The adoption of socio-technical and JIT practices and its relationship with the performance of quality and workers' health

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Abstract

Socio-technical (ST) theory emphasizes the notion that the design and performance of new systems can be improved, and can only work satisfactorily within an organization, if the social and the technical are brought together and treated as interdependent aspects of a work system. The implementation of Lean Manufacturing (LM) principles and practices has become popular, despite increasing demand on the current and emerging work force to achieve higher levels of quality and flexibility with lower costs. Exploratory studies that investigate how LM practices influence the effect of ST practices on performance are still scarce, and a holistic view of such relationship is needed. In this context, this study aims at verifying the moderating effect of just-in-time (JIT) practices on the relationship between socio-technical practices and the performance of quality and workers' health. We carried out a survey with 144 different companies from Southern Brazil that are undergoing a lean implementation. Results indicate that ST practices have a positive significant relationship with such performance, and the concurrent adoption of JIT does not undermine quality and workers' health.

Keywords
Socio-technical practices; Quality; Workers' health; Just-in-time.

1. Introduction

The work organization has been changing at unprecedented rates, partly as a result of the growth of a range of new management practices and techniques (Zare et al., 2016). In this sense, Socio-technical (ST) theory emphasizes the notion that the design and performance of new systems can be improved, and indeed can only work satisfactorily within an organization, if the social and the technical are brought together and treated as interdependent aspects of a work system (Clegg, 2000; Koukoulaki, 2014). In this sense, the ST theory has been defined as an integral theory of work design and quality of working life, whose perspective explicitly embraces the idea that all aspects of a system are interconnected, and none should take logical precedence over the other, and that they should be designed jointly (Molleman and Broekhuis, 2001; Kang et al., 2016). However, many organizations lack an integrated approach that addresses both social and technical change. The existing initiatives often take the technology as given, and the design of the social system must be undertaken around such technology. This fact may entail a partial or narrow implementation of ST practices in their coverage and perspective, undermining the achievement of the full benefits of a ST implementation (Eklund, 2000; Carayon, 2006; Koukoulaki, 2010).
The research related to ST practices has for a long time focused on regular production work to a large extent. The implementation of Lean Manufacturing (LM) principles and practices has become popular among manufacturing industries, services and large commercial areas (Womcak and Jones, 2010). The change towards a LM entails a refinement of the traditional mass production systems by eliminating waste and by responding to unanticipated change at the operational level (Liker, 2006; Liker and Hoseus, 2008). The implementation of LM means a systematic approach of various management methods and practices, which presents the human element as a fundamental factor for continuous improvement sustainability (Seppälä and Klemola, 2004; Bäckstrand et al., 2013).

To achieve a truly lean system, previous research state that LM practices increasingly demand on the current and emerging work force to achieve higher levels of quality and flexibility with lower costs (Plonka, 1997; Guimarães et al., 2015); while pushing individual's muscular, cognitive, and emotional resources to the limit (Hoffmeister et al., 2015). At the same time, it promotes task variety, employment security, financial incentives, development and utilization of skills and knowledge, and knowledge of organizational performance (Saurin and Ferreira, 2009; Toralla et al., 2012), corroborating with the objectives of ST practices.

In this sense, a holistic view of the influence of lean implementation is needed in order to identify whether the concurrent adoption of LM practices support or undermine the effect of ST practices for improving operational performance (Tortorella et al., 2016b). Further, research on the relationship of ST practices and operational performance in organizational contexts that are undergoing a LM implementation may have been hampered by the inadequacies of prior studies both from theoretical and methodological standpoints (Wilson, 2005; Arezes et al., 2015). In fact, few organizations study their operations in detail, and the ones that try to do so usually approach them from a narrow perspective (Hagg, 2003; Arezes et al., 2010). Therefore, an exploratory study that investigates how LM practices influence the effect of ST practices on operational performance is yet to be established in order to fulfill such a research gap.

In this context, this study aims at verifying the moderating effect of lean practices on the relationship between ST practices and the performance of quality and workers' health. We carried out a survey with 144 different companies from Southern Brazil that are undergoing a lean implementation. Respondents are asked to fill three sequential questionnaires in the survey: (i) details about the contextual variables pointed in the literature as influential for performance improvement, which are further considered as control variables; (ii) the implementation level of ST and LM practices; and (iii) the level of performance improvement observed over the last five years regarding quality and health. Our study bridges a gap observed in the literature concerning the integration of LM practices into organizations that have been widely implementing ST practices, as it enables the identification of the effects of such interaction on quality and workers' health performance.

More specifically, we examine the effect of one bundle of lean practices acknowledged by reducing inventories and avoiding overproduction, denoted as just-in-time (JIT). JIT has been extensively studied and empirically validated in lean literature (e.g. Shah and Ward, 2003; Shah and Ward, 2007; Netland and Ferdows, 2014; Marodin et al., 2016), and the existing evidences strongly support that the lean practices combined into this construct corroborate to better operational performance. However, few evidences support that the introduction of JIT may raise other operational issues, such as an increase on emotional and cognitive pressure on workers, leading to different problems which might be hidden or mitigated in traditional mass production contexts. In this sense, there are no empirical evidences that investigate the moderating effect of such practices on the relationship between ST practices and operational performance. The literature on the subject is still scarce and suggests contradictory associations between LM and ST practices for performance improvement. We postulate two bundles of inter-related and internally consistent ST practices, which have been conceptually proposed in the literature; these are: work design (WD) and organizational practices (OP). We empirically validate these bundles and further investigate their simultaneous effects on quality (scrap and rework) and workers' health.

Besides its theoretical contribution, our research provides managerial implications that may support leaders and practitioners to better comprehend the need and the advantages of a concurrent implementation of LM and ST practices across organizations. Further, identifying the interaction effect of these practices may contribute to address specific improvement activities and reinforce the managerial practices that best support the expected performance results on quality and workers' health. Because of the exploratory nature of this research, it is developed as a set of propositions rather than formal hypotheses. Therefore, some propositions are investigated in order to obtain a clearer comprehension around the subject and enable a better understating over the boundary conditions that surround the problem. This rest of this paper is structured as follows. Section 2 presents the theoretical background and propositions developed to achieve our research objective. Section 3 describes how we performed the research method by surveying Brazilian companies and their ST practices and performance, construct validation procedures and testing our propositions using Ordinary Least Square regression. We present the results of our research in Section 4 and discussions in Section 5. Finally, section 6 includes the conclusions and final remarks.

2. Literature and hypothesis

2.1 ST practices and their effect on quality and workers' health

Any successful company must possess effective and efficient work organization at the management level in order to balance the work demands and conditions of the work force and, subsequently, establish the best ST practices conducive for maximum human health, productivity and quality of work (Karwowski et al., 1994; Genaidy and Karwowski, 2003; Jaworek et al., 2010). ST practices aim at improving the work environment in terms of its physical, cognitive and organizational demands, enabling a better working condition to all employees and, hence, entailing a better operational performance. Ultimately, the provision of a good organizational climate is associated to employees' motivation and reinforces a better interpersonal communication and relationship among employees and their managers (Blaikie et al., 2014). Therefore, the underlying concepts to ST practices may be considered into the planning and execution of operational activities, in order to establish proper conditions and better results in the interaction between workers and work environment (Beevis, 2003; Ferreira and Gurgueira, 2013).
Previous researches on ST practices evidence that some of the interdependencies of ST practices may not be as apparent during system design as expected. There may be unintended consequences of various change initiatives whose impacts are hard to be anticipated, and some of these consequences may only become obvious when the system is in operation (Molleman and Broekhuis, 2001; Carayon, 2006; Dixon et al., 2009). In this sense, the proper understanding of the effects of ST practices implementation on the operational performance still needs further research. The implementation of ST practices entail changes in organizational responsibilities, in which the separation between the planning and doing part of the system tend to diminish (Eklund, 2000; Dul and Neumann, 2009; Koukoulaki, 2010). Hence, companies are expected to challenge employees to assume ownership when and where needed; learning from other teams both inside and outside the enterprise is supposed to be prevalent (Joseph, 2003; Thun et al., 2011).
Based on a literature review, 18 practices stand out as the most frequent ST practices in a management level of adoption, as shown in Table 1. From these 18, practices "search for good organizational climate" and "search for the health and safety of workers" appear to be the most cited ones in literature. These practices are usually associated with organizations principles and strategic objectives that are deployed into managerial routines (Azadeh et al., 2014; Hoffmeister et al., 2015). These managerial routines aim to reinforce and provide proper guidance for managers and their teams with regards to technical, organizational and human aspects on a daily basis for all productive activities within the company (Karsh et al., 2014). It is worthy to notice that a few researchers also relate these practices with expected behavioral patterns under the work environment (Asadzadeh et al., 2013; Guimarães et al., 2014). In opposition, "management of staff turnover" seems to be a practice that has not yet been fully adopted and, in particular, recognized as beneficial for implementation of ST practices. However, studies that evidence its importance, e.g. Pavlovic-Veselinovic et al. (2016) and Kang et al. (2016), report advantages in its adoption from the ST perspective. Overall, these 18 ST practices have been consistently evidenced in literature and may represent, for this study's purpose, the implementation of ST practices within a company.
From these, we selected inter-related practices to combine into two main practices bundles associated with WD and OP. The WD bundle may comprehend practices that corroborate for improving ergonomics and health conditions of the work task, including other elements such as tools and physical environment of the work (Clegg, 2000; Arezes et al., 2010). The effects of the WD on the individuals are assumed to be mediated by the stress load that is both physical and psychological (Munck-Ulfsfält et al., 2003; Saurin and Ferreira, 2009). The second bundle, OP, is defined as the way work is structured, distributed, processed and supervised (Dixon et al., 2009). Its full adoption may depend on many factors, such as management style, type of product or service, characteristics of the workforce, level and type of processes technology, and market conditions (Carayon and Smith, 2000; Carayon, 2006; Guimarães et al., 2015).
Research and practice in the field of ST systems have demonstrated that considering only a small number of work factors can be misleading and inefficient in solving job design problems (Zare et al., 2016). However, truly ST systems emphasize an approach in which all elements of the work system should be considered in order to improve performance, and health and quality (Asadzadeh et al., 2013; Kang et al., 2016). Therefore, we argue that the effects of the ST practices, denoted by the bundles of WD and OP, positively influence on the operational quality (scraps and reworks) and workers' health. To better examine that, we propose the following:

Proposition 1: Socio-technical practices, combined into bundles of WD and OP, are positively associated with the performance of quality and workers' health.

Table 1. Appearance of ST practices in literature

ST practices	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
ST_1- Communication and information system	×	×		×	×	×	×	×	×					×	×
ST_2- Problem solving indicators exposure			×			×						×	×		×
ST_3- Overload for achievement of goals				×			×	×	×	×					
ST_4- Management of staff turnover					×									×	×
ST_5- Ergonomics criteria for workstation design		×	×	×	×	×	×	×	×	×	×	×	×	×	
ST_6- Workstations appropriated to workers		×	×	×	×	×	×	×	×	×	×	×	×		
ST_7- Workers' recognition and reward					×		×	×	×		×				
ST_8- Teamwork and coaching					×	×		×	×		×	×			×
ST_9- Clarity in targets definition					×			×			×		×	×	
ST_{10}- Clarity in defining the role of workers		×		×	×		×	×			×	×	×		
ST_{11}- Risk alerts utilization			×	×					×	×	×	×	×		×
ST_{12}- Search for good organizational climate	×		×	×	×	×	×	×	×	×	×	×	×	×	×
ST_{13}- Search for the health and safety of workers	×		×	×	×	×	×	×	×	×	×	×	×	×	×
ST_{14}- Balancing among quality, scope, time and cost	×			×	×		×	×	×	×	×	×	×	×	
ST_{15}- Anticipating and reducing the risk of incidents	×		×	×	×	×	×	×	×	×	×			×	×
ST_{16}- Appreciation for workers training	×			×	×	×	×	×	×	×	×	×			×
ST_{17}- Ergonomics recommendations as regulations	×			×	×	×	×	×			×	×			×
ST_{18}- Regulation of technical, organizational and human aspects	×		×	×	×	×	×	×	×	×	×	×		×	×

(1) Hoffmesiter et al. (2015); (2) Haug (2015); (3) Azadeh et al. (2014); (4) Karsh et al. (2014); (5) Guimarães, et al. (2014); (6) Asadzadeh et al. (2013); (7) Dul and Neumann (2009); (8) Saurin and Ferreira (2009); (9) Guimarães et al. (2015); (10) Koukoulaki (2014); (11) Koukoulaki (2010); (12) Zare et al. (2016); (13) Thun et al. (2011); (14) Pavlovic-Veselinovic et al. (2016); (15) Kang et al. (2016).

2.2 The JIT moderating effect

One of the main pillars of Toyota Production System is the JIT production system (Womack and Jones, 2010), which ideally aims at producing only what the customer wants and when he needs (Liker, 2006). The implementation of JIT is increasingly being seen as a vital way for manufacturing organizations to enhance their competitiveness. Further, there are a set of LM practices which have been extensively studied and empirically validated as part of JIT; they are: (i) takt time, (ii) pull system, (iii) continuous flow, (iv) production leveling and (v) material feeding (Shah and Ward, 2003; Shah and Ward, 2007; Netland and Ferdows, 2014).

Besides improving operational performance, a few evidences state that the adoption of JIT may impact other organizational aspects (Tortorella et al., 2016b). Contradictory evidences regarding the effect of the adoption of JIT practices on human factors are found in literature. On one hand, previous studies (e.g. Plonka, 1997; Eklund, 2000; Saurin and Ferreira, 2009; Sharma, 2012) report that JIT embraces a model of manufacturing that respects innate human strengths and positively employs human factors concepts throughout their improvement activities. They argue that the adoption of JIT tends to improve the manufacturing and production system from the material and information flow perspective; while preparing the work force for responding with agility and effectiveness to customers' demand variations (Jackson and Martin, 1996; Maia et al., 2012).

On the other hand, the integration of JIT practices requests a greater level of self-organization of tasks by the work force, which demands manufacturing teams to develop a collective skill base that enables problem solving and dealing with larger degrees of change (Gunasekaran et al., 1998; Rahul et al., 2014). This demand increase may not always be helpful for employees' performance, especially if employees present a lower cognitive and learning capability (Drews et al., 2007; Eren, 2009; Koukoulaki, 2014). Employees are expected to deal with uncertainty and have greater autonomy in responding to unexpected events and solving problems which may entail harmful pressures on employees, affecting both quality and productivity performance (Langstrand, 2012). Further, the achievement of a JIT production system encompasses tighter cycle times, in which the existing idle times are mitigated, potentially increasing operators' fatigue and physical demands (Womack et al., 2009; Silva et al., 2016).

Complementary literature on ST systems assumes that individuals may be error-prone, unreliable agents and likely resistant to change (Blaikie et al., 2014; Zare et al., 2016), implicitly hindering the implementation of change approaches, such as JIT. Hence, given the aforementioned arguments, it may seem intuitive that the concurrent adoption of JIT and ST practices is more likely to negatively influence the performance of quality and workers' health, although the empirical evidence to support that assumption is still scarce and contradictory. Therefore, to better investigate that, we formulate the following proposition:

Proposition 2: The adoption of just-in-time practices negatively moderates the relationship between socio-technical practices and the performance of quality and workers' health.

3. Method

3.1 Sample selection and characteristics

The criteria for selecting the sample of companies were as follows: (a) to include leaders from companies located in a specific region of the country, in this case the South of Brazil, as to reduce the effects of the external environment (e.g. regional culture, and socio-economic development), since this would be relatively homogeneous within the sample; (b) to include companies from different industrial sectors because LM has been expanding over many kinds of companies in recent years; and (c) respondents should have experience in lean and a leadership role in the company. The non-random choice of companies for surveys and the search for companies that are already known to the researchers is a commonly used strategy in other studies on LM (Saurin et al., 2010; Boyle et al., 2011; Tortorella et al., 2016a). For example, Shah and Ward (2007) used a sample with participants drawn from courses and training events when they conducted a survey on LM, since it was necessary that the respondents had experience in the subject. A recent study by Kull et al. (2014) suggests that national culture could influence the implementation of lean practices. Therefore, a single geographic location also increases the homogeneity of the sample. Additionally, although implementing LM is usually associated primarily with high volume and discrete part manufacturers, pervasiveness of practices across the industrial spectrum is unknown (Tortorella et al., 2015).
Questionnaires were sent by e-mail to 523 former students of executive education courses on lean offered by a large Brazilian University since 2014. A first e-mail message containing the questionnaires was sent in June 2015, and two follow-ups were sent in the following months. The final sample was comprised of 144 valid responses (representing a response rate of 27.53%); respondents' demographics are presented in Table 2. Most respondents were from large companies (74.8%); the majority of companies belonged to the auto parts sector (44.5%). Finally, regarding the lean experience within the companies, most companies (57.7%) presented more than 2 years of LM implementation.

Table 2. Sample characteristics

Company size	Percentage
Small	6.5%
Medium	18.7%
Large	74.8%
Sector	**Percentage**
Auto parts	44.5%
Food	28.2%
Plastic	10.9%
Metallurgic	5.5%
Textile	3.6%
Packaging	2.7%
Chemical	1.8%
Others	2.7%
LM implementation	**Percentage**
Up to 2 years	42.3%
More than 2 years	57.7%

3.2 Questionnaire and data collection

The questionnaire had four parts. The first part aimed at collecting demographic information of respondents and their companies, such as size, sector and respondents' lean experience. We used firm size and time of LM implementation as control variables in our regression model. The second part intended to assess the degree of adoption of the eighteen ST practices (see Table 1). Respondents were asked to indicate the adoption level according to a 5-point Likert scale, ranging from 1 (not applied) to 5 (fully adopted). The third part intended to measure the degree of adoption of the aforementioned five JIT practices. The same Likert scale was used to indicate the level of adoption for JIT practices. Finally, the fourth part of the questionnaire comprised the identification of the degree of performance variation of quality and workers' health over the last five years within the respondents' company. Similarly, a 5-point Likert scale was used to indicate such performance variation, in which 1 indicated 'worsened significantly' and 5 'improved significantly'.

Regarding the assessment of the implementation level of ST and JIT practices, and performance variation, we tested for non-response bias as proposed by Armstrong and Overton's (1977) using Levene's test for equality of variances and a t test for the equality of means between early (respondents of the first e-mail sent) and late (respondents of the two follow-ups) respondents. Results indicated no significant differences (p-value<0.05) in means and variation in both groups. Thus, there is no statistical evidence that our sample is significantly different from the rest of the population for all variables.

3.3 Data analysis

Table 3 presents the CFA for the ST practices. The eighteen practices were combined into two bundles. For instance, all practices related to the design and improvement of the workstations' ergonomics were combined to form WD. The underlying rationale is that WD plays a key role on the achievement of a healthier work life and integration with processes and workers' requirements. The OP bundle comprises practices that can be identified by their focus on improving aspects that are wider than the workstation itself (e.g. communication and information system, problem solving indicators exposure, overload for achievement of goals, management of staff turnover) related to an efficient management of socio-technical aspects implicit to the organizational routines (Blaikie et al., 2014).

Each of the bundles was formed by adding the scores for each of the practices included in the bundle for each responding company. All 18 ST practices were entered for PCA (principal component analysis) and varimax rotation was used to extract orthogonal components, and two components were extracted (WD and OP). Thus, the bundles were empirically validated using PCA with varimax rotation and reliability analysis (Cronbach's alpha), as shown in Table 3. The data was analyzed using SPSS version 23. The results were replicated using oblique rotation as a check for orthogonality and the extracted components were similar. Additionally, unidimensionality of each component was verified and confirmed by applying PCA at the component level. A reliability assessment was performed determining the Cronbach's alpha values for each component, which depends upon the number of items in the scale and the average inter-item correlation (Meyers et al., 2006). All components displayed high reliability, with alpha values above 0.910. Finally, the response value for each bundle was obtained through the average of the corresponding practices included in the bundle weighted by their respective factor loadings from the PCA. The components variable loadings obtained (Thurstones' regression method) were used in the regression. Therefore, the variable loadings of OP and WD were introduced as new independent variables in the regression model.

Analogously, regarding JIT practices, a scale was constructed for JIT measure based on PCA based on PCA of the aforementioned five practices, and the factor scores were used as the moderating variable. Table 4 shows that all five practices load on one factor, with an eigenvalue of 3.13 explaining 62.68% of the variation. Further, the obtained Cronbach's alpha value is 0.850 and the result for the Bartlett's test of sphericity was significant, since it was lower than 0.001 (Meyers et al., 2006). Thus, we assume that all five practices are empirically related and represent a single dimension of JIT.

Finally, a third PCA was undertaken with regards to performance, as shown in Table 5. Both indicators (quality and workers' health) were combined into one performance component, which was later used as dependent variable in the OLS regression models. The result for the Bartlett's test of sphericity was significant, since it was lower than 0.001 (Meyers et al., 2006). The eigenvalue of the performance component was greater than 1.0, and the explained variance was higher than 50%, as recommended by Tabachnick and Fidell (2013). For reliability purpose, Cronbach's alpha value is 0.640, indicating satisfactory validity (Hair et al., 2006).

After the establishment of the components (independent, moderating and dependent variables), we performed a set of OLS regression models to test the theoretical propositions. The calculation of the interaction terms (OP x JIT and WD x JIT) was obtained by the product of the standardized independent variables, as recommended by Baron and Kenny (1986). Therefore, our results report the unstandardized coefficients, since scales were standardized before the analysis, i.e. unstandardized coefficients will represent a standardized effect (Goldsby et al., 2013). Moreover, firm's size and time of LM implementation were included as control variables in the model. Both variables were classified into two categories. Firm's size was coded into large (more than 500 employees) and small (equal or less than 500 employees), as suggested by Tortorella et al. (2015). For time of LM implementation, companies were categorized into the ones that present more than or less than 2 years, as evidenced in the study from Marodin et al. (2016).

Table 3. PCA to validate ST bundles – rotated component matrix

ST practices	1 (Work design)	2 (Organization practices)	Communalities
ST_5	**.651**	.319	.525
ST_6	**.756**	.268	.644
ST_8	**.623**	.504	.643
ST_{11}	**.667**	.430	.629
ST_{12}	**.750**	.353	.688
ST_{13}	**.751**	.362	.695
ST_{14}	**.640**	.466	.626
ST_{15}	**.638**	.486	.643
ST_{17}	**.819**	.251	.734
ST_{18}	**.711**	.469	.725
ST_1	.443	**.700**	.686
ST_2	.330	**.748**	.669
ST_3	.174	**.747**	.589
ST_4	.420	**.663**	.616
ST_7	.352	**.666**	.568
ST_9	.367	**.714**	.644
ST_{10}	.520	**.640**	.680
ST_{16}	.456	**.595**	.561
Eigenvalues	10.560	1.005	
Cronbach's alpha	0.938	0.910	
% of variance	58.66%	5.58%	
Cumulative %	62.68%		
Bartlett test of sphericity	0.000		
Kaiser-Meyer-Okin	0.938		

Table 4. PCA to validate JIT – rotated component matrix

JIT practices	Factor loads	Communalities
Takt time	**.745**	.554
Pull system	**.839**	.704
Continuous flow	**.804**	.646
Production leveling	**.742**	.551
Material feeding	**.824**	.678
Eigenvalue	3.13	
Cronbach's alpha	0.850	
% of variance	62.68%	
Bartlett test of sphericity	0.000	
Kaiser-Meyer-Okin	0.831	

Table 5. PCA to validate performance – rotated component matrix

Indicators	Factor Loads	Communalities
Workers' health	**.859**	.737
Quality (scrap and rework)	**.859**	.737
Eigenvalue	1.47	
Cronbach's alpha	0.640	
% of variance	73.74%	
Bartlett test of sphericity	0.000	
Kaiser-Meyer-Okin	0.600	

We tested the assumptions of normal distribution, linearity and homoscedasticity between independent variables (focal predictor and moderator) and the dependent variables (performance) (Hair et al., 2006). Further, the residuals were examined in order to confirm normality of the error term distribution. Linearity was tested with plots of partial regression for each model. Finally, homoscedasticity was evaluated by plotting standardized residuals against predicted value and examined visually.

4. Results

Table 6 presents the regression models. The first model investigates the relationship between the control variables (firm's size and time of LM implementation) and performance. Model 2 includes the association between ST bundles of practices (WD and OP) and performance, in order to examine the validity of *Proposition 1*. Finally, Model 3 adds the effect of JIT practices and their moderator effect on ST practices (OP x JIT and WD x JIT) to explain performance variation, as stated in *Proposition 2*. The dependent variable (performance) is shown in the columns, while the control and independent variables, and the interaction term are located in the rows. The variance inflation factors (VIFs) in the regressions models were all less than 2.0, suggesting that multicollinearity was not a concern.

Results for Model 2 indicate that almost 30% of performance variance is significantly explained (p-value<0.001). The inclusion of the independent variables (WD and OP) in the regression model significantly improves (F change=19.887; p-value<0.001) the predictability capacity of the model in relation to Model 1 (control variables). Further, both ST bundles (WD and OP) are positively associated (β=0.397 and β=0.286; p-value<0.001, respectively) with quality and workers' health, fully confirming *Proposition 1.* This finding is consistent with the studies of Carayon (2006), Koukoulaki (2010) and Asadzadeh et al. (2013), which state the effect of the adoption ST practices into organizations may lead to beneficial outcomes, contributing on quality, workers' health and performance indicators as whole. Therefore, this result highlights the importance of properly implementing both social and technical aspects, and treating them interdependently within the work system to provide the expected effects.

Although Model 3 appears to significantly explain the performance variation (p-value<0.001), the inclusion of the interaction terms does not seem to significantly improve the capacity of predicting performance when compared to Model 2. Such findings can be evidenced by the results for the predictability improvement of Model 3 over Model 2 (F change=0.647; Sig. F change=0.526), and, hence, do not bear *Proposition 2*. Therefore, we did not find empirical evidences to support *Proposition 2* based on the studied sample, which indicates that the concurrent implementation of JIT practices does not undermine the effect of ST practices on quality and workers' health performance.

Overall, the final model adopted for performance of quality and workers' health was Model 2, suggesting that both sets of ST bundles have a direct and positive effect on performance, and there is no moderation effect with JIT adoption. This finding is somewhat coherent with the results from Jackson and Martin (1996) and Toralla et al. (2012), which affirm that the implementation of JIT and other LM practices does not directly affect the performance on workers' health and quality. In opposition, our results indicate that, if ST practices are effective and consistently implemented within the organization, all the potential side effects of the JIT adoption (e.g. pressure for delivery schedule achievement, establishment and control of processes stabilization and standardization, and fast and assertive problem solving, etc) may not influence the levels of quality and workers' health. This fact demystifies the erroneous assumptions and associations that LM implementation, denoted in this study by the adoption of JIT practices, generates higher levels of physical, psychological and cognitive demands.

Table 6. Results of OLS regression models

	Model 1	Model 2	Model 3
Firm's size	0.276**	0.160**	0.171*
Time of LM implementation	0.134	0.055	0.049
WD		0.397***	0.360***
OP		0.286***	0.258**
JIT			0.042
WD*JIT			-0.071
OP*JIT			-0.045
F	6.078	14.548	8.168
Sig.	0.003**	0.000***	0.000***
Adjusted R^2	0.070	0.297	0.285
F change		19.887	0.647
Sig F change		0.000***	0.526

*significant at 10% / **significant at 5% / *** significant at 1%

5. Conclusions

We conducted a survey-based research and collected data from 144 firms from the Southern Brazil that are undergoing a LM implementation in order to answer the following research questions: (*i*) how does the adoption of JIT moderate the relationship between ST practices and the performance of quality and workers' health? Data was initially analyzed through a CFA in order to confirm the bundles of both ST and JIT practices and one construct of performance. Later, three regression models were generated by applying an OLS regression indicating the significance of the investigated associations.

The contribution of this study is two-fold. First, results show that all the ST bundles of practices (WD and OP) considered in this work are positively associated with the performance of quality and workers' health in the studied companies. Thus, we confirmed that the use of the eighteen ST practices contribute to improve the performance on scrap and rework, as well as enhancing life quality at work mitigating absenteeism and turnovers. This outcome supports the results from previous studies which emphasize the importance of fully implementing ST practices through an integrated design; hence, avoiding the adoption of unilateral aspects that may impair the achievement of the potential benefits.

Secondly, the concurrent adoption of JIT practices, such as takt time, pull system, continuous flow, production leveling and material feeding, does not appear to significantly influence the association between ST practices and quality and workers' health. Therefore, our findings suggest that if ST practices are properly in place, the adoption of JIT may not physically harm employees or their performance over quality. In practical terms, we provided empirical evidence for managers and practitioners that the implementation of LM (restricted here by the adoption of JIT practices) does not occur at the expenses of harming the health of the worker or affecting issues related to quality parameters and process control. Actually, results show that the effect of ST practices may prevail for improving such performance (quality and workers' health), highlighting that both social and technical aspects of organization must be primarily addressed in order to provide an adequate organizational environment for implementing specific LM practices and bundles, such as JIT.

Although our sample size may be considered as small for empirical surveys, tests passed with significant levels from 1 to 10%, as indicated. Those interactions that resulted into a significant effect accepted the sample size with respective degrees of freedom needed. As drawbacks, our results are limited by the sample characteristics (i.e. Southern Brazil location) and may be particular to this case. Thus, expanding the sample to other regions and countries, diversifying to other production sectors and including other LM bundles of practices besides JIT are valid suggestions for future researches. Particularly, it would be interesting to include firms from other emergent economies countries, like China and India, and also from developed countries, like USA and from Europe, for comparing the moderating effect of LM on the relationship between ST practices and performance. Additionally, the patterns of implementation of the ST practices over time could be further investigated in order to produce better frameworks for firms to assess their improvement initiatives.

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