

## **THE STRUCTURE OF INTRA-GROUP TIES: INNOVATION IN TAIWANESE BUSINESS GROUPS <sup>1</sup>**

### **APPENDIX – EXAMPLES OF BUSINESS GROUP TIES AND INNOVATION IN TAIWAN**

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The following examples offer snapshots of the evolution of several business groups and business group affiliates in Taiwan, and depict patterns of operating and investment ties within the groups (see Figure A1 and Table A1). We drew information for these examples from many published sources in the US and Asia, data from the US Patent and Trademark Office and the Taiwan Patent Office, plus discussions with industry personnel in Taiwan and elsewhere in Asia.

#### **Acer Group (founded 1976)**

The Acer Group operates in the personal computer industry. Acer Inc., the group's flagship company, is now one of Asia's graybeard technology companies. Acer Peripherals Inc., one of the affiliates of the group, was one of the top 10 Taiwanese-based recipients of US patents between 1970 and 1999. Firms within the Acer group encompass a broad product line of PCs and PC components, including chipsets, motherboards, DRAMs, keyboards, CD-ROM drives, and monitors. Acer was founded as Multitech International Corporation in 1976 by Stan Shih, beginning with only eleven employees and \$25,000 in capital. In 2000, the Acer Group had revenues of \$9.9 billion, while employing 35,000 people in 232 enterprises spanning 41 countries worldwide, and supporting dealers and distributors in over 100 nations. Acer Inc. provides equity investments for many of the group's affiliates. The founding firm, Acer Inc., also has forward and backward buyer-supplier relationships with other two manufacturing units within the group, Acer Peripherals and Acer Sertek.

Acer has undergone two major reorganizations. During the 1980s, Acer created a confederation of business units, organized in a structure that focused on product lines or regions, with the goal of fostering speed, flexibility, and an entrepreneurial culture. Strategic Business Units (SBUs) were responsible for product design, development and production and were also responsible for OEM sales and marketing. Regional Business Units (RBUs) in specific territories developed and provided support for distribution channels, assembled finished products, and created joint enterprises in local markets. This structure produced a low density of operating ties among Acer affiliates, as well as limited centrality for any firm other than in investment centrality of Acer, Inc. By the mid 1990s, problems of the decentralized structure began to emerge. Affiliate management often made decisions that were sub-optimal from the group's perspective, which caused ineffective use of enterprise resources. The lack of central players appeared to constrain the group's ability to coordinate its activities, including those needed for innovation.

In 1998, Acer initiated a new structure for the group, aggregating most of its business units into five core SBU's based on lines of business. Each SBU became responsible for a line of related products and services, from product development to manufacturing to marketing and support. The goal of the reorganization was to link product development and manufacturing to marketing and services, improve coordination among Acer's primary business units, eliminate redundancy, and increase customer focus throughout the group. In doing, so Acer created more operating ties among affiliates, centered on one or more major firms within each SBU. The group also created several "XBUs" in exploratory or tangential lines of business, as well as a new company designed to pull together Acer's software businesses.

#### **United Microelectronics Group (founded 1980)**

United Microelectronics Corporation (UMC) was founded in 1980 as a spin-off of Taiwan's government-funded Industrial Technology Research Institute (ITRI). In 2005, UMC was the world's number two semiconductor foundry, with factories in Taiwan, Japan, and Singapore, as well as partnerships

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<sup>1</sup> This appendix provides supplemental information for the paper "The structure of intra-group ties: Innovation in Taiwanese business groups", by Ishtiaq Mahmood, Will Mitchell, and Chung Chi-Nien (May 2008).

in China. UMC trailed only Taiwan Semiconductors (TSMC Group), another ITRI-spawned company that pioneered the foundry business in 1987. UMC was the top 10 Taiwanese-based recipient of US patents between 1970 and 1999.

UMC and other members of the UMC Group provide design, engineering, manufacturing, sorting, testing, and packaging services. For the first 15 years of its history, the UMC group and its affiliates engaged in integrated circuit (IC) design and production, as well as electronics contract manufacturing (ECM). In 1995, the group shed its IC design and non-chip contract manufacturing businesses to become a dedicated chip foundry. UMC is now a leader in advanced production technologies in Taiwan, while UMC's majority-owned subsidiary UMCi has opened an advanced fabrication facility in Singapore. The UMC Group includes multiple subsidiaries and minority-investment affiliates, linked through a mix of investment, director, and buyer-supplier ties. UMC and its affiliates have also imported global technology through joint ventures with firms such as Advanced Micro Devices and Hitachi, as well as via cross-border acquisitions such as Nippon Steel's chip foundry business. In 2000, UMC consolidated many of the group's Taiwan-based affiliates, including United Integrated Circuits, United Silicon, United Semiconductor, and UTEK Semiconductor, into the central company.

#### **Mosel Group (founded 1983/1991)**

Mosel Vitelic, the core member of the Mosel Group, was created by the 1991 merger of two private companies: Mosel (an SRAM and advanced logic product manufacturer) and Vitelic (a DRAM and Video RAM manufacturer). Both Mosel and Vitelic were founded in 1983. Mosel Vitelic is based in the Hsin-chu Science Based Park in Taiwan, with subsidiaries in the United States, Japan, and Hong Kong. The combined company's revenue reached \$615M in 1999. Mosel Vitelic designs, manufactures, and markets dynamic RAMs (DRAMs), as well as flash and high-speed static RAMs (SRAMs) for world-wide markets. Mosel Vitelic was one of the top 10 Taiwanese-based recipients of US patents between 1970 and 1999.

ProMos Technologies, a second affiliate of the Mosel Group, is a semiconductor-memory chip provider headquartered in Hsin-chu, Taiwan, founded in 1996. The company manufactures high-performance, high-density commodity DRAM memory chips as well as pseudo-SRAM, lower power SDRAM, and MCM products. ProMos had 2004 sales of \$1.4 billion, with net income of \$323 million. ProMos was the only Taiwan DRAM company to develop 0.12-micron process and 0.11 shrink technology, and the only Taiwan DRAM manufacturer to design and test 256M and 512M DDR2 mainstream products

#### **ASE Group (founded 1984)**

The Advanced Semiconductor Engineering (ASE) Group is a leading provider of semiconductor testing and packaging services. The core firm of the group, Advanced Semiconductor Engineering Inc. (ASE) was founded in 1984 and now provides services for customers such as Advanced Micro Devices, Freescale, IBM, Qualcomm, NVIDIA, and Via Technologies, with sales of \$2.6 billion in 2005. The group also provides services through subsidiaries such as ASE Test in Taiwan and ISE Labs in the Silicon Valley, although there are only limited operating relationships among the affiliates. The group has expanded production capacity and service offerings through multiple acquisitions, such as purchasing a chip packaging and testing plant from NEC Electronics. ASE holds equity stakes in most members of the Advanced Semiconductor Engineering Group. The family of chairman Jason Chang owns a controlling interest in ASE and serve as executives and board members of several group affiliates.

#### **TSMC Group (founded 1987)**

Founded in 1987 as a spin-off of Taiwan's Industrial Technology Research Institute (ITRI), Taiwan Semiconductor Manufacturing Company (TSMC) was a pioneer in the semiconductor foundry business and has been technologically active since its inception. TSMC offers highly efficient advanced wafer production processes. TSMC was the world's largest dedicated semiconductor foundry in 2005, with manufacturing capacity of about 4.3 million wafers and revenues representing about 50% of the global

foundry market (TSMC sales were \$NTD 270 billion in 2005). TSMC operates most of its fab operations in HsinChu Science Park and Tainan Science Park in Taiwan, with additional fabs in Camas, Washington (WaferTech), Singapore (SSMC, a joint venture with Philips Semiconductors), and Shanghai. TSMC has offices in Japan, the Netherlands, and the U.S. (San Jose, Austin, and Boston).

TSMC holds equity stakes and director positions in several other members of the TSMC group, although TSMC has only a moderate number of operating relationships with the other affiliates. One notable TSMC equity link is a 27% holding in Vanguard International Semiconductor Corporation (VIS), a designer and producer of memory integrated circuits, together with several representatives on Vanguard's board of directors. VIS was founded in 1994 as a spin-off of the Sub-Micron project of the ITRI, beginning life as a DRAM producer and then expanding into the semiconductor memory foundry business in 2000. VIS also is based in Hsinchu Science Park, with additional facilities in Europe and the US. Vanguard had sales of \$NTD 16 billion in 2004, including exports to North America, Asia, and Europe. TSMC and Vanguard were both among the top 10 Taiwanese-based recipients of US patents between 1970 and 1999, although TSMC far out-paced Vanguard.

### **UMAX Group (founded 1987)**

UMAX Data Systems, the core member of the UMAX Group, manufactures imaging equipment such as image scanners, LCD projectors, and speakers, plus software for image manipulation. UMAX held about 30% of the U.S. market for scanner equipment in 2005. Founded in 1987, the company has headquarters in Taiwan and a U.S. subsidiary in Fremont, California. UMAX once produced digital cameras. In the early 1990s, UMAX was a leading licensee of the Apple Macintosh technology, producing Macintosh clones until Apple discontinued licensing the technology. The company also once produced Intel-based PCs and notebook computers, but exited that line of business to introduce systems with its own components. UMAX recently started a subsidiary company, ImageOnline.com, which provides online image storage for users.

### **Asustek Group (founded 1989)**

Asustek Computer (ASUS), the core member of the Asustek Group, was spun off from Acer Computers in 1989. ASUS manufactures motherboards, notebooks, VGA cards, servers, broadband modems, and optical storage devices. The company has more than 40,000 employees worldwide, with facilities capable of producing two million motherboards and 150,000 notebook computers monthly. In 2005, 1 out of 4 desktop PCs in the world had an ASUS motherboard.

### **Tie Variation and Patenting Differences Within and Across Groups**

Firms in many groups in Taiwan – and firms within the same groups – demonstrate highly varied patenting, even within the same sectors. For instance, among the leading manufacturers of semiconductors in Taiwan, Nanya Technology Corporation, a member of the Formosa Plastics Group, received only 64 Taiwanese patents from 1991 to 1999 (Table A1a). This is a sharp contrast to United Microelectronics Inc. (the core firm of the UMC Group) and Taiwan Semiconductor Manufacturing Co. Ltd. (core firm of the TSMC group) which both received more than 1,000 Taiwanese patents during the same period. In parallel, high variation exists among affiliated firms within even an innovative group. For example, although both Taiwan Semiconductor Manufacturing Co. Ltd. and Vanguard International Semiconductor Corporation are both members of the same TSMC Group, Taiwan Semiconductor received substantially more patents than Vanguard from 1991 to 1999. The major differences in the innovativeness across and within groups reinforce the importance of the question of why such differences arise.

Intra-group governance and operating ties may help explain why some group affiliates are more or less innovative than others. In the Hon Hai Group example, for instance, senior executives in the group note that each subsidiary has a particular mission, such as making specific components for system assembly. Although the primary focus of a subsidiary is on achieving its mission, rather than on contributing to innovation at other affiliates, operating and managerial links between affiliates can indirectly facilitate innovation by providing component knowledge that helps a partner's systemic innovation.

As another example, one of the reasons why United Microelectronics and Taiwan Semiconductor Manufacturing have been more innovative than other firms within the same industry, such as Nanya Technology Corporation, may have something to do with their access to downstream customers within their groups that offer relevant component knowledge. United Microelectronics Inc. has both buyer-supplier ties and equity ties with Faraday Technology, a sister affiliate of the UMC group that specializes in IC design services. Similar ties exist between Taiwan Semiconductor Manufacturing Corp. and Global UniChip Corp., an affiliate within the TSMC group that specializes in chip design. Ties in the form of inter-locking directorates also may influence innovativeness. For example, Dr. F.C. Tseng was both the chairman of UniChip and the Vice-Chairman of the Taiwan Semiconductor Manufacturing Corporation in 2005. In comparison, Nanya Technology had no operating ties and only two investment ties with the other 19 members of the Formosa Plastics Group. Nanya did, though, have 11 director ties with other Formosa Group affiliates (Table A1a), which raises the question of whether some forms of ties facilitate innovation more than others or, indeed, whether some forms of ties tend to constrain innovation. To the extent that links within groups facilitate or constrain resource sharing, differences in affiliates' access to other members of the group may contribute to differences in their innovative activities.

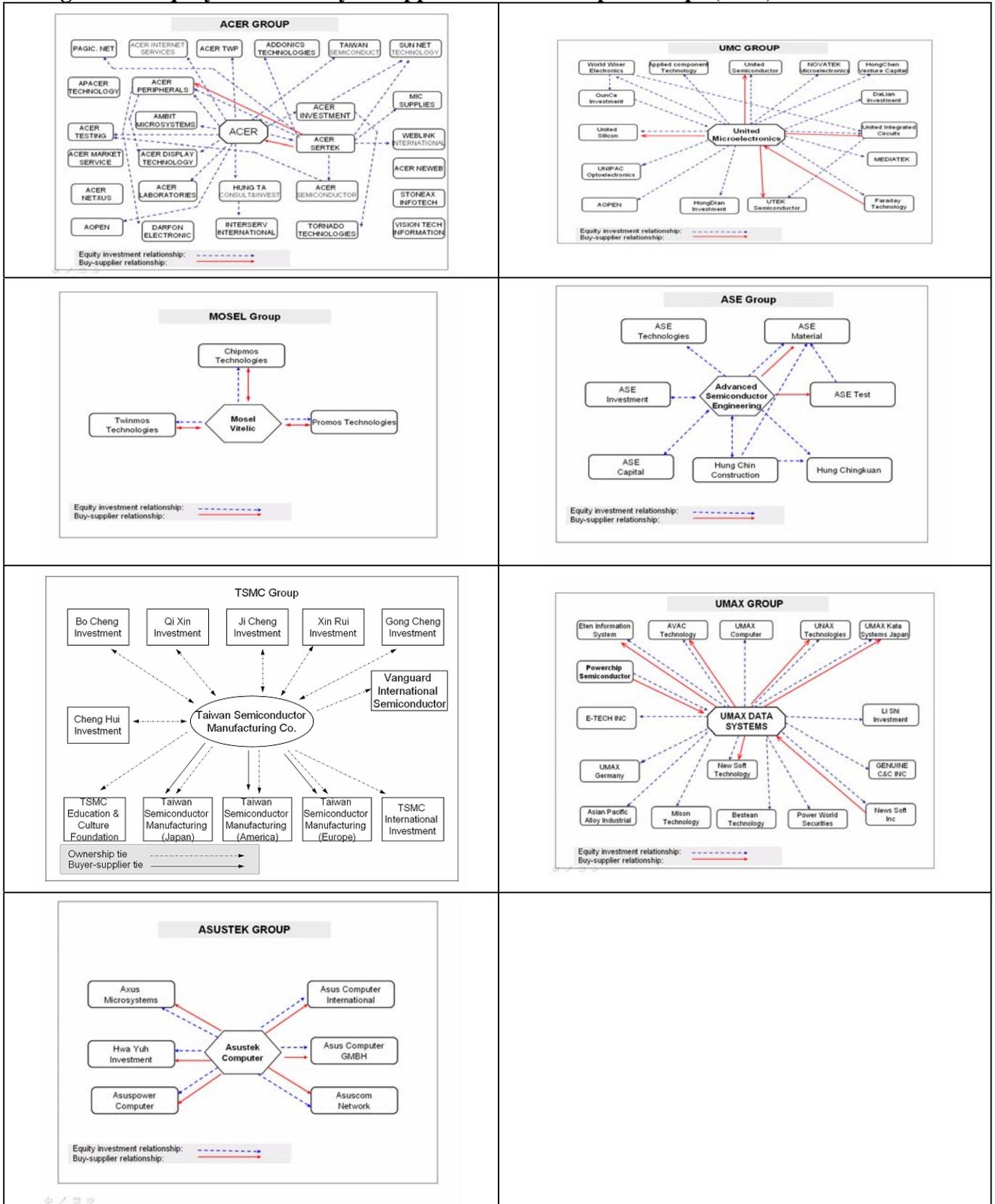
To reinforce this point with another example, consider two firms – United Microelectronics Corporation (UMC group) and Vanguard International Semiconductor (TSMC group) – that are in similar sets of businesses but have different patenting performance. United Microelectronics received 2680 domestic patents from 1991 to 1999. Vanguard International received 531 patents during the same period. Based on 1998 data, United Microelectronics Corporation had 15 investment ties, 9 director ties, and 5 buyer-supplier ties with the 15 other firms in the UMC group. By contrast, Vanguard had only 1 investment tie, 4 director ties, and no buyer-supplier ties with the 13 other firms in the TSMC group (Table A1a). Overall, then, United Microelectronics had far more ties than Vanguard. To the extent that intra-group ties help firms gain access to resources and information necessary for innovative activities, the difference in number of ties offers a potential explanation behind the heterogeneity in patenting performance across firms within the same industry.

Of course, groups differ in terms of numbers of affiliates as well as number of ties. Therefore, it may be useful to consider how firm centrality (the number of ties divided by the number of firms in the group) associates with firms' innovative performance. Mosel Vitelic Inc. and ProMos Technologies Inc. are members of the Mosel Group that operate in the same segment of the semiconductor industry, making memory-based chips such as DRAMs. Mosel Vitelic received 436 domestic patents from 1991 to 1999, whereas ProMos received only 59 patents over the same period. Table A1b shows that Mosel Vitelic had buyer-supplier centrality of 1.0 (all 3 possible ties) while ProMos had buyer-supplier centrality of 0.33 (1 of 3 possible ties). Director centrality was the same for both firms (0.33), but investment centrality was higher for Mosel Vitelic (1.0) than for ProMos (0.33). Differences in firm centrality within the network of their common group might influence patenting differences across the firms.

Nonetheless, differences in firm-level centrality within a group provide only partial hints to why some affiliates are more innovative than others. Remaining within the semiconductor industry, United Microelectronics Corporation and ProMos Technologies Inc. have the same centrality (0.33) in terms of buyer-supplier ties but drastically different patenting activity (Table A1). One major difference between these two firms is the difference in group-level density. ProMos is affiliated with the Mosel Group, which has much higher buyer-supplier density (0.50) than the UMC group to which United Microelectronics belongs (0.04). Thus, group-level density might shape member firms' innovative activities.

These examples provide intriguing hints that firm centrality and group density might influence innovativeness. Of course, the examples cannot control the possibility that different ties concurrently facilitate and constrain innovation, and can not address alternative explanations such as firm size and differences that arise over time. The statistical analysis in the paper examines how the structure of different types of ties facilitates or constrains innovativeness within and across groups.

**Figure A1. Equity Ties and Buyer-Supplier Ties in Example Groups (1998)**



**Table A1a: Leading Manufacturers of DRAM Memory Chips in Taiwan (1998 ties)**

<b>Firm Name</b>	<b>Group</b>	<b>Operating Ties</b>	<b>Director Ties</b>	<b>Investment Ties</b>	<b>Domestic Patents 1991-99</b>	<b>Number of Firms in Group</b>	<b>Domestic Patents 1991-1999</b>
Mosel Vitelic Inc.	Mosel	3	1	3	436	4	436
ProMos Techonologies Inc.	Mosel	1	1	1	59	4	59
PowerChip	Umax	1	8	1	55	17	55
United Microelectronics Corporation	UMC	5	9	17	2680	16	2,680
Taiwan Semiconductor Manufacturing Co. Ltd	TSMC	3	4	13	1583	14	1,583
Vanguard International Semiconductor Corporation	TSMC	0	4	1	531	14	531
Nanya Technology Corporation	Formosa	0	11	2	68	20	68

**Table A1b: Examples of Firm Centrality and Group Density over the Study Period (1998 ties)**

<b>Firm Name</b>	<b>Group</b>	<b>Local Patents 1991-1999 (Firm)</b>	<b>Buyer-supplier Centrality (Firm)</b>	<b>Director Centrality (Firm)</b>	<b>Investment Centrality (Firm)</b>	<b>Buyer-supplier Density (Group)</b>	<b>Director Density (Group)</b>	<b>Investment Density (Group)</b>
Mosel Vitelic Inc.	Mosel	436	1.0	0.33	1.0	0.50	0.33	0.50
ProMos Techonologies Inc.	Mosel	59	0.33	0.33	0.33	0.50	0.33	0.50
United Microelectronics Corp.	UMC	2680	0.33	0.60	1.0	0.04	0.48	0.14
Asustek Computer Inc.	Asustek	14	1.0	0.6.0	1.0	0.33	0.40	0.33
Umax Data Systems Inc.	Umax	55	0.44	0.50	1.0	0.05	0.27	0.12