

REVERSE TRANSFER OF KNOWLEDGE IN BRAZILIAN INSTRUMENTATION AND CONTROL MULTINATIONALS

MARCELO ANTONIO BARROS DE CICCIO
Instituto Nacional de Metrologia – INMETRO
Av. Nossa Senhora das Graças 50, prédio 6 – LATEL
Duque de Caxias, Xerém, Rio de Janeiro, RJ, Brazil
E-mail: macicco@inmetro.gov.br

VICTOR PROCHNIK (corresponding author)
Instituto de Economia da Universidade Federal do Rio de Janeiro (UFRJ)
Av. Pasteur 250, Botafogo, Rio de Janeiro, RJ, Brazil
E-mail: victor@ie.ufrj.br

Acknowledgment – The authors would like to thank Flavia Pirola Rosselli Cicco for her useful comments and help. All remaining mistakes are the responsibility of the authors.

ABSTRACT

The article seeks to identify the contribution made by the reverse transfer of knowledge to innovation at the three largest Brazilian-owned companies in the instrumentation and control industry. To this end, the question arises as to whether the international subsidiaries of these companies systematically use reverse knowledge transfer (RKT), and, if so, how this process assists in their research and development (R&D) efforts and the results (innovations) of this process. The survey was conducted through interviews at the companies selected. The findings are favorable to the existence of RKT. The subsidiaries, with the development of learning and absorption capacity, gradually consolidate the role of creative units, i.e., suppliers of useful knowledge for innovation at headquarters, thereby performing RKT as a matter of course.

Keywords: *Multinational companies, reverse knowledge transfer, innovation*

1. INTRODUCTION

The purpose of this paper is to identify the contribution of international subsidiaries' reverse knowledge transfer (RKT) for innovation at the respective headquarters of the three largest Brazilian-owned companies in the instrumentation and control industry (ALTUS, COESTER and SMAR).

The international knowledge transfer is said to be 'reverse' when it occurs in the opposite direction to the main flow, that is, from subsidiaries to the multinational company's headquarters. RKT occurs when the flow of technical knowledge involves the transfer of know-how or some other form of abstract or concrete technological knowledge, in which the subsidiary holds a key element in this process (MILLAR and CHOI, 2009, p. 390) and the technology is useful for an innovation at headquarters.

The answers to two questions are sought: Do Brazilian multinationals in the automation and instrumentation industry systematically use RKT? If so, how does this process assist in their research and development (R&D) effort and affect the results (innovations) of this process? In addition, characteristics of the RKT process that may be useful for the improvement of management of companies and/or as grounds for policies on technology.

Innovation is a key driver of economic development. But most activities related to R&D and other less formal ways of generating innovation around the world take place in developed countries. Because copying or buying technology is usually cheaper than creating it (FREEMAN, 1974, pp. 132-133), RKT – in association with the firm's own efforts and other flows of information and cooperative work – is a critical dimension for innovation at multinationals in developing countries. The importance of this fact is all the more significant for subsidiaries located in developed countries.

By restricting the definition of reverse flow of knowledge to the context of the subsidiary → headquarters circuit, this paper studies a particular type of transfer, of recognized importance in literature, as the quotes in this article show. However, in general, all information useful for innovation in the direction opposite to that of production flow (i.e., market → company) can be regarded as reverse. Therefore, the study of RKT in this particular case can generate research hypotheses for a much broader universe of companies: although the number of Brazilian multinationals is relatively small, the number of companies with foreign relations is much higher.

However, the focus of this paper is the analysis of subsidiaries that learn technical knowledge / local technology and/or develop new methods / products / processes and promote innovation at headquarters upon transferring this knowledge (CHEN and SHAPIRO, 2012 and PISCITELLO and RABBIOSI, 2006). For example, the pioneering work of Mansfield and Romeo (1984, p. 123) showed that 47% of American multinationals' foreign R&D spending in 1979 resulted in technologies transferred to the US headquarters.

Moreover, the bibliography found does not directly discuss the matter at issue: the impact of the RKT from subsidiaries on the innovation at headquarters, in Brazil. One paper does examine a broader issue – the impact of RKT on the development of competence of all types in Brazil (Silveira, 2013). Others investigate a more restricted issue, such as how the formal activity of R&D, in foreign subsidiaries, accelerates innovation at the parent company in Brazil (BORINI et al. 2012 and BORINI et al. 2014). Additionally, no papers were found that restricted themselves to one industrial sector, technology-intensive, for example.

This paper comprises five sections, including this introduction. The second section presents the theoretical framework; the third, the methodology used. The fourth section presents the results of the fieldwork; the fifth and final section, the findings of this research.

2. THEORETICAL FRAMEWORK

2.1. RKT in the internationalization process of firms

The technical literature recognizes the importance of technical knowledge and respective mechanisms of creation and diffusion for the creation and maintenance of competitive advantages in multinational companies (TEECE, 2014; and GUPTA and GOVINDARAJAN, 1991). Knowledge is based on information – whether concerning tangible or intangible processes – and is, in part, specific to each firm, and developed over time through complex interactions between internal agents, and between internal agents and external agents (RABBIOSI, 2005, p. 4). In particular, the idea became consolidated that the headquarters and subsidiaries of a multinational company form a privileged network for the creation and transmission of technical knowledge (BUCKLEY, 2014 and YANG, MUDAMBI and MEYER, 2008).

But the traditional view of growth and expansion of multinational firms, proposed by Hymer (1979), and later extended by Dunning (1976, 2008), was based on assumptions that companies became multinationals based on their ownership advantages (technology among them), the existence of location advantages in the host countries, and the choice of internalization as the best way to organize flows of knowledge, goods and people that are hard to source in the market or through licensing.

However, as the economy became more and more globalized, firms ceased to rely solely on the proprietary advantages of their countries of origin and started to seek external sources to broaden and complement their advantages (for example, setting up R&D operations in knowledge-intensive regions or high-growth potential markets). The latest version of the model Dunning (2008) recognizes that multinationals make foreign investments not only to exploit their proprietary advantages, but also to have access to sources of excellence, thereby enhancing their stocks of knowledge.

This last observation is particularly important for multinational companies hailing from developing countries (such as those studied in this paper), which in more developed countries may encounter an environment more conducive to learning and innovation.

Thus, companies mobilize overseas in the search for new sources of funding and knowledge, by building networks and units that foster the absorption of new information and technologies, which then increase the relevance of the subsidiaries. Importantly, insofar as the company develops and internalizes the knowledge acquired abroad, it expands its ability to generate innovations. (SHARMA, PEDERSEN and PETERSEN, 2003, pp. 2-4, RABBIOSI, 2005, p. 10). Several studies on RKT (CHEN and SHAPIRO, 2012; AMBOS, AMBOS and SCHLEGELMILCH, 2006; FOSS and PEDERSEN, 2002; MUDAMBI, PISCITELLO and RABBIOSI, 2006; PEDERSEN, PETERSEN and SHARMA, 2003) have been conducted to highlight the benefits, barriers, best organizational forms, communication systems, mandates and subsidiary types that most favor a positive transfer of knowledge, especially in terms of reverse transfer. Thus, the study of RKT is the subject of growing attention in economics and business studies.

2.2. The practice of reverse knowledge transfer

2.2.1. The benefits of RKT and the knowledge absorptive capacity of the headquarters.

In general, headquarters can benefit from the knowledge of their subsidiaries in the following ways: (a) local knowledge can help headquarters with fine tuning and coordination of global strategies; (b) improve own

processes and those of other network units; and (c) provide solutions to issues concerning new product development (AMBOS, AMBOS and SCHLEGELMILCH, 2006, p. 296).

But the availability of these benefits depends on the knowledge absorptive capabilities of headquarters. Absorptive capacity is defined as "ability to recognize the value of new information, assimilate it, and apply it to commercial ends" (COHEN and LEVINTHAL, 1990, in ANDERSSON, FORSGREN and PEDERSEN, 2001, p. 8), as well to be understood as the ability of the firm to deal with the tacit component of transferred knowledge (MOWERY and OXLEY 1995, in AMBOS, AMBOS and SCHLEGELMILCH, 2006).

Absorptive capacity may vary within the organization for two reasons: (a) the extent of prior related knowledge (SZULANSKI, 1996); (b) the extent of inter-unit homophily of the receiving unit vs. the sending unit, (PISCITELLO and RABBIOSI, 2006, p. 5). The greater the extent to which new knowledge relates to current knowledge, the greater the capacity to absorb it, apply it and integrate it in transnational organizations (YANG, MUDAMBI and MEYER, 2008, p. 884). Thus, there are several factors via which headquarters can hinder or facilitate the reverse transfer of knowledge (MUDAMBI, 2011).

2.2.2. A typology of subsidiaries for studying RKT

Within the view that multinationals function as transaction networks comprising flows of capital, goods and knowledge (HARZING, NOORDERHAVEN, 2006, p. 197), the literature has developed taxonomies to better analyze the factors that influence the quality and the quantity of knowledge transfer in the headquarters-subsidiary relationship.

Depending on the type and role of subsidiaries, they could be considered important sources of knowledge, not only for headquarters, but for the transnational's other units. Thus, a differentiated network of the multinational can be classified in terms of subsidiaries' two main groups of mandates: 'competence-creating' and 'competence-exploiting' (MUDAMBI, PISCITELLO, RABBIOSI, 2007, p. 3) The first type refers to assignments involving own initiatives of entrepreneurship, performing creative roles within the organization, and developing new intellectual assets for the transnational network, such as new products, technologies, practices and skills (NARULA, 2014 and YANG et al., 2008, p. 887). The competence-exploiting type refers to more traditional roles, using competencies from headquarters in the local environment.

It is expected that those of the competence-exploiting type transfer and adapt the knowledge from headquarters to local markets; on the other hand, those of the competence-creating type cascade the knowledge to other units in the multinational network (YANG et al., 2008, p. 887). The work of Yang et al. (2008) demonstrated that transfers from headquarters to subsidiaries are higher in the competence-creating type than in exploiting type.

The role performed by the subsidiary influences the form, direction and quality of knowledge flows exchanged in multinationals (HARZING, NOORDEHAVEN 2006). Such studies on subsidiary typologies show the association of subsidiary roles within a multinational organizational network with the direction – inbound or outbound – of knowledge transfer, and are linked to different types of control mechanisms, relative capabilities and product flows (HARZING, NOORDEHAVEN, 2006, p. 212).

2.2.3 RKT mechanisms used in subsidiaries of multinational companies

The literature on forms of knowledge exchange divides transfer mechanisms according to the size of communication systems: rich communication media and print media (MUDAMBI and SWIFT, 2011 and MUDAMBI, PISCITELLO and RABBIOSI 2007, p. 15).

Rich communication media refers to face-to-face contact (informal interactions, a team-based mechanism requiring visits), sharing experiences via personal contacts based on experience. Such media is more costly because it involves travel costs, the involvement of dissimilar organizational and cultural units within the multinational network, and differences in the languages employed. Moreover, they are more informal, subtle, and not usually via print media (MUDAMBI, PISCITELLO and RABBIOSI, 2007).

Print media is cheaper because it involves transfer based on manuals, databases, written instructions, etc., providing the multinational with economies of scale (PEDERSEN, PETERSEN and SHARMA, 2003, p. 9); this mode is also referred to as "mechanical communication methods." Electronic media (MUDAMBI, PISCITELLO and RABBIOSI, 2006, pp. 15-16), on the other hand, refers to the exchange of information mediated by electronic communication systems, such as video conferences, chats, etc.

Piscitello and Rabbiosi (2006) show that the RKT, using rich, people-based communication mechanisms (work groups, teams, manager transfers, for example), have a greater impact on innovation at the headquarters of the

multinational than using electronic media and print media (explicit knowledge) mechanisms. In particular, exchanges of employees, technicians and other staff between the subsidiary and headquarters can be an important tool for increasing the absorptive capacity by promoting the transfer of knowledge, especially tacit.

But the results of the paper by MUDAMBI, PISCITELLO and RABBIOSI (2007) show that RKT mechanisms vary according to the subsidiary type and its degree of autonomy. Competence-creating subsidiaries tend to use more rich communication media because their internal knowledge is more tacit and complex; and competence-exploiting subsidiaries tend to prefer low-cost type print communication, focusing more on objective information. Regarding degree of autonomy, it should be noted that many studies have been undertaken emphasizing the role of decentralization in understanding the occurrence of knowledge transfer within the transnational (SCHLEGELMILCH, AMBOS and CHINI, 2003), with mixed results. Rabbiosi (2008) attempts to resolve the ambiguity of these results in relation to a subsidiary's degree of autonomy by trying to relate it to the communication systems (people-based and electronic-forms based) adopted by these units in their relationship with the multinational's headquarters. The author maintains that the definition of the communication system adopted in the HQ-subsiidiary dyad is crucial to understanding the effects of autonomy on RKT.

The results of Rabbiosi's work (2008) indicate that the use of communication systems based on people, within a high autonomy scenario, will exert a positive influence on RKT; however, in a low autonomy scenario, the influence is positive only in cases of electronic-based communication systems.

3. THE INSTRUMENTATION AND CONTROL SECTOR AND THE COMPANIES INTERVIEWED

This section presents the main characteristics of the instrumentation and control industry (I&C), to which the interviewee companies belong. I&C is a sub-sector of the automated continuous process control area. It is characterized by the rapid evolution of technical knowledge, products and processes, both due to the continuous progress of its core technology, digital electronics, and because of the high degree of competitiveness inherent in the market (VIEIRA, 2009). For example, 5% of the cost of an oil platform and 1% of the cost of pipelines is I&C systems.

In the instrumentation and control industry, technologies are increasingly systemic in nature; that is, they depend on the integration of knowledge coming from an increasingly wide range of areas in science and technology. This characteristic opens up a bevy of opportunities for capturing and/or acquiring technical expertise at the point of origin, since relevant knowledge is available from a wide variety of agents, such as international suppliers, customers, universities, quality control and standardization organizations, consulting firms and competing firms that do not act in Brazil, etc.

The main customers of I&C products and services include the oil and gas production and refining industry; sugar, alcohol and pulp industries, etc. In these sectors, I&C systems collaborate to reduce costs, increase safety, extend the production, etc. Finally, it should be noted that the I&C industry receives special treatment in Brazilian industrial policy, both for its base in digital electronics as well as for its products, which are considered capital goods.

The sales, imports and exports of the instrumentation and control industry are presented in Table 1. The data includes figures for all automation products, of which continuous automation is a segment (in contrast with batch process automation). Note that the share of imports or exports in sales may exceed 100%, and in fact does so in certain cases. In the case of imports, this is possible because not only imports of current inputs are considered: also included are imports of finished products and parts/spares for maintenance/repair of equipment in operation.

Table 1. Sales, exports and imports of instrumentation and automation products in selected years.

(Sales in millions of dollars, exports and imports of parts, components and finished products as a percentage of sales of Brazilian production in the domestic market)

Instrumentation and automation products (*)	2005	2010	2012
Sales (US \$ million)	957	1,840	2,005
Exports (% of sales)	20.7	22.1	27.5
Imports (% of sales)	150.3	178.3	196.1

(*) Includes medical instruments

Source: ABINEE (2013).

As the table above makes clear, company revenues, and industry exports and imports have an upward trajectory. However, the share of export earnings in total sales in the industrial automation sector is still small. The table also shows that imports exceed exports by a wide margin, indicating a clear weakness of the industry in terms of parts and technology and concomitant strong external dependence.

Another aspect relevant to this analysis is the modest size of national companies vis-à-vis their international competitors, including even the Brazilian subsidiaries of the latter (Prochnik, 2013). This fact entails national companies being restricted to and servicing specific market segments, which hampers the development and supply of complete automation solutions, i.e., the larger systems sold by major companies.

4 METHODOLOGY

The empirical section of this research was based on the work of Piscitello, Rabbiosi e Mudambi (PISCITELLO and RABBIOSI, 2003 and 2006; MUDAMBI, PISCITELLO and RABBIOSI, 2006; RABBIOSI, 2005 and 2008). These authors conducted their research using the database generated by the RITMO (Research on Innovation and Technology in Multinational Organizations) project; additionally, their questionnaire was the basis for the preparation of this research.

The qualitative exploratory case study method (based on direct survey of respondents by the researcher) was used. The method enables a comparison to be made of empirical findings with existing theories (Yin, 1994), and is useful for providing insights on issues, situations involving management, or new theories, when the research area is relatively little known and the literature is still engaged in building forms of study (MARSCHAN-PIEKKARI and WELCH, 2004). It is also useful to create new theories, test hypotheses, refine models and predictions (PERREN and RAM, 2004).

As a result, the case study method allows a deeper study of the issues at stake; indeed, it involves a longitudinal approach in the context under analysis and the phenomenon is observed in its own natural environment of action (MARSCHAN-PIEKKARI and WELCH, 2004 pp. 111-112). The authors note that the "results of the research cannot be dissociated from the context in which data is collected and analyzed." Contextual factors are important for the construction and investigation of the analytical framework of the phenomenon. In this line, the context is regarded as "the surroundings associated with the phenomenon that aids in its description" (CAPPELLI and SHERER, 1991, in MARSCHAN-PIEKKARI and WELCH, 2004, p. 247).

The questionnaire used, which was based on that used by the RITMO project and adapted to the context of emerging Brazilian multinationals, analyzed the headquarters-subsidiary diad. Information was sought about the subsidiaries that transferred the most technology and/or knowledge valuable to innovation, how such a transfer is made, and the effects of the transfer on headquarters' performance. Analysis of the results we used the "fitting to template," where the investigator first identifies the patterns of occurrence of RKT in the case studies reported in the literature, theoretical discussions and RKT mechanisms. Then, an analysis of the responses from the questionnaires is developed, seeking to identify the same basic patterns reported in the literature on reverse transfer, thus confirming or denying the fundamental question of this study: whether the Brazilian multinationals investigated in the industrial automation sector perform RKT and whether doing so promotes innovation.

From the universe of companies in the industrial automation, instrumentation and process control sector, the survey selected the three Brazilian owned companies that are multinationals: SMAR, ALTUS and COESTER. This sector was selected for several reasons: (i) fast-growing – both in the international market and in Brazil; (ii) technology-intensive – with large international companies and research institutions, which enhances the possibility of robust RKT impacts for innovation in Brazil. Finally, the sector is considered strategic within current national industrial policy, both because it is part of the capital goods sector and because it involves information and communication technologies in its technical base. The I&C (Instrumentation and Control) industry is important for the economy because the products are relevant to increasing productivity and quality in client businesses.

The study of a small sample such as this (N=3) can be applied to test models and theories in the area of IB, provided applicable parameters are established throughout the research analysis and the research objectives are achieved (VISSAK, 2010).

5. FIELD RESEARCH

5.1. Companies

The three companies are relatively well-established (SMAR was founded in 1974, COESTER in 1963, ALTUS in 1982), which presumably makes them knowledgeable of the business and competitive environment in Brazil. None of them provided data on number of employees, sales or technology strategy. Based on (i) visits to the

facilities, (iii) the level of operations in Brazil and abroad and (iii) older data, the authors estimate that they employ between 300 and 2,000 people. SMAR is certainly the largest.

The number of people in the subsidiaries is rather low for purposes of ongoing RKT. But these subsidiaries can support RKT processes by complementing projects or supporting traveling technicians.

As seen below, the level of internationalization among them varies substantially.

5.1.1. SMAR equipamentos industriais LTDA

SMAR has subsidiaries in USA, France, Germany, Singapore, China, Mexico, Argentina, Netherlands, United Kingdom, and has representatives in more than 90 countries. SMAR exports over 40% of its production.

Although a relatively small company with less than 2,000 employees, SMAR is the largest manufacturer of instruments for process control in Brazil; indeed, its international competitors import most of the systems they sell. The company invests approximately 6% of revenues in R&D. Upwards of 16% of the employees work in this area. The company currently holds 24 international patents, and another 35 pending.

SMAR has no team dedicated exclusively developing new products and/or solutions. R&D activities are performed by qualified staff who devote part of their time to them. This approach ensures a greater dissemination of knowledge by the company, with less compartmentalization of the various departments. At SMAR, work hours are flexible and the company also encourages (including financially) employees (especially R&D) to further themselves through courses and postgraduate programs.

5.1.2. ALTUS Sistemas de Informática S/A

ALTUS has about 300 employees and is a leader in the Brazilian owned industrial automation sector. ALTUS develops industrial automation equipment, such as programmable logic controllers (its main product) and other equipment used in process control. The company also offers complete automation solutions. ALTUS was the first company to manufacture programmable numerical controllers in Latin America. Its main competitors are Siemens and Rockwell.

ALTUS has a national and international network of affiliates, and offices and representatives. The company has operations in the United States, Germany and Argentina. The subsidiaries in the US and Germany are mainly involved in approval activities vis-à-vis company suppliers. The company has deployed its subsidiaries with the aim to source new inputs and new technologies abroad, with access to new markets being a second priority; this approach is consistent with the literature on the role of subsidiaries in local learning (SCHEGELMILCH, AMBOS and CHINE, 2003). The company uses knowledge of the location where the subsidiary is installed to learn about inputs, and especially to provide headquarters with guidance about quality and certification. The number of employees posted to the subsidiaries is quite low, which hampers the practice of RKT.

The company has partnerships with international companies from China, India and the Czech Republic, where it imports and exports products and participates in an international alliance called World Automation Alliance. Among these partnerships, there is a strategic alliance with a company in India and another in the Czech Republic. In these alliances, technology exchanges have proceeded with great success. ALTUS allocates about 5% of revenues to development of innovative products.

5.1.3. COESTER Automação LTDA

Products and services offered by COESTER, a provider of data communications solutions, including connectors, electric actuators, gearboxes, fieldbus and application engineering. The company has about 300 employees.

COESTER's international insertion is restricted to Latin America. About 10% of COESTER's products are exported to various countries, including Mexico and Venezuela. The company has (independent) representative offices in Mexico, Argentina, and Venezuela, where a building a factory is planned). Although the Venezuela office is not a subsidiary, it was decided to keep the company in this research project not only to contrast with the other two, but also because (i) the employees in the Venezuela office are were trained by COESTER researchers, and (ii) activities take place to adapt products and services to the needs of the local market. The respondent reported that the difference in their office abroad is related to logistics/distribution activities. That is, the enriching contribution of the foreign office is restricted to accessing to new markets (Latin America).

5.2 Results of the questionnaire

5.2.1 The importance of internal and external sources of technology

As Table 3 shows, the national sources of technology and competencies (activities internal to firms and external acquisition) are important for all three companies. Only SMAR believes it is important to have a strategy based

on several forms of access to international technology/competencies. For example, SMAR has an international policy of participating in certification bodies, quality, trade shows, etc. With these institutions, technicians have access to formal and informal knowledge flows, which are useful for a company that is often smaller than its international competitors.

ALTUS found a way to access to international technology using a strategic alliance with two other producers.

Table 2. Importance of source of technology/competence by activity of origin (A=ALTUS; C=COESTER and S=SMAR)

Origin of technologies and competencies employed in the company	Criticality of the source of technology/competencies				
	Low = 1	2	3	4	High = 5
Headquarters internal R&D					<u>A, C, S</u>
Acquisition in Brazil (universities, technology centers, etc.)				<u>A</u>	<u>C, S</u>
R&D in foreign subsidiary	<u>A, C</u>				<u>S</u>
International acquisition with intermediation/support from subsidiary	<u>A, C</u>				<u>S</u>
International acquisition without intermediation/support from subsidiary			<u>C</u>		<u>S</u>
International certification/quality, etc., entities.			<u>A</u>	<u>C</u>	<u>S</u>
International partnerships and exchanges with other firms	<u>S, C</u>				<u>A</u>

Source: field research

5.2.2 The contribution of subsidiaries to the economic performance of headquarters

The companies are satisfied with the subsidiaries' contribution to their economic performance (Table 4). The international transfer of technology is less important for the COESTER subsidiary, which is located in another developing country. However, the two companies that have subsidiaries in developed countries leverage this fact to become knowledgeable about and transfer technologies. The subsidiaries of the three companies have also contributed to the economic results of the groups, indicating that overseas investment has been beneficial for them.

Table 3. Contribution of analyzed subsidiary on company economic performance (A = ALTUS; C= COESTER and S = SMAR)

	Highly negative effect = -3	-2	-1	no effect = 0	1	2	highly positive effect = 3
International transfer of technology				C		A, S	
Growth (turnover)					A	C, S	
Market Share				A	C	S	
Profitability (operating margin)					A	C, S	

Source: field research

The small size of the ALTUS subsidiary virtually prevents it from developing new technologies/competencies that can be transferred to headquarters. However, the activity of procurement has been a source of useful information for the absorption and transfer of competencies to its headquarters in Brazil. The subsidiary is perceived as a "[...] contact with the outside world [...]" (GERBASSI, 2012). The subsidiary also absorbed and transferred to headquarters knowledge about standardization and formalization of procedures. SMAR has the advantage of producing abroad, and RKT has occurred, for example, in relation to the manufacture of lead free products, which a requirement for the German market. SMAR also cited other results of RKT in the area of production, marketing and sales, as well as the subsidiaries' support in relation to the product certification and technical support to access foreign markets.

5.2.3 Knowledge transfers

Transfer channels

We sought to identify whether the interviewed companies in any way use the rich communication channel, i.e., personal contacts. ALTUS stressed that there are routines that involve these types of contacts between employees and that such contacts are important. ALTUS uses the Internet and conference calls, trips abroad, and manuals drafted by the subsidiaries' staff to train personnel at headquarters. SMAR also pointed to the use of Internet and conference calls, trips abroad, patents, licenses, manuals, and third-party consultants. Furthermore, SMAR underscores that such exchanges serve as training, scheduling them with some regularity. COESTER stressed the importance of such exchanges, given that staff training in the areas of product and sales is an ongoing activity.

These responses, combined with the question that asks whether the subsidiary supports some kind of knowledge acquisition, indicate that SMAR and ALTUS companies already consider the activities of their subsidiaries that can convey knowledge of some type (be it competencies, skills or even new technology, albeit to a lesser degree) is of key importance. But such flows are relatively light compared with the level or intensity of RKT flows from the European multinationals identified in the RITOMO research. This act indicates that although these Brazilian companies in the automation sector are creative and innovative organizations, they still fail to exploit the potential of their subsidiaries as sources of information for innovation in the company.

The ALTUS subsidiary resembles the type described in the literature as competence-exploiting; in contrast, the SMAR foreign unit has characteristics of implementers. Both companies rely on the knowledge of their subsidiaries more heavily when they need to resolve some technical divergence related to the penetration of the host market to ensure some kind of sales strategy. They direct the knowledge learned in the host market to headquarters when it is related to logistics information, suitability of products and foreign sourcing of raw materials. The core of innovation – which is to develop new techniques, processes or even further development of a product – is not yet well defined.

During the visits to the headquarters of the companies interviewed, it was commonplace to identify that visits from employees and technical and professional from overseas occur often, thus softening the typical characteristics of competence-exploiting subsidiaries, which tend to emphasize on low cost communication channels (thus decreasing the inter-unit exchange of people) (MUDAMBI, PISCITELLO and RABBIOSI, 2007).

Consequences: impact and advantages

Finally, the positive effects resulting from the effective transfer of skills, competencies and technology are the main results of the successful process of reverse transfer of technology. RKT is able to generate new knowledge, thereby broadening the organization's absorption ability and favoring the occurrence of innovations. Table 4 shows the most important positive consequences of knowledge transferred from the subsidiary:

Table 4. Activities that reflected the most significant consequences of knowledge transferred from the subsidiary.

Research and Development	ALTUS	SMAR	COESTER
Productivity in R&D		X	
Development of new technologies	X	X	
Development of new products	X	X	
<i>Time to market</i>			
Management of innovation processes	X		
Activities			
Other			
Production	ALTUS	SMAR	COESTER
Productivity in production		X	
Management of production processes	X		X
Work organization techniques	X		
Other: local production abroad			X
Marketing and Sales	ALTUS	SMAR	COESTER
Development of services to the client		X	
Marketing/sales strategies		X	
Responsiveness to local requirements		X	X
Customer/vendor relationship management	X	X	X

Logistics/distribution	ALTUS	SMAR	COESTER
Logistics systems/techniques	X	X	
Distribution systems/techniques		X	
Management _____	X	X	
Development of distributive network		X	
Acquisition	ALTUS	SMAR	COESTER
Selection of suppliers	X	X	
Supply Strategies	X	X	
General Administration	ALTUS	SMAR	COESTER
Opening of new market/business		X	
Opening of new units abroad	X	X	
Collaboration with the local community (universities, institutions, etc.)	X	X	
Quality	ALTUS	SMAR	COESTER
Selection of inputs	X	X	
Working/control method	X	X	

Source: field research

The responses from the companies mention the absorption of practices aimed at the development of products and new forms of organizational processes: this is evidence that all three are interested in activities to foster the generation of knowledge useful for innovation.

Both ALTUS and SMAR comprise a well-defined framework of activities geared to overseas; on a smaller scale, so does COESTER, which already recognizes the positive importance of "foreign production."

From the mosaic presented in the tables above, these organizations appear to be companies geared to absorbing knowledge mainly in the form of training and skills (logistics/distribution, suppliers, marketing and sales, etc.), recognizing that RKT impacts these activities more than others (R&D). The president of ALTUS confirms this hypothesis, explaining that their technicians abroad,

"[...] know the worldwide chain of basic technology providers. They work in close proximity to, talk with, and visit suppliers. The technical staff are the company's ambassadors; the affiliate is contact with the outside world. For example, they learned and passed on knowledge about communication protocols and new protocol driver software in the electrical area, which are now emerging" (GERBASSI, 2010).

The aim is to better understand the components, whereas the process is an activity created and practiced by the firm. However, recognition by ALTUS and SMAR of the positive aspects of RKT on R&D, and productivity (SMAR), indicates that headquarters are already aware of the importance of the knowledge generated in the subsidiary for R&D.

6 CONCLUSIONS: RKT in Brazilian Multinationals in the Instrumentation Industry

Through the answers reviewed in the survey of three industrial automation companies, we find that the vision each company headquarters has of its subsidiaries as external knowledge receiver agents varies on a slope from very little (COESTER), to good (ALTUS) and very good (SMAR). Even the units are small compared to the subsidiaries of the largest multinationals, both SMAR as well as ALTUS operate positively in RKT activities.

The headquarters of SMAR and ALTUS do recognize their main subsidiaries as generating knowledge useful to headquarters, and that it can be used in product innovation. SMAR has produced innovations in ASICS and HART technologies. ALTUS has a narrower scope in terms of being more interested in absorbing information related to procurement, logistics, sales and marketing.

We find that the reverse-transfer and advantageously-utilized information from subsidiaries could be grouped in a circle of competencies and skills in marketing and sales, logistics/distribution, procurement, human resource management, general management and, to a lesser extent, in an area linked directly to technology development and innovation (apart from SMAR). The SMAR subsidiary is the one that sends back knowledge for technological

content innovation to the highest degree. At ALTUS, the subsidiary relays news, serving as a bridge. In general, the ALTUS and SMAR subsidiaries provide information on the evolution of technology, new protocols, etc.

According to the responses, all three companies are striving to increase exchanges and personal contact between employees at foreign units and headquarters. Social networking, which can develop through interpersonal contacts – either in training or exchanges – are positive features of these companies, because it strengthens social capital, which is all too important to the success of information exchanges and mutual inter-unit trust, which creates fertile ground for the uptake of new knowledge.

The survey data lead to a vision of the SMAR subsidiary as close to a mixture of the implementing type with the creative type, whereas ALTUS' foreign unit fits the competence-exploiting subsidiary type.

The above findings show a framework favorable for existence of typical RKT. With the evolution of learning in subsidiaries, and their absorptive capacity, they can gradually consolidate the role of supplier of creative units supplying innovative and technological knowledge to headquarters, thus performing RKT as a matter of course.

REFERENCES

- AMBOS, T. C., AMBOS, B., & SCHLEGELMILCH, B. B. (2006). Learning from foreign subsidiaries: An empirical investigation of headquarters' benefits from reverse knowledge transfers. *International Business Review*, 15(3), 294–302.
- ANDERSSON, U., FORSGREN, M., & PEDERSEN, T. (n.d.). Subsidiary performance in multinational corporations: the importance of technology embeddedness. *International Business Review*, 10(1), 2–23.
- ASSOCIAÇÃO BRASILEIRA DA INDÚSTRIA ELÉTRICA E ELETRÔNICA (ABINEE). (2013). Panorama Econômico e Desempenho Setorial, 2013. Retrieved from www.abinee.org.br
- BORINI, F. M., COSTA, S., BEZERRA, M. A., & OLIVEIRA, M. DE M. (2014). Reverse innovation as an inducer of centres of excellence in foreign subsidiaries of emerging markets. *International Journal of Business and Emerging Markets*, 6(2), 163–182.
- BORINI, F. M., DE MIRANDA OLIVEIRA, M., SILVEIRA, F. F., & DE OLIVEIRA CONCOR, R. (2012). The reverse transfer of innovation of foreign subsidiaries of Brazilian multinationals. *European Management Journal*, 30(3), 219–231.
- BUCKLEY, P. (2014). FORTY years of internalisation theory and the multinational enterprise. *The Multinational Business Review*, 22(3), 21–30.
- CHEN, V. Z., LI, J., & SHAPIRO, D. M. (2012). International reverse spillover effects on parent firms: Evidences from emerging-market MNEs in developed markets. *European Management Journal*, 30(3), 204–218.
- COHEN, W. M., & LEVINTHAL, D. A. (1990). Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly*, 128–152.
- DUNNING, J. H. (1976). *Trade, location of economic activity and the MNE: A search for an eclectic approach*. University of Reading, Department of Economics.
- DUNNING, J. H., & LUNDAN, S. N. (2008). *Multinational enterprises and the global economy*. Edward Elgar Publishing. Retrieved from http://books.google.com.br/books?hl=pt-BR&lr=&id=Hz6S4BGmGxUC&oi=fnd&pg=PR1&dq=%E2%80%9CMultinational+enterprises+and+the+Global+Economy%E2%80%9D,+&ots=HR_bNohJ_G&sig=1Dvm7q6EmjUZswmTS2dXrbearO4
- FOSS, N. J., & PEDERSEN, T. (2002). Transferring knowledge in MNCs: The role of sources of subsidiary knowledge and organizational context. *Journal of International Management*, 8(1), 49–67.
- FREEMAN, C. (1974). *The Economics of Industrial Innovation*. Harmondsworth: Penguin.
- GERBASSI. (2012, May 27). Entrevista concedida a Victor Prochnik.
- GUPTA, A. K., & GOVINDARAJAN, V. (1991). Knowledge Flows and the Structure of Control within Multinational Corporations. *The Academy of Management Review*, 16(4), 768–792.
- HARZING, A. W., & NOORDERHAVEN, N. (2006). Knowledge flows in MNCs: An empirical test and extension of Gupta and Govindarajan's typology of subsidiary roles. *International Business Review*, 15(3), 196–214.
- Hymer, S., Cohen, R. B., & Dennis, N. (1979). *The multinational corporation: A radical approach: Papers*. Cambridge: Cambridge University Press.
- MANSFIELD, E., & ROMEO, A. (1984). "Reverse" Transfer of Technology from Overseas American Firms. *IEEE Transactions on Engineering Management*, 31, 122–127.
- MARSCHAN-PIEKKARI, R., & WELCH, A. (2004). *Handbook of qualitative research methods for international business*. Edward Elgar Publishing.
- MILLAR, C. C., & CHOI, C. J. (2009). Reverse knowledge and technology transfer: imbalances caused by cognitive barriers in asymmetric relationships. *Int. J. Technology Management*, 48(3), 389–402.

- MOWERY, D. C., & OXLEY, J. E. (1995). Inward technology transfer and competitiveness: the role of national innovation systems. *Cambridge Journal of Economics*, 19(1), 67–93.
- MUDAMBI, R. (2011). Hierarchy, coordination, and innovation in the multinational enterprise. *Global Strategy Journal*, 1(3-4), 317–323.
- MUDAMBI, R., PISCITELLO, L., & RABBIOSI, L. (2003). *Knowledge transfer in cross border acquisition*. Presented at the DRUID Summer Conference 2003 on CREATING, SHARING AND TRANSFERRING KNOWLEDGE, Copenhagen.
- MUDAMBI, R., PISCITELLO, L., & RABBIOSI, L. (2007). Mandates and Mechanisms: Reverse Knowledge Transfer in MNEs. Retrieved from www.cbs.dk
- MUDAMBI, R., & SWIFT, T. (2011). Leveraging knowledge and competencies across space: The next frontier in international business. *Journal of International Management*, 17(3), 186–189.
- NARULA, R. (2014). Exploring the paradox of competence-creating subsidiaries: balancing bandwidth and dispersion in MNEs. *Long Range Planning*, 47(1), 4–15.
- PEDERSEN, T., PETERSEN, D., & SHARMA. (2003). Knowledge Transfer Performance of Multinational Companies. Retrieved from <http://openarchive.cbs.dk/>
- PERREN, L., & RAM, M. (2004). Case-Study Method in Small Business and Entrepreneurial Research: Mapping Boundaries and Perspectives. *International Small Business Journal*, 22(1), 83–101.
- PISCITELLO, L., & RABBIOSI, L. (2006). How does Knowledge Transfer from Foreign Subsidiaries affect Parent Companies' Innovative Capacity? DRUID Working Papers, n.06-22.
- PROCHNIK, V. (2013). The local content policy of in the oil and gas industry: the case of suppliers of process instrumentation and control equipment. In *Anais do XV Encontro Latino-Iberoamericano de Gestão da Tecnologia*. Porto, Portugal: Associação Latino Ibero-Americana de Gestão de Tecnologia (ALTEC).
- RABBIOSI, L. (2005). The evolution of reverse knowledge transfer within multinational corporations. Politécnico di Milano.
- RABBIOSI, L. (2008). The Impact of Subsidiary Autonomy on MNE Knowledge Transfer: Resolving the Debate. SSRN eLibrary.
- SCHLEGELMICH, B. B., AMBOS, B., & CHINI, T. C. (Winter). Are You Ready to Learn from Your Offshore Affiliates. *European Business Forum*, 16(ISTEI - Instituto di Economia d'Impresa), 50–54.
- SHARMA, D., PEDERSEN, T., & PETERSEN, B. (2006). Knowledge Transfer Performance of Multinational Companies. *International Business Review*, 15(3), 94–112.
- SILVEIRA, F. F. (2013). *Determinantes da transferência reversa de conhecimento tecnológico nas empresas multinacionais brasileiras*. Faculdade de Economia, Administração e Contabilidade University of São Paulo. Retrieved from <http://www.teses.usp.br/teses/disponiveis/12/12139/tde-10022014-151046/>
- SZULANSKI, G. (2006). Exploring Internal Stickiness: Impediments to the transfer of best practice within the firm. *Strategic Management Journal*, 17(winter special issue), 27–43.
- TEECE, D. J. (2014). A dynamic capabilities-based entrepreneurial theory of the multinational enterprise. *Journal of International Business Studies*, 45(1), 8–37.
- VIEIRA, L. D. (2009). *O CRESCIMENTO E A EXPANSÃO INTERNACIONAL DA SMAR: UMA ANÁLISE A PARTIR DOS MODELOS DE DUNNING E MATTHEWS* (Monografia). Instituto de Economia da Universidade Federal do Rio de Janeiro – UFRJ, Rio de Janeiro.
- VISSAK. (2010). The Qualitative Report, 15(2), 370–388.
- YANG, Q., MUDAMBI, R., & MEYER, K. E. (2008). Conventional and Reverse Knowledge Flows in Multinational Corporations. *Journal of Management*, 34, 882–902.
- YIN, R. K. (1994). *Case study research: design and methods*. London: SAGE.