ABSTRACT

Operational glitches (OGs) of different severity are a periodical occurrence in many firms. We argue and show that firms that make use of a transactive memory system (TMS) when facing unexpected situations in production stages are better able to prevent OGs from becoming external quality failures (EQFs). Building on the notion that glitch mitigation requires firms to develop problem-solving capabilities, we argue that TMSs provide resilience to OGs by underlying the exchange of informational resources across functional specialties. We test this hypothesis on a sample of 153 European industrial manufacturers through a survey of 4 different informants from each firm.

KEYWORDS: Glitches, Transactive Memory Systems, Knowledge Sharing, Survey, Hierarchical Regression
INTRODUCTION
Defects experienced by customers, or external quality failures (EQFs), are of primary concern to manufacturing firms. Orders delivered with flaws reduce operating profits, decrease customer satisfaction and hurt future sales (Lewis, 2003b; Tatikonda and Tatikonda, 1996). Failure to conform to market requirements and expectations has a detrimental effect on short-term financial performance (Hendricks and Singhal, 2005; Zsidisin et al, 2015) and on the sustainability of long-term competitive advantage (Su et al, 2014). As is manifested by product recalls in the automotive and pharmaceutical industries (Steven, 2015), by warranty claims in the computer and appliance industries (Warranty Week, 2015) or by liability litigation in the chemical and industrial equipment industries (Owen, 2002) many firms suffer from recurrent EQFs, in spite of obvious incentives to avert their incidence. Explanations as for why EQFs occur converge to two possibilities. One is that imperfect appraisal routines result in quality failures not being internally detected. Another is that EQFs reflect operational glitches (OGs) that, while detected, were not successfully addressed within the firm. This study is concerned with the latter possibility. OGs constitute unintended deviations from what is planned or expected of a given production process (Tenhiala and Salvador, 2014) and their manifestation is a periodical occurrence in many firms (Field and Sinha, 2005; Koh and Saad, 2006; Zu, et al., 2008). The occurrence of OGs triggers the engagement in problem-solving tasks that pose two general challenges for organizations (Lambert and Shaw, 2002; Van Dyck et al, 2005). On the one hand, organizations need procedures to identify and exploit problem-solving knowledge and information that exists internally. However, due to the unpredictability of glitches, structured approaches to accessing organizationally-disperse expertise are commonly rendered ineffective (Christiansen and Varnes, 2009). As an inherently improvisational activity, glitch mitigation requires the activation of knowledge search and transfer processes that are adaptable to the specificities of particular disruptions (Hansen, 1999; Majchrzak et al., 2012). On the other hand, in situations in which existing knowledge resources are not sufficient and new knowledge has to be generated, organizations need the ability to creatively recombine current expertise for the development of adequate solutions (Hargadon and Bechky, 2006). To the extent that OGs represent the inadequacy of devised production plans, addressing them involves the integration of specialized functional knowledge and information regarding customers, technical specifications or manufacturing constrains (Rauniar, et al, 2008; Peng et al, 2014). Regrettably, achieving knowledge integration across functional boundaries is hindered by communication barriers attributable to lack of common vocabulary and understandings (Grant, 1996; Kogut and Zander, 1996, Bechky, 2003).

Drawing on organizational problem-solving and glitch mitigation research, our paper suggests that the association between deviations from production plans and the incidence of EQFs can be negatively moderated under three concurrent conditions. In order for firms to increase their chances of inhibiting internal disruptions from becoming EQFs, manufacturing functions have to firstly acknowledge the potential validity of expertise located outside their functional boundaries (Levin and Cross, 2004; Watson and Hewett, 2006). Furthermore, manufacturing functions must be able to access glitch relevant expertise that is dispersed across functional specialties (Hoopes and Postrel, 1999; Faraj and Xiao, 2006; Koufteros et al, 2010). Finally, firms must coordinate the application of this specialized expertise during glitch mitigation routines (Gittel, 2002, 2006). According to the literature on knowledge integration in groups (Lewis, 2003; Brandon and Hollingshead, 2004), the concurrence of these conditions signals the operation of a cross-functional transactive memory system (TMS) for glitch mitigation. Transactive memory
theory defines TMSs as an orderly set of processes that continuously divide responsibilities for encoding, storing and retrieving task-relevant knowledge and information within a formal group (Wegner et al., 1991; Wegner, 1995). These processes erect a structure of differentiated expertise between individual group members that is integrated by the awareness each one has of the nature and usefulness of the knowledge possessed by the others (Lewis and Herndon, 2011). In this paper, we extend the application of transactive memory theory to expertise transfers occurring across organizational functions and investigate whether firms that develop a TMS to cope with glitch-generated disruptions are able to alleviate the latter’s association with EQFs. We test this hypothesis on a sample of European industrial equipment manufacturers through a survey of 4 informants from each firm.

We argue that firms that operate as TMSs when engaged in glitch mitigation routines are better able to overcome the challenges posed by the incidence of OGs. On the one hand, TMSs support the integration of specialized functional expertise by generating a shared blueprint of where relevant problem-solving information can be located. The collective maintenance of this blueprint allows functions to remain specialized in circumscribed domains without losing the ability to communicate with each other and engender creative solutions. On the other, TMSs also enable the operation of flexible collaboration processes by assisting distinct functions in selectively using each other as information repositories. This ensures that dispersed problem-solving expertise can more be more easily searched for, transferred and applied to specific problem-solving situations. Hence, our paper engages with current research on glitch mitigation capabilities as capabilities to cope with and recover from the inevitable occurrence of disruptions (Craighead et al, 2007; Blackhurst el al, 2011). This line of inquiry postulates that resilience to glitches is more likely when organizations have slack (Sheffi and Rice, 2005), manufacturing processes are flexible (Tang and Tomlin, 2008) resources can be easily re-configurable (Ambulkar et al, 2015) and cross-functional integration suitably achieved (Braunscheidel and Suresh, 2009). However, we still miss more fine-grained empirical research on the mechanisms with which these constituents of a glitch mitigation capability can be realized in practice (Juttner and Maklan, 2011; Ambulkar et al, 2015). Our study seeks to complement this literature by advancing TMS as underlying element that drives the deployment of slack, flexibility, resource re-configurability and cross-functional integration in the face of OGs.

The rest of the paper will proceed as follows. We begin by shortly reviewing the reasons behind the periodical incidence of OGs. Afterwards, we offer 2 sets of theoretical explanations as for why OGs are positively associated with EQFs and offer statistical evidence of this relationship in the equipment manufacturing industry. On the one hand, we argue that OGs are sometimes neglected as a result of cross-functional cooperation failures. On the other, we also suggest that, even when not outright ignored, coordination failures drive firms into coming up with imperfect solutions for glitches. Then, building on the notion that glitch mitigation requires firms to develop cross-functional problem-solving capabilities that make use of available knowledge resources (Rauniar, et al, 2008; Peng et al, 2014), we argue that TMSs provide resilience to OGs by supporting manufacturing’s access to and integration of informational resources that lie across functional specialties. We then present the findings that support this conjecture and conclude with a set of implications for glitch mitigation theory and practice.

2 – LITERATURE REVIEW AND HYPOTHESES

2.1 – Sources of Internal Glitches
There are multiple reasons for why internal disruptions may occur. Causes range from defective materials and equipment maintenance issues (Jonson, 2000) to faulty designs (Adler, 1995). OGs can also stem directly from human resource failings in the form of employee malpractice and managerial errors (Garvin, 1986). In spite of many firms continuous investment in prevention activities, error-free manufacturing is almost impossible to achieve (Perrow, 1984). As it is, OGs of different severity occur periodically in many firms and industrial settings (Field and Sinha, 2005; Koh and Saad, 2006; Tehniala and Salvador, 2014; Zu, et al., 2008). In this sense, it is crucial that organizations become capable of reacting to the occurrence of disruptions, in order to prevent unavoidable internal problems from becoming avoidable EQFs.

2.2 – The relationship between detected Operational Glitches and External Quality Failures

Research on the costs of achieving quality predicts that the more quality failures are internally captured, the fewer EQFs will be experienced by customers. In this paper, we draw on the glitch mitigation literature to challenge the direction of this association. This research stream posits that the ability to address detected glitches is contingent on the achievement of knowledge integration in cross-functional problem-solving processes (Hoopes and Postrel, 1999; Koufteros et al., 2010; Rauniar et al, 2008). Cross-functional integration of knowledge entails two distinct requirements: cooperation and coordination (Gulati and Wohlgezogen, 2012). Cross-functional cooperation is dependent on the degree to which interests are aligned within a task environment. Cooperation failures result from incentive structures unable to motivate collective behaviors conducive and reactive to knowledge sharing (Kretschmer and Puranam, 2008). Cooperation failures also occur due to organizational norms that discourage teamwork and dampen the motivation to engage in organization wide expertise sharing processes (Tucker and Edmondson, 2002). Coordination, in turn, refers to the cross-functional alignment of actions for effective task completion (Srikanth and Puranam, 2011). Coordination failures stem from the inability of organization designers to fully anticipate the nature of knowledge interdependencies between tasks and organizational units (Puranaman et al., 2012). Coordination failures are innate to unstable task environments (Davis et al. 2009), such as the ones posed by the occurrence of OGs. To the extent that cross-functional integration is thwarted by cooperation and coordination failures, we suggest two related explanations as to why operational glitches may fail to be properly corrected, even when timely detected.

2.2.1 – Cooperation Failures: dismissing operational glitches

The infamous Challenger disaster that resulted in the death of all passengers in January 1986 was attributed to the malfunction of a specific component – the rubber O-rings that sealed the joints of the shuttle’s rocket boosters. Leading up to the disaster, Nasa’s launch managers discounted evidence and dismissed formal warnings regarding the O-rings potential vulnerabilities to low temperatures, which ultimately caused the Space Shuttle’s demise. Similarly, in the case of Turkish Airlines flight 1951 crash at Schiphol Airport, Boeing had been repeatedly warned by multiple airliners about altimeter blips. The U.S. manufacturer recognized the blips but deemed them not a safety problem, which would end up proving a grave misconception (Dutch Safety Board, 2009). Glitches can remain unaddressed due to an inability to properly relate to and acknowledge failings reported by other departments. These tragedies illustrate how operational glitches can be easily dismissed as trivial and remain unaddressed, because their potential for escalation into major problems is not equally appreciated across
functional boundaries. Glitches can equally go unaddressed if employees have a narrow view of their responsibilities and a tendency to neglect problems that are not immediately tied to their specific work roles (Parker et al., 1997). This type of employees is less likely to take actions to correct faulty procedures or problematic product solutions (Staw and Boettger, 1990). In cases in which, for instances, manufacturing deems glitches as indication of design faults or incorrect communication of customer specifications there might be an unwillingness to tackle the issues for which one does not accept responsibility. In a study of hospital staff, Tangirala and Ramanujam (2008) showed that nurses were unlikely to report important issues regarding patient safety to doctors unless they revealed high levels of identification with their work group and perceived high levels of procedural justice within the organization. Fear of retaliations has been specifically shown to dampen the motivation to communicate issues that might direct blame to outsiders (Miliken et al, 2003; Premeaux and Bedeian, 2003). Thus, cross-functional relationships are liable to opportunistic behaviors that hamper collective efforts for joint-problem solving (Williamson, 1985). The occurrence of glitches whose ownership spawns across functions is likely to generate disagreements and occasions for engagement in blame games (Koufteros et al., 2010). These behaviors decrease the likelihood of acting on detected problems whose solving requires cross-functional expertise (Sitkin, 1992). Hence, it is expectable that some operational glitches are dismissed and never properly addressed due to failures in mobilizing the requisite cooperative behaviors for cross-functional knowledge sharing.

2.2.2 – Knowledge Coordination Failures: devising imperfect solutions

Even when operational glitches are taken seriously, there is no guarantee that they will be fixed in conformance to customers' requirements. To the extent that glitches represent the unexpected failure of a planned operational process, addressing them involves reconsidering customer, design and manufacturing-related knowledge (Peng et al, 2014). However, it is not uncommon for time constraints to take precedence over quality concerns (Ha and Porteus, 1995; Su et al, 2014). The occurrence of OGs typically translates into delays across multiples stages of a project (Koufteros et al., 2010). This put firms under time pressures to come up with rapid solutions, in order to avoid customers' switching behavior due to delivery failures (Lam et al, 2004). The more rework has to be performed due to the occurrence of OGs, the more firms are driven into cutting corners and developing quick fixes in order to avoid parts of the project remaining idle while other parts are being repaired (Oliva and Sterman, 2001). Regrettably, quick fixes may not fully integrate the necessary organizationally dispersed knowledge to satisfy customers' requirements, potentially leading to unfulfilled expectations in terms of product functionality and/or aesthetics.

The later in the development process glitches manifest themselves the more difficult it typically is to come up with correct solutions (Loch and Terwiesch, 1999). The complexity of many products implies intricate architectural couplings between components and functional expertise (Terwiesch and Loch, 1999a). When a solution for a particular operational glitch is put forward, it might not take into account hidden interdependencies between different product components and specifications. This may lead to the development of incorrect fixes that fail to be internally recognized as such. In order to advance correct solutions, various development stages might have to be revisited. In this sense, the successful fixing of glitches requires that distinct organizational functions reach a consensus about the causes and potential consequences of a particular problem. The more functions have to be involved in the glitch mitigation process, the more difficult reaching such consensus is, because departments tend to have their own idiosyncratic interpretation of events (Rauniar et al., 2008). To the extent that consensus over
solutions is hard to reach, the risk of coming up with the wrong solution to a given glitch is non-trivial.

The preceding sections have argued that successfully addressing OGs requires organizations to engage in problem-solving processes that rely on the integration of knowledge across functional boundaries. However, cross-functional integration is difficult and costly to achieve (Turkulainen and Ketokivi, 2013). The preceding sections have shown that knowledge integration is hampered by cooperation and coordination failures that either prevent detected glitches from being properly fixed or allow them to remain entirely unaddressed.

For these reasons, we expect that:

H1 – The frequency of occurrence of Operational Glitches is positively associated with the frequency of occurrence of External Quality Failures.

2.3 – Transactive Memory and Knowledge Integration

2.3.1 – Transactive Memory and Knowledge Integration in Teams

In this paper we draw on transactive memory theory as a theory of knowledge integration within organizational teams. This theory predicts that as people share experiences within ongoing working relationships, they learn how to identify experts across knowledge domains (Hollingshead, 1998). Over time, they develop a collective shared understanding of who possesses expertise in what fields (Griffith and Neale, 2000). In this sense, transactive memory theory postulates that each member of a team complements its individual declarative (know-that) and procedural memory (know-how) with information about who within the team is knowledgeable about what subjects (Wegner, 1987). This knowledge is called transactive memory and constitutes the basis on which the collaborative differentiation of responsibilities for knowledge work occurs in teams (Hollingshead, 2001). Teams that maintain systematized processes for encoding, remembering and retrieving task-relevant expertise based on their individual members’ transactive memory are said to become TMSs (Wegner et al., 1991; Ruke and Rao, 2000; Lewis, 2003, 2004). Teams that operate as TMSs allow individual members to continuously specialize in particular expertise domains while securing their collective access to the pool of information held by other members (Brandon and Hollingshead, 2004). This specialization reduces individuals’ cognitive load and ensures that the expertise available to the team is codified, stored and communicated by the most appropriate team members (Hollingshead, 1998). Access to each other’s knowledge and information is activated by TMS processes that assist the team in recombining the specialized expertise it requires to perform its task (Lewis et al., 2005). In this sense, TMSs constitute a powerful resource in that they accommodate and foster individual specialization without crippling the achievement of integration for task performance. In fact, TMSs have been repeatedly shown to benefit team performance in multiple settings (Moreland and Myaskovski, 2000; Austin, 2003; Rulke and Rao, 2000; Lewis, 2004).

2.3.2 – Transactive Memory and Knowledge Integration in Organizations

Transactive memory evolves over the course of a particular project (Lewis, 2004) and has been observed to remain operative even after disbandment of a particular team (Lewis et al, 2005). In this sense, transactive memory promotes learning at the organizational level as more people become aware of whom to go to for particular bits of knowledge and information (Austin, 2003). If increasing groups of people are able to generalize the usefulness of transactive memory
acquired in a particular project to other task demands, TMSs develop around more general organizational routines (Moreland and Argote, 2003). Although TMS researchers have recognized the presence of transactive memory beyond the task requirements of formal teams (Anand et al, 1998; Jackson and Koblas, 2008, Argote and Ren, 2012), empirical work has been limited (Peltokorpi, 2012). In this paper, we extend TMT to the context of expertise transfers occurring between organizational units. We contend that as departments work together to address matters requiring cross-functional collaboration people learn how to identify useful experts across functional boundaries. To the extent that they collectively develop processes for encoding, remembering and retrieving relevant cross-functional expertise, TMT can be extended from knowledge integration in teams to a theory of knowledge integration in organizations.

Whereas team TMSs are defined by the need to deliver on the mandate specifically afforded to the group, cross-functional TMSs require the type of commitment evoked by well-defined organizational tasks. In this sense, TMSs can be viewed as a property of how certain organizational tasks are performed (Moreland and Thompson, 2006). TMT predicts that the processes that underlie the emergence, development and maintenance of a TMS are more often elicited by complex and uncertain task requirements than by stable ones (Lewis and Herndon, 2011; Peltokorpi, 2012). For a TMS to emerge beyond the transient commitment to a formal team task, distinct groups of people have to be challenged by task demands that expose their expertise limitations. For a TMS to develop, task demands have to be sufficiently patterned for people to create a shared mental blueprint of where in the organization task relevant expertise can be found (Brandon and Hollingshead, 2004). For a TMS to be maintained, this blueprint has to be useful for recurrent task demands whose knowledge requirements fail to be addressed by other means. This shared blueprint maps the existence, location and means of retrieval of task-relevant information that is cross-functionally dispersed (Anand et al, 1998).

2.4 – Transactive Memory Systems and Glitch Mitigation

In this paper, we look into the effects of the emergence and maintenance of a TMS for the task of addressing OGs. As unexpected and unique events glitches cannot always be addressed by standard procedures. Nevertheless, their frequent occurrence makes it necessary to routinely find and implement cross-functional responses. In accordance with TMS literature, the operation of a TMS to deal with operational glitches implies three co-occurring manifestations (Moreland and Mayakovskiy, 2000; Lewis, 2003). Firstly, a TMS stimulates a differentiated structure of functional expertise regarding glitches. This means that distinct groups of people will possess unique specialized knowledge to deal with these unexpected events. Secondly, a TMS to respond to glitches implies that each organizational function trusts that the specialized knowledge possessed by the others is accurate, credible and useful for the focal task. Thirdly, a TMS is observed to be in operation when people in distinct organizational structures are able to effectively mobilize cross-functional expertise and information to address glitch-related problems. Organizations that possess a TMS to deal with unexpected deviations from production plans ensure that responsibilities are divided so that expertise codification, preservation and retrieval processes are deployed through the right groups of people. Codification processes identify, articulate and encode worthy pieces of glitch related experience. Preservation processes guarantee that information is adequately stored, whilst retrieval processes facilitate the recall and communication of the right information during glitch mitigation efforts. We contend that firms that develop a TMS around their glitch mitigation routines are in better conditions to elude the cooperation and coordination failures that result in EQFs.
A TMS restricts cooperation failures by operating on a shared partition of responsibilities regarding knowledge work for problem-solving. The salient nature of this partition makes it harder for employees to engage in shirking behaviors when OGs manifest themselves. The collective mental blueprint stimulated by a TMS reduces the ability of employees to claim ignorance on matters outside their immediate work roles. Furthermore, the mutual expectation of participation in expertise transfers processes makes opportunistic behaviors easier to curtail. If distinct groups of people in the organization acceptingly rely on each other’s knowledge to address the occurrence of OGs, there is less reason to be fearful of breeding disagreements across functional boundaries. In this sense, the existence of a TMS for glitch mitigation routines makes it less likely that problems are dismissed due to the inability in mobilizing cooperative efforts for cross-functional transfers of expertise.

**TMSs and Coordination Failures**

A TMS diminishes coordination failures in tackling operational glitches by creating shared understandings between differentiated functional structures (Fiol, 1994). As a consequence of discrepancies in experiences and expertise, functional structures tend to develop interpretative frameworks that are confined in nature (Jelinek and Schoonhoven 1990). Specialization endows different functions with opposing cognitive orientations (Lawrence and Lorsch, 1967), conflicting thought worlds (Dougherty, 1992) and localized practices (Sole and Edmondson, 2002). A TMS’s blueprint of who knows what creates overlaps between specialized stocks of functional knowledge and expertise, thus bolstering organizational efforts for joint-problem solving (Tortoriello et al., 2012). Shared understandings between departments increase the effectiveness of problem-solving activities, by engendering agreements about the nature of glitches and their prospective solutions (Bechky, 2003). The codification, storage and retrieval processes underlying TMSs assist distinct functions in sharing, integrating and reconfiguring non-redundant pieces of information and expertise (Grant, 1996). The re-combination of non-redundant pieces of information and expertise conduces to jointly generated solutions (Lovelace et al. 2001; Carlile 2004).

Field studies have provided ample indication that group outcomes consistently benefit from the coordination in the search and implementation of expertise afforded by a TMS (Faraj and Sproul, 2000; Hollingshead, 2000; Pelotokorpi, 2004; Agkun et al., 2005). A TMS activated by unanticipated situations enables distinct functions to access a larger pool of expertise domains, thus increasing the capacity the organization brings to bear on glitch responsiveness. It also secures the processes through which cross-functional knowledge transactions are adjustable to the inherently improvisational nature of problem-solving activities (Majchrzak et al., 2012). The awareness of where relevant information can be located promotes coordination in accordance with the specificities of particular glitches. By sharing an emergent cartography of where and how the right information can be retrieved, specialized functions can engage in more efficient and effective interaction processes through a reduction in disagreements and misunderstandings.

**TMSs and the relationship between OGs and EQFs**

TMSs create resilience to the occurrence of OGs by facilitating collaborative action in the cross-functional integration of information and expertise. They create resilience by empowering functions to remain specialized in circumscribed fields of expertise, without compromising integration effectiveness. Thus, they ensure that the informational content available for glitch mitigation is magnified, while remaining accurate. The codification, storage and retrieval
processes underlying the operation of a TMS generate the ability to swiftly leverage glitch related expertise dispersed throughout the organization. This ability assists firms in overcoming rigidities in internal cooperation and coordination processes that underlie the positive association between OGs and EQFs. By reaping the benefits of functional specialization while enjoying the advantages of a flexible and effective mutual adjustment mechanism (Thompson, 1967), organizations that activate a TMS should be more apt at solving the problems posed by unexpected glitches (Hargadon and Sutton, 1997). This paper contends that by making sure that organizationally dispersed information is efficiently recalled, communicated and integrated glitch mitigation is more successful in firms that are able to activate TMSs when dealing with unplanned situations.

Hence, we would expect that:

H2 – Firms that possess a TMS to cope with unexpected events alleviate the positive impact of OGs on EQFs more than firms who don’t.

3 – METHODS

3.1. Sample

This study is part of a research project about medium-sized enterprises (MEs) [We employ the definition of MEs put forward by the European Union: firms between 50 and 250 employees] in the industrial manufacturing industry in Italy and Spain. This industry employs over 3 million people around the continent and constitutes one of the most important manufacturing sectors in Europe (Johannson, 2008). We targeted this industry, because firms in it typically employ engineer-to-order strategies in order to cope with high variation in customers’ requests (Salvador et al, 2014). The inability of these types of firms to employ historically successful recipes to alleviate the complexities implied by product variety – such as, for instances mass customization (Pine, 1999) or configure-to-order (Salvador et al., 2014) production processes – makes them particularly vulnerable to the occurrence of OGs (Tenhiala and Ketokivi, 2012).

We delimited search criteria to 3 two-digit primary SIC codes (34, 35, 36) [In order to target a similar number of firms in both countries it was subsequently decided to include in the Spanish sample firms with the 35 code as secondary]. These categories cover the bulk of ME activity in industrial manufacturing in both countries. We targeted firms with a number of employees between 50 and 250. We excluded firms with less than 50 employees, because we wanted to study TMSs in a context substantively different from work teams. We considered that researching TMSs in small firms would make it hard to empirically distinguish the associated phenomena from team-level research. We also excluded firms that were geographically dispersed, in order to control for the communication idiosyncrasies inherent to multi-site organizations. Inserting these criteria into the Orbis Database identified 687 firms in Spain and 667 in Italy.

3.2. Data Collection

3.2.1. Primary data

3.2.1.1. Survey Design and Implementation

Following guidelines from Bogen (1996) we limited surveys to one page in order to reduce the burden of the respondent and increase response rate. We also attempted to minimize common
method variance by distributing dependent and independent variables across different informants. Likewise, we tried to maximize response accuracy by asking more than one respondent about certain firm characteristics. We developed four surveys per firm, customized to the Directors of the Marketing, Product Design, Manufacturing and Human Resources departments. Thus, we ensured that each of the respondents would provide information on the measures most likely under their responsibility. In terms of implementation, we contacted all sampled firms by telephone in order to explain the nature and scope of the study. After either the CEO or the Director of Human Resources agreed to collaborate, each participating firm received the four surveys through email. Depending on firms’ choices, responses were retrieved by either email or telephone. Only firms that retrieved all four surveys were considered for the study. We received complete responses (4 surveys) from 60 companies in Italy and 132 in Spain. The response rates were respectively 9% and 19%, which are in line with typical survey response rates (e.g. Braunscheidel and Suresh, 2009; Kristal et al., 2010). Table 1 presents the country and industry breakdown of the sample.

Table 1 Sample by country and industry

<table>
<thead>
<tr>
<th>Industry</th>
<th>Total</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Italy</td>
</tr>
<tr>
<td>Fabricated Metal Products (34)</td>
<td>28%</td>
<td>3%</td>
</tr>
<tr>
<td>Industrial and Commercial Machinery (35)</td>
<td>44%</td>
<td>28%</td>
</tr>
<tr>
<td>Electronic and Other Electric Equipment (36)</td>
<td>12%</td>
<td>1%</td>
</tr>
<tr>
<td>35 as secondary code</td>
<td>16%</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>32%</td>
</tr>
</tbody>
</table>

No statistical differences were found between email and phone respondents, in terms of size, financial performance (Profits, EBIT and Sales volume), and survey measures. Before the final analysis, 39 firms were removed from the sample for missing data in at least one of the focal variables of the study, yielding 153 usable surveys.

3.2.1.2. Non-response bias

We investigated non-response bias in two different ways. Firstly, given that all companies were initially contacted by phone, we were able to inquire on the reasons why participation in the study was declined. Issues related to time pressures were predominantly mentioned. Secondly,
we selected a random sample of 200 non-respondents and found no statistical differences between them and the participating firms on both financial performance and demographics.

3.2.2. Secondary Data

We collected secondary data from the Bureau Van Dijk’s Orbis Database, which provides coverage of financial information for private and public firms. This database offered information on firm-level performance data, size (number of employees) and contact information. In cases in which contact information proved to be erroneous, internet searches helped us retrieve the correct data.

3.3. Measures

3.3.1. Dependent Variable

The dependent variable for this study was external quality failures. EQFs refer to product problems experienced by customers. Following the quality literature, EQFs represent situations in which a product does not conform to pre-specified customer requirements (Dale et al, 2007). The construct was measured by the survey item: % of orders delivered in which customers detect quality problems. The respondent for this item was the Director of the Sales Department, for it was considered to be the organizational actor more likely to possess a close relationship to customers and, therefore, be informed about their complaints.

3.3.2. Independent Variables

3.3.2.1. Operational Glitches

OGs correspond to deviations from plans in production processes and represent non-conformities between expected outcomes and achieved outcomes (Rauniar et al., 2008; Koufteros et al., 2010). In most manufacturing settings, OGs are a frequent occurrence during final inspection activities. The Director of the Manufacturing Department reported on the % of orders in which quality problems are detected during production or before shipment. Furthermore, in the context of industrial equipment manufacturing OGs also frequently manifest themselves in the form of errors in product documentation, such as bills of materials, production sequences or assembly guidelines (Jiao et al, 2000). These glitches typically manifest mistakes in the product design stage. Thus, we asked the Director of the Product Design or Engineering Department to report on the % of orders in which errors are detected in product documentation during production phase. Change orders represent a further source of deviations from initially laid plans in this industrial setting. Change orders reflect modifications in customers’ specifications during order fulfillment (Uskonen and Tenhiala, 2014). We asked the Director of the Sales Department for the % of customer orders that undergo modifications in product specifications in relation to what was originally agreed upon during order entry. The OG construct was measured with these 3 survey items. We conducted a Principal Component Analysis in order to extract one component to insert in the regression analyses. This component accounted for 55.2% of the items’ variance.

3.3.2.1. Transactive Memory System (for dealing with deviations from initial manufacturing plans)

Empirical research at the team-level has posited that the existence and operation of a TMS can be discerned from three co-occurring manifestations, together reflecting the scattered yet
cooperative nature of information exchanges characteristic of a TMS (Moreland and Mayakovksy, 2000). A TMS exists when encoding, storage and retrieval processes ensure the coordination of distributed, yet pertinent, informational domains. According to team-level literature (Liang et al., 1995), a TMS is reflected by the collection of behaviors that produce specialization, credibility and coordination of information. Thus, a TMS for coping with unplanned events in production should be inferred from multiple functions specializing in complementary relevant information domains, granting credibility to each other’s expertise and coordinating that expertise in the performance of that task. Specialization reflects the existence of functionally differentiated cognitive responsibilities when facing unplanned events. Credibility refers to the general confidence characterizing cross-functional expertise transactions. Coordination, in turn, manifests the integration effectiveness of dispersed informational domains in dealing with the unexpected. The full measurement model represents TMS as second-order factor composed by three first-order factors each of which reflective of the specialization, credibility and coordination characterizing the performance of the focal task within the organization. Survey items were adapted from the scale developed in Lewis (2003) for measuring team-level TMSs. This scale has been used in the large majority of TMS field studies published since (for a review, see Ren and Argote, 2012). The wording of the items, loadings and scale reliability can be found in the appendix. The items are not formulated in the first person, precisely because the respondent is reporting on practices and behaviors that serve as representation of aggregated individual agencies. The respondent was the Director of the Manufacturing Department.

3.3.3. Control Variables

The study employed several control variables. Given that the dependent variable is EQFs, the study controls for factors that may impact quality failures, but remain outside the scope of this research.

3.3.3.1 Confounding Effects

In order to isolate the effect of both OGs and TMSs on EQFs, we use control variables for possible confounding effects. All items can be found in Table 3 (see appendix). Past research has argued and shown that the occurrence of OGs is more likely to occur in high engineer-to-order environments (Haug et al., 2011; Tenhiala and Ketokivi, 2012). Hence, we control for the incidence of engineer-to-order activities. The respondents for this item were the Directors of Sales, Engineering and Production. We averaged the responses of the 3 after having checked that the intra class correlation coefficient is above 0.9, thus indicating a high level or interrater reliability.

Research has equally evidenced that incentives for cross-functional cooperative behaviors might impact the degree to which mistakes get fixed (Kretschmer and Puranam, 2008). Organizations in which individual recognition and compensation is more dependent on collective action are more likely to collaborate to successfully correct glitches. We define cooperation incentives as the extent to which different organizational members’ individual goals and rewards are interrelated with each other. This construct was measured using Campion et al.’s (1993) scales for goal and reward interdependence. The respondent was the director of Human Resources.

Correcting glitches benefits from the integration of cross-functionally dispersed information. Following contingency theories assertions (Lawrence and Lorsch, 1967; Thompson, 2003),
formal coordination mechanisms facilitate the management of information processing across functional boundaries (Daft and Lengel, 1986). In order to more aptly isolate the impact of TMSs on EQFs, we control for the extent of use of cross-functional teams (task forces), permanent interdepartmental committees and managerial integrator positions. We asked the Director of Human Resources to rate the frequency of use of each of these coordination mechanisms using a 5-point Likert scale ranging from 1 = never, 3 = sometimes, to 5 = always. We then conducted a principal component analysis and used the obtained variable in the analysis as control. This component explained 67.2% of the variance of the underlying variables.

Finally, we also controlled for firm size. Previous research evidences that size can explain variation in firm’s operational performance for it is often associated with the existence of more slack resources (Tan and Peng, 2003). More specifically, size has been shown to influence the level of EQFs (Ahire and Dreyfus, 2000). We control for the effect of size operationalized as the number of employees active in the firm. This information was collected from the Orbys Database.

### 3.3.3.2. Industry and country dummies

We employed three industry dummies (SIC codes for Fabricated Metal Products, Electronic and Other Electric Equipment and Industrial and Commercial Machinery as secondary code. Industrial and Commercial Machinery is the reference category. This served to account for industry-related factors in the analysis of firm performance. Likewise, we also employed a country dummy to control for unobservable heterogeneity due to country-specific factors.

### 4 – RESULTS

#### 4.1 – Measurement Properties

Confirmatory factor analysis (CFA) implemented in MPLUS (version6) was employed to evaluate construct validity and reliability (Bollen, 1989). The fit of the CFA for the TMS construct is in accordance with good fit levels ($\chi^2 = 48.96; df = 32; p-value = 0.03; \chi^2/df = 1.5; CFI = 0.96; RMSEA = 0.05; SRMR = 0.05$). Unidimensionality and convergent validity are supported, given that each indicator is significantly associated with its latent construct and each of the three first-order constructs are significantly associated with the TMS construct (loadings and significance levels in Table 2).

The cooperation incentives construct (loadings and significance levels in appendix) also makes use of a previously validated scale, namely Campion et al’s scale for goal and reward interdependence within an organization. Given that our goal was to control for the existence of firm incentives for cooperation we used all six items of the scale in one single construct. The fit of the CFA for this construct was equally adequate ($\chi^2 = 12.51; df = 8; p-value = 0.13; \chi^2/df = 1.5; CFI = 0.98; RMSEA = 0.05; SRMR = 0.04$).
<table>
<thead>
<tr>
<th>Construct</th>
<th>Standardized loadings</th>
<th>t-Value</th>
<th>Composite reliability</th>
<th>Average variance extracted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialization</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S1</td>
<td>0.52</td>
<td>***</td>
<td>4.84</td>
<td>0.77</td>
</tr>
<tr>
<td>S2</td>
<td>0.61</td>
<td>***</td>
<td>7.01</td>
<td></td>
</tr>
<tr>
<td>S3+</td>
<td>0.34</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>S4</td>
<td>0.67</td>
<td>***</td>
<td>10.34</td>
<td></td>
</tr>
<tr>
<td>S5</td>
<td>0.58</td>
<td>***</td>
<td>6.46</td>
<td></td>
</tr>
<tr>
<td>Credibility</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>0.74</td>
<td>***</td>
<td>13.93</td>
<td>0.82</td>
</tr>
<tr>
<td>C2</td>
<td>0.83</td>
<td>***</td>
<td>17.76</td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td>0.82</td>
<td>***</td>
<td>20.98</td>
<td></td>
</tr>
<tr>
<td>C4+</td>
<td>-0.1</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>C5+</td>
<td>0.3</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Coordination</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO1</td>
<td>0.74</td>
<td>***</td>
<td>9.33</td>
<td>0.83</td>
</tr>
<tr>
<td>CO2</td>
<td>0.51</td>
<td>***</td>
<td>4.27</td>
<td></td>
</tr>
<tr>
<td>CO3+</td>
<td>0.33</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>CO4</td>
<td>0.64</td>
<td>***</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>CO5+</td>
<td>0.42</td>
<td>-</td>
<td>8.17</td>
<td></td>
</tr>
<tr>
<td>TMS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialization</td>
<td>0.70</td>
<td>***</td>
<td>7.73</td>
<td>0.81</td>
</tr>
<tr>
<td>Credibility</td>
<td>0.96</td>
<td>***</td>
<td>12.07</td>
<td></td>
</tr>
</tbody>
</table>
Overall model fit statistics: ($\chi^2 = 48.964; df = 32; \chi^2/df = 1.53; p = 0.03; CFI = 0.96; TLI = 0.95; RSMEA = 0.05$).

In order to assess discriminant validity, we inspected the correlation table among all research variables. As we can see from table 4, there are no high correlations between any constructs. We have also tested the discriminant validity between our two latent variables by first allowing them to freely correlate and then fixing their correlation to 1. The fact that the chi-square difference between the two models is significant is indication of discriminant validity (Bagozzi et al., 1991).

Reliability was assessed through the average variance extracted (AVE) and composite reliability statistics (Williams et al, 2003). All AVE values are equal to or above 0.5 and all composite reliability values are equal to or above 0.7 (see appendix), indicating adequate levels of construct reliability (Fornell and Larcker, 1981).

4.2 – Analytic Approach

Given that the two models implied by H1 and H2 are nested, we opted to conduct an hierarchical regression analysis. In the first step we enter the control variables (model1). Next, the principal component representing operational glitches is entered to test H1 (Model 2). In the final step, we enter TMS to test the moderation effect hypothesized in H2 (model3).

4.3 – Results

Table 4 presents means, standards deviations and Pearson correlations between all the variables employed in the study. As can be observed, EQFs are significantly and highly correlated with the component representing OGs. In line with previous research, the incidence of ETO activities is also shown to correlate significantly and positively with the quantity of EQFs.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>St.Deviation</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-TMS</td>
<td>0</td>
<td>0.32</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-EQFs</td>
<td>5.9</td>
<td>14.5</td>
<td>-0.06</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-OGs</td>
<td>0</td>
<td>1</td>
<td>-0.10</td>
<td>0.61***</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-CI</td>
<td>0</td>
<td>0.5</td>
<td>0.39***</td>
<td>-0.02</td>
<td>-0.12</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-FCM</td>
<td>0</td>
<td>1</td>
<td>0.04</td>
<td>-0.05</td>
<td>0.02</td>
<td>0.12*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-SIZE</td>
<td>109.5</td>
<td>64.8</td>
<td>0.09</td>
<td>0.03</td>
<td>0.03</td>
<td>0.11</td>
<td>0.01</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>7-ETO</td>
<td>40.3</td>
<td>36.2</td>
<td>0.09</td>
<td>0.15**</td>
<td>0.46**</td>
<td>-0.07</td>
<td>0.07</td>
<td>0.02</td>
<td>1</td>
</tr>
</tbody>
</table>

* p < 0.10, ** p < 0.05, *** p < 0.01
Table 5 presents the 3 models that helped to test the hypotheses postulated in the study. The analysis of control variables reveals that firms that have to engage in higher levels of ETO activities generate more EQFs (model1). Likewise, this model evidences that firms operating in the electronic and other electric equipment sub-industry (SIC36) have a lower incidence of EQFs than the ones in the industrial and commercial machinery (SIC35). The other controls do not have a significant first-order effect at the 5% level.

Model 2 evidences support for H1. As hypothesized, Operational glitches are shown to have a significant and positive impact (0.7, p < 0.01) on EQFs. This result suggests that firms that face a greater number of operational problems deliver more products with quality shortcomings. This model has a good explanatory value (R-square = 55%) and represents a significant explanatory improvement from model1.

Model 3 lends support to H2. As can be observed, the interaction term, is negative and significant, meaning that TMS moderates the effect of OGs on EQFs, i.e. organizations whose manufacturing departments take part of a TMS to deal with unexpected problems manage to mitigate the positive relationship between OGs and EQFs. As is shown in the last column of Table 5, the addition of the interaction term brings about a 4 percentage points significant change in the model's explanatory power.

Table 5 Regression Results

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperation Incentives</td>
<td>-0.06</td>
<td>0.03</td>
<td>0.05</td>
</tr>
<tr>
<td>Formal Coordination</td>
<td>-0.02</td>
<td>-0.07</td>
<td>-0.07</td>
</tr>
<tr>
<td>Mechanisms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ETO</td>
<td>0.14*</td>
<td>-0.2</td>
<td>-0.17</td>
</tr>
<tr>
<td>SIZE</td>
<td>0.07</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Country</td>
<td>0.19*</td>
<td>0.1</td>
<td>0.07</td>
</tr>
<tr>
<td>SIC Code 34</td>
<td>-2.1*</td>
<td>-0.07</td>
<td>-0.05</td>
</tr>
<tr>
<td>SIC Code 36</td>
<td>-2.1**</td>
<td>-0.17**</td>
<td>-0.13*</td>
</tr>
<tr>
<td>SIC Code 35 as secondary</td>
<td>-0.08</td>
<td>-0.03</td>
<td>0.5</td>
</tr>
<tr>
<td>OGs</td>
<td>–</td>
<td>0.7***</td>
<td>0.7***</td>
</tr>
<tr>
<td>TMS</td>
<td>–</td>
<td>–</td>
<td>-0.04</td>
</tr>
<tr>
<td>OGs*TMS</td>
<td>–</td>
<td>–</td>
<td>-0.19***</td>
</tr>
<tr>
<td>Adjusted R-square</td>
<td>0.07</td>
<td>0.45</td>
<td>0.48</td>
</tr>
</tbody>
</table>
R-square | 0.07 | 0.48 | 0.52
Delta R-square | – | 0.41*** | 0.04***
F-Value | 1.3 | 14.7 | 15.75

* p < 0.10, ** p < 0.05, *** p < 0.01

Figure 1 displays interaction plots of the relationship between OGs and EQFs across 2 levels of TMS. As can be inspected from this figure, firms that possess a more developed TMS are able to weaken the association between internal glitches and EQFs.

**Figure 1 Interaction Plot**

4.4 – Robustness Check

In addition to the analyses above reported, we conducted path analysis with structural equation modeling (SEM) as a robustness check for our results. Following guidelines from Bollen (1989), we ran two structural models with TMS as a second-order latent variable. The first one modeled the mains effects, whereas the second one introduced the interaction between OGs and TMS. The latter model revealed improved fit in terms of AIC and BIC indexes. Given that the two models are nested, we also conducted a likelihood-ratio test. The likelihood-ratio statistic was equal to 18.8 with 1 degree of freedom (p-value <0.0001). Hence, our moderation hypothesis is supported in the context of SEM (see Table 8 in appendix).
4.5 – Post-hoc Analyses

4.5.1 - Breaking Down Glitches

Our independent variable was a composite measure of three different types of deviations from planned production processes. In that sense, after we had confirmed the worth of TMS as a moderating effect on the association between OGs and EQFs, we decided to replicate the analysis breaking down our independent variable into its individual constituents. The results of that analysis are summarized in Table 6 (in appendix). In short, we notice that design generated glitches have the strongest association with EQFs and that change orders do not seem to have a significant impact on external failures (see also figure 2 in appendix). This could be an indication that errors committed at the product design stage are the most complicated to resolve, because their solution might require a complex combination of “upstream” customer knowledge and “downstream” manufacturing knowledge. Table 6 also presents the moderating effect of TMS on the different types of glitches. Noticing that TMS has the strongest moderating impact on this type of glitches constitutes further suggestion that their solution strongly benefits from the integration of functionally-dispersed knowledge. The fact that TMS does not seem to moderate the impact of change orders on EQFs at all also provides indirect evidence. Change orders are oftentimes managed in high interaction with customers (Tehiniala and Ketokivi, 2012), whereas in our study a TMS for glitch mitigation is geared towards internal interaction, not supply-chain ones.

4.5.2 – Breaking down TMS Components

As conjectured by transactive memory theory scholars (Moreland and Mayakovsky, 2000; Lewis, 2003), a TMS for a given task or set of tasks is reflected by the co-occurrence of specialization, credibility and coordination. In order to tease out whether any of these components had a particularly important effect for glitch mitigation, we also decided to analyze them individually. Table 7 (in appendix) presents the results. Of all the three components, specialization is the one with the strongest moderation effect. In this context, specialization means that the organization possesses differentiated glitch mitigation expertise disseminated throughout multiple functions. The fact that this element in and of itself assists organizations in alleviating the association between OGs and EQFs serves as testament to the lasting validity of organizational theoretic notions regarding the value of specialized knowledge (Lawrence and Lorsch, 1967; Thomson, 1967). Glitches can be quite unique events that affect distinct functions differently and, accordingly, mobilize glitch mitigation efforts with differing strength. In cases in which cross-functional knowledge transactions are less relevant in that a particular glitch mostly distresses a single function, credibility and coordination are hardly necessary. Specialized glitch mitigation knowledge, however, is always necessary as part of a glitch mitigation capability.

5 – DISCUSSION

This study contributes to a more complete understanding of how firms can alleviate the impact of deviations from pre-established order-fulfillment plans on quality failures experienced by customers. In summary, our results indicate that organizations in which manufacturing takes active part in a cross-functional TMS for glitch mitigation are more likely to weaken the effect of OGs on EQFs. Our post-hoc analyses further signal that TMS has the strongest moderation effect when it comes to design-related glitches, but that it does not seem to mitigate the impact of change orders on EQFs.
5.1 – Implications for Glitch Mitigation Research

The emerging literature on glitch mitigation focuses on the capabilities that firms must develop to respond and prove resilient to the occurrence of operational disruptions (Craighead et al, 2007). Our study contributes to research on glitch mitigation capabilities and organizational resilience in three ways. Firstly, following Tehniala and Salvador (2014), it departs from the emphasis of extant research on catastrophic events (e.g. Craft et al., 2005; Kleindorfer and Saad, 2005; Majchrzak et al., 2007; Knemeyer et al., 2009) by examining the role of TMSs in the context of routinely occurring OGs. Secondly, the study presents an alternative outlook to the prevailing focus on supply chain-level analyses (Tomlin, 2006; Craighead et al., 2007; Braunscheidel and Suresh, 2009) by focusing on glitch-mitigation practices that take place within the firm. Thirdly and most importantly, our study responds to calls for more fine-grained research on glitch mitigation capabilities (Craighead et al. 2007; Blackhurst et al, 2011). Past studies have pointed to the importance of agility in generating resilience to disruptions (Swafford et al., 2006; Braunscheidel and Suresh, 2009) without providing specific insights into what sort of practices help firms to be agile in recovering from the occurrence of OGs and preventing the incidence of EQFs. This literature stream highlights the importance of having flexible manufacturing processes (Tang and Tomlin, 2008), because they are more adaptable to unplanned requirements and better allow firms to be responsive to disruptive events. Literature has also stressed the need to involve multiple functional structures in an integrated effort to overcome deviations from plans (Hoopes and Postrel, 1999; Braunscheidel and Suresh, 2009). Involvement of distinct functions is thought to secure access to a wide pool of expertise and information domains and bring more capacity to bear on organizational problem-solving activities. Glitch mitigation research also advances that the ability to reconfigure existing organizational resources is more valuable than acquiring new resources when reaction speed is critical (Bode et al., 2011; Ambulkar et al., 2015). If faced with OGs, firms have to make due with organizationally dispersed resources at their immediate disposal. Finally, glitch mitigation is also expected to be more effective when productions processes are endowed with slack, such as excess capacity or inventory buffers (Sheffi and Rice, 2005; Hendricks et al, 2009). In evidencing the glitch mitigation effect of TMSs, our paper elaborates on how these capabilities can be achieved to conduce to more agile and resilient organizations.

Our results suggest that a cross-functional TMS for glitch mitigation enables flexibility in manufacturing processes in that they provide an emergent knowledge sharing mechanism capable of accommodating the unique requirements posed by distinct OGs. By maintaining a collective blueprint of where relevant expertise is located in the organization and how it can be retrieved, TMSs also facilitate the timely access to organizational dispersed knowledge resources. The processes of expertise retrieval that characterize a TMS help ensure that the groups directly responsible for glitch mitigation activities are utilizing a wide pool of existing internal capabilities, thus increasing the likelihood of adequate solutions being generated. Furthermore, TMSs also provide organizations with a measure of slack to the extent that transactive memory affords glitch mitigation routines with redundant capacity to address any given OG. In this sense, our study offers a better understanding of the practices that underlie glitch mitigation capabilities. The broader relevance of our findings is that they shed light on how firms can become able to integrate specialized knowledge resources to respond to everyday glitches that are too unique to be effectively handled by formal coordination mechanisms and too recurring and consequential to remain unaddressed. This paper complements the glitch mitigation literature by offering an explanation of how manufacturing firms can overcome the inherent obstacles posed by specialization to create effective levels of common knowledge and
shared understandings. The maintenance of a collective directory of expertise location reduces the need for individual functions to be permeated by others functions’ interpretative frameworks or to be proficient on outside knowledge domains. In this sense, a TMS facilitates integrated problem-solving by lowering the requirements for cross-functional knowledge overlaps that are hard and costly to achieve. The fact that our post-hoc analysis indicate that a TMS is most effective in tackling design related OGs constitutes evidence that they are particularly apt for dealing with interdependencies between multiple functional specialties. While customer change orders and problems identified in final inspection are likely to be resolved with interactions between sales and engineering or sales and manufacturing, glitches at the design stage can potentially imply the concurrent reconsideration of customer requirements, technical constraints and manufacturing capabilities. Thus, there is good reason to believe that developing and maintaining a TMS constitutes an important component of a glitch mitigation capability that is able to circumvent collaboration failures in recovering from OGs. To the best of our knowledge, this is the first study to investigate the effects of TMSs on organizational resilience.

5.2 – Implications for managers

The immediate implication of our results is that managers should engage in the active development of transactive memory processes. Our results show that the average firm in our sample would reduce the association between OGs and the incidence of EQFs if it develops a properly working TMS to deal with unexpected situations. Our post-hoc analysis indicate that the average firm with an average number of glitches detected during final inspection would reduce the incidence of EQFs by 13% if it went from a low to a high level of TMS. The equivalent effect is even greater in the case of design-related glitches in which the reduction of EQFs would reach 20%. Given the detrimental effects EQFs have on customer satisfaction and profitability these constitute important reductions. Even though creating and maintaining a cross-functional directory of glitch-relevant expertise might not be a trivial task – considering that research on organizational TMS antecedents is still in its infancy – our results clearly indicate that firms with more developed TMSs are able to achieve a superior glitch mitigation capability. Extant TMS research on work teams establishes personal familiarity (Agkun et al., 2005; Lewis 2004) and frequency of communication (Peltokorpi and Manka, 2008; Jackson and Moreland, 2009) as underlying more developed TMS. In the context of small groups these tend to be trivial aspects; in the context of larger organizations managers would do well to devise mechanisms that increase familiarity and communication across functions. In particular, managers would do well to devise training programs on efforts to make individual competences salient and easy to recognize. In this sense, traditional team-building exercises should start placing less attention on the development of interpersonal trust and more on the ability to match competences to particular individuals. Likewise, efforts to create formal boundary-spanning structures to deal with recurring but unique events such as OGs should be evaluated against the alternatives that benefit the development of a TMS, because the latter tend to be more flexible and adapted than the former. Finally, TMS research has also highlighted the sensitivity of these systems of differentiated expertise to instability in group membership (Moreland and Argote, 2000; Miller et al, 2012). This means that managers should consider the potential effects of hiring and firing large numbers of people on existing TMSs for glitch mitigation.

5.3. Limitations and Future Research

Our study has a number of limitations. First, our cross-functional research design cannot establish causal links between the studied variables. To do so, future research should conduct longitudinal studies on the development of TMSs and its relationship with glitch mitigation. We
have also investigated our claims in the glitch prone context of industrial equipment manufacturing (Haug et al, 2011). In this sense, some of our findings may be context-bound to manufacturing settings which employ engineer-to-order strategies in order to cope with high variation in customers’ requests (Salvador et al, 2014) and in which operational glitches constitute a recurring concern. It would be interesting to check whether our results replicate in firms that employ other historically successful recipes to alleviate the complexities implied by product variety – such as, for instances mass customization (Pine, 1999) or configure-to-order (Salvador et al., 2014) production processes.

Besides the above extensions, which stem from the limitations of the study, future studies could also explore organizational factors that stimulate the development of TMSs around the response to unexpected events, thus further integrating TMS theory with glitch mitigation literature. It could be specifically worthwhile to examine whether TMS could develop across organizations in the same supply-chain. Such studies would be able to establish whether a link between the supply chains’ TMSs and supply chain resilience to glitches exists or not.

**APPENDIX**

**Table 3 Survey Items**

<table>
<thead>
<tr>
<th>ITEMS</th>
<th>RESPONDENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialization</td>
<td>Head of Manufacturing</td>
</tr>
<tr>
<td><strong>During situations in which the original manufacturing plans cannot be executed (due to technical problems, changes in customer requests, etc.):</strong></td>
<td></td>
</tr>
<tr>
<td>S1</td>
<td>The specialized knowledge of several different departments is needed</td>
</tr>
<tr>
<td>S2</td>
<td>Each department has specialized knowledge of some relevant aspect to perform these activities</td>
</tr>
<tr>
<td>S3</td>
<td>Manufacturing personnel has knowledge that no other department has*</td>
</tr>
<tr>
<td>S4</td>
<td>Different departments are responsible for expertise in different aspects</td>
</tr>
<tr>
<td>S5</td>
<td>Manufacturing personnel know which departments have expertise in specific areas</td>
</tr>
<tr>
<td>Credibility</td>
<td></td>
</tr>
<tr>
<td><strong>During situations in which the original manufacturing plans cannot be executed (due to technical problems, changes in customer requests, etc.):</strong></td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>Manufacturing personnel are comfortable accepting procedural suggestions from other departments</td>
</tr>
<tr>
<td>C2</td>
<td>Manufacturing personnel trust that other departments’ knowledge is credible</td>
</tr>
<tr>
<td>C3</td>
<td>Manufacturing personnel are confident in relying on the information that other departments bring to discussion</td>
</tr>
</tbody>
</table>

* Not included in final analysis.
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C4</td>
<td>When other departments give information, manufacturing personnel double-checks it.</td>
<td></td>
</tr>
<tr>
<td>C5</td>
<td>Manufacturing personnel do not have much faith in other departments’ expertise.</td>
<td></td>
</tr>
</tbody>
</table>

**Coordination**

*During situations in which the original manufacturing plans cannot be executed (due to technical problems, changes in customer requests, etc.):*

| CO1 | People from several areas work together in a well-coordinated fashion. |
| CO2 | People from several areas have very few misunderstandings about what to do. |
| CO3 | People from several areas have to backtrack and start over a lot. |
| CO4 | People from several areas accomplish these activities smoothly and efficiently. |
| CO5 | There is much confusion about how to accomplish these activities. |

**External Quality Failures**

**Head of Sales**

| EQF | Please indicate the % of orders delivered in which customers detect quality problems. |

**Operational Glitches**

**Head of Sales**

| OG1 | % of customer orders that undergo modifications in product specifications in relation to what was originally agreed upon during order entry? |

**Head of Design**

| OG2 | Please indicate the % of orders in which errors are detected in product documentation (bills of materials, production sequences, etc.) during production phase. |

**Head of Manufacturing**

| OG3 | Please indicate the % of orders in which quality problems are detected during production or before shipment. |

**Cooperation Incentives**

**Head of Human Resources**

| CI1 | Managerial work goals come directly from the goals of the company. |
| CI2 | Managerial work activities in any given day are determined by the company’s goals for that day. |
| CI3 | Managers do very few activities on the job that are not directed to the goals of the company. |
| CI4 | Feedback about how managers are doing comes primarily from information about how well the entire company is doing. |
| CI5 | Managerial performance evaluation is strongly influenced by how well the organization performs. |
| CI6 | Many rewards for managerial jobs (e.g. pay, promotion, etc.) are determined in large part by |
Cotta, Salvador et al  

The Association between Glitches and External Quality Failures

<table>
<thead>
<tr>
<th>Formal Coordination Mechanisms</th>
<th>Head of Human Resources</th>
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<tbody>
<tr>
<td><strong>FCM1</strong> Interdepartmental committees</td>
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<td><strong>FCM2</strong> Task forces (temporary bodies set up to facilitate interdepartmental collaboration on a specific project)</td>
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<tr>
<td><strong>FCM3</strong> Liaison personnel with the job of coordinating the efforts of several departments for the purposes of a project</td>
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<tr>
<td>Percentage of engineered-to-order products</td>
<td>Heads of Sales, Design and Manufacturing</td>
</tr>
<tr>
<td><strong>ETO</strong> % of customer orders that require engineer-to-order activities (design modifications are needed to meet customer specifications)</td>
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<th>Table 6 Post-Hoc – Glitch Breakdown (regression coefficients)</th>
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<td>Change orders</td>
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<tr>
<td><strong>EQFs</strong></td>
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<tr>
<td>Change orders*TMS</td>
</tr>
<tr>
<td>n.s.</td>
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</tbody>
</table>

n.s. – non significant, ** p < 0.05, *** p < 0.01

Main effects coefficients are left unstandardized for ease of interpretation.

<table>
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<tr>
<th>Table 7 Post-hoc – TMS breakdown (regression standardized coefficients)</th>
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<tbody>
<tr>
<td>Specialization*OGs</td>
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<td><strong>EQFs</strong></td>
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** p < 0.05, *** p < 0.01

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<th>Table 8 Robustness check – model comparison SEM</th>
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<td>AIC</td>
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<td>Main effects model</td>
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<td>Interaction model</td>
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Log likelihood difference test with 1df: p<0,001
Figure 2 Post-hoc – glitch breakdown, main effects
Figure 3 Post-hoc – interaction plots, glitch breakdown
Figure 4 Post hoc – TMS breakdown
REFERENCES


