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Contingency factors and complementary effects of adopting advanced manufacturing tools and managerial practices: Effects on organizational measurement systems and firms' performance

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ABSTRACT

Anchoring its theoretical background in the concepts of contingency and complementary effects, while simultaneously answering calls for the improved integration of organizational theories and operations management, this work argues that contingency factors are antecedents for the adoption of advanced manufacturing tools (AMT) and managerial practices (AMP), as well as influencing the use of measurement systems in organizations, which has implications for firms' performance. Original data from a sample of over 200 Italian manufacturing firms provides the empirical basis for testing the research framework based on numerous hypotheses. A combination of anticipated and unexpected findings emerged: (i) overall, contingency factors (mainly organizational decentralization and environmental uncertainty) play an important role in the combined adoption of AMT and AMP, which in turn shape the measurement systems adopted by organizations; (ii) although both financial and non-financial measures were relevant for organizations overall, quality management-related practices were shown to play a central role in organizational competitiveness; (iii) unexpectedly, the correlation between organizational strategy and the adoption of AMT and AMP was not as strong as hypothesized *a priori*, and therefore deserves future investigation, constituting an important implication for future research.

1. Introduction

Drawing on the theoretical perspectives of contingency theory (Donaldson, 2001; Sousa and Voss, 2008) and complementary effects (Choi et al., 2008; Khanchanapong et al., 2014), this work empirically tests an original framework connecting the consequences of adopting contemporary organizational practices and performance measures to antecedents in a sample of over 200 Italian manufacturing firms. Based on calls for improved integration of organizational theories and operations management (Dubey et al., 2018; Sarkis et al., 2011; Gunasekaran and Ngai, 2012; Ketchen and Hult, 2007), with a particular focus on the relationship between the adoption of contemporary management practices and firms' performance (Agarwal et al., 2013), this work argues that contingency factors are antecedents for the adoption of advanced manufacturing and managerial practices, while simultaneously influencing the use of measurement systems in organizations, with implications for firms' performance.

Global trends and competition have forced manufacturing firms to adopt world-class manufacturing and managerial practices capable of boosting firms' performance (Dubey et al., 2017). However, there has been a persistent gap in the body of knowledge concerning the combination of theoretical angles – which are necessary to understand the

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complex relationship between contingency factors – adoption of complementary organizational practices, adoption of performance measurement systems, and firms' performance. This work makes the case for an integrated perspective on topics that, until now, have been studied individually rather than jointly. This work focuses on the Italian manufacturing sector, exploring the suggestion that it is important to understand the antecedents of the link between the practices and performance of firms in mature economies, which face competitive pressure from emerging economies (Agarwal et al., 2013).

The findings of this research have further implications for studies which have argued that contingency factors are significant for some companies, but lose relevance in explaining the practice-performance link for other firms (Golini and Kalchschmidt, 2015). This work also underlines the contingency factors that can trigger – or hamper – the joint adoption of AMT and AMP. As Blome et al. (2013) point out, the notion of complementary effects has been accepted in the state-of-the-art literature. This debate, however, has a gap, as complementary studies generally offer little insight into the contingencies and contextual conditions under which such complementary effects emerge. As the number of emergent manufacturing practices and tools increases, it is important to further understand the critical factors that may affect the adoption of these tools (Jabbour et al., 2018). We thus contribute to this debate.

The state-of-the-art literature yields research findings regarding the adoption of either manufacturing (McAdam et al., 2016; Yang 2010; Van der Bij and Broekhuis, 1998; Morton and Hu, 2008, Tayles and Drury, 1994) or managerial practices (Otley, 1980; Abdel-Kader and Luther, 2008; Ketokivi and Schroeder, 2004) viewed through the lens of contingency theory (Donaldson, 2001) and applied to operations management (Sousa and Voss, 2008). Additionally, there have been contributions on the complementary effects (Ennen and Richter, 2010) that may arise when firms adopt different sets of organizational practices simultaneously (Soda and Furlotti, 2017; Khanchanapong et al., 2014; Choi et al., 2008), which can positively influence firms' performance through the cumulative effect of adopting multiple practices (Agarwal et al., 2013; Cua et al., 2001). However, while a number of relevant works defend the idea of a contingency-based approach to understanding the link between the adoption of managerial practices and firms' performance (Sousa and Voss, 2008), there are also findings (Agarwal et al., 2013) that suggest no clear evidence for this relationship.

This work extends the current knowledge on the topic – particularly the work of Khanchanapong et al. (2014) and Choi et al. (2008) – by integrating constructs and theoretical angles that have previously been only partially studied, as well as providing original empirical evidence from over 200 Italian manufacturing firms. This research further expands the debate on contingency factors, which may explain the adoption of management practices in manufacturing firms, a hypothesis which is still far from conclusive (Agarwal et al., 2013). Italian manufacturing firms were selected for this research due to the strength of Italy's economy. Italy's economy is the 3rd-largest national economy in the Euro zone and the 8th-largest in the world by nominal GDP, with an important industrial sector, responsible for approximately 25% of GDP. However, the literature (Khanchanapong et al., 2014; Choi et al., 2008) has not portrayed the reality of Italian manufacturing firms. For instance, Agarwal et al. (2013) suggest that the manufacturing sectors of mature economies have faced major challenges, and deserve a fuller understanding of the impact of antecedents on contemporary practices in firms' performance.

2. Literature review, theoretical framework and development of hypotheses

In this work, contingency theory is applied to operations management, shedding light on the contingency factors that can influence the adoption of advanced manufacturing and managerial practices. Contingency theory has been widely explored in the accounting management field (Donaldson, 2001; Hayes 1977; Waterhouse and Tiessen 1978; Otley, 1980; Dent, 1990; Langfield-Smith, 1997). However, the contingency perspective as applied to operations management is in need of further development (Smith and Reece, 1999; Sousa and Voss, 2008; Sarkis et al., 2011). This work addresses that gap by using contingency theory to explore the influence of factors such as environmental uncertainty, decentralization, and organizational strategy on the adoption of advanced manufacturing tools and advanced managerial practices. As suggested by Sila (2007), contingency theory attempts to explain the context-structure-performance relationship. The theory suggests that organizations which are able to establish a fit between organizational structure and environmental uncertainty will achieve higher organizational performance results, while an equivalent misfit will have a negative effect on organizational performance (Donaldson, 2001). Contingency theory has become a dominant theoretical perspective in management, and has been adopted to support the development of theoretical assumptions in a wide range of disciplines, such as sustainability (Tsai and Liao, 2017), human resources (Balkin and Gomes-Mejia, 1987) and marketing (Ruekert et al., 1985).

In operations management, the majority of studies indicate that contingency factors can explain the adoption of management practices in manufacturing firms. For example, in a renowned study, Flynn et al. (2010) suggest that contingency factors positively influence the relationship between supply chain integration and firms' performance. Wong et al. (2015) suggest that supply chain integration positively affects firms' performance, and such a relationship is contingent on the level of market and product complexity. Monday et al. (2015) find that contingency-based strategic management has significant effects on the profitability and operational performance of manufacturing companies in an emerging economy.

However, additional research efforts are necessary, as there are findings and emerging perspectives which suggest that contingency factors cannot always explain the adoption of contemporary practices in manufacturing firms. For example, Agarwal et al. (2013) affirm that contingency theory can be countered with 'best practice' perspectives, in which companies tend to adopt universally accepted practices, rather than contingency-based practices. Agarwal et al. (2013) also state that manufacturing firms in mature economies have faced unprecedented competitive pressures, which justifies future research into the relationship between contingency factors and the link between practices and performance. Golini and Kalchschmidt (2015) find that, when grouping companies according to various contingency factors, linkages between globalization, the supply chain, and inventory management are valid only for some groups of companies, not all. The findings of Agarwal et al. (2013) and Golini and Kalchschmidt (2015) align with recent positions such as Granlund and Lukka (2017), who argue that, even if the contingency approach is a 'highly established research paradigm', this theory should not be taken for granted in understanding contemporary organizational issues.

Previous research (e.g. Badri et al., 2000) suggests that the environment appears to have a tangible impact on strategic choices in operations management. A link between the environment and operations strategy also appears to help determine organizational performance. Ignoring the appropriate combination of environmental effects in a strategic model of operations is likely to result in a specification error, which can lead to erroneous findings. For this reason, the first contingency factor, environmental uncertainty (Khandwalla, 1972; Duncan, 1972), can be defined as 'rate of change and level of instability in the business environment' (Cheng and Krumwiede, 2017) which can influence firms''initiatives (Chan et al., 2016).

Consequently, it is hypothesized that:

H1a. Perceived environmental uncertainty influences the adoption of advanced manufacturing tools.

H1b. Perceived environmental uncertainty influences the adoption of advanced managerial practices.

Through examining organizational decentralization it is possible to understand the issue of authority and power distribution within an organization (Waterhouse & Tjessen, 1978), which may affect the adoption of organizational practices (Gupta et al., 1997). Thus, the following hypotheses are proposed:

H2a. Organizational decentralization influences the adoption of advanced manufacturing tools.

H2b. Organizational decentralization influences the adoption of advanced managerial practices.

Finally, organizational strategy concerns patterns of behavior used by firms in adjusting to their context, with implications for the practices organizations adopt in order to deal with competitive challenges (Miles and Snow, 1978; Snow and Hrebiniak, 1980; Fisher 1995). Acur et al. (2003) suggest that companies with a formal strategy tend to have operations programs that are significantly better aligned than companies without such levels of formalization (Acur et al. 2003). However, the link between organizational strategy and manufacturing practices is not always straightforward (Papke-Shields and Malhotra, 2001). In this context, a number of factors may influence the translation of organizational strategies into the adoption of advanced manufacturing practices and tools. For example, even in companies with good organizational strategy alignment, the adoption of advanced manufacturing practices and tools can be influenced by a variety of critical factors (Jabbour et al., 2018), such as top management actions (Schniederjans, 2017). In this context, the influence of organizational strategy on the adoption of both AMT and AMP deserves to be further understood. Finally, Blome et al. (2013) suggest that the joint adoption of organizational practices (AMT and AMP) and their complementary effects have not been fully understood, mainly because it is not totally clear which contingencies and contextual conditions will enhance or hamper the adoption of such practices. Consequently, the state-of-the-art literature makes the case for further exploration of the following hypotheses:

H3a. Organizational strategy influences the adoption of advanced manufacturing tools.

H3b. Organizational strategy influences the adoption of advanced managerial practices.

In this work, the adoption of advanced manufacturing tools and advanced managerial practices is viewed through the lens of complementary theory, which is a useful perspective to understand firms' adoption of distinct types of practices (Khanchanapong et al., 2014). Complementary effects arise in situations where one action may have implications for other actions (Choi et al., 2008). Complementary effects may be found when certain organizational activities and practices are mutually complementary, and therefore tend to be adopted together (Milgrom and Roberts, 1995). Concepts regarding complementarity have been applied to a variety of subjects, such as supply chain management (Blome et al., 2013), knowledge management (Choi et al., 2008), and sustainability (Christmann, 2000).

According to Blome et al. (2013), one example of complementarity is supply chain ambidexterity and, in particular, ambidextrous organizational governance, which proposes a dual focus on both innovation and cost performance in supply chains.

Regarding research on knowledge management, Kung et al. (2015) conducted a survey of 94 companies based in Taiwan in order to understand potential complementary effects of the adoption of knowledge management practices on firms' performance. They found that the majority of knowledge management practices had a complementary positive effect on firms' performance. Choi et al. (2008) analyzed strategies and organizational performance in a sample of 131 Korean firms. They proposed that the complementary effects of knowledge management strategies can be considered crucial from the perspective of their influence on organizational performance. These authors found that combining the tacit-internal-oriented and explicit-external-oriented knowledge management strategies results in a complementarity relationship, with positive effects on performance.

Potential complementary effects have been studied in sustainable operations. For example, Christmann (2000) finds that complementary assets are required for firms to achieve successful adoption of environmental best practices, which, in turn, may explain why some firms' performance is improved by their adoption of environmental practices, while others do not experience this. The idea of complementarity is also useful for understanding adoption patterns of external and internal green supply chain practices (Zhu et al., 2013). In this context, it has been suggested that institutional pressures have driven manufacturers' adoption of internal GSCM practices, which in turn relates to their adoption of external GSCM practices (Zhu et al., 2013). Kotha and Swamidass (2000) investigate the complex relationships between strategy, advanced manufacturing technology and performance using survey responses from 160 U.S. manufacturing firms. The results of this study validate the key premise that a fit between strategy and AMT use is associated with successful performance.

The use of advanced manufacturing tools involves the adoption of a variety of manufacturing systems in terms of material requirements planning (Maxie Burns et al., 1991), enterprise resource planning (Umble et al., 2003), flexible manufacturing systems (Tao et al., 2017), computer aided manufacturing (Tao et al., 2017), computer integrated manufacturing (Tao et al., 2017) and computer numerical control (Tao et al., 2017). Complementary advanced managerial practices include, among others, economy value added (Chen and Dodd, 1997), activity-based costing (Cooper and Kaplan, 1991), activity-based management (Armstrong, 2002), throughput accounting (DugDale and Jones, 1998), total quality management (Porter and Parker, 1993) and benchmarking of organizational performance (Maiga and Jacobs, 2004). The adoption of these practices will influence the characteristics of the performance measurement system adopted by firms (Neely et al., 1995). For example, Gonzáles-Benito (2005) finds that proactive manufacturing practices influence firms' performance. Consequently, it is hypothesized that:

H4. Adoption of advanced manufacturing tools influences firms' performance measurement systems.

H5. Adoption of advanced management practices influences firms' performance measurement systems.

Performance measures have been widely investigated in recent decades (Kaplan and Norton 1996; Kaplan and Atkinson 1998), with the literature suggesting a wide group of organizational measures, which can either be more financially-oriented or less financially oriented (Keegan et al., 1989; Fisher, 1992; White, 1996; Kaplan and Norton, 1996, 2000; Gosselin, 2005).

This work considers a comprehensive performance measurement system containing a large variety of performance measurements regarding, in particular, customer measures (Ittner and Larcker, 1998), internal process measures (Skyrme and Amidon, 1998), R&D innovation measures (Parisi et al., 2006), quality measures (Hackman and Wageman, 1995), human resource measures (Huselid et al., 1997) and financial measures (Perera et al., 1997). This group of performance measures tends to influence overall organizational performance and the firm's competitive advantage (Kueng, 2000). However, Dangayach and Deshmukh (2001) affirm that operations management research has not fully examined the use of a wide range of measures when dealing with performance measurement. Accordingly, in order to contribute to the start-of-the-art literature, we deal with performance measurement through a wide range of measures, including both more and less financially-oriented items.

Therefore, it is possible to propose the following final hypothesis:

H6. Firms' performance measurement system influences overall organizational performance.

Figure 1 portrays the theoretical framework which is empirically

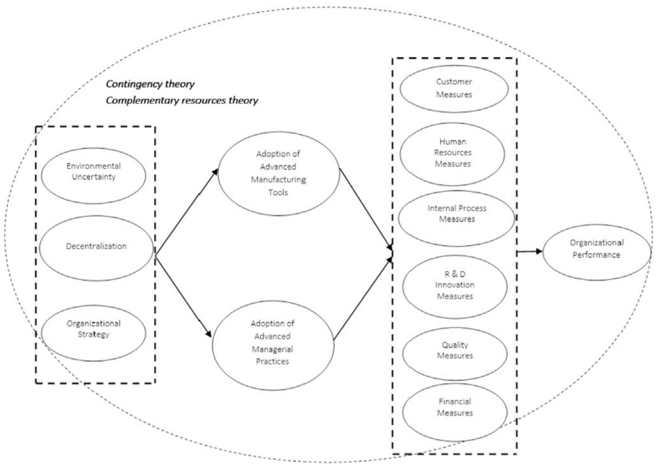

Fig 1. Theoretical framework and relationships among variables.

tested in this work.

3. Research methods

3.1. Sample and data collection

To test our research model, we used a survey-based questionnaire. An initial draft of the survey was discussed with academic scholars to ensure that the questions would be correctly understood and easily answered by respondents. The development of the survey-based questionnaire was an interactive process which started by carefully reviewing the primary operations management literature, drafting a first version of the survey and presenting it for review to a group of six colleagues from the department of one of the authors. These academics were selected based on their varied cultural backgrounds, both in operations management and in management accounting, with all of them having as a common research interest the performance management literature. This step was necessary to improve the clarity, simplicity, and content validity of the survey instrument.

Next, an improved version was pre-tested with a group of five large manufacturing firms to further increase clarity and comprehensiveness. An introductory letter clarifying the purposes and objectives of the entire project accompanied the survey.

To gather sample for the main round of questioning, a group of 1000 large Italian manufacturing companies was randomly selected from Bureau van Dijk, a global provider of business intelligence which provides information on private and listed companies around the world. The Bureau van Dijk database was used to gather initial contact information for managers working in the randomly selected companies, while all the data used in the analysis were collected via the cross-sectional survey. After follow-up contact was made with non-respondents, 229 questionnaires were returned (220 usable). This gives a response rate of 23%, which represents an acceptable figure when dealing with top and middle management (Chief Executive Officers, Chief Financial Officers, and Group Controllers). Possible response time bias was analyzed using an independent sample *t*-test which, however, failed to detect any significant difference between early and late respondents. Table 1 reports the profile of the firms represented.

Table 1
Non-response bias test

Construct	Sig. Levene's Test	Sig. *t*-test for Equality of Means
Environmental Uncertainty (EU)	0.671	0.284
Decentralization (DCN)	0.651	0.278
Organization Strategy (STR)	0.597	0.301
Advanced Manufacturing Tools (AMT)	0.421	0.131
Advanced Managerial Practices (AMP)	0.997	0.312
Performance Measures Systems (PMS)	0.177	0.868
Organizational Performance (ORGP)	0.403	0.996

Table 2
Profile of firms

Category	Number	Percentage
Employees		
<250	36	16%
250–300	18	8%
301–500	68	31%
501–1000	53	24%
>1000	45	20%
Total	**220**	**100%**
Sales Volume		
<25 million €	9	4%
26–50 million €	23	10%
51–100 million €	61	28%
101–200 million €	50	23%
>200 million €	77	35%
Total	**220**	**100%**
Industry		
Food	12	5%
Textile	23	10%
Paper	22	10%
Chemical	45	20%
Metal products	26	12%
Machinery and equipment	80	36%
Other manufacturing	12	5%
Total	**220**	**100%**

3.2. Measures

All survey items were adapted from previously published works and existing operations management literature. In the first part of the questionnaire, respondents were asked to indicate on a seven-point Likert scale the extent to which their organizations use a variety of performance measures (White,1996; Kaplan and Norton 1996; Gosselin, 2005), grouped into six categories: Customers (CM), Internal Processes (IPM), R & D Innovation (RDM), Quality (QM), Human Resources (HRM), and Financials (FM).

The second part listed a series of various contingency factors regarding Environmental Uncertainty, Decentralization, Organizational Strategy, Advanced Manufacturing Tools, and Advanced Managerial Practices. Environmental Uncertainty (EU) was measured using five items adapted from Gordon and Naryanan (1984) and Gul and Chia (1994). Organizations were asked to indicate on a seven-point Likert scale – from 1 (negligible) to 7 (extremely intense) – the intensity of each of the eight items in their industry.

Decentralization (DCN) was measured using three items: Delegation of power; Feedback towards employees; Formalization and job description. Organizational Strategy (STR) was described using three general statements related to the concepts of Prospectors, Defenders and Analyzers, first proposed by Miles and Snow (1978), and developed by Snow and Hrebiniak (1980). Firms were also asked to pinpoint on a three-point scale (1: not implemented; 2: partially implemented; 3: systematically implemented) the extent to which they use six Advanced Managerial Practices (AMP): Activity-Based Costing (Cooper, 1990); EVA (Stern and Stewart, 1995); Activity-Based Management (Turney, 1992); Throughput Accounting (Goldratt, 1990); Total Quality Management (Deming, 1986); and Benchmarking of Performance (Camp, 1989).

The Advanced Manufacturing Tools (AMT) scale was adapted from

Abdel-Maksoud (2004). Respondents were asked to evaluate seven AMTs on a seven-point Likert scale from 1 (not at all) to 7 (extensively).The AMTs included were: Material Requirements Planning (MRPI/II); Enterprise Resource Planning (ERP); Flexible Manufacturing Systems (FMS); Computer Aided Design (CAD); Computer Aided Manufacturing (CAM); Computer integrated Manufacturing (CIM); and Computer Numerical Control (CNC).

The Organizational Performance scale (ORGP) was adapted from Henri (2006) and measured in terms of ROI, Turnover, Market share, Employee Growth and Operational Cash Flow. These organizational performance measures were chosen given their ability to assess firms' effectiveness along several dimensions (Govindarajan and Fisher, 1990). Respondents assessed these by comparing their performance in these factors with that of their competitors in the same industry over the last three years.

3.3. Data analysis

We used a covariance-based SEM (CB-SEM) method to perform data analysis in this study. CB-SEM is one of the second-generation analysis techniques; this approach allows researchers to examine the relationships between unobserved variables simultaneously and to perform confirmatory factor analysis. The main advantages we considered when selecting this method are as follows: 1) CB-SEM allows us to test causal relationships between variables, where hypotheses are formed based on strong theoretical support, with goodness of fit indices available, making CB-SEM superior to partial least squares path modeling (PLS-PM) in this case; 2) CB-SEM is suited to the purpose of confirmatory research, examining the relationships between variables and validating theoretical frameworks designed to explain these relationships; 3) there have been recent major advances in CB-SEM, providing the technique with the robustness to handle non-normal data and small sample sizes.

In contrast with non-parametric approaches such as PLS-PM, CB-SEM requires the establishment of many parametric assumptions before estimating structural models. Assumptions such as large sample size, normal distribution of data, possibility of identifying models, absence of multicollinearity between predictors and goodness of fit between data and models must be met. The sample size required to validate the effectiveness of CB-SEM is over 200 cases with power analysis greater than 0.85 (Kline, 2016; Schumacker and Lomax., 2016). Our study is consistent with these validity criteria, and our sample size meets the minimum sample requirements. The data analysis procedure in this study is divided into three sub-processes. First, we assessed the measurement model via confirmatory factor analysis (CFA) to make sure each indicator was reliable and valid. We found that some construct indicators were invalid, and these were accordingly excluded from the model. Second, we assessed the structural model by looking at the coefficient of determination (R^2), effect size (f^2), variance inflation factor (VIF), and goodness of fit indices. Finally, we tested the proposed hypotheses using a 95% confidence interval with 5% (one-tailed) significance.

4. Results

We used the AMOS 24.0 program to execute the structural equation model (SEM) (Arbuckle, 2016), selecting the maximum likelihood (ML) estimator. Before evaluating the measurement and structural models, a crucial assumption in conducting SEM analysis in general, and specifically in the use of AMOS (Arbuckle, 2016), is that the data must be of multivariate normal distribution. We assessed the normality of the data in AMOS as described by Byrne (2010), examining the critical ratio (CR) values of skewness and kurtosis. The rule of thumb for CR suggests a skewness value of < 3 and a kurtosis value of < 10 (Kline, 2016). From our analysis, the kurtosis value was $6.945 < 10$, which means the data has normal multivariate distribution. The results we obtained are described in the following section.

4.1. Measurement model assessment

To assess the measurement model, we looked at the value of loading factors and the average variance extracted (AVE) for convergent validity. The loading factor value for each variable indicator in the model should be > 0.7, and the AVE should be > 0.5. However, a loading factor value of > 0.6 is still acceptable, as long as the AVE value meets the requirements to strengthen content validity (see Hair et al., 2017; Latan and Noonan., 2017). An AVE value of >0.5 indicates that all indicators can explain the variance of the construct; AVE of <0.5 indicates a poor measurement and that there may be bias in the sample selection. In addition, we assessed the reliability of constructs by using Cronbach's Alpha (α) and composite reliability (ρ_c). Cronbach's Alpha (α) and composite reliability (ρ_c) values greater than 0.70 suggest that an indicator has good consistency in measuring constructs in the model. The results of our analysis in Table 3 confirm that all indicators for the contingency variables (Environmental Uncertainty, Decentralization, Organizational Strategy, Advanced Manufacturing Tool and Advanced Managerial Practices) met convergent validity and reliability requirements, indicating that these indicators are adequate in explaining the constructs and that they have consistency.

We used the repeated inductors approach to assess the second-order (performance measurement systems) measurement model. This approach uses all the first-order indicators as a combined aggregate indicator of the second-order construct (Byrne, 2010; Hair et al., 2017; Schumacker and Lomax., 2016). The measurement evaluation for the second-order constructs was similar to that used in the previous process. From analyzing the results presented in Table 4, we conclude that the performance measurement system model has good convergent validity and reliability.

We also tested the convergent validity and internal consistency and reliability for the organizational performance variable. The results of this analysis, shown in Table 5, convey similar conclusions to the previous

Table 3
Construct indicators and measurement model of organizational context.

Indicator/Item	Code	FL[a]	AVE	α	ρ_c
Environmental Uncertainty					
Quality-based competition	EU2	0.658			
Competition by diversity of products	EU3	0.793			
Bidding for purchases or raw materials	EU4	0.727	0.558	0.765	0.834
Competition for manpower	EU5	0.802			
Decentralization					
Delegation of power	DCN1	0.714			
Feedback to employees	DCN2	0.776	0.620	0.765	0.829
Formalization and job description	DCN3	0.873			
Organizational Strategy					
Frequency workers are informed of target results	OSRT1	0.823			
Proxy level in the organization	OSTR2	0.806	0.679	0.827	0.864
Intense decision-making process	OSTR3	0.842			
Advanced Manufacturing Tools					
Flexible Manufacturing Systems (FMS)	AMT3	0.696			
Computer Aided Design (CAD)	AMT4	0.775			
Computer Aided Manufacturing (CAM)	AMT5	0.810	0.553	0.829	0.860
Computer integrated manufacturing (CIM)	AMT6	0.749			
Computer Numerical Control (CNC)	AMT7	0.679			
Advanced Managerial Practices					
Activity Based Costing (ABC)	AMP2	0.765			
Activity Based Management (ABM)	AMP3	0.737			
Throughput accounting	AMP4	0.691	0.594	0.783	0.879
Total Quality Management (TQM)	AMP6	0.797			
Benchmarking of performance	AMP7	0.854			

[a] FL is factor loading

Table 4
Construct indicators and measurement model of performance measures system.

Indicator/Item	Code	FL[a]	AVE	α	ρ_c
Customer Measures					
Customer satisfaction index	CM1	0.701			
Length of time from order to delivery	CM2	0.721	0.575	0.764	0.801
Length of time taken to reply to customers	CM3	0.845			
Internal Process Measures					
Time taken for development of new products	IPM1	0.755			
Time taken for material throughput	IPM2	0.675			
Time taken for planning/realized production	IPM3	0.788	0.568	0.767	0.867
Number and length of down time periods	IPM4	0.824			
Inventory turnover ratio	IPM5	0.717			
R & D Innovation Measures					
Rate of new projects carried out	RDM3	0.689			
Number/age of patents	RDM4	0.749	0.597	0.791	0.854
Rate of intake of graduated employees	RDM5	0.743			
Rate of introduction of new products	RDM6	0.895			
Quality Measures					
Rate of incidence of production defects	QM3	0.820			
Tonnage of production waste produced	QM4	0.958	0.722	0.897	0.911
Amount of material scrap produced	QM5	0.924			
Costs of damaged products/ reprocessing	QM6	0.666			
Human Resources Measures					
Return on employee salaries	HRM3	0.655			
Total sales per employee	HRM4	0.703			
Number of suggestions per employee	HRM5	0.802			
Number of hours (training, adjournment, learning)	HRM6	0.721	0.566	0.849	0.886
Empowerment	HRM7	0.857			
Employees' alignment with strategic decisions	HRM8	0.759			
Financial Measures					
Total sales revenue	FM1	0.719			
Return on sales (ROS)	FM2	0.796	0.614	0.793	0.862
Return on investment (ROI)	FM3	0.936			
Total net cash flow	FM5	0.655			

[a] FL is factor loading.

Table 5
Construct indicators and measurement model of organizational performance.

Indicator/Item	Code	FL[a]	AVE	α	ρ_c
Organizational Performance					
ROI	ORGP1	0.695			
Turnover	ORGP2	0.817	0.583	0.830	0.848
Market share	ORGP3	0.779			
Operational cash flow	ORGP5	0.759			

[a] FL is factor loading.

variable.

We also assessed discriminant validity using the Fornell-Lacker criterion (Fornell and Larcker, 1981). The variables within the model achieve discriminant validity if the square root of AVE is greater than the correlation between the constructs. From the results of our analysis, as shown in Table 6, we identified that all the square roots of AVE (presented on the diagonal line) were greater than the correlations between the constructs in the model, which indicates no high correlation between constructs or variables in the model showing significant discriminant validity. We also used HTMT to test discriminant validity. This measure is superior in methodological robustness and overcomes the potential bias of the previous approach (Hair et al., 2017; Latan and Noonan., 2017). The HTMT value is required to be > 0.90 for all constructs in the model. From the analysis results, also shown in Table 6, it was found that all HTMT values were over this threshold.

4.2. Common method bias assessment

We assessed the data for common method bias. Common method bias or common method variance (CMV) has been one of the most-discussed issues in social science research over the past three decades. This bias generally arises from a variant of the process that affects the correlation between variables measured using the same method (Doty and Glick, 1998; Podsakoff et al., 2003). This problem is often associated with self-reporting techniques involving questionnaire survey data collection and potential measurement errors. Some researchers have suggested means by which scholars can control for this bias (MacKenzie and Podsakoff, 2012); these means of control seek to avoid inflated results which can lead to a wrongly-identified strong relationship being established between variables and/or support for a theory (type I error), and also to avoid deflation, which results in the relationship between variables becoming weak and/or prompting a rejection of the theory (type II error). To address this issue, we used the CFA marker technique in CB-SEM, as proposed by Williams et al. (2010). The results show no difference between the baseline model and the CFA marker model, which means that CMV is not a threat to our results.

4.3. Structural model assessment

After confirming that all the indicators of the variables were reliable and valid in the first step, the next step involved assessing the results of the structural model and testing the hypotheses (see Figure 2 below). Since AMOS provides a large selection of goodness of fit indices, we chose to report approximate fit indices: Comparative Fit Index (CFI); Incremental Index of Fit (IFI); Normed Fit Index (NFI); Tucker-Lewis Index (TLI); Parsimony CFI (PCFI); Parsimony NFI (PNFI) and Steiger-Lind Root Mean Square Error of Approximation (RMSEA). Klein (2016) argues that scholars only need to report some stable fit indices, as certain older indices exhibit problems, which require compensation through sample size and model complexity. We also report r-square, variance inflation factor (VIF), and effect size (f^2) values for each variable in the model.

Before discussing the results of this second stage of analysis in more detail, it should be noted that we tested the collinearity of the structural model. To assess collinearity, we used the same measure as for multiple regression. The recommended VIF values of <3.3 or <5 were acceptable for all variable predictors in the model (Hair et al., 2017; Latan and Noonan, 2017). The results of the analysis presented in Table 7 show that there is no collinearity problem interfering with the results. Furthermore, we evaluated the structural model by looking at the goodness of fit indices, coefficient of determination (R^2), and effect size. The goodness of fit results generated by our model are good (see Table 7), with CFI, IFI and NFI values close to 0.90, which fulfils the rule of thumb (Kline, 2016; Schumacker and Lomax., 2016). We believe that our models fit with observational data, given the complexity of our models which affect these indices. Furthermore, the PCFI and PGFI values produced are above 0.60, which also indicate that they meet the rule of thumb (Byrne, 2010). Finally, the RMSEA value generated by our model is 0.055 < 0.08, as recommended.

The coefficient of determination measures the predictive power of the model and represents the amount of variance in the endogenous variable that can be explained by all exogenous variables. A coefficient of determination above 0.20 can be considered high in some disciplines, but values between 0.25 and 0.50 are generally considered good (Hair et al., 2017).

In Table 7, it can be seen that the values of R^2 produced are good, ranging from 0.089 to 0.340. Also, the effect size values generated by each predictor variable in the model range from 0.001 to 0.163. The

Table 6
Correlations and discriminant validity results.

Construct	1	2	3	4	5	6	7	8	9	10	11	12
AMP	*0.771*	0.444	0.415	0.408	0.320	0.241	0.472	0.428	0.196	0.333	0.212	0.461
AMT	0.426	*0.744*	0.300	0.234	0.185	0.162	0.232	0.364	0.055	0.166	0.289	0.281
CM	0.366	0.310	*0.758*	0.414	0.358	0.221	0.518	0.610	0.054	0.265	0.281	0.552
DCN	0.361	0.253	0.358	*0.787*	0.241	0.252	0.485	0.346	0.031	0.391	0.188	0.396
EU	0.274	0.202	0.346	0.204	*0.747*	0.437	0.376	0.286	0.187	0.166	0.137	0.349
FM	0.243	0.202	0.288	0.264	0.347	*0.784*	0.354	0.291	0.068	0.211	0.254	0.229
HRM	0.409	0.348	0.440	0.400	0.337	0.384	*0.752*	0.556	0.080	0.259	0.349	0.587
IPM	0.355	0.304	0.522	0.272	0.250	0.237	0.512	*0.754*	0.126	0.207	0.585	0.655
STR	0.077	0.016	0.027	0.020	0.155	0.036	0.085	0.007	*0.824*	0.137	0.137	0.087
ORGP	0.290	0.185	0.223	0.321	0.135	0.162	0.243	0.159	0.108	*0.764*	0.692	0.774
QM	0.245	0.325	0.359	0.190	0.162	0.230	0.424	0.494	0.120	0.118	*0.850*	0.310
RDM	0.396	0.341	0.497	0.319	0.311	0.305	0.558	0.525	0.095	0.210	0.330	*0.773*

Diagonal and italicized elements are the square roots of the AVE (average variance extracted).

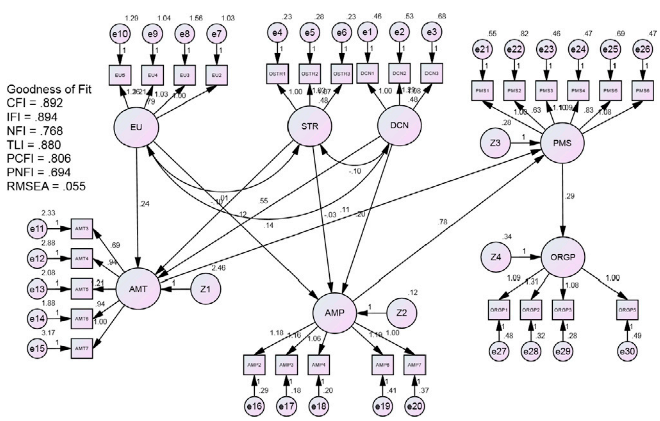

Fig 2. Evaluation of the measurement model and structure.

effect size value indicates the partial contribution of each predictor in explaining the variance of the endogenous variable. Our results show that the effect size value generated by each predictor in the model is in the small-medium category (Hair et al., 2017; Latan and Noonan., 2017).

4.4. Hypothesis testing

We tested the hypotheses with a view to the coefficient parameter and the significant value generated from the 95% confidence intervals of each independent variable. As shown in Table 8, all path coefficients indicate significant value (at the $p = 0.05$ level). Only the relationships between STR → AMT and STR → AMP are not significant. Based on the analysis in Table 8, environmental uncertainty has a significant positive effect on AMT and AMP. From the results obtained, the coefficient value (β) of the relationship EU → AMT is 0.240, and for EU → AMP it is 0.118, with a p-value < 0.01. This means that hypothesis 1ab (H1a,H1b) is supported. In addition, it can be seen the coefficient value (β) for the relationship DCN → AMT is 0.548, and for DCN → AMP it is 0.198, with a p-value < 0.05. This means that hypothesis 2ab (H2a,H2b) is also fully supported.

Table 8
Relationships between variables (direct effect).

Structural path	Coef(β)	S.D	P-Values (95% CI)	C.R	Conclusion
EU → AMT	0.240	0.062	0.000**	3.870**	H1a supported
EU → AMP	0.118	0.042	0.005**	2.835**	H1b supported
DCN → AMT	0.548	0.217	0.012*	2.526*	H2a supported
DCN → AMP	0.198	0.064	0.002**	3.099**	H2b supported
STR → AMT	-0.098	0.190	0.606	-0.516	H3a not supported
STR → AMP	-0.030	0.045	0.504	-0.668	H3b not supported
AMT → PMS	0.086	0.031	0.006*	2.764*	H4 supported
AMP → PMS	0.783	0.161	0.000**	4.691**	H5 supported
PMS → ORGP	0.317	0.090	0.000**	3.534**	H6 supported

Note: **, *statistically significant at the 1 percent and 5 percent levels, respectively.

Furthermore, Table 8 shows that the adoption of advanced manufacturing tools (AMT) has a positive effect on the performance measurement systems (PMS) with a coefficient value of (β) = 0.086, and this relationship, AMT → PMS, was significant at 0.006. This means that hypothesis 4 (H4) is supported. The relationship AMT → PMS gives significance 0.000 with β = 0.783, meaning that hypothesis 5 (H5) is also supported. Finally, we found that the relationship between PMS → ORGP is significant, with β = 0.371 and significance at 0.000. This supports hypothesis 6 (H6).

4.5. Additional testing

We also tested for endogeneity bias, which poses another potential threat to our results. Endogeneity testing is intended to maintain the robustness of our analysis results. Endogeneity bias generally arises from the selection of non-random sample, in which there may be bidirectional relationships between variables or as a result of the effect of omitted variables (Jean et al., 2016; Ketokivi and McIntosh., 2017). Endogeneity bias causes the ML estimate to be distorted and thus poses a threat to the validity of the results. To control for this, we used the Heckman test to obtain propensity scores in assessing endogeneity with the help of the Stata program. We found that the significance obtained from both models

Table 7
Structural model results.

Constructs	R^2	f^2	VIF	GoF	Cut-off
Environmental Uncertainty (EU)	–	0.019–0.049	1.057	CFI = 0.892	Fit
Decentralization (DCN)	–	0.027–0.111	1.042	IFI = 0.894	Fit
Organizational Strategy (STR)	–	0.001	1.017	NFI = 0.768	Marginal
Advanced Manufacturing Tools (AMT)	0.089	0.046	1.167	TLI = 0.880	Marginal
Advanced Managerial Practices (AMP)	0.237	0.163	1.167	PCFI = 0.806	Fit
Performance Measures Systems (PMS)	0.340	0.075	–	PNFI = 0.694	Fit
Organizational Performance (ORGP)	0.097	–	–	RMSEA = 0.055	Fit

Table 9
Endogeneity test.

Structural path	Coef(β)	S.D	P-Values	z	Conclusion
EU → AMT	0.100	0.032	0.000**	3.03**	Not different
EU → AMP	0.210	0.014	0.007**	2.78**	Not different
DCN → AMT	0.395	0.092	0.000**	4.26*	Not different
DCN → AMP	0.853	0.332	0.010**	2.56**	Not different
STR → AMT	-0.695	0.104	0.504	-0.67	Not different
STR → AMP	-0.294	0.372	0.430	-0.79	Not different
AMT → PMS	0.830	0.543	0.000**	5.21**	Not different
AMP → PMS	0.413	0.159	0.009**	2.59**	Not different
PMS → ORGP	0.215	0.099	0.000**	4.30**	Not different

Note: **, *statistically significant at the 1 percent and 5 percent levels, respectively.

remained the same (see Table 9), which means that endogeneity bias is not a potential threat to our results.

5. Discussion and implications for theory and practice

5.1. Discussion

The findings of our research demonstrate that, overall, the proposed research framework is well-grounded and suitable for understanding the reality of the surveyed firms. However, the main point of interest of our study is not only the overall acceptability of our research framework, but, surprisingly, the rejection of H3a and H3b, which deal with the relationships between organizational strategy (STR) and the adoption of advanced manufacturing tools (AMT) and managerial practices (AMP). This result presents an opportunity to deepen the debate on critical factors that may influence the adoption of advanced manufacturing practices, which have flourished in manufacturing environments (Jabbour et al., 2018).

In general, the adoption of advanced manufacturing tools (AMT) and advanced managerial practices (AMP) tend to be positively influenced by contingency factors (mainly environmental uncertainty and decentralization), while AMT and AMP themselves exert positive influence on the set of performance measures adopted by manufacturing firms, as signaled by the data's support for H1a-H1b, H2a-H2b, H4, H5, and H6.These performance measures will ultimately influence firms' performance, as suggested by Neely et al. (1995).

Our results show that environmental uncertainty and organizational decentralization influence the adoption of both AMT and AMP, which supports H1a-H1b and H2a-H2b, and is aligned with related literature (Badri et al., 2000; Chan et al., 2016; Gupta et al., 1997). Surprisingly, however, the relationship between organizational strategy (STR) and adoption of AMT was not confirmed, as H3a and H3b were rejected. This unexpected result suggests that, in manufacturing firms, the dynamic linkage between firms' strategy and the adoption of tools and practices may not always be straightforward. This process can face inherent difficulties, as suggested by Miles and Snow (1978), and by Snow and Hrebiniak (1980).This unanticipated result can also be aligned with Agarwal et al. (2013), who argue that manufacturing firms in mature economies – such as Italy – may have to adopt management practices that are accepted as global best practice, regardless of their fit with strategic and specific organizational goals. This universalist effect may help to explain why some globally-accepted management practices (AMP) have been adopted even when they are not totally justified by firms' strategy. Finally, the lack of support for H3a-H3b finds similarity with Golini and Kalchschmidt (2015) suggestion that contingency factors may not always explain firms' performance. There are contingency factors which lose relevance when it comes to explaining the practices and performance of certain companies. The rejection of H3a-H3b has implications for the literature gap pointed out by Blome et al. (2013), who affirmed that the contingency factors which may influence the flourishing of complementary effects are still to be fully understood.

This work also confirms that both AMT and AMP together influence the characteristics of firms' performance measurement systems, supporting H4 and H5. The positive effects of this joint adoption can be understood to be aligned with previous findings on the synergistic effects of organizational practices on firms' competitiveness (Soda and Furlotti, 2017). The link between the performance measurement systems adopted and organizational performance was also confirmed, supporting H6. The findings confirm that manufacturing firms have adopted both financial and non-financial measures, which has been noted to be relevant for competitiveness (Keegan et al. 1989; Fisher 1992; White, 1996; Kaplan and Norton 1996, 2000; Gosselin 2005). This finding is aligned with the literature on overall organizational performance influences and firms' competitive advantage (Kueng, 2000). However, while we found that customer measures, internal process measures, R&D innovation measures, quality measures, human resource measures, and financial measures were all relevant, our research findings lean towards those of Hackman and Wageman (1995), who discuss the vital role played by quality measures in contemporary organizational performance measurement systems.

5.2. Implications for theory

From a theoretical point of view, our research has implications for the application of organizational theories to operations management (Sarkis et al., 2011); primarily contingency theory and complementary effects theory, with regards to the adoption of practices in organizations, firms' performance and performance measurement systems. For example, our research considers organizational strategy as a contingency factor, which has so far been a research gap (Khanchanapong et al., 2014), and which produced the most interesting finding of this work.

By being one of the first works to test the complex relationship between contingency factors (Donaldson, 2001; Sousa and Voss, 2008), complementary effects (Choi et al., 2008; Khanchanapong et al., 2014), the adoption of advanced managerial practices and manufacturing tools and their effects on firms' measurement systems and performance (Neely et al., 1995), we integrate a number of constructs that have previously only been investigated separately. We extend, in terms of complexity, the work of Khanchanapong et al. (2014), who studied the complementary effects of manufacturing technologies and lean practices in manufacturing organizations. We also contribute to the debate on the adoption of AMP and AMT in manufacturing firms from mature economies, which can tend to adopt more universalist best practices rather than practices driven by contingent variables (Agarwal et al., 2013). Our results are aligned with Golini and Kalchschmidt (2015) in suggesting that contingency factors will not always be capable of explaining the performance of manufacturing firms.

The rejection of H3a-H3b may be theoretically linked to the fact that organizational strategy and manufacturing actions are not always straightforward (Papke-Shields and Malhotra, 2001). In this context, a number of factors may influence the implementation of organizational strategies and the adoption of advanced manufacturing practices, tools and trends. For example, even in companies with good organizational strategy alignment, the adoption of advanced manufacturing practices and tools can be influenced by a variety of critical factors (Jabbour et al., 2018), such as top management actions (Schniederjans, 2017). Thus, the most interesting implication of our research findings – the rejection of H3a-H3b – contributes to the necessary discussion around whether contingency factors trigger or hamper complementary effects (Blome et al., 2013).

This work also has implications for the literature on performance measurement systems (Neely et al., 1995). First, we propose that the configuration of organizational measurement systems can be shaped by the kind of practices companies adopt. For example, as we found, the prevalence of AMP in manufacturing firms is directly linked to the prevalence of quality management-driven measurement systems. This provides an explanation for the emergence of quality measures as the most salient construct of organizational measurement systems. This work supports the existing literature by making the case for having a balanced organizational measurement system capable of considering both financial and non-financial measures. We found that both kinds of measure can positively influence firms' performance.

5.3. Implications for practice

This research provides a number of implications for practitioners and industrial policy decision-makers. Our discoveries highlight the need for practitioners to be aware that the adoption of both AMT and AMP can influence which measures will be relevant when measuring organizational performance; they may also be interested to note that both AMT and AMP will be facilitated through properly managing contingency factors. Special attention should be given to the alignment between firms' strategy and the adoption of manufacturing practices and tools.

The main implication of our research concerns the adoption of practices in manufacturing. Our research reveals that contingency factors – mainly environmental uncertainty and organizational decentralization – have a positive influence on the adoption of both AMT and AMP. Thus, practitioners should pay close attention to contingency factors in order to successfully implement new managerial and manufacturing practices and tools. However, we would point out that the adjustment between organizational strategy and the adoption of AMP and AMT should be prioritized, as a consequence of the rejection of H3a-H3b.This can occur due to the fact that many managerial practices are currently adopted for reasons beyond strategic relevance. For example, some researchers affirm that companies have been pressured to adopt fashionable practices (Abrahamson, 1991, 1996). This highlights the necessity of managers working in manufacturing firms from mature economies having a clear understanding of whether they should take a more contingent or a more universalist approach when adopting management practices (Agarwal et al., 2013). Managers should also keep in mind that contingency factors can vary in terms of the influence they exert on performance (Golini and Kalchschmidt, 2015; Blome et al., 2013). This advice is particularly relevant as the number of new industrial practices and tools expands (Jabbour et al., 2018).

This work suggests that the adoption of both AMT and AMP can be complementary, positively shaping the measurement systems of organizations. In this context, manufacturing firms should pay attention not only to manufacturing tools, but also to managerial practices that may lead to competitive advantages. We also found that, alongside the adoption of AMT and AMP, companies require a comprehensive measurement system, which takes into account both financial and non-financial measures. In this context, we advise managers to pay particular attention to quality management measures, which tend to play a significant role.

6. Conclusion

In conclusion, this work has achieved its objective concerning the investigation of the complex relationship between contingency factors (environmental uncertainty, organizational decentralization, and organizational strategy) and the adoption of advanced manufacturing tools (AMT) and advanced managerial practices (AMP). It has also investigated whether and to what extent AMT and AMP shape organizational management systems, which in turn impact the organizational performance of manufacturing firms.

Overall, our theoretical framework has been supported by the empirical data. However, the link between organizational strategy and the adoption of AMP and AMT should be further explored, which in order to shed light on a number of research fronts, including strategic alignment (Khanchanapong et al., 2014), factors relevant to explaining complementary effects (Blome et al., 2013) and critical factors for the adoption of manufacturing practices (Jabbour et al., 2018). We have also contributed to the literature in defense of balanced organizational performance measurement systems which include both financial and non-financial measures, which will ultimately improve organizational performance.

While our empirical data comes from the Italian manufacturing sector, our unexpected finding – the rejection of H3a-H3b –may be useful for other mature economies facing increased competition from emerging economies. Our results are aligned with concerns that manufacturing firms in mature economies may have begun to adopt more universalist best practices rather than practices driven by contingent variables (Agarwal et al., 2013). The adoption of universalist best practices, sometimes lacking in contextual relevance, may lead to strategic misalignment.

This research has also proposed implications for practitioners, primarily suggesting that efforts should be channeled towards achieving better alignment between organizational strategy and the adoption of AMP. Additionally, this research had called attention to the complexity of adequately managing contingency factors, complementary practices, and organizational performance.

6.1. Research limitations

This research has some inherent limitations that can be seen as opportunities for future research. The first is that the lack of support of H3a-H3b cannot be totally explained by the data we collected. For example, the literature has been concerned with a variety of critical success factors that may influence the adoption of emerging manufacturing trends (Jabbour et al., 2018). However, this research did not consider all such possible critical success factors.

Another limitation is the focus on only one country – Italy. Italy is well known for its influential and innovative business sector, an industrious manufacturing sector (Italy is the second largest manufacturer in Europe behind Germany) and a competitive agricultural sector (Italy is the world's largest wine producer). Italy is also known for its creative and high-quality automobile production, intense machinery, automotive, aerospace and naval production and fashion design. Italy has the largest market for luxury goods in Europe, and the third-largest in the world. Although we hope our work is relevant to understanding the challenges of manufacturing in mature economies (as suggested by Agarwal et al., 2013), we also acknowledge that firms from different economic contexts (e.g. emerging economies, transition economies) could have been included in this project, in order to generate more generalizable results. Finally, although our sample could be considered more sizable than similar works in the field of empirical operations management, it could have been larger.

6.2. Potential directions for future research

Although previous literature has warned about the difficulties of strategic management in manufacturing firms, future research should explore the lack of a significant relationship between organizational strategy and the adoption of manufacturing actions. Rather than strategically adopting AMP and AMT, companies may have adopted practices due to other factors, such as isomorphism. Another avenue for future studies would be to consider contingency factors as moderators in similar research frameworks. In this context, we suggest the following topics for future research in this field: (i) to better understand contingency factors – mainly strategic management –which may either boost or hamper the adoption of manufacturing practices; (ii) to test frameworks for critical success factors in the adoption of AMT and AMP; (iii) to replicate our research framework in firms from different economic backgrounds, such as emerging economies.

Below the diagonal elements are the correlations between the construct values. Above the diagonal elements are the HTMT values.

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