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Abstract: Despite numerous promises on the links between data-driven and adaptive leadership, non-financial sustainability and financial sustainability, scholars have not conducted enough empirical research to test the links. This study therefore scrutinizes the links based on the data collected from chief executive officers, managing directors and senior operations managers.

The results raised from structural equation modelling indicate that data-driven and adaptive leadership is a key determinant for non-financial sustainability, which in turn contributes to financial sustainability. Directly, the leadership also plays a vital role for financial sustainability. Interaction effects further depict that the companies which apply more data-driven and adaptive leadership practices perform better compared to those which less focus on such practices. Consequently, the results provide the deeper understanding of the mechanism of how global supply chain leaders can use data-driven and adaptive leadership to co-create financial and non-financial sustainability.

11 August 2015

Guest Editors

International Journal of Production Economics

Sub: Special Issue - Sustainable Consumption and Production in Emerging Markets

Dear Prof. Tseng,

We are pleased to submit our manuscript (data-driven and adaptive leadership contributing to sustainability: global agri-food supply chains connected with emerging markets) to the special issue. This study investigates the effects of data-driven and adaptive leadership on sustainability by applying structural equation modeling and interaction effects on the data collected from 220 chief executive officers, managing directors and senior operations managers.

This empirical study substantially contributes to the knowledge gap and has considered high quality journals to produce this research.

Additionally, the manuscript has not been previously published and is not under consideration in the same or substantially similar form in any other peer-reviewed media. Also, to the best of my knowledge, no conflict of interest, financial or other, exists.

We have strictly followed the journal guide, including its general structure, methodology, data analysis and other key criteria. We would now be grateful if you could have it reviewed in order to check whether it would be suitable for the publication in the special issue. A copy of the manuscript has also been emailed.

Thank you in advance for your consideration. We look forward to hearing from you soon.

Sincerely,

Pervaiz Akhtar (corresponding author)

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Title:

Data-driven and adaptive leadership contributing to sustainability of global agri-food supply chains connected with emerging markets

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Data-driven and adaptive leadership contributing to sustainability: global agri-food supply chains connected with emerging markets

Despite numerous promises on the links between data-driven and adaptive leadership, non-financial sustainability and financial sustainability, scholars have not conducted enough empirical research to test the links. This study therefore scrutinizes the links based on the data collected from chief executive officers, managing directors and senior operations managers.

The results raised from structural equation modelling indicate that data-driven and adaptive leadership is a key determinant for non-financial sustainability, which in turn contributes to financial sustainability. Directly, the leadership also plays a vital role for financial sustainability. Interaction effects further depict that the companies which apply more data-driven and adaptive leadership practices perform better compared to those which less focus on such practices. Consequently, the results provide the deeper understanding of the mechanism of how global supply chain leaders can use data-driven and adaptive leadership to co-create financial and non-financial sustainability.

Keywords:
Data-driven and adaptive leadership;
Sustainability;
Global agrifood supply chains;
Structural equation modelling;
Endogeneity;

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4 **1. Introduction**
5

6 Data-driven and adaptive leadership is a social process in which managers use data
7 analytics to lead and direct supply chain partners (Datnow and Park, 2014). Managers also
8 adapt internal and external changes effectively and involve supply chain partners to balance
9 decision-making power, which ultimately sustains overall performance. This values
10 appreciation, opinions and group work. If insights from data show poor performance, the key
11 supply chain partners also apply command-and-control rules to improve productivity (Akhtar
12 et al., 2012; Datnow and Park, 2014).
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22 Such leadership is useful to achieve financial and non-financial sustainability in global
23 agri-food operations, particularly connected with emerging markets (Akhtar et al., 2012). The
24 research published in the Harvard Business Review stated that companies that use data-driven
25 leadership show 5-6% higher productivity (Barton and Court, 2012). Erik Brynjolfsson et al.
26 (2011) also claimed 4-6% higher productivity. Additionally, the productive results from
27 empowering supply chain partners and sharing of decision power give an impression that
28 these characteristics should be considered essentials of modern agri-food operations. Pfeffer
29 (1998) provided evidence that a company decreased 38% of defective rates by employing an
30 adaptive leadership approach; as a result, the company increased its performance by 20%. In
31 support, Mehta et al. (2003) and Akhtar et al. (2012) also stated that performance is more
32 effective when adaptive leadership practices are used. Several firms also reported an increase
33 in their productivity by applying such practices. For example, General Motors and Xerox did
34 not only improve their production but also showed a decreased rate in their workers'
35 absenteeism (Ichniowski et al., 1996)
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54 If analytics produced from data show poor performance, managers use directive
55 leadership (command-and-control rules) to improve productivity. For example, a study
56 conducted by Bititci et al. (2004) in the US multiple industries (rolling mill, bottled water
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4 producer, transport, and distribution companies) supported such findings. In a similar vein,
5
6 Kruglanski et al. (2007) believed that a directive leadership is appropriate when the nature of
7
8 work is sensitive, goals are comprehensible and a leader has more experience than group
9
10 members.

11
12
13 Undoubtedly, a number of studies conducted in certain industries and countries
14
15 scrutinized leadership roles that contribute to the success of financial and non-financial
16
17 sustainability. For example, in the USA, Finnish and Polish automobile industry, Mehta et al.
18
19 (2003) empirically analyzed that adaptive leadership skills positively affect key components
20
21 of financial and non-financial sustainability. Likewise, Werder and Holtzhausen (2009) found
22
23 similar applications and outcomes in the US public-relationship organizations. In selected
24
25 Palestinian organizations, As-Sadeq and Khoury (2006) found that adaptive leadership shows
26
27 the greatest impact on performance factors such as satisfaction, willingness to exert extra
28
29 efforts and effectiveness among employees.
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31

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33
34 Also, Karami et al. (2006) conducted a survey in the UK electronics industry and found
35
36 positive relationships between adaptive leadership practices and strategy development. To
37
38 explore similar practices, Smith (2006) emphasized retail sectors in the UK and Norway. A
39
40 study conducted by Ling et al. (2008) in the US multiple industries concluded that adaptive
41
42 leadership impacts firm-level outcomes and is strongly related to marketing practices.
43
44

45
46 Limited studies on data-driven and adaptive leadership have been conducted in global
47
48 agri-food supply chains connected with emerging markets. A study conducted by Akhtar et
49
50 al. (2012) in agri-food chains (dairy, meat, fruits and vegetables) explored theoretical links
51
52 between leadership practices and sustainability. However, the knowledge gap of estimating
53
54 the links between data-driven and adaptive leadership practices and their impacts on financial
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56 and non-financial is still unaddressed. Research also believes that data-driven supply chains
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58 have emerged recently and data is currently being generated exponentially, which compile
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4 researchers to test new data-driven leadership practices and sustainability (Erevelles et al.,
5
6 2015; Schoenherr and Speier-Pero, 2015). Although leadership or its styles have been over-
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8 researched in developed countries, not enough research has been conducted on the topic in
9
10 semi-developed countries' (e.g., New Zealand) trading mainly with emerging markets. Thus,
11
12 this study broadens the existing literature and knowledge by analyzing the data collected
13
14 from global import and export agri-food supply chains connected with emerging markets
15
16 (China, Indian, Pakistan, Bangladesh, Sri Lanka, Hong Kong, Chile, South Africa and
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18 Hungary).

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22 Following the introduction, the second section provides a background literature review.
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24 The third section presents a theoretical framework and hypotheses. Section four outlines
25
26 research methodology. Section five describes the main results raised from structural equation
27
28 modeling. This study is concluded by section six that discusses findings and implications.
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30

31 **2. Background**

32
33 A supply chain is the combination of designing, developing, optimizing and managing
34
35 different components such as material, information and financial flows and distribution of
36
37 finished products. In other words, it is a way through which products or services are moved
38
39 (Prajogo and Olhager, 2012). A supply chain is also defined as a synthesis of different
40
41 activities such as inventory management, logistics and distribution of material or finished
42
43 products. Managing these activities is called supply chain management (Doukidis et al.,
44
45 2007), which basically manages a network of supply chain partners (manufacturers,
46
47 processors, importers, exporters and retailers) who work together and integrate supply chain
48
49 activities to achieve certain objectives (Akhtar et al., 2012).
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54 A graphical view of an agri-food supply chain and possible flows among supply chain
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56 partners are shown in Fig. 1. The arrows represent the potential interactions between supply
57
58 chain partners (Doukidis et al., 2007). The chain normally consists of farmers,
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processors/wholesalers, retailers and consumers. Chemical dealers, input suppliers and other cooperatives that often support farmers and supply material are also part of the chain. Additionally, transport companies act as logistics supporters and research institutions bring novelty in the form of new products or processes. Importers and exporters are also involved in international or global agri-food supply chains (Doukidis et al., 2007)

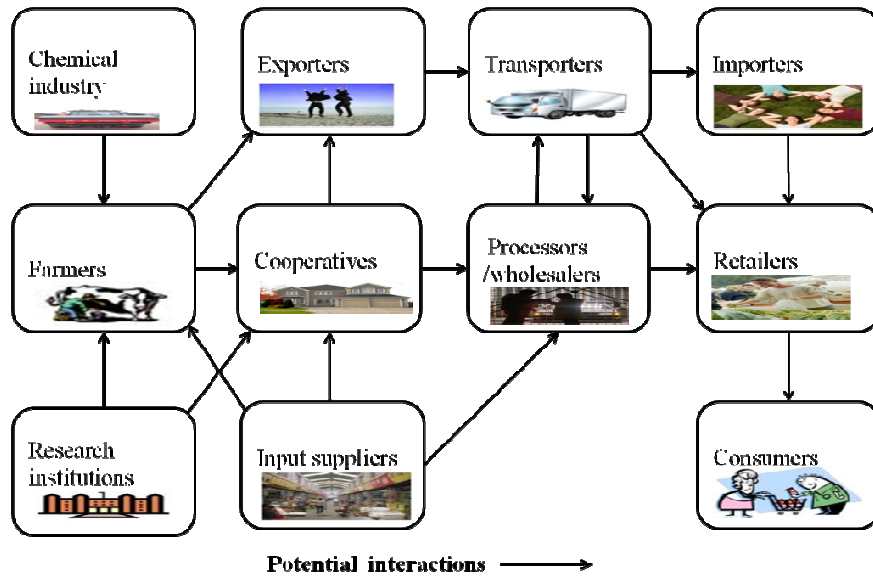


Fig .1. A graphical view of agri-food supply chains. Source: (Doukidis et al., 2007)

In agri-food supply chains, five different types of value chain governance structures are adapted. These structures shown in Fig. 2 are market, modular, relational, captive and hierarchy (Gereffi et al., 2005; Kalantaridis and Vassilev, 2011; Loconto and Simbua, 2012).

1. Market value chains are typical spot markets where sellers have control to set prices and make other major decisions. Furthermore, the bi-directional information complexity is low and suppliers need little information from buyers. Consequently, little explicit coordination is practiced for sustainability.

2. In modular value chains, products are made to customer specifications. Suppliers take full responsibility of technology standardization and also simplify specifications of products, components and processes. Consequently, it reduces costs and increases speed and flexibility that contribute to financial and non-financial sustainability.

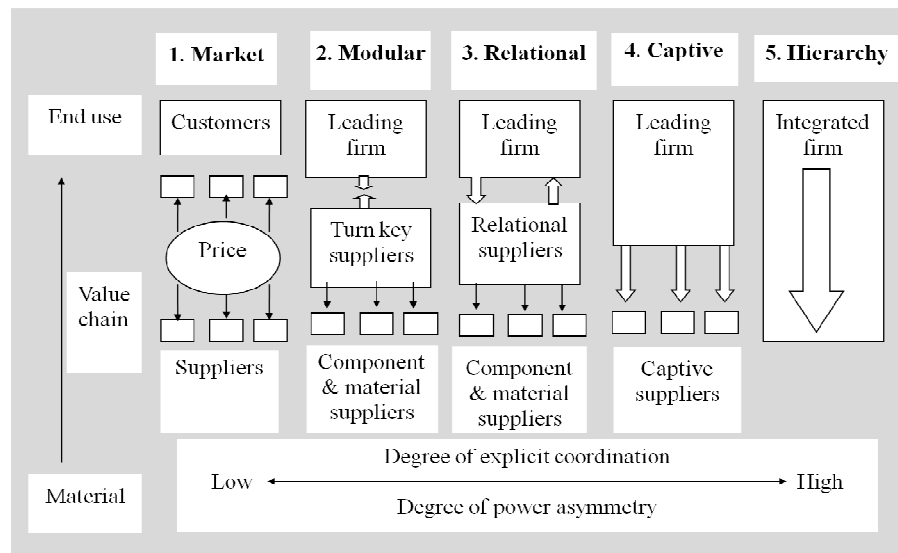


Fig. 2. Types of value chain governance. Source: (Gereffi et al., 2005)

3. Relational value chains have complex interactions between buyers and sellers. Both parties focus on relationships and trust. Moreover, product specifications are higher, thus, codification is not possible and complex information is often exchanged by face-to-face communication with high levels of explicit coordination for sustainability.

4. In captive value chains, a focal firm with considerable power monitors and controls the system. The focal firm also leads in logistics, purchasing, designing and technology upgrading and suppliers are only engaged in assembly processes.

5. Control flow comes from managers to subordinates in hierarchy value chains. Managers make major data-driven decisions and subordinate workers have to follow them. Furthermore, product specifications cannot be codified due to the nature of complexity. It

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4 is also difficult to find competent suppliers. Therefore, often a focal firm develops and
5
6 manufactures products. Moreover, data and information are exchanged between value
7
8 chain activities that emphasize sustainability (Gereffi et al., 2005; Kalantaridis and
9
10 Vassilev, 2011; Loconto and Simbua, 2012)

11
12
13 Gereffi et al. (2005) also found that sustainability trends have changed towards explicit
14
15 coordination in global agri-food supply chains. The relational and captive governance
16
17 structures are mostly used instead of market and modular structures. In other words, arm's-
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19 length relationships and little explicit coordination practices that were focused in 1980s have
20
21 been terminated (Gereffi et al., 2005; Kalantaridis and Vassilev, 2011; Loconto and Simbua,
22
23 2012; Akhtar et al., 2012). New practices help them to focus on data-driven outcomes that
24
25 contribute to bring fresh and quality products to their customers. Sharing operational linkages
26
27 and using analytics assist supply chain partners to co-create sustainability (Dorling et al.,
28
29 2005; Akhtar et al., 2012; Chae et al., 2014).

30
31
32 Sustainability should characterise with dynamic perspectives, both financial and non-
33
34 financial measures. Researchers (e.g., Matos and Hall, 2007; Jones et al., 2013; Merad et al.,
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36 2013; Govindan et al., 2014) have proposed that true sustainability can be created by
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38 increasing environmental performance (e.g., reusable packaging, material efficiency,
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40 wastewater reduction, total waste reduction for recycling, overall impacts and energy
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42 consumption), operational performance (e.g. service quality and product quality), relationship
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44 performance (trust in and satisfaction with supply chain partners) and financial performance
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46 (e.g., sales, profit and market growth). We thus define sustainability is a combination of
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48 these financial and non financial performances (Batt, 2003; Rao et al., 2006; Aramyan et al.,
49
50 2007; Gimenez et al., 2012; Jones et al., 2013; Merad et al., 2013)

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4 **3. Theoretical framework and hypotheses**
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6 Data-driven and adaptive leadership has been an essential tool-kit for managers to
7 manage modern agri-food supply chains. It helps managers to provide right directions about
8 duties and rights of chain partners. It also controls major decision-making and formal chains
9 of authority and grievance actions that contribute to sustainability (Akhtar et al.,
10 2012; Datnow and Park, 2014).
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17 Sustainability depends on such leadership that fastens workforce, board level and trade
18 unions into a single associated unit (Jung et al., 2003). Research conducted by Batt (2003)
19 noticeably provided a positive relationship between agri-food supply chain members'
20 empowerment and outcomes. Gereffi et al. (2005) and Smith (2006) also stated that
21 managers' capability to produce analytics, develop and sustain good relationships depends on
22 a data-driven and adaptive leadership theory. Using such practices, managers emphasize team
23 work and coordination among agri-food supply chain partners, which are the key resources
24 for achieving financial and non-financial sustainability.
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35 Such leadership practices bring supply chain partners together to organize and plan
36 their strategies effectively. For instance, adaptive leadership practices produce better
37 sustainability outcomes for Tesco, a UK-based retailer (Smith, 2006). The study conducted
38 by Brodt et al. (2006) in the US agri-food supply chains (i.e., almond and grapes) stated that
39 such adaptive decision makers are keen to manage resources in cooperation with other supply
40 chain partners. They also give higher priority to the preservation of operational quality and
41 environmental sustainability.
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51 The major benefits and the higher level of trust in and satisfaction with supply chain
52 partners are related to data-driven and adaptive leadership, which also assists to achieve
53 better service quality and financial performance of global agri-food supply chains (Akhtar et
54 al., 2012; Datnow and Park, 2014).
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4 Consequently, trust plays an important role to increase financial sustainability. Trust is
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6 associated with the expectations of supply chain partners who are keen to share something in
7
8 an optimistic manner. Trusted partners in agri-food supply chains have self-confidence and
9
10 believe in the words and actions. In such relationships, data and analytics are shared that
11
12 produce evidence-based decisions improving service quality (Batt, 2003; Akhtar et al., 2012).
13
14 Salamon and Robinson (2008) also believed that trust improves service quality that ultimately
15
16 affects overall supply chain sustainability.
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20 Sustainable outcomes such as good relationships, better market share, good service
21
22 quality and increased sales are the results of trusted and satisfied supply chain partners. The
23
24 development in these components motivates supply chain partners to grow their businesses,
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26 which totally depend on data-driven decision making and adaptive leadership practices
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28 (Tavella and Hjortsø, 2012; Chae et al., 2014). Data and analytics keep supply chain partners
29
30 connected. As a result, it improves service and product quality that also affect environmental
31
32 performance and relationships among supply chain partners (Chae et al., 2014; Schoenherr
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34 and Speier-Pero, 2015).
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38 The literature discussed above shows that data-driven and adaptive leadership practices
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40 are the key determinants for financial and non-financial sustainability. Hence, it can be
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42 summarized by positing the following hypotheses:
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45 **H₁**. Data-driven and adaptive leadership has a positive and significant relationship (i.e., a
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47 correlation, not a causal relationship) with financial sustainability.
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49 **H₂**. Data-driven and adaptive leadership has a positive and significant relationship with non-
50
51 financial sustainability.
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54 Non-financial sustainability consists of operational performance (i.e., relative service
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56 and product quality), environmental performance (i.e., reusable packaging, material
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58 efficiency, wastewater reduction, total waste reduction for recycling, overall impacts and
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4 energy consumption) and relationship performance (i.e., relative satisfaction with and trust in
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6 supply chain partners). Non-financial sustainability significantly influences financial
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8 sustainability of agri-food supply chains (i.e., relative profit, sales and market share). The
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10 relationships between the individual components of these constructs have been examined.
11
12 For instance, a study of over 200 US firms conducted by Lado et al. (2011) stated a
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14 significant positive relationship between service quality and financial sustainability. In
15
16 supporting the findings, Sichtmann et al. (2011) also stated that service quality significantly
17
18 affect monetary outcomes.
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22 Moreover, it is suggested that components related to service and product quality
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24 (delivery in a timely manner, orders filling rates and flexibility) are the key operational
25
26 outcomes of agri-food supply chains and increase sales, market share and profit (Aramyan et
27
28 al., 2007). In fact, service quality and produce quality are interconnected with operational
29
30 flows that enable agri-food supply chain partners to build a better match between financial
31
32 resources and demands. Effective service quality and product quality also increase inventory
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34 turnover (i.e., sales) and reduce extra costs that directly contribute to financial sustainability
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36 (Akhtar et al., 2012; Merad et al., 2013).
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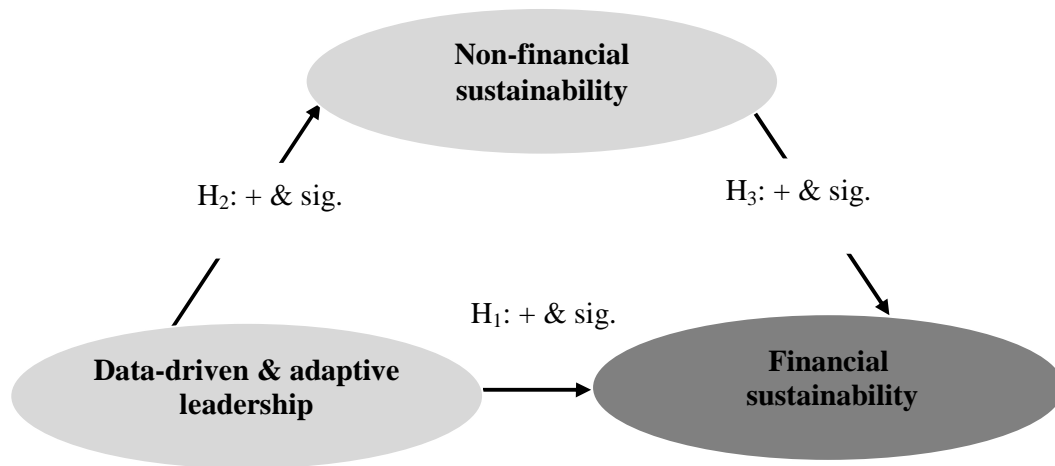
39
40 Additionally, social components such as trust in and satisfaction with agri-food supply
41
42 chain partners are associated with financial sustainability. Trustworthy and satisfied agri-food
43
44 growers and market agents constantly add value by coordinating activities. The outcomes are
45
46 high-performing supply chains in which profit is increased (Batt, 2003). Also, trust is used to
47
48 achieve better financial outcomes and trusted supply chain partners make more investments.
49
50 It is a main tool that is used to solve coordination issues and assists to sustain long-term
51
52 business relationships that positively influence financial sustainability of agri-food supply
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54 chain partners (Batt, 2003; Lindgreen et al., 2009). It also helps them to create and deploy co-
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56 specialized business processes that contribute to environmental sustainability, which in turn
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contributes to financial sustainability. Also, satisfaction that provides feeling of equitability with supply chain partners is the key determinants of financial outcomes. In conclusion, these components of financial and non-financial sustainability intersect and affect each others (Batt, 2003; Rao et al., 2006; Aramyan et al., 2007; Gimenez et al., 2012; Jones et al., 2013; Merad et al., 2013). From the above discussion, the following hypotheses are proposed.

H₃. Non-financial sustainability has a positive and significant relationship with financial sustainability.

H₄. Non-financial sustainability also mediates the relationship between data-driven and adaptive leadership and financial sustainability

To sum up, the theoretical framework shown in Fig.1 depicts the interrelationships discussed in the literature. Data-driven and adaptive leadership positively and significantly affects financial and non-financial sustainability. Non-financial sustainability also affects financial sustainability and plays the role of a mediator.



H₄: Non-financial sustainability also mediates the relationship between data-driven and adaptive leadership and financial sustainability

Fig. 3. Framework of data-driven and adaptive leadership contributing to sustainability

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4 **4. Research methodology**
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6 Structural equation modelling (SEM) approach using MPlus was applied to test the
7
8 framework. Descriptive statistics and interaction effects were computed using SPSS version
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10 21.

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13 *4.1 Sample*
14

15 The sample for this study consists of selected global import and export agrifood supply
16
17 chains connected with emerging markets (dairy, meat, vegetables and fruits). The companies
18
19 were headquartered in China, India and New Zealand, and they were importing and exporting
20
21 from emerging markets (e.g., China, Indian, Pakistan, Bangladesh, Sri Lanka, Hong Kong,
22
23 Chile, South Africa and Hungary). The KOMPASS database was used to reach CEOs,
24
25 managing directors, and senior operations manager who would be likely to have the required
26
27 information.
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31 A questionnaire using five-point Likert scales (strongly disagree: 1 and strongly agree:
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33 5) was used to facilitate respondents to know their degree of agreement or disagreement. The
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35 questionnaire was also pilot tested and the issues were resolved. During the pilot survey
36
37 process, the respondents also mentioned that a questionnaire-based survey was more
38
39 appropriate and time efficient. A total of 600 copies of the questionnaire were sent. After
40
41 excluding unusable responses, a total of 220 (36.67% response rate) responses were used to
42
43 execute structural equation modelling with parcelling as the strategy utilized by other
44
45 researchers (Marsh et al., 2004; Coffman and MacCallum, 2005; Goodhue et al., 2007; Kline,
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47 2011). The sample characteristics are listed in Table 1.
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Table 1
Sample characteristics.

	Category	No	%
Job titles	Senior operations managers	98	45
	Managing directors	93	42
	CEOs	29	14
Agrifood networks	Veg. & fruits	107	49
	Meat	77	35
	Dairy	36	16
Employees	<20	63	29
	20-100	86	39
	101-200	71	32
Turnover(\$m)	<15	34	15
	15-60	186	85
Total		220	100

4.2 Measurement Scales

To assess the characteristics of adaptive leadership, we used items from Mehta et al. (2003). To best of our knowledge to date, no items have been developed to assess the data-driven leadership characteristics, thus, the relevant literature from different fields (e.g., Davenport, 2006; Cohen et al., 2009; Chen et al., 2012) guided us to include relevant questions (items), which were later refined by using exploratory factor analysis (EFA). EFA with varimax rotations, eigenvalues ≥ 1 and scree plots assisted to develop the constructs. A total of 8 items were utilized that measure data-driven and adaptive characteristics of leadership.

Non-financial sustainability consisted of three dimensions of performance: environmental, operational and relationship. These dimensions were assessed by utilizing more than 15 items. Although we executed EFA to further develop them, they were chosen

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4 from well established research. Environmental performance measured reusable packaging,
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6 wastewater reduction, material efficiency, total waste reduction for recycling, overall
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8 environmetnal impact and energy consumption (Rao et al., 2006). Operational performance
9
10 assessed service quality (order accuracy, deliveries on time and order flexibility) and product
11
12 quality (product defective rates, product safety and product reliability) (Aramyan et al.,
13
14 2007). Social performance was represented by satisfaction and trust. Additionally, finanical
15
16 sustainability included profit, sales and market growth (Cullen et al., 1995; Batt, 2003). The
17
18 scales, constructs and their codes are listed in Appendix A.
19
20

21 22 *4.3 Biases and endogeneity*

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24 No difference between the respondents and non-respondents (non-response bias) was
25
26 detected. It was assessed by executing chi-square difference tests. Additionally, a test of
27
28 comparing early to late respondents did not show significant differences.
29
30

31
32 Endogeneity biases mainly include common-method variance, measurement error and
33
34 omitted variables. Research shows that (e.g., Hamilton and Nickerson, 2003; Antonakis et al.,
35
36 2010) 90% of studies published in premier journals have not even adequately addressed
37
38 endogeneity biases. As a result, “at least 66% and up to 90% of design and estimation
39
40 conditions make the claims invalid” (Antonakis et al., 2010: p.1086). It is worthy to note that
41
42 the claims are based on selected studies, they do not include all premier journals. Despite
43
44 recent methodological developments and the relevant extant literature in
45
46 econometrics/psychology, other social science disciplines are naively calculating inconsistent
47
48 parameters because of not addressing such biases. This study thus addressed the possible
49
50 issues theoretically as well as empirically.
51
52

53 54 *Common-method variance*

55
56 This study develops a systematic questionnaire and measures (items) not only based on
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58 theories but also statistically refines them using exploratory factor analysis. As guided (e.g.,
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4 Tourangeau et al., 2000), double-barrelled questions, unfamiliar words and technical words
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6 were avoided. The items were not clustered in conceptual dimensions. The extensive use of
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8 negatively-worded items was avoided because they could distrust the participants' pattern of
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10 responding that can creat a source of method bias, as highlighted by Podsakoff et al. (2003).
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12 We also informed anonymity of the survey and avoided a single-informant bias, as the data
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14 was collected from CEOs, managing directors and senior operations managers.
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18 Statistically, Harman's one-factor test was applied. The analysis with multiple factors
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20 explained greater variance compared to a single factor solution or combinations. While all
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22 statistical approaches to control for CMV bias have some advantages and disadvantages
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24 (Podsakoff et al., 2003; Malhotra et al., 2006), the marker variable method (the variable was
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26 the number of languages respondents knew) proposed by Lindell and Whitney (2001) with
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28 small correlations provided a reasonable proxy. Also, the latent factor method did not show
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30 that CMV bias was an issue (Malhotra et al., 2006).
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33 *Measurement error*

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36 Although SEM analysis, that is maximum likelihood estimate, correct for "the biasing
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38 effects of random measurement errors" (Frone et al., 1994: p.573) or "successfully correct for
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40 the small amount of measurement errors in the items" (DeShon, 1998: p.417), researchers
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42 still should control for the measurement errors if they use a single indicator approach
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44 (DeShon, 1998). In this case, the relevant loadings (i.e., $SD * \text{square-root of alpha}$) and
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46 variances for the parcels are fixed (Bollen, 1989; DeShon, 1998; Antonakis et al., 2014).
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48 However, we utilized a multiple indicator approach, thus, the correction was not necessary.
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51 *Omitted biases*

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54 Omitted biases exist in various forms (for details see Antonakis et al., 2010; Antonakis
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56 et al., 2014). One case could be that researchers testing validity of a construct without
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58 including important variables/constructs. For instance, one measures non-financial
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sustainability without environmental performance. In this regard, the most important guide is “theory, theory and more theory” (Antonakis and Dietz, 2011: p.218; Antonakis et al., 2014) . Compared to other studies that often employed one or two dimension of sustainability, this study includes four dimensions, which themselves consist of multiple constructs (e.g., service quality and product quality formed operational construct; trust and satisfaction relationship construct).

5. Results

The descriptive results with a correlation matrix are listed in Table 2. The mean values (\bar{x}) show that data-driven and adaptive leadership (DDAL), non-financial sustainability (NFS) and financial sustainability (FS) all were rated over 4 on a 5-point Likert scale, indicating positive relationships between the underlying constructs.

Table 2
Descriptive statistics.

Constructs	\bar{x}	σ	DDAL	NFS	FS
Data-driven and adaptive leadership (DDAL)	4.28	0.38	1		
Non-financial sustainability (NFS)	4.20	0.30	0.58	1	
Financial sustainability (FS)	4.17	0.37	0.63	0.81	1

\bar{x} (mean); σ (standard deviation); n=220; all correlations are significant at $p < 0.01$

To further refine the constructs and to test the hypotheses, a two-stage structural equation modelling approach was utilized. Firstly, the measurement models refined the items and constructs by conducting a series of checks, including items reliability, composite reliability, convergent validity and discriminant validity. The item DDAL8 was excluded because of the low loading. Secondly, the hypotheses were tested by examining the structural relationships. During this process, another item (DDAL2) was excluded due to high modification indices with other items. To establish the final model, mainly p-value and fit-indices ($p \geq 0.05$; CFI ≥ 0.90 ; TLI ≥ 0.90 ; RMSEA ≤ 0.08) were also employed to see

whether the models can substantially be improved or not (Lance et al., 2006; Kline, 2011; Pandey and Jha, 2012).

The exploratory results are presented in Table 3. The alpha (α) values and construct reliability (CR) values showed the level of consistency. The loadings (λ ; highly significant at $p < 0.01$) highlighted convergent validity. In addition to the loadings, average variance explained and construct reliability values gave further confidence (Sekaran, 2000; Kline, 2011; Pandey and Jha, 2012).

Table 3
Evaluation of measurement models.

Constructs	Items*	α	λ	AVE	C.R
Data-driven leadership (DDL)	DDAL1	0.91	0.82	0.64	0.91
	DDAL2 (HMI*)				
	DDAL3		0.76		
	DDAL4		0.86		
	DDAL5		0.87		
	DDAL6		0.76		
	DDAL7		0.71		
	DDAL8 (LL*)				
Non-financial sustainability: ENV, OP and REL	ENV	0.78	0.78	0.54	0.78
	OP		0.70		
	REL		0.72		
Financial sustainability	FIN1	0.75	0.69	0.51	0.75
	FIN2		0.70		
	FIN3		0.74		

* Items DDL2 and DDL8 were deleted because of high modification index(HMI)/low loading(LL); α = items reliability; λ = loadings; AVA =average variance explained; C.R =construct reliability;

Distriminant validity was measured using two methods. First, as given in Table 4, the square of the correlation (ϕ^2) by each pair of constructs was less than the average variance

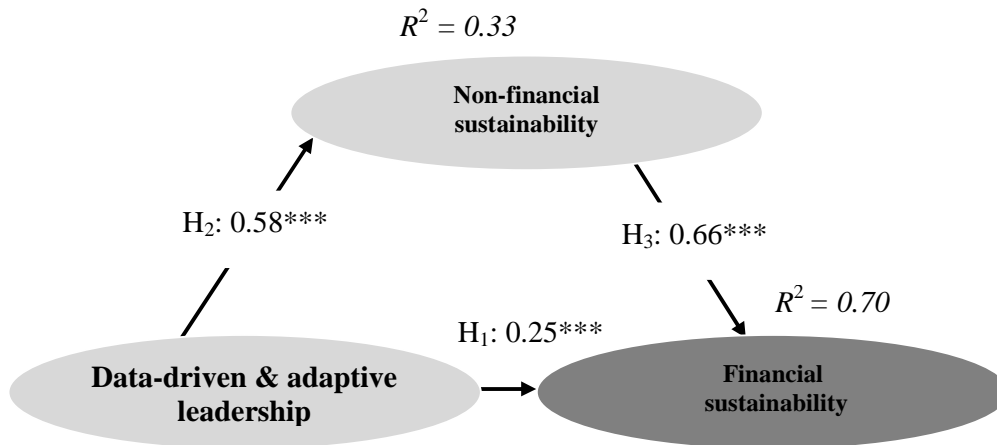
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4 explained (AVE), except for financial and non-financial sustainability. These two constructs
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6 are strongly correlated based on the theoretical grounds. Thus, it was not surprising that both
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8 constructs could not meet the criteria because of high correlation between them (i.e., 0.81)
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10 (Sekaran, 2000; Chiang et al., 2012). In such case, the correlation between the constructs
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12 should be less than 0.85 for discriminant validity (second method), even some researchers
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14 recommend up to 0.90 (Kline, 2011). Collectively, by investigating the dataset in details, the
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16 results showed sound psychometric properties.
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22 **Table 4**
23 Discriminant validity, first method

Constructs	Statistics			Condition met
	ϕ	* ϕ^2	**AVE	$\phi^2 < AVE$
DDAL & NFS	0.58	0.34*	0.59**	Yes
DDAL & FS	0.63	0.40	0.58	Yes
NFS & FS	0.81	0.66	0.53	No

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32 ϕ =correlation between factors, * ϕ^2 , $0.44*0.44 = 0.19$; **AVE, $(0.64+0.54)/2 = 0.59$ (AVE for
33 DDL & NFS)
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36 Fig. 2 presents the hypotheses and standardized results. Hypothesis H₁ proposes that
37 data-driven and adaptive leadership has a positive and significant relationship (i.e., a
38 correlation, not a causal relationship) with financial sustainability. Based on the structural
39 results, the hypothesis is supported at $p < 0.01$. Hypotheses H₂ (data-driven and adaptive
40 leadership has a positive and significant relationship with non-financial sustainability) and H₃
41 (non-financial sustainability has positive and significant relationship with financial
42 sustainability) are positive and significant. Additionally, the fit indices with a non-significant
43 p-value (0.108) and R² values ranging from 33% to 90% are provided.
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H₄: Non-financial sustainability also mediates the relationship between data-driven leadership and financial sustainability

*** statistically significant at $p < 0.01$

$n = 220$; $p\text{-value} = 0.108$; $\chi^2/df = 1.25$; $CFI = 0.991$; $TLI = 0.988$; $RMSEA = 0.034$

Fig. 2. Structural results for hypothesis testing, R^2 values and fit indices

To test H₄, mediating analysis were conducted using three approaches: a) causal-steps approach (Baron and Kenny, 1986), b) Sobel typed-tests (Sobel, 1982) and c) Bootstrapping method (Preacher and Hayes, 2008). The causal-steps approach tested that the independent variable (data-driven and adaptive leadership) affects dependent variable (financial sustainability) with $\beta = 0.64$ and $p < 0.001$. The independent variable also affects mediating variable (non-financial sustainability), as $\beta = 0.39$ and $p < 0.001$. Finally, when the model was controlled for the mediating variable (non-financial sustainability), the previous relationship (i.e., data-driven and adaptive leadership \rightarrow financial sustainability) reduced ($\beta = 0.25$ and $p < 0.001$). The results thus showed partial mzzediation rather than full medication as the previous relationship was still significant. The Sobel test also showed that the indirect effect of the independent variable on the dependent variable via the mediator is significantly different from zero at $p < 0.001$. Additionally, the Aroian and Goodman tests showed the same results.

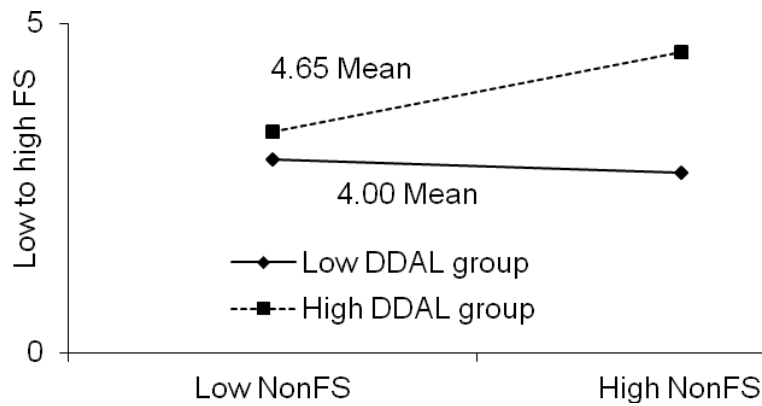
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4 The bootstrapping method with 5000 samples and 95% confidence interval was also
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6 used (Preacher and Hayes, 2008). The relevant items were parcelled to conduct the multiple
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8 regressing analysis. First, it was found that data-driven and adaptive leadership was positively
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10 associated with non-financial sustainability [$\beta = 0.41$, $t(218 \text{ df}) = 8.83$, $p < 0.001$], path a].
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12 It was also found that the effect of non-financial sustainability was positively related to
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14 financial sustainability [$\beta = 0.61$, $t(218 \text{ df}) = 8.61$, $p < 0.001$, path b)]. The total affect of
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16 data-driven and adaptive leadership on financial sustainability was positive [$\beta = 0.54$, $t(218$
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18 $\text{df}) = 9.54$, $p < 0.001$, c path)], which later reduced ($\beta = 0.29$, $\text{CI} = 0.17$ to 0.36 , c-prime path)
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20 when controlling for the mediating variable (non-financial sustainability), thus, suggested
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22 partial mediation.
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26 **6 Discussions**

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28 Although leadership has generally been research extensively, research on data-driven
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30 and adaptive leadership is in its infancy. Particularly, the new leadership characteristics of
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32 data-driven practices have got scholarly attention recently because of developments in global
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34 data-driven supply chains, where data is being generated exponentially. Unfortunately, not
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36 enough research has been conducted on data-driven practices. Thus, to address this knowledge
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38 gap, we have simultaneously tested the links between data-driven and adaptive leadership and
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40 sustainability. The data was collected from the selected global data-driven agrifood supply
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42 chains and developed hypotheses showed significant relationships.
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48 To further investigate practical implications of the relationship between the intensity of
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50 data-driven and adaptive leadership and sustainability, surveyed companies were categorised
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52 into high or low intensity of such leadership practices. The t-test showed that the grouping is
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54 significantly different (at $p < 0.00$) with means (\bar{x}) 4.00 and 4.63 for low data-driven and
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56 adaptive leadership and high data-driven and adaptive leadership respectively. The results
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58 conclude that the more financial sustainability comes when companies apply extensive data-
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4 driven and adaptive leadership practices. Similarly, companies create the more financial
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6 sustainability when data-driven and adaptive leadership practices interact with non-financial
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8 sustainability ($\beta = 0.35, p < 0.05$). It is thus worthwhile to take this on board that companies
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10 should focus on data-driven and adaptive leadership practices and non-financial sustainability
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12 as they are the key determinants for financial sustainability. The relationships are also
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14 shown in Fig. 3.



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Fig.3. Interaction effects

The findings are vital in the context of changing business environments and leadership practices in modern agri-food supply chains. Companies often emphasize traditional leadership practices (i.e., participative and directive leadership styles) that might not be suitable for modern global data-driven supply chains. By applying data-driven and adaptive leadership, data driven-companies create better sustainable outcomes by improving their service quality, product quality, sales, profit and market growth (item-based discussion). They also build enduring relationships by building trust in and satisfaction with supply chain partners. Similarly, these factors contribute to environment-related outcomes such as waste recycling, reusable packaging, material and waste-water efficiency and energy controls, ultimately contributing to financial sustainability.

Academic implications, a number of management schools are offering leadership programmes. However, the integration of data-driven practices and techniques (e.g.,

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4 mathematics and statistics, optimisation techniques) in these courses is still questionable. It is
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6 inferred from the research that modern leaders and managers need more data-oriented skills.
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8 Thus, an interdisciplinary curriculum development approach between various departments
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10 (management schools, mathematics and statistics) is useful for future business leaders or
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12 data-savvy managers. If management schools do not make these developments, non-
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14 management schools might take over to meet the demand. Additionally, leaders and
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16 managers, who already have theoretical-based degrees but do not have data-driven skills,
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18 should consider to take part in data-related courses that can help them to apply data-driven
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20 leadership practices. Also, the relevant free online short courses (e.g., Coursera and edX) can
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22 help them to build foundations for such leadership practices.
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27 The study limitations are employed for survey research in general. Firstly, although the
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29 theoretical framework is developed based on the arguments raised from literature and
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31 endogeneity biases are addressed, no causal claims can be made. Secondly, the study is based
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33 on the selected agrifood supply chains that do not reflect other industries. Importantly, data-
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35 driven leadership is still in its infancy and the underlying construct can behave differently in
36
37 various industries. However, there are useful insights for other industries or firms that have
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39 similar characteristics. Finally, data-related technologies rapidly change and the timing of our
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41 research might affect the results. Thus, future studies might find more advanced data
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43 technologies that have differently impacts on leadership practices and sustainability.
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48 Future research should focus on data-related education that can help to produce
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50 automotive decisions and develop evidence-based leadership practices for policymaking.
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52 Research believes that 90% of (big) data has been generated in the last few years and this
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54 trend has thrown many challenges for top management (skills shortage, data quality and
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56 cybersecurity issues). This also provides many opportunities for future research in these
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58 arenas.
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Appendix A.

Constructs	Brief items description	Codes
Data-driven and adaptive leadership	• Determination of policies depends on our data-driven leadership	DDAL1
	• Lower level managers (e.g., duty managers, area managers) do not pass ideas to top management (*)	DDAL2
	• Lower level managers determine promotional allowances based on quantitative measures	DDAL3
	• Top level managers (e.g., CEO, managing directors) encourage to use data-driven decision making	DDAL4
	• Top level managers provide sufficient guidelines and instructions on data-driven performance	DDAL5
	• Our performance sustainability depends on data-driven leadership	DDAL6
	• Top level managers adapt changes as data and analytics suggest	DDAL7
	• Our operational performance do not depend on data-driven performance (*)	DDAL8

Non-financial sustainability Environmental performance	• Total waste to output ration is reducing	ENP1
	• Follow reusable packaging policy	
	• Material efficiency is increasing	ENP2
	• Water consumption is increasing (*)	ENP3
	• Energy consumption is decreasing	ENP4
	• Impact of practices on natural environment is reducing	ENP5 ENP6

Operational performance:	• Provide deliveries on time	SRQ1
	• Do not fulfil 100% orders with accuracy (*)	SRQ2
	• Offer very flexible options for changing orders' quantity	SRQ 3
	• Product defective rate is very low	PRQ1
	• Provide 100% products safety certification	PRQ2
	• Very reliable products are not offered (*)	PRQ3

Relationship performance:	• Relationships with main SC partners are satisfactory	SAT1
	• Our main partners are not good companies for business (*)	SAT 2
	• Are satisfied with main-partners' performance	SAT 3
	• Have successful coordination with main partners	SAT 4
	• Do not have high confidence in main partners (*)	TST1
	• Main partners always consider our best interests	TST2
	• Main partners do not always keep their promises (*)	TST3

Financial sustainability	• Profitability growth is high	FIN1
	• Sales growth is increasing	FIN2
	• Market share growth is reducing (*)	FIN3

*Items reversed. The used items were adjusted to the purpose of this study

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