TECHNOLOGY MANAGEMENT IN CENTRAL AMERICAN MAQUILAS

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ABSTRACT

This study of four individuals managing technology transfer, implementation, and support in the Central American manufacturing facilities of US multinational corporations provides empirical support for five of six daily technology management activities (Acquisition, Exploitation, Identification, Learning, Protection, and Selection) suggested by Cetindamar, Phaal, and Probert (2016). The technology managers accomplished their jobs through communication and learning activities as multilingual boundary spanners in the interorganizational network by facilitating the transfer of tacit, explicit, and codified knowledge. As repositories of special information in the organization's transactive memory system, they exercised referent and expert power making them more influential than one would expect based on their position in the global organizational hierarchy.

INTRODUCTION

Although technology management has become a traditional business subject and recognized as an essential component of strategic planning for decades (e.g., Bursic, & Cleland, 1991), the literature is rather limited in the area of the people who are responsible for the management of technology and technology management education (Cetindamar, Phaal, & Probert, 2016; Gudanowska, 2017). The increasing use of computer and robotic technologies on the manufacturing shop floor has significantly reduced the dependence on traditional worker skills in many industries. However, the increased use of technology increased the need for skilled technicians and technically oriented managers to support and manage the technology in the modern manufacturing firm. Concurrent with these technological advancements, neoliberal trade policies, usually in the form of trade agreements such as the 1983 Caribbean Basin Initiative (CBI) now DR-CAFTA, and the 1994 North American Free Trade Agreement (NAFTA), facilitated the shift of manufacturing to many low wage nations.

Initially, the significant difference in wages in industrialized nations versus lesser-developed nations allowed manufacturing firms to use labor-intensive processes and avoid investment in state-of-the-art technology for offshore factories. However, in the global economy of the twenty-first century where manufacturing in low wage countries is now the norm, low wage labor alone no longer provides a sustainable competitive advantage for manufacturing firms. In terms of productivity, manufacturing facilities in low wage nations must meet or exceed global benchmarks, "Low labor productivity endangers the company's survival" and "low labor costs no longer give enough of a cost advantage to offset low labor productivity" (Drucker, 1999, p. 61). The implications in developing nations is that comparative advantage requires a combination of lower-cost and technological edge (Sharif, 1997); therefore, all manufacturing plants must implement cutting edge technology to obtain "productivity equal to that of the world's leaders in a given industry" (Drucker, 1999, p. 62). This also holds true for the Latin American maquila industry (Mital, Girdhar, & Mital, 2002). However, "effective management of

globally dispersed project teams involves a complex set of variables" (Thamhain, 2011, p. 35) and even intra-company transfers of technology are seldom efficient and differences in knowledge backgrounds, competency levels, language, and skills are factors in multi-national enterprises (Malik, & Bergfeld, 2015).

Although researchers pointed out the importance of incorporating manufacturing strategy in to corporate strategy decades ago (e.g., Hill & Still, 1980; Skinner, 1969, 1985; Wheelwright, 1978, 1984), corporate strategy is still predominately based on marketing decisions and manufacturing is forced to react at the backend of the process (Hill & Hill, 2009). This places additional burdens on the technology manager (TM) because "technology is a primary cause of change….technology managers must be able to forecast and assess technological change to obtain competitive advantage" (Roper et al., 2011, p. 1). As a result, while marketing may drive the strategy at the beginning of the process, implementing the strategy in the operational phase requires the TM to quickly identify, acquire, and implement the appropriate technologies. Given that global manufacturing strategies often include co-production across multiple facilities, management of intrafirm technology transfer is of increased strategic importance (Malik, 2002). This indicates that language and communication skills would be a key factor in a TM's successful execution of their duties. Regardless of whether a TM's input is part of the front end of strategic planning or during the back-end operationalization, it is apparent that the TMs play a key role in the success of any multinational manufacturing firm. Obviously, technology transfer is a long-term competence and someone must coordinate the development and implementation of technological capabilities in order to shape and accomplish the strategic and operational objectives of an organization (Cetindamar et al., 2016, 2009; Malik, & Bergfeld, 2015).

The number of technology management, management of technology, engineering management, and engineering technology degree programs in the US has increased in recent years. A cursory Internet search reveals well over 100 easily identifiable degree programs at the associate, bachelor, masters, and doctoral levels, offered at higher education institutions ranging from community colleges to Tier 1 land grant research universities. Despite this increased interest on the part of academia to develop competent TMs, the extant literature provides little insight about what TMs actually do (Cetindamar et al., 2016; Minty, 2003) and the interactive nature of intra-company technology transfer (Malik, & Bergfeld, 2015).

This study provides a valuable contribution to the literature by using field research, as suggested by Meredith (1998), to understand the work of TMs in the off-shore factories of publicly traded US multinational manufacturing firms through direct observation of the tasks they perform. These observations of "the people who actually work in the area in their daily life", as suggested by Cetindamar et al. (2016, p. 10), provide empirical support for five of six specific activities/capabilities that Cetindamar et al. (2016) suggest TMs exercise in their daily work. These TMs engaged in *acquisition* through purchases, collaboration with suppliers, and in some instances, internal development. *Exploitation* was the most obvious activity and it took place through technology implementation, operation, and ongoing support in the factory. *Learning*, *identification,* and *selection* were omnipresent and overlapping as the TMs were routinely called on to seek out information, usually in English and then transfer it into the organization through translation to Spanish, identify solutions for a wide range of needs, gather data to report to management on ongoing projects, and to inform themselves and provide recommendations for technology implementations needed to support the organization's strategic goals. However, *protection* was not a commonly observed activity because these TMs were not

involved in obtaining patents and intellectual property protection and employee retention to protect trade secrets was not a frequent issue in the manufacturing facilities where they worked.

LITERATURE REVIEW

A popular definition of technology management combines Fayol's (1949) commonly cited management processes of planning, directing, controlling, and coordinating with developing and implementing technological capabilities to accomplish strategic and operational objectives (National Research Council, 1987). This definition combines the hard aspects of technology with the softer dimensions related to the management aspects (Phaal, Farrukh, & Probert, 2004); "however, it does not make explicit distinction between technical and managerial issues associated with TM and is a rather static definition" (Cetindamar, Phaal, & Probert, 2009). While the literature contains countless studies that highlight the importance of managing technology to create and maintain competitive advantage, the vast majority of empirical research is at the firm or industry level and provides suggestions, models, frameworks, or identifies obstacles in the area of technology transfer and technology management (e.g., Bommer, Janaro, & Luper, 1991; Gilbert & Cordey-Hayes, 1996; Jensen & Szulanski, 2004; Levin, 1997; Ounjian & Carne, 1987) without providing insight into how individual TMs go about accomplishing their work (Cetindamar et al., 2016). Johnson and Medcof (2007, p. 485) emphasize both the importance and difficulties of the TM's job:

> *Technology managers currently grapple with tremendous challenges as they attempt to mobilize internationally dispersed capabilities within globally integrated strategies. The leveraging of subsidiary technology initiatives has come to be seen as one effective strategy for attaining competitive advantage. However, we know little about the work these individuals perform.*

The literature is virtually silent about the daily work of the people responsible for technology management at the factory level. Despite an increasing number of degree programs in technology management or the management of technology, there is very little empirical evidence on the tasks that constitute a TM's work (Cetindamar et al., 2016; Minty, 2003) and "practitioners feel that the literature on the management of technology is too sparse and fragmented and does not adequately address their concerns, issues, and problems" (Levin & Barnard, 2008, p. 23). The goal of this study is to provide needed insight into the work of TMs at the factory level in offshore subsidiaries of MNCs and identify promising issues for future research.

Technology

The context of technology in this study relates to equipment and process technology in the manufacturing industries, which aligns with Level II (technology acceptance), and Level III (technology application) technology transfer (see Gibson & Smilor, 1991). Level I (technology development) was not a significant part of the TMs daily routines because these factories focused on manufacturing and not research and development. The geographical context of this study is the underdeveloped region of Central America and the TMs firms had factories in Honduras, El Salvador, and Costa Rica.

The Evolution of Manufacturing Strategy Thought

Since the early works of Skinner (1969, 1985) and Wheelwright (1978, 1984) manufacturing strategy has evolved from being viewed as ridged processes focused on planning and trade-offs toward a view of manufacturing strategy being more of a cumulative capability model that responds to the dynamic environment through manufacturing tasks following a sequence of improvement in order to build manufacturing capability more effectively (Dangayach & Deshmukh, 2001; Paiva, Roth, & Fensterseifer, 2008). Drawing on previous studies (Amundson, 1998; Marucheck, Pannesi, & Anderson, 1990; St. John, Cannon, & Pouder, 2001), Paiva et al. (2008) examines organizational knowledge and the manufacturing strategy process through the lens of the resource-based view (RBV) (Barney, 1991; Peteraf, 1993; Teece, 1986; Wernerfelt, 1984). From the RBV perspective a heterogeneity of capabilities and resources exists among a population of firms; therefore, firms can gain competitive advantage through the causal ambiguity related to difficult to duplicate resources, proprietary processes, and equipment that result from internal and external learning (Schroeder, Bates, & Junttila, 2002); therefore, one can conceptualize a manufacturing firm with a sustainable competitive advantage as "an accelerated learning organization driven by dynamic processes that create superior knowledge and translate that knowledge into competitive capabilities and core competencies" (Roth, Marucheck, Kemp, & Trimble, 1994, p. 27). Arguably, having competent TMs throughout the organizational network to efficiently facilitate knowledge transfer through communication would be a prerequisite to becoming an accelerated learning organization.

Cetindamar et al. (2009) argue that technology management is a dynamic capability (Eisenhardt & Martin, 2000; Teece, Pisano, & Shuen, 1997). Dynamic capabilities theory retains RBV's concept of the heterogeneity of capabilities and resources among firms and addresses how a firm allocates resources to sustain continual innovation, how the firm deploys existing resources, and where the firm obtains new resources (Teece et al., 1997). Lall (1990) defined technological capability as the ability to execute all technical functions entailed in operating, improving, and modernizing a firm's productive facilities. Jin and von Zedtwitz (2008) enhanced that definition to not only make effective use of technical knowledge and skills to improve and develop products and processes but also to improve existing technology and generate new knowledge and skills in response to the dynamic business environment. Relevant to this research context, Kim (1997) brings the discussion back into the realm of organizational learning and knowledge by pointing out that in developing countries technological capabilities could be used interchangeably with absorptive capacity (Cohen & Levinthal, 1990). Finally, these two streams of research have merged and moved toward a dynamic resource-based theory (Helfat, 2000) that includes the concept of a capability lifecycle (Helfat & Peteraf, 2003).

Technology transfer research exists in the literature across multiple disciplines and at numerous levels of analysis ranging from the national level, and even economic development classifications such as least developed nations, to the interpersonal level. There is even some degree of confusion over what the term technology transfer means (Williams & Gibson, 1990). This study adopts the definition of technology transfer being fundamentally the application of knowledge (Segman, 1989 as cited in Gibson & Smilor, 1991). Technology transfer between subsidiaries in MNCs is an essential element in terms of developing and maintaining a strategic advantage (e.g., Mital, Girdhar, & Mital, 2002)); however, much of the knowledge is tacit and not codified so transfer in a complex multinational organization requires considerable resources

(Teece, 1977). Although modern information and communication technologies certainly facilitate knowledge transfer when compared to the process just a couple of decades ago, these technologies favor codified knowledge and tacit knowledge is best captured by personal interactions (Nonaka, 1991; Persaud, Kumar, & Kumar, 2001). Therefore, the true opacity that makes a dynamic capability a competitive advantage in the multinational context lies in the organization's ability to transmit tacit and non-codified knowledge effectively across national, cultural, and linguistic boundaries.

Although the literature provides little insight into the work that TMs do, it is axiomatic that language plays a major role in international knowledge transfer (Welch, Welch, & Piekkari, 2005; Welch & Welch, 2008) and strategy implementation (Brannen & Doz, 2012). Nonetheless, several scholars argue that international business researchers have not examined the role of language sufficiently (e.g., Brannen, Piekkari, & Tieze, 2012; Welch et al., 2005). Operating across nations with different cultures provides the MNC promising opportunities (Doz, Santos, & Williamson, 2001); however, language can create significant barriers that inhibit information from reaching decision makers (e.g., Harzing, Köster, & Magner, 2011) and the transfer of knowledge (Welch et al., 2005; D. E. Welch & Welch, 2008). One approach to this dilemma is to adopt a common organizational language (Harzing et al., 2011; Welch et al., 2005) as the default business language. Organizations often choose English even if the firm does not speak English in the headquarters or subsidiaries. Even with a common organizational language, knowledge transfer issues still exist because language fluency varies greatly across functions and organizational levels in MNCs (Barner-Rasmussen & Aarnio, 2011) and individuals across the organization analyze the information from different interpretive frames (Henderson, 2005). Therefore, "projects involving cross-national and multidisciplinary teams are likely to be influenced by the cultural filters team members use to create, share, and transfer knowledge. Thus, it is fairly easy for a receiver to interpret information in a way not intended by the original sender" (Persaud, Kumar, & Kumar, 2001, p. 13). Brannen (2004) argues that the message goes through some degree of adaptation to the host country context if only through the process of cross-cultural communication. If this is the case, then TMs must have a good understanding of all cultures across the global organization to transfer the knowledge across subsidiary boundaries effectively. This paper provides a significant contribution by providing insight into the role of language and communication in the daily activities associated with the transfer of knowledge and technology in and out of MNC manufacturing subsidiaries.

RESEARCH METHODOLOGY

Qualitative research methods such as field research, observation, and interviews allow the researcher to engage the phenomena first hand and gain insight into complex issues that researchers know little about (e.g., Creswell, 2005; Glaser & Strauss, 1967; Mintzberg, 1968, 1973, 2005; Wright, 2003). In the field of international management research, "we are only beginning to know the right questions to ask" (Wright, 2003, p. 49) and qualitative methods allow the researcher to "understand new dimensions, to probe, to be systematic" (Mintzberg, 1973, p. 229) as to "develop an understanding of things we know nothing about" (Mintzberg, 1970, p. 89).

Following the reasoning that a job is no more or less than the sum of all the individual activities (Mintzberg, 1968), this study used the structured observation research methodology. It recorded tasks in a chronology record and multi-coded them, collected anecdotal information,

assigned purpose codes, and from that determined the roles of TMs in this context. Mintzberg's (1968) framework with some modifications for modern communications technology and the particular context and objectives of this study proved effective.

The researcher functions as a kind of "black box" that records events and translates them into abstract categories and theories (Mintzberg, 1968, p. 67); therefore, the credibility of the study depends on the readers' confidence in the researcher's theoretical sensitivity and ability to make appropriate decisions in the field (Patton, 2002). The awareness and insight of the researcher gives meaning to the data, the capacity to understand, and the capability to separate the pertinent information from the irrelevant (Glaser & Strauss, 1967; Strauss & Corbin, 1990) and germane professional experience and familiarity with related literature provide theoretical sensitivity. Addressing this point, I speak Spanish fluently as a second language and lived in Central America for over a decade while working in the maquila industry implementing information and process technologies.

The Coding Key

Mintzberg (1973) contains a full explanation of his framework, codes, and logic in assigning them. Like Stephens (1991), I found it necessary to change some codes and add others. The term director changed to superior and peer expanded to specify the contact as internal or external to the TM's global organization. The code of subordinate applied to operatives on the shop floor, warehouse, and the receptionist even though they were not technically the subordinates of the TM. All other persons working in the TM's global organization but not in the direct line of authority above the TM received the code of internal peer. In this study, the purpose code technical task facilitates identification of activities where the TM engaged in hands-on technical tasks such as adjusting shop floor machines, writing computer program code, performing time studies, and testing devices in the quality lab. Every task except email received a code of international or local and technical or managerial in nature.

This study coded mail with the same twelve purpose codes for incoming mail and nine purpose codes for outgoing mail used in Mintzberg (1968, 1973). Email was only in its infancy in academia in 1968 and only a few commercial businesses were using it in, mostly internally, in 1991 and cell phone text-messaging did not even exist. Stephens (1991) assigned purpose codes and role codes to email; however, there were only 102 of them over the five-week observation period; there were thousands of emails in this study. A pilot study revealed that assigning purposes and roles to email required a detailed analysis requiring real-time input from the TM and that would severely affect the validity of the study. My interest was observing the tasks of TMs under normal work conditions; therefore, this study did not code the emails or text messages received or sent by the TMs because doing so completely disrupted the normal course of activities. Data from software developed and installed on the TMs' computers for self-reporting of email proved to be time consuming and insufficient to resolve the problem; the TMs simply did not have time to enter the needed information consistently. Due to confidentiality concerns, the firms would not allow the storage or forwarding of emails for afterhours evaluation.

This study added the roles of technologist and consultant. The need for these roles formed during the first observation and the distinction between the two evolved throughout the study. The consultant roll is ostensively a one-way flow of technical knowledge from the TM to another person, usually in response to a request for that information. The technologist role is a

more collaborative two-way interaction, often with a technical peer or subordinate, or when the TM performs technical tasks that address a need of the firm.

Selection of the Research Participants

There are four main industry segments of the maquila sector in Central America, apparel, automotive components, electronics, and textile. This study purposefully selected the subjects for this study. "In qualitative inquiry, the intent is not to generalize to a population, but to develop an in-depth exploration of a central phenomenon;" therefore, the researcher "purposefully or intentionally selects individuals and sites" (Creswell, 2005, p. 203). The study included one TM from each segment; however, the objective was to get and aggregate view and not to compare and contrast the work of TMs in each segment with each other.

Potential candidates worked in wholly owned subsidiaries and joint ventures of publicly traded US based MNCs in each segment that had a position where a technically oriented individual performed a managerial role as a middle manager. Within the companies, people referred to each participant with the title of engineer, which is common practice in Spanish speaking countries. This study classified middle management as having clearly identified subordinates and the authority to hire and terminate those subordinates as well as delegate task, assign responsibility, and allocate resources as opposed to supervisors with extremely limited or nonexistent authority to allocate company resources. The selected TMs had worked in their current positions for more than two years and all had started their careers as technicians and risen to management positions. They all held undergraduate degrees in engineering or industrial technology and the apparel and textile TMs also held MBA degrees. The textile mill and apparel manufacturer operated within the same large-cap conglomerate; however, they operated in separate divisions and had no business interactions. The automotive components supplier was a large-cap industry leader with operations around the globe. The electronics firm was a small-cap firm with a global supply and distribution chain. The apparel TM was female while the remaining three were male.

RESULTS

Observation Time and Locations

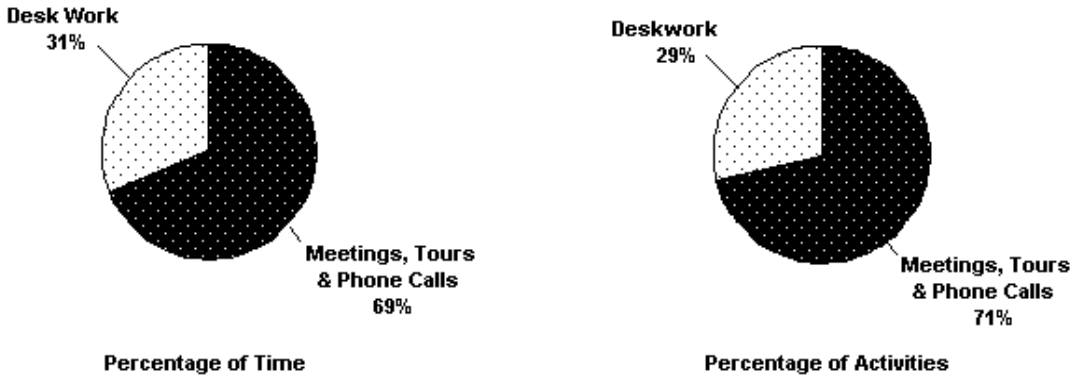
This study is of the four selected TMs at work in their respective factories for five consecutive working days for each TM. During the observation period, the four TMs perform 927 tasks during 12,275 minutes or 204 hours and 35 minutes. The study omits 41 tasks that consumed 1,014 minutes or 16 hours and 54 minutes because they were non-work activities, such as lunch, travel between facilities, and personal hygiene breaks. As a result, there were 886 work tasks performed by the TMs in 11,261 minutes or 187 hours and 41 minutes (see Table 1). This study did not code individual emails; therefore, some results, as noted, exclude 1,669 minutes spent in150 email sessions.

Table 1
OBSERVATION TIME BREAKDOWN

Observation Breakdown	Activities	Minutes	Min/Activity
Total Activities Observed	927	12275	13.24
Non-Work Activities Omitted	41	1014	24.73
Net Activities Observed	886	11261	
Synchronous Communications	625	7802	12.48
Deskwork Total	261	3459	13.25
Deskwork Non-Email	111	1790	16.13
Deskwork Email	150	1669	11.13
Net Work Observed	886	11261	12.71
Work Observed Email Excluded	736	9592	13.03
Work Observed Deskwork Excluded	625	7802	12.48

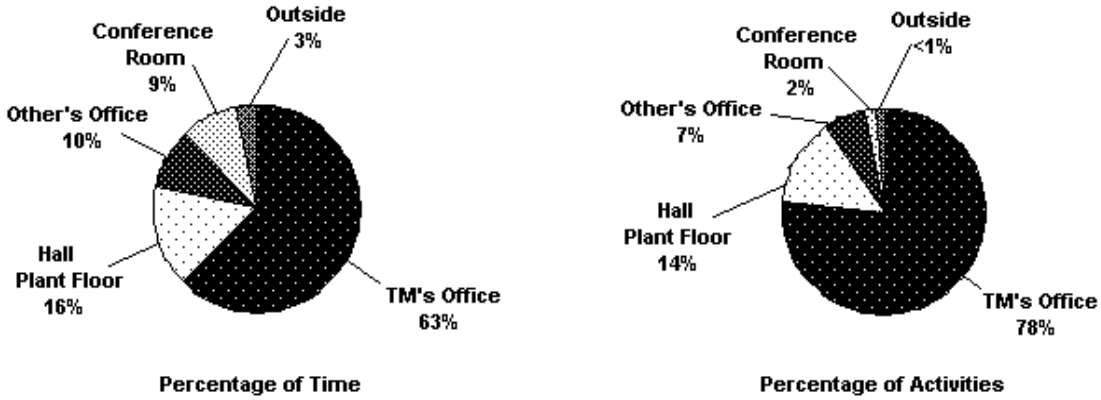
Verbal or synchronous communication, meetings, and observational tours accounted for 69% of the time and 71% of activities for all TMs combined. The TMs spent the remaining 31% of the time doing deskwork that accounted for 29% of the activities (see Figure 1). Email accounted for 48% of the deskwork time and 57% of the deskwork activities.

Figure 1. Distribution of Deskwork versus Other Activities



Combined, TMs spent 63% of the time in their offices and 78% of all activities took place there. Note that time spent sitting at the desk but speaking on the phone applied to the verbal contact record and is not included in the deskwork time; therefore, the deskwork activities category is not a comprehensive indicator of the total time spent in the office (see Figure 2). The automotive TM and the electronics TM had one task each outside of the facility with people from another organization.

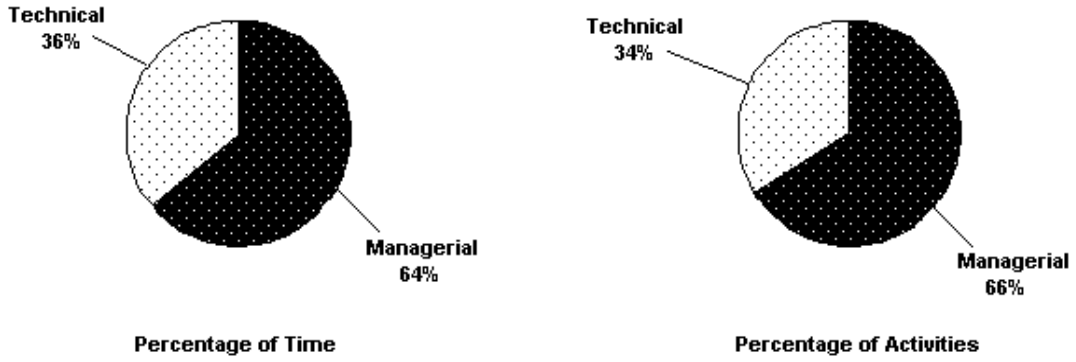
Figure 2*:* Distribution by Location



Technology versus Management

As a group, TMs spent 64% of their time on activities that were ostensively managerial in nature and they constituted 66% of all activities (see Figure 3). This study excluded time dedicated to email when evaluating technical versus managerial tasks because it was impossible to identify the context of each individual email without affecting the activities of the TM; however, this study did code time spent on other deskwork as technical or managerial in nature.

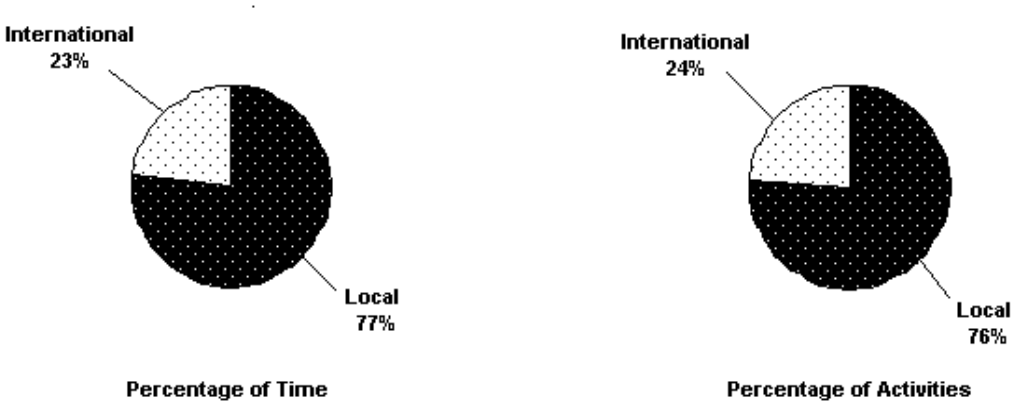
Figure 3. Distribution Between Technical and Managerial Tasks (non-email)



International versus Local

As a group, local issues accounted for 77% of the TMs' non-email time and 76% of the non-email activities (see Figure 4). The TMs spent the remaining time on issues that contained an international component. All activities coded as international in this study involved a language other than Spanish or translating. The other spoken language was always English but the textile TM dealt with German, French, English, and Spanish when modifying the information system to print out export documents for shipments to the European Union and North Africa.

Figure 4. Distribution Between Local and International Tasks.

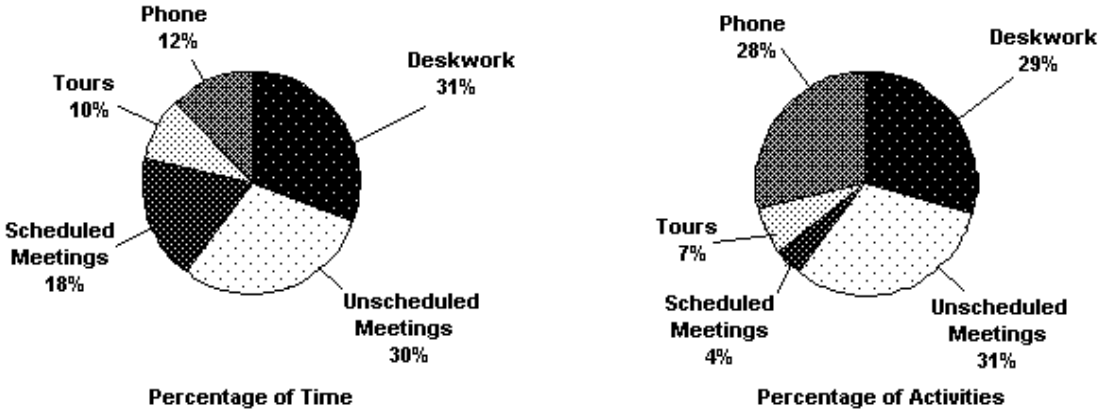


Forty-three percent of these international issues activities involved logistics and they accounted for 31% of the time spent on international issues. Although not anticipated, logistics issues always contained a language component because the export documents and discussions always had terms in at least Spanish and English. Spanglish more appropriately describes the language used in the maquila industry. Those working in the maquila have adopted the English names of many machines and other terms like BL for Bill of Lading or Invoice and even non-English speakers use them in conversations and written communications.

Activity Categories

As a group, deskwork activities, including email but not counting telephone calls, accounted for 31% of TMs' time and 29% of their tasks. Email accounted for 48% of the time spent on deskwork but only 17% of deskwork activities. TMs spent the remaining deskwork time working on computer applications, miscellaneous sorting and organizing, operations reports, purchase orders, reading paper mail, performing technical skills, or browsing the Internet (see Figure 5).

Figure 5. Distribution of activities

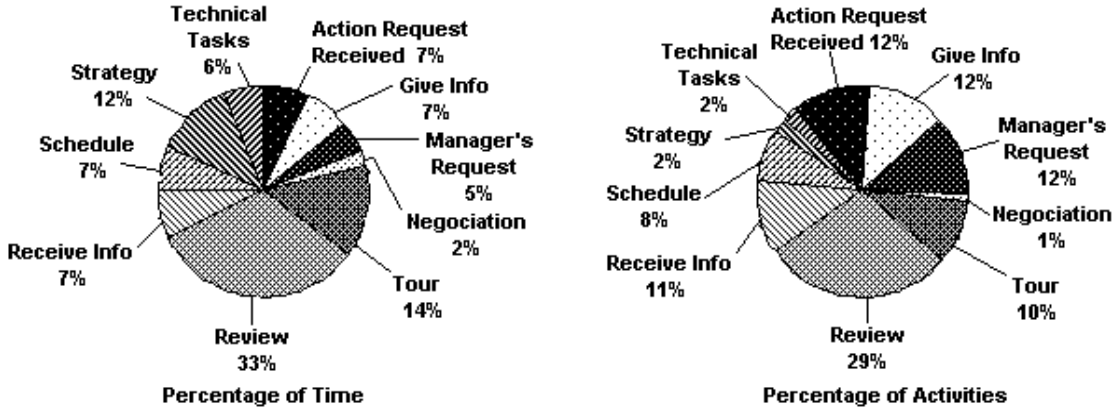


Unscheduled meetings consumed 30% of the TMs' time and accounted for 31% of all activities. The other party, not the TM, initiated most, 57% of the unscheduled meetings. The majority occurred in the TM's office, 63%, with only one other person who was usually a subordinate. Scheduled meetings averaged 55.36 minutes and consumed 18% of the TMs' time; however, they amounted to only 4% of all activities. Scheduled meetings were most often with internal peers, held in a conference room, and more than four people attended. While verbal telecommunications consumed only 12% of the TMs' time, the category accounted for 28% of the total activities. The average conversation lasted 5.2 minutes, usually occurred in the TM's office with the TM initiating the call. Most conversations, 45%, were with subordinates and 37% were with internal peers. Only 6% of the conversations were with the TM's superior. TMs spent 10% of their total time, including email time, on observational tours.

Purpose Categories

Following the framework used in Mintzberg (1968) and Stephens (1991), this study coded verbal or non-desk work activities according to purpose (see Figure 6). The TMs spent 59% of their time and 54% of the activities exchanging information with others in review sessions where information flowed two ways or received information or gave information in one-way exchanges. In strategy sessions information flow was two way, so they were also review sessions, but not double coded.

Figure 6. Distribution of purpose



As a group, TMs spent 14% of the non-email time on observational tours and they accounted for 10% of their activities. The tours varied in length; while the mean was 17.92 minutes, the mode was 5 minutes. TMs conducted 69% of all tours alone. The TMs used observational tours for two main reasons: monitoring the activities of subordinates or going to see something firsthand.

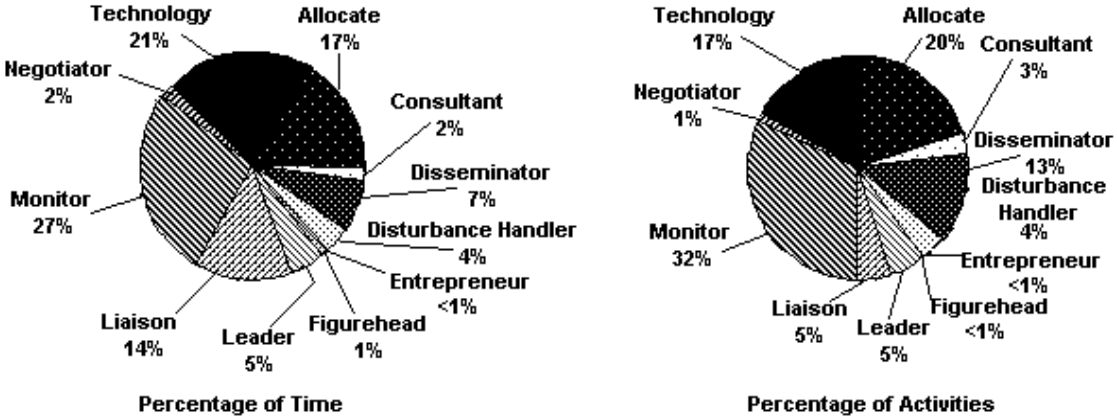
TMs dealt with action requests received from others and that consumed 7% of the TMs' time or 12% of their activities. These requests were from internal peers, subordinates, superiors, and external suppliers. TMs spent 5% of their time and 12% of their activities making requests of others. TMs spent time scheduling and that consumed 7% of the TMs' time and constituted 8% of their activities. Two purpose categories, negotiation, and ceremony received little activity. Only 6% of the TMs' time and 2% of the activities were technical tasks.

Role Analysis

The TM plays many roles in the performance of his or her job (see Figure 7). The informational role of monitor was most prominent and consumed 27% of the non-email time accounting for 32% of the activities. As a monitor, the TM receives information from within his or her department, inside the larger organization, and from outside the organization. The TMs spent 7% of the non-email time and 13% of the activities on the informational role of disseminator. Tasks that fit the informational role of spokesperson did not occur during the study.

The interpersonal role of liaison consumed 14% of the TMs' time and accounted for 5% of the non-email activities. The TMs in this study played the figurehead role on only five occasions and they constituted less than 1% of the non-email time. The interpersonal role of leader constituted 5% of both the non-email time and activities. The leader role applied to interactions with employees including educating and mentoring subordinates on technical issues. A broad view of leadership skills permits many of the TMs activities to fall into the leader role; however, for the purposes of this study only activities where the TM exerted the extra effort to coach a subordinate, provide positive feedback, or demonstrate a unique skill received the leader code.

Figure 7. Distribution of roles



The decisional role of being the person authorized to allocate department resources consumed 17% of the non-email time and 20% of the TMs activities. The decisional role of disturbance handler accounted for 4% of the TMs' non-email time and activities. The decisional role of negotiator consumed only 2% of the TMs time and 1% of the non-email activities. There were only three activities of one TM where the decisional role code of entrepreneur applied.

The TMs spent 21% of their non-email time and 17% of the activities playing the role of technologist. Since the technologist role also includes discussing and collaborating, it includes activities that fell outside the purpose category of technical task, which amounted to only 6% of the time. The role of consultant accounted for only 2% of the time and 3% of the non-email activities.

Mail Analysis

There were only 72 pieces of incoming paper mail and 31 pieces of outgoing paper mail in this study. The coding of incoming paper mail used the codes: events, authority request, general reports, reports on operations, and periodical news. All outgoing paper aligned with one code: written report. All of the paper mail was routine, and the TMs gave little importance to it. It was the instantaneous information via email and the corporate information systems that attracted the TMs' attention; unfortunately, attempts to code the email were unsuccessful.

DISCUSSION

The chronology record of tasks collected during the observations, anecdotal evidence, and discussions with the TMs during meals, travel, after working hours and follow up interviews form the basis for the discussion and conclusions. While the total time of observation was similar (see Table 2), a comparison of the chronology record indicates that the distribution of activities for the TMs in this study is different (see 10) from those of the CIOs studied by Stephens in 1991 (see also Stephens, et al., 1992), and the CEOs studied by (Mintzberg, 1968, 1973). At first glance, the number of activities—886 versus 623 and 527 respectively—stands out and further analysis indicates that continuously checking email throughout the day accounts for most of that increase. The frequent use of email in today's business environment further underlines the important role that electronic communication plays in the global transfer of knowledge and technology.

Table 2
PREVIOUS STUDIES TIME COMPARISONS

Comparison Categories	This	Stephens CIO	Mintzberg
Total Hours Observed	204.58	215	220
Excluded (lunch, travel) Hours	16.9	7	18
Net Hours of Work	187.68	208	202
Net Number of Activities	886	623	547

International Issues

The TMs spent most of their time gathering and disseminating information in the local context and less time receiving or disseminating information in a language other than Spanish. The fact that they used their foreign language skill in only about one out of four activities does not undermine the importance of speaking more than one language fluently; it was a key job requirement and critical to the organization's ongoing operation.

International logistics issues occupied only 7% of the TMs' non-email time, and only 31% of the total time spent on international issues, but the international logistics situations were the most dramatic because of the potential to stop production or delay important projects. The expected arrival date of parts, supplies, and equipment was the main constraint for scheduling projects and important to decide when foreign peers or installers from the supplier should fly in to help set up equipment. These situations usually arose because some issue, usually human error by the sender, delayed the import of needed items. The procedures and documents required for international shipments are quite different from those for domestic shipments and most errors traced back to the sender's lack of understanding. Unlike domestic delivery routes that run daily, ships depart every few days, containers must have seals with documents submitted well in advance. Airfreight is faster and more frequent but without the correct documentation, one wastes the additional cost as the shipment sits in customs for days. Shipping delays had a ripple effect. The TMs in this study were not directly responsible for performing the task of customs brokers or import/export agents; however, they had to get involved because the issue effected receiving items they needed to start a project or their language skills were essential to resolving the issue through communication with the foreign supplier or company subsidiary.

Table 3
PREVIOUS STUDIES CATEGORY COMPARISONS

Categories	This Study	Stephens CIO	Mintzberg CEO
Desk Work - % Time	31%	28%	22%
Time Spent - Hours	57.65	59	44
Number of Activities	261	122	179
Desk Work - % Activities	29%	20%	33%
Mean Duration - minutes	13.25	29	15
Maximum Duration - minutes	80.00	44	20
Minimum Duration - minutes	1.00	16	12
Unscheduled Meetings - % Time	30%	14%	10%
Time Spent - Hours	56.00	30	20
Number of Activities	275	176	101

Unscheduled Meetings - % Activities	31%	28%	18%
Mean Duration - minutes	12.22	11	12
Maximum Duration - minutes	148.00	17	24
Minimum Duration - minutes	1.00	8	6
Scheduled Meetings - % Time	18%	48%	59%
Time Spent - Hours	33.22	103	120
Number of Activities	36	109	105
Scheduled Meetings - % Activities	4%	17%	19%
Mean Duration - minutes	55.36	59	68
Maximum Duration - minutes	218.00	73	98
Minimum Duration - minutes	4.00	44	40
Verbal Telecom - % Time	12%	9%	6%
Time Spent - Hours	21.62	19	13
Number of Activities	249	174	133
Verbal Telecom - % Activities	28%	28%	24%
Mean Duration - minutes	5.21	6	6
Maximum Duration - minutes	58.00	12	20
Minimum Duration - minutes	1.00	3	12
Observational Tours - % Time	10.19%	2%	3%
Time Spent - Hours	19.12	3	5
Number of Activities	64	42	29
Observational Tours - % Activities	7%	7%	5%
Mean Duration - minutes	17.92	6	11
Maximum Duration - minutes	104.00	9.5	8
Minimum Duration - minutes	2.00	2	0
Percentage Activities Over 60 Min	2.03	9	10

Technology Gatekeepers

In this study there were actions that clearly aligned with the daily activities/capabilities of *Identification, Selection,* and *Acquisition* suggested by Cetindamar et al. (2016). The TMs did play a significant role in evaluating technology investments and acting as gatekeepers to address the control of the consumption of technology being like "drinking from a fire hydrant" as described by Synnott and William (1981, p. 12). Calculating and discussing the return on investment (ROI) for technology expenditures was common as was evaluating competing technologies. The TMs were key participants in the decision-making process any time technology was involved. They considered support cost, local availability of support, total cost of acquisition and life cycle among other things when providing their input. The TMs' superiors and peers sought out the TMs' opinion and it was often the pivotal information contributing to the final decision.

The Factory's Technical Information Expert

In all four firms, the daily activities/capabilities of *Learning* and *Exploitation* (see, Cetindamar et al., 2016) occurred and intermixed with activities related to *Identification*, *Selection*, and *Acquisition*. The TM was the factory's technical information expert, the one with the precursory technology knowledge (Harris, 1989). This ranged from explaining how an email spam filter worked to determining the British Thermal Unit (BTU) value of bunker fuel based on the American Petroleum Institute (API) number (related to two competing quotes from suppliers

that listed different API values) even though the TM had to look it up on the internet because he did not have any background in petroleum products. Superiors, peers, and subordinates relied on the TM's technical expertise and research skills and expected them to know or find out quickly. The TMs where called upon several times a day to provide technical advice or explanations to others. Peers and superiors also asked them to investigate technology solutions for a wide range of situations. The *learning* activity directly relates to the *exploitation* activities, which also links to technology *identification*, *selection*, and *acquisition*. The TMs constantly scanned for relevant new technologies and knowledge and that lead to *identification, selection,* and *acquisition* activities. *Learning* linked to *exploitation* through the transfer of knowledge gained from outside the local factory to those inside the factory that would implement and utilize the knowledge and technology. Technology evolves at a rapid pace and this requires technologist to be constantly aware of innovations. The TMs spent very little time on browsing the Internet, reading technical manuals, or industry periodicals during working hours. However, from the content of conversations it was obvious that they kept themselves well informed on current issues related to their respective industries and the technologies they worked with. Follow up interviews revealed that they all spent time outside of working hours to keep themselves current and the Internet was the source they used most frequently. They also traveled to headquarters, subsidiaries, and suppliers for training several times per year.

The Work Day

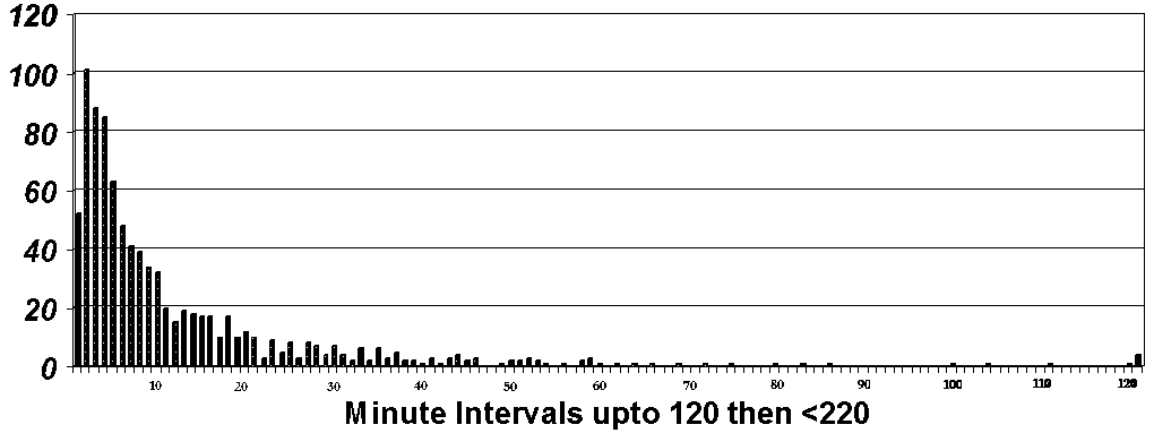
The management processes absorbed most of the TMs' time. They participated in strategic planning and budgeting sessions, organized ad hoc groups to perform tasks, participated in hiring and terminating employees, directed subordinates, and allocated company resources. The TMs in this study were fully empowered managers directing subordinate technologist while collaborating with peers and superiors to select, implement, manage, and support the technologies the firm required. They were not acting as technicians with only ancillary managerial activities.

Although managerial tasks dominated the TM's workday, it was apparent that technical expertise was an absolute prerequisite; each TM in this study demonstrated that they were also skilled technicians. When a pressing technical problem arose and no subordinate was available or a subordinate presented a problem they could not resolve, the TMs took a hands on approach and did whatever was needed to solve the problem. It was apparent that they were capable of performing the duties of most of their subordinates. Without hesitation the apparel TM adjusted shop floor machines, the automotive TM disassembled and reassembled computer server, the textile TM wrote program source code, and the electronics TM tested circuit boards in the quality lab to locate defects.

Brevity, variety, and fragmentation characterize the TMs' activities and this is in keeping with previous studies of managerial work. Most activities were brief with 62% lasting less than 9 minutes and only 2% lasting more than an hour; however, the range of duration was large (see Figure 8). The average duration was 14 minutes with a standard deviation of 20, the shortest activities recorded lasted 1 minute, and the longest was a strategy session that lasted 2 hours and 18 minutes. The fragmentation caused by unscheduled meetings and phone calls combined with the unpredictability of the duration of activities left the TMs with little ability to predict or control their daily agenda. Input from others, often via email, drove most of the TMs' activities. The initiation codes in the contact record are somewhat misleading. Following the framework,

many activities coded as initiated by the TM were in fact the TM's response to a meeting, call, or email initiated by another party.

Figure 8: Histogram of Activity Duration



The following scenario provides a realistic picture of the workday of the TMs in this context. They started the workday with a mental or written list of things-to-do for the day and the rest of the week. The first task of the day was to logon to their computer and check email. The emails caused the TMs to reply, forward emails to others, write new emails, and initiate telephone calls or unscheduled meetings. If the emails and related calls and meetings failed to uncover some production-stopping crisis, the TMs then proceeded to address their list of things-to-do. The interruptions began, usually within minutes, as people called or came to the TMs' office. From that first interruption forward, the TMs wedged the activities they initially intended to accomplish in between the interruptions and scheduled meetings as the day progressed.

Occasionally the frequently demand for translation frustrated the TMs because it took time away from focusing on core responsibilities and key projects. Most translated conversations did not involve difficult technical issues or complex problem solving. The parties just were not able to speak the same language fluently enough to effectively transmit the intended message and verify that the other party or parties understood. Internal peers from non-technical departments also sought out the TM to relay non-technical messages in the other language that were unrelated to the TMs area of responsibility. Moderately bilingual subordinates and internal peers also called on the TMs frequently to clarify confusion caused by homonyms, colloquialisms, or regional accents. This is a good example of the *cultural filters* that that complicates communication in cross-national teams (Persaud, Kumar, & Kumar, 2001) and provides support for the point made by Barner-Rasmussen and Aarnio (2011) that language fluency varies greatly across and functions and organizational levels in an MNC.

The TMs' communicated across the interorganizational network (Ghoshal & Bartlett, 1990) and did not routinely follow a chain of command. In fact, only about 7% of the time spent on the phone and in meetings, 5% of the net observation time, was with their superior. Therefore, they operated rather autonomously. There also did not appear to be a preference in the automotive, apparel, or textile sectors to communicate through the headquarters to get information from other subsidiaries. The communications appeared informal, as discussed by Macdonald (1996), within an integrated network of active and flexible links with both the headquarters and other subsidiaries as described in Gassmann and von Zedwitz (1999). The

electronics firm seemed to communicate through the headquarters and being more of a technology driven firm this concurs with von Zedtwitz and Gassmann (2002). However, it is noteworthy that the electronics firm had significantly fewer subsidiaries to communicate with than the other firms in the study did.

Language barriers intensified the "dilemma of delegation" described by Mintzberg (1973). The TMs were one of the few fluently bilingual people in the factory and usually the only one with technical expertise. This caused them to be highly sought out as communication facilitators because they could receive, evaluate, translate, and then disseminate information—from the most general to the highly technical, codified or tacit—on the fly. The dilemma is that the solution or needed action existed as a collage in the TM's mind and not codified into an easily transferable form; or if codified information existed, as were the instructions to program a new wireless multiunit phone system, it was in the wrong language. This created barriers to delegation and dissemination because delegating without insuring the subordinate had full comprehension presented an unacceptable risk of failure or miscommunication; however, codifying the knowledge into an appropriate knowledge transfer instrument in the correct language required time and resources the TM did not have. The situation overloaded the TM with communication tasks instead of technical tasks; however, it also appeared to endow them with a noticeable amount of respect throughout the global organization.

The analysis of the data collected in this study indicates that language expertise and technical expertise combine to make the job of the TMs in this context fundamentally one of communication, which they leveraged to be effective managers. Their felicitous skill set enabled them to facilitate communication flows competently regardless of the degree of complexity or technical subject matter and this resulted in them being a boundary spanner or gatekeeper as discussed in Cranefield and Yoong (2007). By being an agent to pass information across boundaries these TMs were a key individual in the organization's memory (Walsh & Ungson, 1991) and became a repository of knowledge in what Wegner (1995) labeled as an organization's *transactive memory system*. Superiors, peers, subordinates, and individuals throughout the TMs global supply chain embedded the TMs in their meta-memories and sought them out. Although the TMs position afforded them little legitimate power (Raven & French, 1958) at the level of the global organization, they had noticeable informal influence (see Cobb, 1980). Their combined technical knowledge and language abilities resulted in expert and referent power (Raven & French, 1958) that "allowed them to find themselves in more powerful positions than would normally be the case" (Marschan-Piekkari, Welch, & Welch, 1999). These TMs participated in important strategic decision making at the corporate level, initiated change, allocated resources, spearheaded some limited entrepreneurial projects, negotiated with people inside and outside the organization, and played an important role as a disturbance handler to resolve issues that affected both operational effectiveness and organizational harmony.

Industry and Gender Effects

Although the goal of the study was to capture the daily work activities of TMs across different manufacturing industries and not to focus on individual industry differences, readers may find a cursory review of a few minor differences beneficial. During the observations there were no obvious differences in the workday of the TMs between the different industries. A fragmented day was the norm in all four industries and the needs and inquiries of others drove the schedule more than the TM's own predetermined schedule. There were also no obvious

differences that one could attribute to gender. The daily activities of the female apparel TM were very much like those of the three male TMs. The textile TM spent less than 1% of his time on observational tours while his counterparts spent 10% to 19% of their time on observational tours. This coincides with only 27 minutes spent on the shop floor for the textile TM compared to 316 to 872 for the other TMs. This difference most likely relates to textile manufacturing having significantly fewer manual labor processes on the shop floor and this reduces the need for observational tours and shop floor meetings. The automotive and textile TMs also spent more of their time in scheduled meetings, 21% and 25% respectively, as opposed to 12% and 13% for the apparel and electronics TMs, respectively. The automotive and electronics TMs spent a larger percentage of time, 37% and 38% respectively, on desk work than the apparel and textile TMs did at 23% and 27% respectively. These differences were apparent only after compiling and examining the data and there was no effort taken to explain these differences. A full breakdown of the data collected is available on request.

CONCLUSION

This study provided empirical support for five of the six daily activities/capabilities suggested by Cetindamar et al. (2016). The fact that there were not any *protection* activities observed does not discount it as a relevant activity of TMs in general. These TMs simply were not involved in obtaining patents and intellectual property protection and employee retention to protect trade secrets was not a frequent issue in the context where they worked.

The maquilas in this study utilized world-class technology and the TMs observed facilitated the successful implementation and managed the ongoing support. They spent most of their time on tasks that are ostensively managerial in nature. While they were also practicing technologist with the required precursory technology knowledge (Harris, 1989), they played this role through planning, researching, collaborating, advising, and consulting on technical aspects of the firms daily activities and strategic initiatives; they spent little time performing technical tasks themselves. However, these TMs rose to their current position because of their technical expertise in their respective areas. Foreign language fluency and experience in the technology portion of the title occurred before adding the authoritative title of manager.

The TMs accomplished their jobs essentially through communication. They worked quiet autonomously as they used their linguistic and technical expertise to transfer tacit, explicit and codified knowledge—often through translation—in and out of the subsidiary via the interorganizational network. Through their communications, they gain access to information and become a repository of special information in the organization's transactive memory system and that caused them to have more power and influence than the position in the organizational hierarchy would suggest. They participated in the organization's strategic decision-making process and often acted as technology gatekeepers to control the technology obsession that can lead to inappropriate technology investments. They did this through careful evaluation of the particular technology, by analyzing competing technologies, and through calculating the total cost of acquisition and the potential return on investment.

During this study, information flowed in multiple directions (up, down, horizontal and diagonal) and via a variety of means including phone calls, meetings, video conferences, email, electronic databases, and written documents. This supports the view of technology transfer being an ongoing and continuous interactive process where many activities, functions, and networks operate simultaneously to overcome barriers to the transfer process. The TMs were essential

network components that received, evaluated, stored, and disseminated that information with the highly sought-after ability to recode into another language if needed. This makes the TMs contribution instrumental when it comes to turning a dynamic capability into a sustainable competitive advantage in the multinational context.

Practitioner Relevance

There are significant managerial implications associated with operations in developing countries because of "the distinctive nature of the business environment, which varies considerably from that of the more developed nations" (Austin, 1990, p. 1). In addition, foreign direct investment (FDI) in manufacturing facilities plays an important role in transferring the knowledge and technology needed for economic development (Contractor & Sagafi-Nejad, 1981; Kosteas, 2004; Saggi, 2002; Stiglitz, 2003). One can assume that TMs in these factories are the primary facilitators of this needed transfer of knowledge and technology.

The lack of technology in developing nations is apparent. Stiglitz (2003) asserted that development requires more than just capital and resources; advancement requires the elimination of technology and knowledge gaps. However, technology and knowledge do not simply flow from the high to the low as if they were fluids (Patel, 1974); it requires education and management to facilitate its transfer. Unfortunately, the education systems in most developing and transitional economies are inadequate (Salmi, 2003). Therefore, issues related to absorptive capacity (Cohen & Levinthal, 1990) arise and management in these MNC subsidiaries must address this through human resource development activities combined with individuals possessing the required precursory technology knowledge that can identify technology and knowledge gaps and facilitate processes to address the deficiencies. Arguably, this is the role of the TM and the job would require interaction with other subsidiaries, suppliers, customers, industry organizations, and other stakeholders around the world to identify new knowledge and technology and facilitate its transfer into the local subsidiary. Therefore, the technology manager not only plays an important role as a boundary spanner or gatekeeper (Cranefield & Yoong, 2007; Johnson & Duxbury, 2010) but also as a facilitator of human resource development activities.

In discussions and interviews with US executives in the months preceding these observations, while the difficulty associated with transferring and maintaining technology was at the forefront of discussions, the executives did not accentuate the importance of the role and work tasks of the TM in the local subsidiary. The emphasis was toward the importance of US support staff providing assistance to the offshore manufacturing subsidiaries and going down to help the out on projects. During these observations, there were US support people in the factories; however, these were also the busiest days for the TMs as they spent time learning from the US team and then translating that knowledge and training the local staff who did not speak English. Each TM, in their own unique way, indicated that they did not feel that upper management truly understood what they did or appreciated the contribution it made to subsidiary success. Given the scarcity of fully bilingual, with emphasis on *fully*, individuals who also possess technical competence, executives should take steps to understand the daily work of the subsidiary TMs and assure that they receive the organizational-wide support they need and that they are aware that upper-management appreciates their contribution.

Limitations and further research

This study used the structured observation methodology; therefore, the associated major limitations: sample size, reliability checks, coding methodology, conceptual problems, and assumption of generalizable relationships apply to this study. Martinko (1988) and Stephens (1991) discuss these limitations in detail. Nevertheless, structured observation was an effective methodology to gain insight into that which we knew little about.

One area for future research is a better understanding of exactly whom, both inside and outside the organization, the TM communicates with. This study only recorded generalities such as internal or external peer. A more detailed understanding of the relationship and exact nature of the exchange and the technology and processes discussed would provide useful insight. A detailed mapping of email communications would likely provide valuable understanding and support the use of email history when conducting the *Experience Scans* investigated by Routley, Phaal, Athanassopoulou, and Probert (2013). Today email is "critical to the ongoing success of an enterprise" and contains up to 60% of the vital business data in the average company (Gray, 2001, p. 54). While this study demonstrated the difficulty of recording those communication flows for analysis, it also demonstrated the need. The challenge lies in accurately collecting the data without excessively disrupting the natural flow of activity we seek to understand. A properly configured study mapping the TMs contacts through all mediums, including email, and categorizing them by topic, contact position, location, and language would provide interesting insight into intricate web of informal information flow that facilitates technology transfer and strategic decision-making in MNCs.

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