and the uninformed principal [61] [62]. However, the problems of the theory can be seen in the previous point [21].

d. Numerous publications deal with the issue of information asymmetries and offer numerous solutions to make information more transparent and counteract these asymmetries. However, there has been no significant paper that calculates information asymmetries and shows whether there is a low, medium, or high information asymmetry between the actors.

The identified gaps in the current state of science require the conception of an enhanced model. For this purpose, a multivariate model might be developed based on the principal-agent theory, perhaps extending the theory by drawing on methods from neighbouring disciplines.

4. Discussion

Although the topic of asymmetrical information along with its associated problems and pertinent solutions has been pointed out in numerous research publications, the research range still exhibits numerous gaps. In order to keep information asymmetries in check, numerous actors in a supply chain must incur expenses to obtain information from the opposite side, which leads to transaction costs [63]. One of the supply chains which has an immense asymmetric information flow is the food supply chain. This is because the quality and the issue of food safety are not always clear not only to the actors in the supply chain, but also to the consumers. End consumers, who are most affected by asymmetric information, increasingly complain that they find food labelling very confusing and information-distorting and are compelled to investigate the product in more detail to find out if it meets their own nutritional needs [64] [65].

5. Conclusion

Numerous researchers have addressed the issue of information asymmetries in general as well as specifically in the food chain. In this regard, the principal-agent theory has proven to be an effective model to describe and explain information asymmetry between two actors. Ref. [25] finally presents essential solutions that can lower any type of information asymmetry, for example screening and signalling [66] [67]. Although the theory has numerous applications, according to the literature it has some imperfections and requires the use of theories from neighbouring disciplines such as game theory in order to fulfil its purpose. The literature notes that the theory should be extended in its framework and should also be applied in multi-stage value chains rather than in situations with only two actors. Finally, the literature points out that the topic of asymmetric information and the principal-agent theory should be evaluated empirically [21]. Finally, a fundamental overview of possible information asymmetric influencing variables should be described, which can enable the understanding of the occurrence of information asymmetries.

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