Organization Innovation and Entrepreneurship: The Role of the National Laboratories in Promoting Industrial Development

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Abstract: The development of IC industry in Taiwan began with a technology transfer from the U.S. based RCA Company, which was conducted by Industrial Technology Research Institute (ITRI). ITRI’s Technology Transfer Team (TTT) members were first incubated in the National Laboratories at ITRI, and then dispatched to spin-off companies in the Hsinchu Science and Industrial Park (HSIP). Many of these TTT members are now the CEOs of leading companies within the IC industry. The aim of this study is to examine how ITRI’s Electronics Research and Service Organization (ERSO) shaped R&D engineers into technical entrepreneurs (Technopreneurs), and how ERSO has promoted Taiwan’s industrial development. This study uses in-depth interviews with 16 TTT members, combined with critical incident analysis of historical documents to support the following two themes: (1) ERSO/ITRI’s organizational innovation inspired IC technopreneurs to realize the “Innovative Spirit” and “Technopreneurship”. This was done by ERSO’s adaptation of new-enlightened experimentation procedures, by ERSO’s cultivation of the “Innovative Spirit” of technopreneurs under transformational leadership, and by ERSO’s innovative climate. Besides, the all-purpose training of operation executives was conducted in an environment that simulated market and business operations, which perfected the managing skills of these “technopreneurs”. (2) As national laboratories in Taiwan, ERSO has contributed human capital and social capital to the development of IC industry in
Taiwan, and it has also effectively linked Taiwan’s common innovative infrastructure with the geographical advantages of individual industrial clustering, thus creating the national innovative capability of Taiwan’s IC industry.

**Keywords**: Organizational Innovation; Technopreneurship; Innovative spirit; IC industry.

**Biographical Notes**:

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1. Research Purpose and Goals

Taiwan is currently a leading production base within the IC industry (Table 1). A massive amount of research has been conducted concerning the development of the IC industry in Taiwan, such as regional industrial features obtained from analysis of geographical economy (industrial district, [1]), the government's role in industrial development [2,3], technology transfer strategies [4,5], and other aspects of research supplied from the social network and authorities [6,7]. Yet studies that examine the shaping and the development of high-tech entrepreneurs are still deficient. This study explores how the technology transference team (TTT) in charge of IC technology transference from RCA has created vertical integration and horizontal divisions of labor within Taiwan's semiconductor industry, resulting in an industrial clustering based in the Hsinchu Science-Based Industrial Park (HSIP), also known as “Taiwan’s Silicon Valley”. The TTT’s effort is also a key factor to Taiwan's success in the IC industry. Studies on economic and social development within Chinese society have nearly always been focused on overall generalities, such as governmental roles, market mechanisms and the influence of Confucianism; yet the function of entrepreneurship has been largely overlooked. An examination of entrepreneurship is valuable towards industrial development because an entrepreneur’s leading style and tactics bring change and growth in an industry.

Taiwan’s government realized that the building-up of a technology-intensive industry would be extremely critical to reinforcing a macro economic performance. In light of this, the Industrial Technology Research Institute (ITRI) was established through legislature in 1973, and ran initially on governmental funding. ITRI’s Electronics Research and Service
Organization (ERSO) was subsequently founded in 1974 as one of ITRI’s three divisions, in order to create R&D capability in the semiconductor area. ERSO then acquired grants and projects from the government, and dedicated its efforts to technology development of IC process design, testing, and other technology related to the commercialization of the final products.

The establishment of Taiwan's IC industry started out at ITRI’s ERSO. Since the transfer of IC technology from the RCA Company in 1976, their production capacity has risen from zero to approximately twenty billion USD in 2002. Former TTT members who took part in the RCA technology transfer were now leading technopreneurs in the IC industry, such as the executives of United Microelectronics Corp. (UMC), and Taiwan Semiconductor Manufacturing Company, Ltd. (TSMC). These are also spin-off companies that were brought forth through ERSO. As a national research institute sponsored by the Taiwanese government for the promotion of the electronics industry, ERSO's mission was to carry out the "IC Development Plan". TTT members who were sent to the U.S. shared an incubation experience within ERSO, and a subsequent common experience of having founded ERSO's spin-off companies. This has contributed to the flourishing of Taiwan's IC industry and its spin-off organizations. Figure 1 shows that Taiwan's IC industry population is concentrated in the HSIP, and that a high number of these organizations have been formed through ERSO's technology transfer program and talent recruitment plan (as seen in Figure 2). The purpose of this study is to analyze the TTT's incubation experience at ERSO, and to examine how these technology-based engineers were shaped into entrepreneurs by ERSO. This study will serve as an independent case study for the National Laboratory's future technopreneur development plan.
2. Research Methods

The type of methodology employed in this study is by historical research [8], which is a systematic process of searching for facts, then using the information obtained to describe, analyze, and interpret the past. Data within this study was obtained from in-depth interviews with TTT members, and combined with critical incident analysis of historical document files for analysis. Interviewees are former TTT members, who were sent to RCA for technology transfer, had subsequently spent an incubation period at ERSO, and are now burgeoning entrepreneurs in the IC industry. These are classic examples of engineers turned technopreneurs; the 16 interviewees and their background information are as shown in Table 2. This study conducts an analysis of the interview contents and historical data combined, to serve as documentary support for the concluding result of this study. Historical document and interview data analysis are processed using Strauss’s Open Coding Technique in five phases: initial reading, coding, first order analysis, second order analysis, and pictorial representation of themes. The analyzed data is represented through a “technopreneur shaping model”, as shown in Figure 3. Consistent analysis results were adopted, while differing results between researchers were reviewed and further discussed. TTT members have also given their individual assessments, which helps to reinforce the validity of this study.

Advantages in obtaining information for this study lie in (1) how the efforts of Taiwan's IC industry have already produced tangible results. Leading companies in the IC industry share commonly transferred technology, and a common incubation experience in ERSO. This helps in shaping a complete study for "Organizational Innovation and Entrepreneurship; the role of the National Laboratories in promoting Industrial Development". Although this
study is an examination of a historical case, it will still act as a basis for the further development of the "technopreneur shaping model". (2) TTT members who participated in the IC technology transfer twenty five years ago are still active within the IC industry today; this study's hands-on contact with historical incident witnesses lend credibility and validity to the results. (3) The historical data supporting this study was obtained through courtesy of the Office of the ITRI President, and of ITRI’s Industrial Economics and Knowledge Center (IEK). The author of this study has been with ERSO since its establishment, which will help greatly in the deciphering and application of historical incidents.

3. Research Results

There are two major findings within this study: one is the revelation of the distinctive and unique features of ERSO’s organizational innovation. The other is ERSO’s role in promoting industrial development.

First of all, ERSO’s organizational innovation has shaped the entrepreneurial and innovative spirit: (1) Under transformational leadership and an innovative climate, ERSO's attempts at organizational innovation, together with its adaptation of the enlightened experimentation as innovation procedure, has molded the "innovative spirit" shown by engineers within their innovation efforts. (2) In order to promote the commercialization of industrial technology, ERSO also focuses on the overall development of future executive leaders. With the development of commercialized technology as an ultimate goal, the managerial skills of technopreneurs are cultivated through the nurturing of operation executives in an environment, which simulates market and business operations.

Secondly, ERSO has contributed the following three functions in the development of IC
industry in Taiwan: (1) Besides the transfer of technology from RCA, ERSO has also contributed human capital to IC industry in Taiwan, through its “Innovative Spirit”, and through its shaping of “Technopreneurs”. (2) ERSO’s many-talented innovation team and its “ERSO-born” personnel act as social capital for the clustering and the continuous innovation efforts of Taiwan’s IC industry. (3) As a collaboration institute, ERSO effectively creates a geological advantage by linking together Taiwan’s common innovation infrastructure with individual industrial clusters; this creates the building up of National Innovation Capability of Taiwan [9].

These two results are further elaborated in the following 7 Propositions, which composes the framework of the proposed model in Figure 3.

3.1 Proposition 1: The International political and economical status of those times inspired the Government and the TTT’s determination to make a spectacular breakthrough.

The government’s determination in developing an industry. Internationally, the U.S. was unstably caught up in the Vietnamese War; domestically, the Diaoyutai Incident had fired up strong nationalist sentiments [10]. Taiwan had cut off relationships with Japan and the U.S., and international status of Taiwan was in jeopardy. Moreover, both global and domestic economy was in bad shape; the Middle-East war had created a worldwide oil crisis, and Taiwan’s export industry was showing signs of recession. The Premier of the Executive Yuan at that time demanded that a recovery plan be proposed, in order to break through the political and economical standstill, and to create an economical changeover. Because the IC industry was reputed to be the most profitable of industries at that time, and because the minister of Economics, as well as many cabinet members, came from an electronics
engineering background, Taiwan’s government decided to go for the development of an IC-based industrial plan.

The TTT’s Determination to Establish a National Industrial Buildup. “The government had invested over US$10 million in development of the IC industry, and was determined to make history.”[11] Overseas scholars were encouraged to return to participate. The Minister’s steadfast support and the governmental strategic team’s confidence in this large-scale project were crucial in countering the many uncertainties that this long-term project would inevitably face. Strong ambition and stamina would be required of those willing to devote themselves to a newly developing industry that entailed daunting challenges and risks.[10] Under the aforementioned political and economical situation, a strong sense of purpose was aroused in the project participants, and the young TTT members were filled with the need for achievement.[12] This type of need is not only a core quality in technopreneurs[13], it is also the fundamental driving force behind innovation[14]. Taiwan’s easily attainable high-tech talents, combined with the geographical advantage of nearby academic establishments (National Chiao Tung University), and the sense of purpose mentioned above, became an advantage in Taiwan's efforts in talent recruitment for industrial development.

3.2 Proposition 2: Transformational Leadership Style forming and vitalizing ERSO’s Innovative Climate.

The Breakthrough of Organizational Inertia. The leadership style of the IC project executive, Ding-Hua Hu, was a major influence in the formation of the organization’s innovative climate[15]. Because ITRI was a statutory non-profit research institute, it had
inherited a kind of semi-bureaucratic conservative culture that was detrimental to the development of organizational innovation [16]. The executive leader’s effort in breaking through bureaucratic conventionalism and governmental vice, plus his supportive leadership style that asserted “I will take full responsibility”, enthused ERSO’s colleagues to adapt to new approaches and unconventional strategies [17].

**Accelerating the Formation of an Innovative Organizational Climate.** This type of “transformational leadership” [18,19] is also seen among the governmental top management levels involved in the IC project. Consultant Win-Yuan Pan, who worked with both RCA and Taiwan’s government officials, trusted the younger generation, was willing to help the younger generation, and encouraged them to discover new ideas and apply unconventional strategies. For example, the idea of having the production of 4” wafers reach 4,000 pieces per week in the laboratory might have seemed doubtful to Win-Yuan Pan, but he acknowledged this idea after learning of the reasoning behind it. The Minister of Economic Affairs, R. O. C., Mr. Yun-Suan Sun also gave his full support to innovation, and he staunchly believed in the professionals’ expertise and opinions [20]. All of these factors contributed to the formation of ERSO’s innovative leadership style.

This transformational leadership style that the government adopted for the IC project was a major force in breaking through the ties of bureaucratic conventionality in national research institutes, and it also motivated an organizational reform. This approach conforms to Schein’s proposal [21] that the role of leadership is crucial in shaping organizational culture.

3.3 Proposition 3: ERSO’s establishment of an Innovative Procedure, using the Enlightened
Experimentation approach

Creative innovation relies largely on a swift and well-thought-out Experimental System, so that promising ideas for research can be picked out and realized. ERSO adopted the “Enlightened Experimentation” approach as an innovative procedure [22], which was supportive of an accelerated experimental laboratory system, and a trial-and-error learning attitude, as well as efficient experimentation management.

Enlightened Experimentation is an Innovative Procedure that will accelerate the Experimental Process. ERSO is made up of a team of diverse professionals, including design engineers, testing engineers, and process engineers. Prompt sharing of information was encouraged, to ensure that each unit was aware of the requirements of others, and that each unit had the information necessary to push experiments at a fast pace. ERSO’s IC Common Design Center is such a common platform for information sharing. Besides this, the “Green Form”, an evaluation sheet adopted by ERSO, is a matrix performance appraisal and reward method, which various project leaders use to record and evaluate additional contributions made by colleagues in cross-departmental development teams besides their primary department. This type of efficient and complete organization structure (IC Common Design Center and Green Form) in an innovation team is what pushes ERSO to renew itself.

A Positive Attitude towards Trial and Error enhances Experimentation Management. An important part of ERSO’s innovative spirit is its ability to face failure squarely. Current ITRI President Chintay Shih states that “Experimental failure does not in any way reflect on the ability of the scientist/engineer,” and he encourages engineers with
the idea of “trial by error being the quickest way to success.” Apart from supportive leadership, a trial-and-error environment helps in the build up of an innovative climate, and in enhancing innovative ability [23]. Amabile [14,15] believes that “Features of Innovative Organizations” should include: tolerance of errors, showing respect for ideas that not have worked out well, but were creative and had potential; obtaining the interest and attention of professionals and leading executives. A high-level executive that sets an example of eliminating obstructions to innovation is a sure sign of an innovative climate in a promising organization.

**Experimental Management using front-loaded research.** In order to work according to principles, and to effectively gain some form of knowledge from experimental errors. ERSO’s “Project Management Handbook” emphasizes how errors may be pinpointed from failure analysis, how experimental procedures may be modified, how to clearly define experimental goals (estimation of what may be gleaned), and how to hypothesize (estimate what may occur). This kind of liberal style, educative approach and respect for intellectual property is a kind of work ethic and experimental spirit that was found during the technology transfer in the U.S. [20]. IC project executive Ding-Hua Hu fully recognizes the value of front-loaded development, and the choice between saving cost or achieving precision. What has been done is that low-cost designs are applied in the earlier stages of experimental development, while accuracy and precision is aimed for in later stages, after a learning pattern has been established.

3.4 Proposition 4: ERSO’s Innovative Climate and Innovate Procedure into the Innovative Spirit shape the TTT’s Sense of Purpose.
The ERSO’s transformational leadership style has shaped its innovative climate, while a newly created enlightened experimentation system has boosted its innovative abilities. These two conditioning factors are the key to ERSO’s creation of an environment fired with innovation and enthusiasm.

TTT members at that time were all young, with stable jobs (in telecommunications or in academia), and their choice to throw their lots in with the highly uncertain IC industry showed that they possessed a “risk-taking propensity” [24]. This clustering effect among adventurous technopreneurs [25] became infectious, and grouped polarization risk [26] became a commonly seen phenomena. A good example is of the co-founders of the first IC design house, Mr. Kuo-Chiao Wang and Mr. Jiin-Ming Shieh. Group venturing was further encouraged by ERSO’s error-tolerant and trial-encouraging practice. This cultivated the notion of the person-organization supplementary fit [27], which was in accordance with the theories at that time concerning innovation [28,29] and organization restructuring [16], which commonly stressed the importance of rapport between person and organization. The government’s determination and the reassurance of sufficient R&D resources helped to encourage less-venturesome parties to participate, and to make innovative-risk-taking a sort of social phenomena. It is important to allow the younger generation opportunities for inventive ventures [30]. They are the future cores of the R&D innovative force.

3.5 Proposition 5: Comprehensive Training of Operation Executives Enables Technopreneurial Competence

A Defined Goal for Industrial Development. The IC project’s clearly defined goal was to build up an industry; Project Executive Ding-Hua Hu’s ability to maintain a
controlled orientation of the project was a key element in its success. With “building an industry” as the ultimate goal, establishment of a future industrial model was the prior concern in the execution of the project. Due to this, TAC’s (Technology Advisory Consultants) mini-laboratory in the U.S. was turned into a 4” wafer fabrication plant, and “all executives were required to learn how to review financial statements, and how to run a profit center. Ten operation centers were established within the organizational structure, for full phase learning. This method was practiced because the ultimate goal of the project was to build up an industry; people were hired with the intention of training them to become future business managers.” [10] “Ding-Hua Hu had a sense of purpose in building up an industry, and in totally realizing a targeted goal by using a strict, yet fair management style.” [31] In terms of goal realization, the leaders “gave team members plenty of opportunity and free reign for development.” This type of “goal orientation and morale boosting” [32] accelerated the nurturing of future technopreneurs.

**Multi-functional Combinations and All-Purpose Development.** Because the ultimate goal of the project was to establish an industry, the IC Development project was to be a complete setup of a set of commercialized technology; team members were recruited from various fields, and a diverse team of talents was formed. Damanpour [33] believed that diversification encouraged effectual innovation, and a conglomeration of diverse professionals was more likely to present a unique and successful solution to problems. This study believes that mixed talents in a team would nurture mutual respect of professional knowledge among team members, and form a professionally based business relationship. This explains the cooperative network that has been established by the cluster of IC firms in the HSIP [7], as well as the mechanisms and features of its formation [33]. Moreover,
ERSO’s learning system is a simulation of market and organization operation, and entire sets of technology, personnel and management can be transplanted as spin-off companies are established. This “ERSO born” relationship among the IC cluster network not only forms the social capital for technological exchange among IC professionals in the Hsinchu Science-Based Industrial Park; its effectiveness also extends to administrative and managerial systems, such as inter-support in the purchasing and acquisition of materials. The HSIP Human Resource Association is another such “ERSO born” group whose purpose is to discourage malicious competition within the IC industry.

**Comprehensive Training of Future Project Executives.** ERSO differs from other divisions within ITRI (Mechanical Industry Research Laboratories, Energy and Resources Laboratories, and Union Chemical Laboratories), in its OP31 (IC operation code) training experience. In order to differentiate technological features among its operation plans, and to promote a matrix-styled management planning, ERSO assigns each of its projects with a code. For example Operation 31 signifies the "Integrated Circuit contract service business operation project" ("3" represents the business project itself, while 1 shows that the project is an IC project). This code differs from Operation 21 in that “2” represents governmentally funded scientific projects, while the “1” here still signifies that it is an IC project. This means that ERSO’s "Integrated Circuit contract service business operation project" will overlap with the governmentally funded scientific project to some extent, showing that this is an attempt to launch governmentally commissioned technology within the industry. OP31 is a project similar to operation plans that function by Strategy Business Unit that is categorized into sub-plans. The project leader would be similar in function to the President of a company, and would oversee areas such as IC design, production, test marketing,
financial management, and be in sole charge of any operations related to the product. After such an experience, managers and executives will have achieved a fair idea of the basics of operation management. This is one chief reason why ERSO’s managers (colleagues) that have ventured to entrepreneurship (or to service) within the IC industry are successful as entrepreneurs or managers. ITRI supports the all-purpose training of managerial leaders, since it has a far vision of its goal in the development of commercialized technology in the industry. Apart from providing an environment, which encourages learning, OP31 encompasses the complete IC commercial learning experience. This has made ERSO into an organization, which simulates market and company operations, instead of merely being a research institute. Absolute empowerment and the requirement to act independently have cultivated a practical and complete learning experience. Most research institutes are seen as merely technology-focused, yet ERSO functions as a preparatory organization that is continually carrying on the innovative spirit – in the form of nurturing budding technopreneurs.

3.6 Proposition 6: ERSO’s Innovative Spirit and Entrepreneurial Competence Training shapes TTT Members into Technopreneurs

The determination of the TTT members, plus their trial-and-error approach helped to develop the “Innovative Spirit”, under transformational leadership and an innovative climate. The goal of industrial development through commercialized technology and the all-purpose training of executive operation managers are carried out within a simulation of the market and business organization environment; absolute empowerment and full back-support is what creates the managing skills of technopreneurs. This study proposes that the “Innovative Spirit” and “Technopreneurship” are additional resources which ITRI
has contributed to the IC industry, besides Technology transfer. Technopreneurship of the IC industry are born through a combination of innovative spirit and entrepreneurial skills.

3.7 Proposition 7: ERSO has effectively linked Taiwan’s common innovative infrastructure with the geographical advantages of individual industrial clustering, thus creating the national innovative capability of Taiwan’s IC industry.

Taiwan's IC Industry has flourished through ERSO's organization innovation, through its cultivation of the "Innovative Spirit" and "Technopreneurs", and from the human capital and social capital that has been brought forth from ERSO. The innovative environment in which Taiwan's IC industry has been developed has created many competitive advantages within the industry. These "technological seedlings", bursting with innovation and potential, have started off as spin-off companies and grown into benchmark companies; under the government's sound plan for innovation, these companies will be the builders of the National Innovation Capacity of Taiwan's IC industry. This conforms to [9] reshaping model of industrial nations and burgeoning economical systems.

**Shaping a Sturdy Foundation for Innovative Build-up.** Taiwan's government shows its dedication towards the development of the IC industry, in its offering of human and financial resources, in its innovation-related public policies, and in its maturing economical body. Apart from these, the government is also placing emphasis on the protection of innovation-related intellectual property rights, on offers of tax credit for innovation, on encouraging competitive innovation, and in allowing trade and investments to be conducted. The investment and effort that Taiwan has put into building an industry foundation structure during the past decade, has its results in the form of the HSIP.
The Cluster-specific Environment for Innovation. While a sturdy common as innovation infrastructure has been established, the clustering of the IC industry within the HSIP shows how businesses will proceed to innovate and induce commercialization; this will in turn create a geological superiority. Innovation occurs most frequently where there is clustering—the geographic concentrations of interconnected companies and institutions in a particular field. The potential advantage of clustering is that the need and the opportunity for continuous innovation will arise. At the same time, clustering offers flexibility and power that will empower businesses to act promptly and be able to put their ideas into action. Businesses within the cluster will be able to have their requirements for new parts, service, and equipment satisfied much more swiftly. Local suppliers and business partners will also be able to participate in the innovation process. The pressures within the cluster—competitive pressure, peer pressure, and customers’ demands and comparisons—are in itself an incentive and a source of motivation to be continuously creative. Moreover, it is vital to the rate of innovation that the powerful spillovers and externalities across discrete industries.

ERSO’s multi-functional technology innovation team encourages knowledge sharing among its members, and it also values the needs of the teams that they co-work with. The promptness and the all-encompassing organizational structure (IC Common Design Center and Performance Appraisal Method) of such an innovation team not only enhances ERSO’s innovative capabilities, it also serves as the partnership basis for the division of technological skills in the IC industry. The ERSO learning pattern’s simulation of market and business operations also allows for entire sets of technical and managerial personnel to be transplanted as soon as spin-off companies are established. These “ERSO born”
personnel and the clustering effect created by their interpersonal network, provides the social capital for technological interchange among HSIP engineers, and among other administrative and managerial systems within the industry.

**ERSO as a Top-notch Institute of Collaboration.** ERSO’s role function is to provide an effective link between technology and industry, and to practically apply “creativity”, “innovation”, and “technopreneurship”. The innovative climate formed under ERSO’s transformational leadership has induced ingenuity in R&D; liberal experimental processes effectively transform innovative ideas into tangible results; all-purpose and on-hands training of operation executives is in itself an entrepreneurship that helps innovation to become commercialized and standardized. The common foundations for innovation, and the industrial clustering in Taiwan’s IC industry, are due to ERSO’s efforts to provide a link between technology and business. ERSO has become what is called, “an institute of collaboration”.

4. Conclusion

The progression of Taiwan’s metamorphosis into a globally renowned IC industrial nation started from the IC technology transfer from RCA, in the U.S. The TTT members who participated in the technology transfer had been trained by ERSO, and had accumulated business experience in spin-off companies. Many have now become business leaders in Taiwan’s IC industry, such as the executives of TSMC and UMC. The purpose of this study is to analyze the innovative features of ERSO’s R&D team, and to examine its shaping (molding) mechanism in producing technopreneurs. The role of ERSO in the development of new industries is also examined. Results of this study are: (1) The Organizational
innovation of ERSO has inspired IC technopreneurs to realize the “Innovative Spirit” and “Technopreneurship”. (2) ERSO has contributed “human capital and “social capital” to the development of Taiwan’s IC industry, and (3) it has also served as an “collaboration institute” to link national innovative infrastructure and clustering specific innovative environment, thus creating the national innovative capability of Taiwan.

4.1 Innovative Spirit and Technopreneurship Within the R&D Team

The organizational innovation of ERSO has inspired IC technopreneurs to realize the “Innovative Spirit” and “Technopreneurship”. This was done by (1) adapting to new trial-and error experimentation procedures; cultivating the “Innovative Spirit” of technopreneurs under transformational leadership, and within an innovative climate. (2) Viewing the commercialization of industrial technology as the ultimate project goal. The all-purpose training of operation executives was conducted in an environment that simulated market and business operations, which perfected the managing skills of these “technopreneurs”. 

4.2 ERSO’s role in the development of a new industry

ERSO has contributed “human resource capital and “social capital” to the development of Taiwan’s IC industry, and it has also served as a “collaboration institute”. (1) The “Innovative Spirit” and the “Technopreneurs” nurtured by ERSO, are the human resource capital which ERSO has contributed to Taiwan’s IC industry, besides the technological transfer from RCA. (2) The “ERSO” born team of multi-functional and wide-ranging technological staff, serve as the “social capital” for the innovative clustering of businesses in Taiwan’s IC industry. (3) As a collaboration institute, ERSO has effectively linked
Taiwan’s common entrepreneurial foundation with the geographical advantages of individual industrial clustering, thus creating the national innovative capability of Taiwan’s IC industry.

4.3 Points for further Examination and Discussion

The purpose of this study is to analyze the innovative features of ERSO’s R&D team, and to examine its shaping (molding) mechanism in producing technopreneurs, to serve as a reference for future development of national innovative capacity, and the development of new industries. Future studies may also focus on a combination of social economy, technological strategy, and workforce trends to obtain an all-encompassing and complete case of study. Further points for study include: (1) a comparison of the entrepreneurial behavior and the social networking between original TTT members, and of returned talents from Silicon Valley. (2) Governmental policy mechanisms in developing new industrial plans. (3) How the timing by which ITRI releases its spin-off companies has impacted, and set an example for the development of Taiwan’s IC industry. Examination of its interaction with the international business cycle and (4) Understanding the nature of the Innovative Spirit, and understanding how it may be further applied on the development of new knowledge systems.

5. Reference


### Table 1: Critical Milestones in Taiwan’s IC Industry in 2001

<table>
<thead>
<tr>
<th>Industry Chain</th>
<th>Capacity (million USD)</th>
<th>Global Market Share (%)</th>
<th>Global Ranking</th>
<th>Leading Nations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>3,616</td>
<td>25.9</td>
<td>2</td>
<td>U.S.</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>8,966</td>
<td>7.4</td>
<td>4</td>
<td>U.S., Japan, Korea</td>
</tr>
<tr>
<td>Foundry Service</td>
<td>6,070</td>
<td>72.9</td>
<td>1</td>
<td>Taiwan</td>
</tr>
<tr>
<td>Assembly</td>
<td>2,285</td>
<td>30.4</td>
<td>1</td>
<td>Taiwan</td>
</tr>
<tr>
<td>Testing</td>
<td>750</td>
<td>35.7</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

Source: ITRI Industrial Economics and Knowledge Center (Dec. 2002)
## Table 2 Backgrounds of Interviewees

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Organization</th>
<th>Title</th>
<th>Former Highest Position at ERSO (Year)</th>
<th>Position held at the time of technology transference</th>
<th>Industry area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ding-Hua Hu</td>
<td>Macronix International Co.</td>
<td>Chairman</td>
<td>General Director of ERSO (1984)</td>
<td>Superintendent of ERSO</td>
<td>B</td>
</tr>
<tr>
<td>2</td>
<td>Chintay Shih</td>
<td>Industrial Technology Research Institute</td>
<td>President</td>
<td>General Director of ERSO (1989)</td>
<td>Team executive</td>
<td>D</td>
</tr>
<tr>
<td>3</td>
<td>Fang-Churning Tseng</td>
<td>TWN Semiconductor Mfg. Corp.</td>
<td>President</td>
<td>Demo Plant Manager (1986)</td>
<td>Engineer</td>
<td>C</td>
</tr>
<tr>
<td>4</td>
<td>Yin-Dar Liu</td>
<td>United MicroElectronics Corp.</td>
<td>Vice Chairman</td>
<td>Department Manager of Demo Plant (1980)</td>
<td>Engineer</td>
<td>C</td>
</tr>
<tr>
<td>5</td>
<td>Ding-Yuan Yang</td>
<td>Winbond Electronics Corp.</td>
<td>Vice Chairman</td>
<td>Deputy General Director of ERSO (1980)</td>
<td>Squad executive</td>
<td>B</td>
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<td>6</td>
<td>Hyley Huang</td>
<td>Wintek Corp.</td>
<td>Chairman</td>
<td>Section Manager of Production (1980)</td>
<td>Engineer</td>
<td>D</td>
</tr>
<tr>
<td>7</td>
<td>Parkson Chen</td>
<td>Taiwan Mask Corp.</td>
<td>President</td>
<td>Department Manager of Mask operation (1983)</td>
<td>Engineer</td>
<td>D</td>
</tr>
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<td>8</td>
<td>James Chew</td>
<td>Fortune Venture Investment Co.</td>
<td>Executive</td>
<td>Director of QA Division (1986)</td>
<td>Engineer</td>
<td>D</td>
</tr>
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<td>9</td>
<td>Jiin-Ming Shieh</td>
<td>Yi-Chuan Technology Corp.</td>
<td>President</td>
<td>Division Director of Computer Program Design (1985)</td>
<td>Engineer</td>
<td>A</td>
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<tr>
<td>10</td>
<td>Chi-Ping Chang</td>
<td>Sino Matrix Technology Inc.</td>
<td>President</td>
<td>Department Manager of Digital Electrical Design (1986)</td>
<td>Engineer</td>
<td>A</td>
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<td>11</td>
<td>Chin-Yung Shu</td>
<td>Hermes Systems Inc.</td>
<td>President</td>
<td>Section Manager of Mask operation (1986)</td>
<td>Engineer</td>
<td>D</td>
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<td>12</td>
<td>Ling-Yuan Tseng</td>
<td>Taiwan Micro Vision Corp.</td>
<td>President</td>
<td>Office Manager of U.S.A. Branch Office(1980)</td>
<td>Staff</td>
<td>D</td>
</tr>
<tr>
<td>13</td>
<td>John Hsuan</td>
<td>United Microelectronics Corp.</td>
<td>CEO</td>
<td>Department Manager of Operation Support (1981)</td>
<td>Staff</td>
<td>C</td>
</tr>
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<td>14</td>
<td>Ming-Kai Tsai</td>
<td>MediaTek</td>
<td>Chairman</td>
<td>Department Manager of IC Design (1980)</td>
<td>Engineer</td>
<td>B</td>
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<td>15</td>
<td>Shyuh-Der Lin</td>
<td>Holylite Microelectronics Corp.</td>
<td>President</td>
<td>Division Director of IC Design (1988)</td>
<td>Engineer</td>
<td>B</td>
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<td>16</td>
<td>Shin-Shi Chang</td>
<td>VXIS Technology Corp.</td>
<td>President</td>
<td>Division Director of IC Design (1987)</td>
<td>Engineer</td>
<td>D</td>
</tr>
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</table>

Note1: Current entrepreneurial leaders in the IC Industry, who were sent to RCA in the U.S. for IC technology transfer, and were incubated at ERSO/ITRI. These are archetypal examples of engineers turned technopreneurs.

Figure 1: Statistical graph of ERSO spillover talents
Establishment of ERSO (Ding-hua Hu, Chin-Tai Shih, Robert Tsao, Ding-Yuan Yang, Ching-Jin Chang, Fan Churng Tseng)

Spun-off of United Microelectronics Corp. (UMC) (*Robert Tsao, John Husan, *Yin-Dar Liu)

Syntek Semiconductor Co., Ltd. (*Kuo-Chao Wang)

Ho Der Integrated Circuit Ltd.


Silicon Systems Corp., Integrated

B Weltrend Semiconductor Inc (*Shih-Min Lin)

Macronix International Co., Ltd. (*Ding-hua Hu)

Avid Electronics Corp. (*Ding-Hua Hu, Jiin-Tang Chen)

AsLic Microelectronics Corp.

Winbond Electronics *Ching-Chu Chang, *Ding-Yuan Yang)

Holtek Semiconductor Inc. (Chi-Yung Wu)

ChipDesign Technology Ltd.

Geoforce Technologies Co., Ltd. (*Hyley Huang)

Wintek Corp

Faraday Technology Corp. (*Ming-Jieh Tsai)

USC, UICC, USIC (Chong-der Chang, *Jiin-Zhong Hsu), Mediatek Corp.

Novatek Microelectronics Corp.

Figure 2: ERSO Member Dispersion and Spin-off System

Note 1: The meanings of the symbols in this figure: A: Design Industry, B: IC Manufacturing Industry, C: Foundry

Note 2: represents technological transfer, talent transfer, or joint development.
Figure 3: ERSO’s “Technopreneur Shaping Model”

Note: ERSO/ITRI’s has inspired IC technopreneurs to realize the “Innovative Spirit” and “Technopreneurship”, and it has played as a ‘Collaboration of Technology and Industry’ (C) to link ‘Common Innovative Infrastructure’ (A), with ‘Cluster-specific innovation environment’ (B). (A), (B), and (C) contribute to National innovative capability of Taiwan’s IC industry.