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Abstract:

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 based on globally and massively connected emerging supply chains. This study therefore scrutinizes the interlocking links by applying the data collected from chief executive officers, managing directors and senior operations managers of such supply chains rooted in emerging markets.

The possibly purified results raised from structural equation modeling 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 modeling;
Endogeneity;

1. Introduction

Data-driven and adaptive leadership is a social process in which managers use data and analytics to improve supply chain operations (Datnow and Park, 2014; Tan et al., 2015). Managers also adapt internal and external changes effectively and involve supply chain partners to balance decision-making power, which ultimately sustains overall performance. This values appreciation, opinions and group work. If insights from data show poor performance, supply chain partners also apply command-and-control rules to improve productivity (Akhtar et al., 2012; Datnow and Park, 2014).

Such leadership is useful to achieve financial and non-financial sustainability in globally and massively connected agri-food supply chain operations (Akhtar et al., 2012). The research published in the Harvard Business Review stated that companies that use data-driven leadership show 5-6% higher productivity (Barton and Court, 2012). Brynjolfsson et al. (2011) also claimed 4-6% higher productivity. Additionally, the productive results from empowering supply chain partners and sharing of decision power give an impression that these characteristics should be considered essentials of modern agri-food operations. Pfeffer (1998) provided evidence that a company decreased 38% of defective rates by employing an adaptive leadership approach; as a result, the company increased their productivity by 20%. In support, Mehta et al. (2003) and Akhtar et al. (2012) also stated that performance is more effective when adaptive leadership practices are used. Several firms also reported an increase in their productivity by applying such practices. For example, General Motors and Xerox did not only improve their production but also showed a decreased rate in their workers' absenteeism (Ichniowski et al., 1996)

If analytics produced from data show poor performance, managers can use directive leadership (command-and-control rules) to improve productivity. For example, a study conducted by Bititci et al. (2004) in the US multiple industries (rolling mill, bottled water

producer, transport, and distribution companies) supported such findings. In a similar vein, Kruglanski et al. (2007) believed that a directive leadership is appropriate when the nature of work is sensitive, goals are comprehensible and a leader has more experience than group members.

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

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

Limited studies on data-driven and adaptive leadership have been conducted in global agri-food supply chains connected with emerging markets. A study conducted by Akhtar et al. (2012) in agri-food chains (dairy, meat, fruits and vegetables) explored theoretical links between leadership practices and sustainability. However, the knowledge gap of estimating the links between data-driven and adaptive leadership practices and their impacts on financial and non-financial is still unaddressed (Wamba et al., 2015). Research also believes that data-driven supply chains have emerged recently and data is currently being generated

exponentially, which compile researchers to test new data-driven leadership practices and sustainability (Erevelles et al., 2015; Schoenherr and Speier-Pero, 2015). Although leadership or its styles have been over-researched in developed countries, not enough research has been conducted on the topic in semi-developed countries (e.g., New Zealand compared to technologically advanced countries such as the USA, Japan and Australia) trading mainly with emerging markets. Thus, this study broadens the existing literature and knowledge by analyzing the data collected from global import and export agri-food supply chains connected with emerging markets (China, Indian, Pakistan, Bangladesh, Sri Lanka, Hong Kong, Chile, South Africa and Hungary). Additionally, endogeneity issues are addressed, which have been naively ignored by 90% of past studies published even in premier journals (Antonakis et al., 2010; Hamilton and Nickerson, 2003), although the claims are made based on the selected journals.

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

2. Background

A supply chain is the combination of designing, developing, optimizing and managing different components such as material, information and financial flows and distribution of finished products. In other words, it is a way through which products or services are moved (Prajogo and Olhager, 2012). A supply chain is also defined as a synthesis of different activities such as inventory management, logistics and distribution of material or finished products. Managing these activities is called supply chain management (Doukidis et al., 2007), which basically manages a network of supply chain partners (manufacturers,

processors, importers, exporters and retailers) who work together and integrate supply chain activities to achieve certain objectives (Akhtar et al., 2012).

A graphical view of an agri-food supply chain and possible flows among supply chain partners are shown in Fig. 1. The arrows represent the potential interactions between supply chain partners (Doukidis et al., 2007). The chain normally consists of farmers, 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)

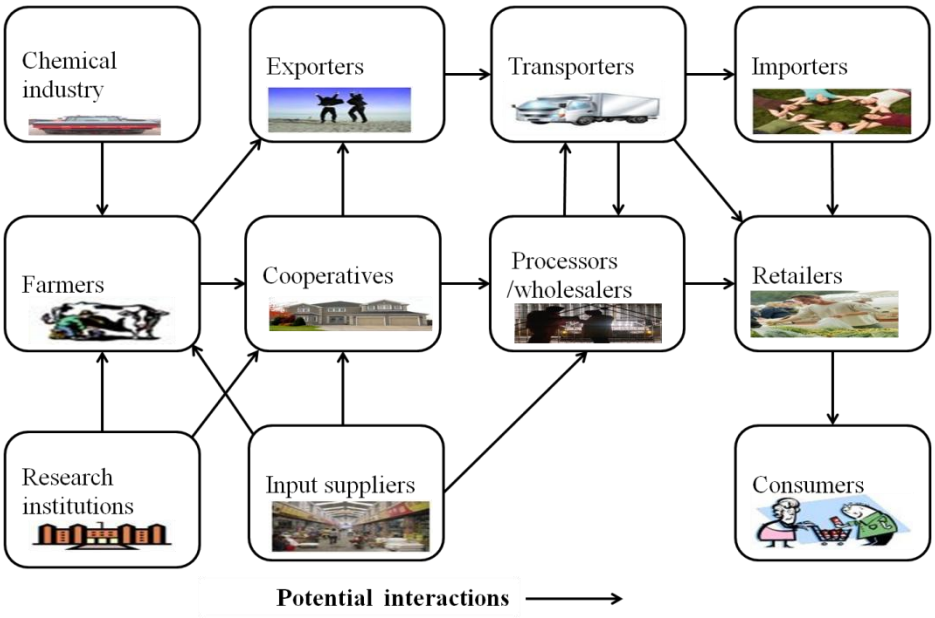


Fig .1. A graphical view of agri-food supply chains. Source: (Doukidis et al., 2007)

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.

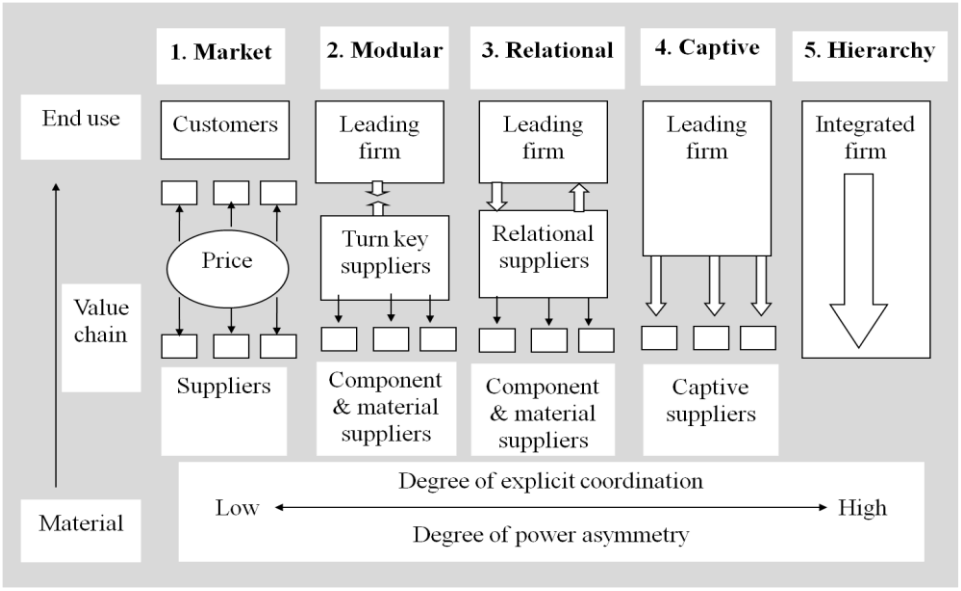


Fig. 2**.** Types of value chain governance. Source: (Gereffi et al., 2005)

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

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

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

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

3. Theoretical framework and hypotheses

Today's supply chains are inundated with data (structured and unstructured data such as tweets, videos, click-streams and other forms) that helps to understand processes, products and services linked with financial and non-financial sustainability. Thus, leadership views data as an imperative source of business value creation in globally and massively connected supply chains (Hazen et al., 2014; Tan et al., 2015). Dutta and Bose (2015) also found that active involvement of top management, which also creates a data-driven culture, is essential for the success of data-driven supply chains. Mirhedayatian et al. (2014) and Chae (2015) further detect that twitter data and analytics carry strong sentiments that can be used to improve sales and delivery services, contributing to sustainable supply chain practices.

Data-driven and adaptive leadership has been an essential tool-kit for managers to manage modern agri-food supply chains. It helps managers to provide right directions about duties and rights of chain partners. It also controls major decision-making and formal chains of authority and grievance actions that contribute to sustainability (Akhtar et al., 2012; Datnow and Park, 2014).

Sustainability depends on such leadership that fastens workforce, board level and trade unions into a single associated unit (Jung et al., 2003). Research conducted by Batt (2003) noticeably provided a positive relationship between agri-food supply chain members' empowerment and outcomes. Gereffi et al. (2005) and Smith (2006) also stated that managers' capability to produce analytics, develop and sustain good relationships depends on a data-driven and adaptive leadership theory. Using such practices, managers emphasize team work and coordination among agri-food supply chain partners, which are the key resources for achieving financial and non-financial sustainability.

Such leadership practices bring supply chain partners together to organize and plan their strategies effectively. For instance, adaptive leadership practices produce better

sustainability outcomes for Tesco, a UK-based retailer (Smith, 2006). The study conducted by Brodt et al. (2006) in the US agri-food supply chains (i.e., almond and grapes) stated that such adaptive decision makers are keen to manage resources in cooperation with other supply chain partners. They also give higher priority to the preservation of operational quality and environmental sustainability.

The major benefits and the higher level of trust in and satisfaction with supply chain partners are related to data-driven and adaptive leadership, which also assists to achieve better service quality and financial performance of global agri-food supply chains (Akhtar et al., 2012; Datnow and Park, 2014).

Consequently, trust plays an important role to increase financial sustainability. Trust is associated with the expectations of supply chain partners who are keen to share something in an optimistic manner. Trusted partners in agri-food supply chains have self-confidence and believe in the words and actions. In such relationships, data and analytics are shared that produce evidence-based decisions improving service quality (Akhtar et al., 2012; Batt, 2003). Salamon and Robinson (2008) also believed that trust improves service quality that ultimately affects overall supply chain sustainability.

Sustainable outcomes such as good relationships, better market share, good service quality and increased sales are the results of trusted and satisfied supply chain partners. The development in these components motivates supply chain partners to grow their businesses by using data-driven decision making and adaptive leadership practices (Chae et al., 2014; Tavella and Hjortsø, 2012). Data and analytics also keep supply chain partners connected. As a result, it improves service and product quality that also affect environmental performance and relationships among supply chain partners (Chae et al., 2014; Schoenherr and Speier-Pero, 2015).

The literature discussed above shows that data-driven and adaptive leadership practices are the key determinants for financial and non-financial sustainability. Hence, it can be summarized by positing the following hypotheses:

H_1. Data-driven and adaptive leadership has a positive and significant relationship (i.e., a correlation, not a causal relationship) with financial sustainability.

H_2. Data-driven and adaptive leadership has a positive and significant relationship with non-financial sustainability.

Non-financial sustainability consists of operational performance (i.e., relative service and product quality), environmental performance (i.e., reusable packaging, material efficiency, wastewater reduction, total waste reduction for recycling, overall impacts and energy consumption) and relationship performance (i.e., relative satisfaction with and trust in supply chain partners). Non-financial sustainability significantly influences financial sustainability of agri-food supply chains (i.e., relative profit, sales and market share). The relationships between the individual components of these constructs have been examined. For instance, a study of over 200 US firms conducted by Lado et al. (2011) stated a significant positive relationship between service quality and financial sustainability. In addition, Sichtmann et al. (2011) also stated that service quality significantly affect monetary outcomes.

Moreover, it is suggested that components related to service and product quality (delivery in a timely manner, orders filling rates and flexibility) are the key operational outcomes of agri-food supply chains and increase sales, market share and profit (Aramyan et al., 2007). In fact, service quality and product quality are interconnected with operational flows that enable agri-food supply chain partners to build a better match between financial resources and demands. Effective service quality and product quality also increase inventory

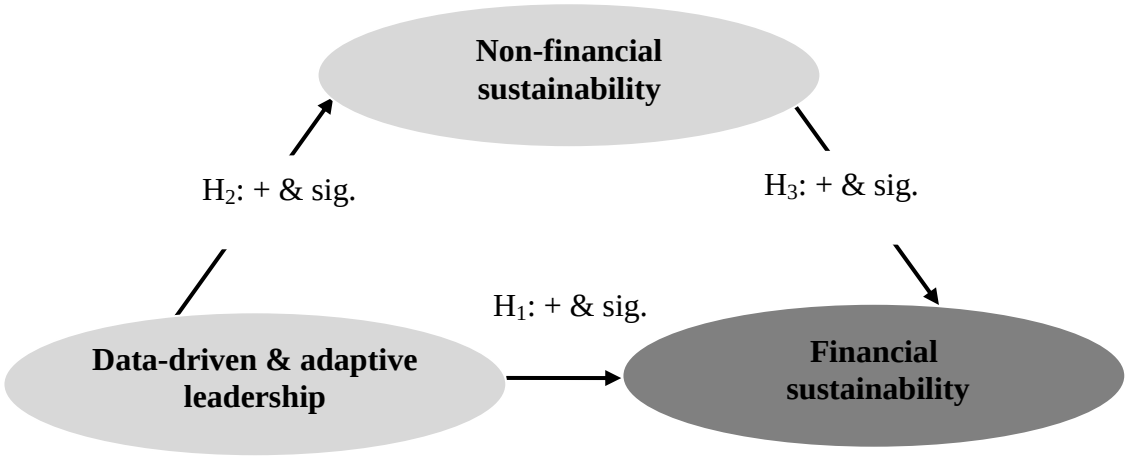
turnover (i.e., sales) and reduce extra costs that directly contribute to financial sustainability (Akhtar et al., 2012; Merad et al., 2013).

Additionally, social components such as trust in and satisfaction with agri-food supply chain partners are associated with financial sustainability. Trustworthy and satisfied agri-food growers and market agents constantly add value by coordinating their supply chain activities. Consequently, they develop high-performing supply chains and the profit is significantly higher in such supply chains (Batt, 2003). Also, trust is used to achieve better financial outcomes and trusted supply chain partners make more investments. It is a main tool that is used to solve coordination issues and assists to sustain long-term business relationships that positively influence financial sustainability of agri-food supply chain partners (Batt, 2003; Lindgreen et al., 2009). Trust also helps them to create and deploy co-specialized business processes that contribute to environmental sustainability, which in turn contributes to financial sustainability. Also, satisfaction that provides feeling of equitability with supply chain partners is the key determinant of financial outcomes. In conclusion, these components of financial and non-financial sustainability intersect and affect each others (Aramyan et al., 2007; Batt, 2003; Gimenez et al., 2012; Jones et al., 2013; Merad et al., 2013; Rao et al., 2006). From the above discussion, the following hypotheses are proposed.

H_3. Non-financial sustainability has a positive and significant relationship with financial sustainability.

H_4. Non-financial sustainability also mediates the relationship between data-driven and adaptive leadership and financial sustainability

To summarize, the theoretical framework shown in Fig. 3 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.



H_4: 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

4. Research methodology

Structural equation modeling (SEM) approach using Mplus (version 6) was applied to test the framework. Descriptive statistics and interaction effects were computed using SPSS version 21.

4.1 Sample

The sample for this study consists of selected global import and export agrifood supply chains connected with emerging markets (dairy, meat, vegetables and fruits). The companies were headquartered in China, India and New Zealand, and they were importing and exporting from emerging markets (e.g., China, Indian, Pakistan, Bangladesh, Sri Lanka, Hong Kong, Chile, South Africa and Hungary). The KOMPASS database was used to reach CEOs, managing directors and senior operations manager who would be likely to have the required information.

A questionnaire using five-point Likert scales (strongly disagree: 1 and strongly agree: 5) was used to facilitate respondents to know their degree of agreement or disagreement. The questionnaire was also pilot tested and the issues were resolved. During the pilot survey process, the respondents also mentioned that a questionnaire-based survey was more

appropriate and time efficient. A total of 600 copies of the questionnaire were sent. After excluding unusable responses, a total of 220 (36.67% response rate) responses were used to execute structural equation modeling with parceling as the strategy utilized by other researchers (Coffman and MacCallum, 2005; Goodhue et al., 2007; Kline, 2011; Marsh et al., 2004). The sample characteristics are listed in Table 1.

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. Chen et al., 2012; Cohen et al., 2009; Davenport, 2006) 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 conducted EFA to further develop them, the items were chosen from well-established research. Environmental performance measured reusable packaging, wastewater reduction, material efficiency, total waste reduction for recycling, overall environmental impact and energy consumption (Rao et al., 2006). Operational performance assessed service quality (order accuracy, deliveries on time and order flexibility) and product quality (product defective rates, product safety and product reliability) (Aramyan et al., 2007). Social performance was represented by satisfaction and trust. Additionally, financial sustainability included profit, sales and market growth (Batt, 2003; Cullen et al., 1995). The scales, constructs and their codes are listed in Appendix A.

4.3 Biases and endogeneity

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

Endogeneity biases mainly include common-method variance, measurement error and omitted variables. Research shows that (e.g., Antonakis et al., 2010; Hamilton and Nickerson, 2003) 90% of studies published in premier journals have not even adequately addressed endogeneity biases. As a result, "at least 66% and up to 90% of design and estimation conditions make the claims invalid" (Antonakis et al., 2010). It is worthy to note that the claims are based on selected studies, they do not include all premier journals. Despite recent methodological developments and the relevant extant literature in econometrics/psychology, other social science disciplines are naively calculating inconsistent parameters because of not addressing such biases. This study thus addressed the possible issues theoretically as well as empirically.

Common-method variance

This study develops a systematic questionnaire and measures (items) not only based on theories but also statistically refines them using exploratory factor analysis. As guided (e.g., Tourangeau et al., 2000), double-barreled questions, unfamiliar words and technical words were avoided. The items were not clustered in conceptual dimensions. The extensive use of negatively-worded items was avoided because they could distrust the participants' pattern of responding that can create a source of method bias, as highlighted by Podsakoff et al. (2003). We also informed anonymity of the survey and avoided a single-informant bias, as the data was collected from CEOs, managing directors and senior operations managers.

Statistically, Harman's one-factor test was applied. The analysis with multiple factors explained greater variance compared to a single factor solution or combinations. While all statistical approaches to control for CMV bias have some advantages and disadvantages (Malhotra et al., 2006; Podsakoff et al., 2003), the marker variable method (the variable was the number of languages respondents knew) proposed by Lindell and Whitney (2001) with small correlations provided a reasonable proxy. Also, the latent factor method did not show that CMV bias was an issue (Malhotra et al., 2006).

Measurement error

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

Omitted biases

Omitted biases exist in various forms (for details see Antonakis et al., 2010; Antonakis et al., 2014). One case could be that researchers testing validity of a construct without including important variables/constructs. For instance, one measures non-financial sustainability without environmental performance. In this regard, the most important guide is "theory, theory and more theory" (Antonakis et al., 2014; Antonakis and Dietz, 2011) . 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 ($\overline{x}$) 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	$\overline{x}$	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

$\overline{x}$ (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 modeling 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 (Kline, 2011; Lance et al., 2006; 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 (Kline, 2011; Pandey and Jha, 2012; Sekaran, 2000).

Table 3
Evaluation of measurement models.

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

* Items DDAL2 and DDAL8 were droped due to high modification index(HMI)/low loading(LL); α = items reliability; λ = loadings; AVE =average variance explained; C.R =construct reliability;

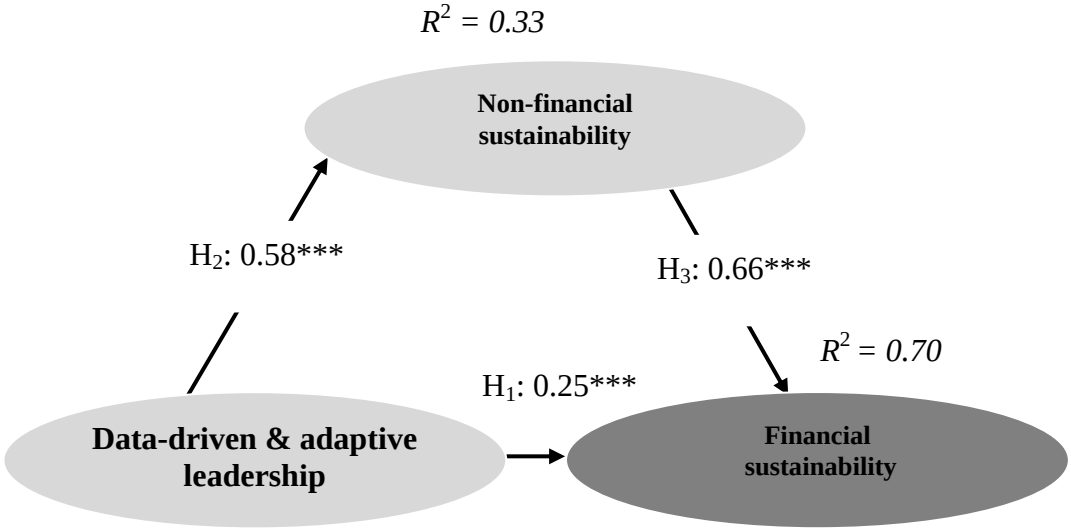
Distriminant validity was measured using two methods. First, as given in Table 4, the square of the correlation (ϕ^2) by each pair of constructs was less than the average variance explained (AVE), except for financial and non-financial sustainalbity. These two construct are strongly correlated based on the theoretical grounds. Thus, it was not surprising that both construct could not meet the criteria becuase of high correlation between them (i.e., 0.81) (Chiang et al., 2012; Sekaran, 2000). In such case, the correlation between the constructs should be less than 0.85 for discriminant validity (second method), even some researchers recommend up to 0.90 (Kline, 2011). Collectively, by investigating the dataset in details, the results showed sound psychometric properties.

Table 4
Discriminant validity, first method

	Statistics			Condition met
Constructs	ϕ	$^{*}\phi^2$	**AVE	ϕ^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

ϕ=correlation between factors, $^{*}\phi^2$, 0.58*0.58 = 0.34; **AVE, (0.64+0.54)/2 = 0.59 (AVE for DDAL & NFS)

Fig. 4 presents the hypotheses and standardized results. Hypothesis H_1 proposes that data-driven and adaptive leadership has a positive and significant relationship (i.e., a correlation, not a causal relationship) with finanical sustainability. Based on the structural results, the hypothesis is supported at $p < 0.01$. Hypotheses H_2 (data-driven and adaptive leadership has a positive and significant relationship with non-finanical sustainability) and H_3 (non-finanical sustainability has positive and significant relationship with finanical sustainability) are positive and significant. Additionally, the fit indices with a non-significant p-value (0.108) and R^2 values ranging from 33% to 70% are provided.



H_4: Non-financial sustainability also mediates the relationship between data-driven leadership and financial sustainability

*** statistically significant at $p < 0.01$
n = 220; p-value = 0.108; χ^2/df = 1.25; CFI = 0.991; TLI = 0.988; RMSEA = 0.034

Fig. 4. Structural results for hypothesis testing, R^2 *values* and fit indices

To test H_4, 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 → 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.

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

6 Discussions and conclusion

Although leadership has generally been research extensively, research on data-driven and adaptive leadership is in its infancy. Particularly, the new leadership characteristics of data-driven practices have got scholarly attention recently because of developments in global data-driven supply chains, where data is being generated exponentially. However, not enough research has been conduct on data-driven practices. Thus, to address this knowledge gap, we have simultaneously tested the links between data-driven and adaptive leadership and sustainability. The data was collected from the selected global data-driven agrifood supply chains and developed hypotheses showed significant relationships.

To further investigate practical implications of the relationship between the intensity of data-driven and adaptive leadership and sustainability, surveyed companies were categorised into high or low intensity of such leadership practices . The t-test showed that the grouping (ration; 120:100) is significantly different (at p < 0.00) with means ($\overline{x}$) 4.00 and 4.63 for low data-driven and adaptive leadership and high data-driven and adaptive leadership respectively. The results conclude that the more finanical sustainalbity comes when

companies apply extensive data-driven and adaptive leadership practices. Similarly, companies create the more financial sustainability when data-driven and adaptive leadership practices interact with non-financial sustainability (β = 0.35, p < 0.05). It is thus worthwhile to take this on board that companies should focus on data-driven and adaptive leadership practices and non-finanical sustainalbity as they are the key determinnants for financial sustainability. The relationships are also shown in Fig. 5.

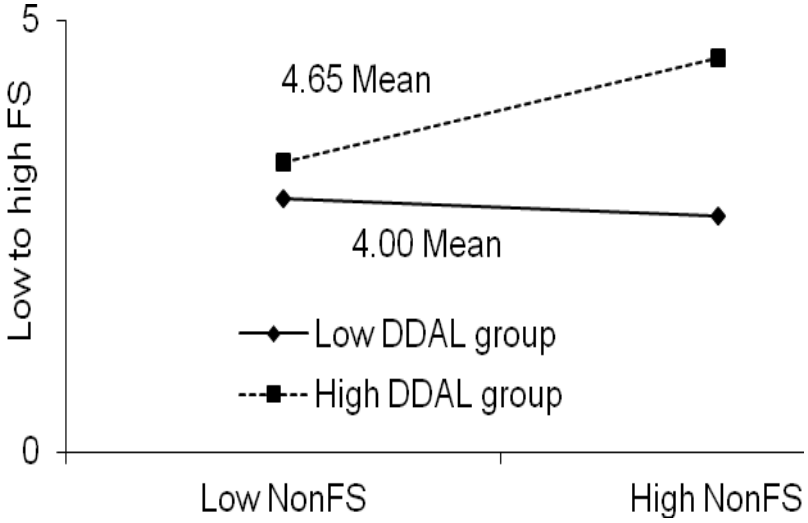


Fig.3. Interaction effects

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., mathematics and statistics, optimization techniques) in these courses is still questionable. It is inferred from the research that modern leaders and managers need more data-oriented skills. Thus, an interdisciplinary curriculum development approach between various departments (management schools, mathematics and statistics) is useful for future business leaders or data-savvy managers. If management schools do not make these developments, other schools (such as computer science or external consultancy firm) might take over to meet the demand. Additionally, leaders and managers, who already have theoretical-based degrees but do not have data-driven skills, should consider to take part in data-related courses that can help them to apply data-driven leadership practices. Also, the relevant free online short courses (e.g., Coursera and edX) can help them to build foundations for such leadership practices.

The study limitations are employed for survey research in general. Firstly, although the theoretical framework is developed based on the arguments raised from literature and endogeneity biases are addressed, no causal claims can be made. Secondly, the study is based on the selected agrifood supply chains that do not reflect other industries. Importantly, data-driven leadership is still in its infancy and the underlying construct can behave differently in various industries. However, there are useful insights for other industries or firms that have similar characteristics. Finally, data-related technologies rapidly change and the timing of our research might affect the results. Thus, future studies might find more advanced data technologies that have differently impacts on leadership practices and sustainability.

Future research should focus on data-related education that can help to produce automated decisions and develop evidence-based leadership practices for policymaking. Research believes that 90% of (big) data has been generated in the last few years and this trend has thrown many challenges for top management (skills shortage, data quality and

cybersecurity issues). This also provides many opportunities for future research in these arenas.

Appendix A

Constructs	Brief items description	Codes
Data-driven and adaptive leadership	• Determination of policies depends on our data-driven and adaptive leadership	DDAL1
	• Lower level managers (e.g., duty managers, area managers) do not pass new ideas produced from data to top management (*)	DDAL2
	• Lower level managers determine promotional allowances based on quantitative measures and data analytics	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 and adaptive leadership	DDAL6
	• Top level managers adapt changes as data and analytics suggest	DDAL7
	• Our operational performance does not depend on data-driven leadership and analytics (*)	DDAL8
Non-financial sustainability Environmental performance	• Total waste to output ration is reducing	ENP1
	• Follow reusable packaging policy	ENP2
	• Material efficiency is increasing	ENP3
	• Water consumption is increasing (*)	ENP4
	• Energy consumption is decreasing	ENP5
	• Impact of practices on natural environment is reducing	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
	• Provide100% 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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