East and Southeast Asian countries experience with Patenting and technology development in the Integrated Circuits Industry

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1. Introduction

• Comparing technology policies of different countries is never easy.
• The economic importance of patenting is a function of industry type, the level of development and trade structure of the firm.
• Although the evidence is not as convincing as in pharmaceuticals, patent filing in the integrated circuit (IC) has been strong.
• The need for patenting increases as firms move closer to the technology frontier.
  National firms
• China’s multi-path approach differs significantly from policies of smaller East and Southeast Asian economies
• Some countries have explicit technology policy with strong government support – e.g. Singapore and Malaysia.
• Some countries have ad hoc technology-related policy instruments – e.g. Thailand, Indonesia, Philippines and Viet Nam.
• Some countries have no clear policy blueprint on technology promotion – e.g. Brunei, Cambodia, Laos and Myanmar.
• Japan, Korea and Taiwan province of China have enjoyed most pronounced development of patenting in the US in ICs among the East and Southeast Asian national firms. Given its earlier development, this presentation excludes Japan.
2. Policy Types

- Sectoral technology promotion policies – on the basis of existing endowments or based on strategic policy decisions drove technological catch up in ICs in Korea and Taiwan province of China. Both economies have enjoyed strong patent take up in the US.
- China has a multi-path approach that varies from national funding of technology ventures (especially in high tech clusters) to county and province driven initiatives (e.g. button cluster in Qiaotou) or the EPZ framework of Shenzen.
- Singapore has matured from EPZ framework to leveraging framework to drive technological upgrading to level 4 activities. Foreign MNCs enjoy grants for upgrading.
- Malaysia has both the EPZ framework and efforts to finance technological upgrading.
- General guidelines for technology promotion without any strategic emphasis (Indonesia, Thailand, Philippines and Viet Nam). EPZ framework.
- No serious emphasis (Brunei, Cambodia, Laos and Myanmar).
3. Typology of Technological Capabilities by Level of Development

- General classification of systemic development of technological capabilities (see Table 1). Government policy in the successful countries such as Japan, Korea and Taiwan Province of China changed as firms moved from level 1 to level 5 activities.
- Incentives are strong drivers of catch up from level 1 to 2 and level 3. Grants are the major driver of a shift to levels 4 and 5. Direct government support critical in formative years in IC development.
- Technology transfer agreements, and strong vetting, monitoring and appraisal ex post critical to prevent dissipation of rents.
- Singaporean strategy – successful in coordinating smoothly quick changes to macro-institutions to support upgrading – essential to support continuous expansion in value added.
- Government policy has driven many industries to frontier phase in Singapore (level of designing and adaptive R&D).
- Some industries in China have attained level 4 sophistication (e.g. buttons, clothing).
- No industry have moved significantly to level 4 activities that involves strong participation in R&D in the second-tier NIEs of Southeast Asia. Singapore shows strong involvement in level 4 activities, while Korea and Taiwan Province of China have reached level 5 activities. Figure 5 shows the importance of levels 4 and 5 activities with a focus on R&D as the highest stage of public goods.
- Only Korean and Taiwan province of China firms in the group have strong IC patent take up in the US (see Figure 3).
- Singapore (e.g. Avago), China (e.g. Hong Hua) and Malaysia (e.g. Silterra) have significantly fewer patent take up in the US.
<table>
<thead>
<tr>
<th>Basic Infrastructure</th>
<th>High Tech Institutions</th>
<th>Network Cohesion</th>
<th>Integration in Regional and Global Markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Conditions (1). Myanmar</td>
<td>Political stability and efficient basic infrastructure</td>
<td>Critical mass of economic agents</td>
<td>Social bonds driven by the spirit to compete and achieve</td>
</tr>
<tr>
<td>Learning Phase (2). Cambodia and Laos</td>
<td>Strengthening of basic infrastructure with better customs and bureaucratic coordination</td>
<td>Import, learning by doing and duplicative imitation. Human capital development</td>
<td>Expansion of tacitly occurring social institutions to formal intermediary organizations to stimulate connections and coordination between economic agents</td>
</tr>
<tr>
<td>Catch Up Phase (3). China, Malaysia, Philippines, Thailand, Viet Nam</td>
<td>Smooth integration with all institutions in 4 pillars</td>
<td>Import, creative duplication and innovation. Developmental research. Creative destruction is a major source of technological catch up (Schumpeterian Mark I). IPR regulation becomes strong from this phase.</td>
<td>Participation of intermediary and government organizations in coordinating technology inflows, initiation of commercially viable R&amp;D</td>
</tr>
<tr>
<td>Advanced Phase (4). Singapore</td>
<td>Advanced basic infrastructure instruments to support short lead times</td>
<td>Developmental research to support accelerate creative destruction (schumpeterian Mark I). Strong filing of patents in the US starts here.</td>
<td>Strong participation of intermediary and government organizations in coordinating technology inflows, initiation of commercially viable R&amp;D</td>
</tr>
<tr>
<td>Frontier Phase(5) Korea and Taiwan Province of China</td>
<td>Novel basic infrastructure support instruments to support short lead times</td>
<td>Basic research. Creative accumulation (Schumpeterian Mark II system). Generating knowledge new to the universe. Technology shapers generate invention and design patents extensively here</td>
<td>Participation of intermediary organizations in two-way flow of knowledge between producers and users</td>
</tr>
</tbody>
</table>
Figure 1: Knowledge Synergies Associated with Research

- Research
- Non-monetary knowledge spillover
- Money
- Time
- Knowledge
- Patents, designs, layouts and trade secrets
- Development
- Commercialization
- Innovation

Knowledge Synergies

- t-7 t-6 t-5 t-4 t-3 t-2 t-1 t0 t1 t2 t3
Figure 2: Value Chain of ICs, 2010

Value Added
- Capacity Implant Development and Specifications
- Chip Design
- Wafer Fabrication
- Assembly
- Packaging and Test
- Marketing
- Sales

Source: Adapted from Marsh (1981)
4. Industry Specific Example of Leveraging on MNCs

- Leveraging strategies of governments depend on the level of economic development of host-sites.
- The level of technological infrastructure and policies is reflected in the IC trade balance, specialization in IC stages and patent take up shown in Figures 3-4, and revenue performance of national firms shown in Tables 2-3. Malaysia in 1990 and Philippines positive balances distorted by tax holidays enjoyed by MNCs.
- Korea has enjoyed positive trade balance in 1990-2008.
- LDCs of Cambodia, Laos and Myanmar do not have any IC firm with critical size. They could appropriate IC synergies by attracting application specific circuit assemblies to drive automation of processing and assembly industries.
- Taiwan Province of China’s and Singapore’s trade balance improved dramatically to become strongest in 2008.
- China’s trade balance seriously negative.
- In such a high technology industry the shift from knowledge adaptation activity to R&D is important for China to reverse its current trade imbalance in the industry.
- MNCs with foreign names dominate IC manufacturing in Singapore whereas national firms dominate in Korea and Taiwan Province of China.
- National-owned Hua Wei (telecommunications) and Lenovo (computers) dominate in China.
- No National or foreign firm dominate in Malaysia, though, Intel, Motorola, Altera and Agilent have designing activities in Penang, and Silterra, Infineon, Osram and 1st Silicon undertake wafer fabrication activities.
4. Performance of IC Trade

- The level of technological infrastructure and policies is reflected in the IC trade balance shown in Figure 2. Malaysia in 1990 and Philippines positive balances distorted by tax holidays enjoyed by MNCs.
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<table>
<thead>
<tr>
<th></th>
<th>Nation</th>
<th>2005</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Revenue</td>
<td>Rank</td>
</tr>
<tr>
<td>Intel</td>
<td>United States</td>
<td>35395</td>
<td>1</td>
</tr>
<tr>
<td>Samsung Electronics</td>
<td>Korea</td>
<td>17838</td>
<td>2</td>
</tr>
<tr>
<td>Texas Instruments</td>
<td>United States</td>
<td>11300</td>
<td>3</td>
</tr>
<tr>
<td>TSMC*</td>
<td>Taiwan P. China</td>
<td>8217</td>
<td>8</td>
</tr>
<tr>
<td>Toshiba</td>
<td>Japan</td>
<td>9045</td>
<td>4</td>
</tr>
<tr>
<td>STMicroelectronics</td>
<td>Italy</td>
<td>8870</td>
<td>5</td>
</tr>
<tr>
<td>Renesas Technology</td>
<td>Japan</td>
<td>8266</td>
<td>7</td>
</tr>
<tr>
<td>Qualcomm</td>
<td>United States</td>
<td>3457</td>
<td>18</td>
</tr>
<tr>
<td>Sony</td>
<td>Japan</td>
<td>6420</td>
<td>9</td>
</tr>
<tr>
<td>Hynix Semiconductor</td>
<td>Korea</td>
<td>5599</td>
<td>10</td>
</tr>
<tr>
<td>Infineon Technologies</td>
<td>Germany</td>
<td>8297</td>
<td>6</td>
</tr>
<tr>
<td>AMD</td>
<td>United States</td>
<td>3936</td>
<td>16</td>
</tr>
</tbody>
</table>

Table 2: World’s Top Integrated Circuits Firms by Revenue, 2005 and 2008 (US$ Millions)
Table 3: Market Share of World’s Top DRAM manufacturers by Revenue, 1st half of 2009

<table>
<thead>
<tr>
<th>Rank</th>
<th>Company</th>
<th>Home Country</th>
<th>Sales (US$ Millions)</th>
<th>Market share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Samsung</td>
<td>Korea</td>
<td>4,924</td>
<td>33.3</td>
</tr>
<tr>
<td>2</td>
<td>Hynix</td>
<td>Korea</td>
<td>3,189</td>
<td>21.6</td>
</tr>
<tr>
<td>3</td>
<td>Elpida</td>
<td>Japan</td>
<td>2,705</td>
<td>18.3</td>
</tr>
<tr>
<td>4</td>
<td>Micron</td>
<td>United States</td>
<td>1,762</td>
<td>11.9</td>
</tr>
<tr>
<td>5</td>
<td>Nanya</td>
<td>Taiwan P. China</td>
<td>830</td>
<td>5.6</td>
</tr>
<tr>
<td>6</td>
<td>Powerchip</td>
<td>Taiwan P. China</td>
<td>601</td>
<td>4.1</td>
</tr>
<tr>
<td>7</td>
<td>Winbond</td>
<td>Taiwan P. China</td>
<td>312</td>
<td>2.1</td>
</tr>
<tr>
<td>8</td>
<td>ProMos</td>
<td>Taiwan P. China</td>
<td>153</td>
<td>1.0</td>
</tr>
<tr>
<td>9</td>
<td>Etron</td>
<td>Taiwan P. China</td>
<td>136</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td></td>
<td>183</td>
<td>1.2</td>
</tr>
</tbody>
</table>
5. Conclusions

• IC firms in East and Southeast Asia are in different levels of technology development.

• In a high tech industry such as ICs China has not evolved to the frontier level 5 activities of Korea and Taiwan Province of China. Singapore is still very much at the level 4 stage.

• The assembly and Test activities of China is similar to that of Malaysia, Philippines and Thailand (Viet Nam is emerging now in this area).

• For China, Malaysia, Philippines, Thailand and Viet Nam to reach levels 4 and 5 technological capability activity and enjoy positive trade balance they must support R&D activities and strengthen the high tech infrastructure.

• Incentives and grants are critical in stimulating progression of firms from level 1 to level 5 activities with the former important in levels 2 and 3, while the latter in levels 4 and 5.

• Licensing, acquisition and government-subsidized or funded start ups were the entry routes of successful IC firms (patent take up in the US) in East and Southeast Asia.

• To prevent dissipation of rents, technology transfer agreements, and vetting, monitoring and appraisal critical to ensure movement of firms enjoying incentives and grants to reach level 5 activities.