รายงานวิจัยฉบับสมบูรณ์

กรณีศึกษาการถ่ายทอดเทคโนโลยีในระดับวิศวกรรมผลิตภัณฑ์และการออกแบบในอุตสาหกรรมผลิตรถยนต์ของไทย

(A Study on Transferring of Product Engineering and Design Technology in the Thai Automobile Industry)

โดย
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บทคัดย่อ

งานวิจัยนี้ศึกษาถึงการวิวัฒนาการของการถ่ายทอดเทคโนโลยีในอุตสาหกรรมผลิตรถยนต์ของประเทศไทยที่ได้กลายมาเป็นส่วนหนึ่งในเครือข่ายการผลิตระดับโลก (โดยเฉพาะการผลิตรถกระบะและรถเอนกประสงค์) ของผู้ผลิตรถยนต์หลายค่าย ประเด็นที่ทำการศึกษาวิจัยคือบทบาทของผู้ผลิตรถยนต์ญี่ปุ่นรายหนึ่งที่ได้ปรับเปลี่ยนกลยุทธ์การลงทุนและเลือกไทยเป็นศูนย์กลางการผลิตว่าได้ทำการถ่ายทอดเทคโนโลยีระดับที่สูงขึ้นแก่ฐานผลิตในประเทศไทยหรือไม่ และ ด้วยวิธีการอย่างไร ผู้วิจัยได้อธิบายถึงวิธีการถ่ายทอดเทคโนโลยีโดยผู้ผลิตรถยนต์และวิเคราะห์ถึงผลกระทบที่เกิดขึ้นผู้ผลิตชิ้นส่วนด้วย จากการสำรวจการเปลี่ยนแปลงเชิงกลยุทธ์ในภาพรวม พบว่าผู้ผลิตรถยนต์ต้องการทำธุรกิจกับผู้ผลิตชิ้นส่วนที่มีความสามารถในการออกแบบ การบริหารจัดการ และ ความสามารถด้านวิศวกรรมการผลิต การวิจัยนี้ได้นำเสนอกรณีศึกษาของสามบริษัทเพื่อที่จะชี้ให้เห็นถึงโอกาสของผู้ผลิตชิ้นส่วนไทยที่จะพัฒนาความสามารถทางเทคโนโลยีได้โดยการลงทุนด้านเทคโนโลยีควบคู่กับการเรียนรู้ผ่านความช่วยเหลือที่ได้รับจากลูกค้าที่เป็นผู้ผลิตรถยนต์

Abstract

This study investigates the evolution of technology transfer in the Thai automobile industry, which has gradually been integrated into global production network of some specific automotive models (one-ton pickups). This paper discusses the role of an automobile assembler in transferring technology to its affiliate and the way their strategic changes bring about heightened demands on the technological capacity of suppliers and the contents of technology transfer. With higher competition at the global level, both assemblers and parts suppliers are required to improve their technical and managerial skills, especially in the area of 'product engineering' capability. The author examines the roles of an assembler in transferring technology and discusses the implications to Thai suppliers. The changing environment suggests that local suppliers should improve their engineering and management skills, which will enable them to utilize inter-firm relationship with assemblers as a means to improve their own technological capabilities. The dynamic process of capability formation in local parts firms, through intensive efforts and learning inducements brought about by inter-firm relationships, are also discussed.

Executive Summary

บทสรุปผู้บริหาร

ปัญหาที่ทำการวิจัย และความสำคัญของปัญหา

อุตสาหกรรมการประกอบรถยนต์เป็นอุตสาหกรรมหนึ่งที่มีบทบาทสำคัญต่อภาคเศรษฐกิจของไทยทั้งในแง่การจ้างงาน การผลิต การส่งออก รวมถึงการพัฒนาอุตสาหกรรมต่อเนื่องต่างๆ ผลจากการกำหนดชุดนโยบายต่างๆ ที่มีความชัดเจนเพื่อกระตุ้นให้เกิดการพัฒนาอุตสาหกรรมการผลิตรถยนต์ในประเทศทำให้ไม่เพียงแต่อุตสาหกรรมการประกอบรถยนต์เท่านั้นที่มีการเติบโตอย่างรวดเร็ว แต่รวมถึงการขยายตัวของอุตสาหกรรมการผลิตชิ้นส่วนและอุตสาหกรรมสนับสนุนต่างๆ อย่างมากอีกด้วย การเติบโตที่เป็นรูปธรรมนี้สะท้อนได้จากจำนวนรถยนต์ที่ผลิตและปริมาณการส่งออกที่เพิ่มขึ้นอย่างต่อเนื่อง จำนวนผู้ผลิตชิ้นส่วนที่เพิ่มขึ้น ความเที่ยงตรงและคุณภาพของชิ้นส่วนที่ผลิตได้ในประเทศสูงขึ้น ซึ่งสะท้อนให้เห็นว่าประเทศไทยโดยรวมมีการพัฒนาระดับเทคโนโลยีการผลิตอย่างมากเมื่อเทียบกับในยุคเริ่มต้นที่ไม่ความสามารถใดๆ เลย (Techakanont and Terdudomtham 2004a)

แม้ว่าประเทศไทยได้กลายเป็นประเทศส่งออกรถยนต์รายใหญ่รายหนึ่งของภูมิภาคเอเชีย และ เป็นศูนย์กลางการผลิตและส่งออกในฐานะหนึ่งในเครือข่ายการผลิตรถยนต์ที่สำคัญของค่ายรถต่างๆ ความสงสัยว่าที่ผ่านมานั้นมีการถ่ายทอดเทคโนโลยีสู่ประเทศไทยจริงจังเพียงใดยังคงมีอยู่ในกลุ่มนักวิชาการจำนวนไม่น้อยซึ่งเห็นว่าประเทศไทยไม่ได้ประโยชน์อะไรมากไปกว่าการเป็นประเทศที่ให้บริการด้านแรงงานเพื่อกิจการประกอบรถยนต์แก่ต่างชาติ ซึ่งบริษัทเหล่านี้ไม่ได้ทำการถ่ายทอดเทคโนโลยีอย่างจริงจังเพราะจวบจนปัจจุบันนี้คนไทยก็ยังไม่สามารถผลิตรถยนต์ได้ด้วยตัวเอง อย่างไรก็ดี การกล่าวเช่นนี้ก็ดูจะไม่เป็นธรรมนัก เพราะในความเป็นจริงแล้วประเทศไทยได้มีการพัฒนาความสามารถในการผลิตเพิ่มขึ้น ไม่ว่าจะเป็นคุณภาพสินค้าที่ดีขึ้น (รถยนต์ที่ส่งออกจำเป็นต้องมีมาตรฐานความปลอดภัยและคุณภาพได้มาตรฐานโลก) จำนวนรุ่นที่มากขึ้น ปริมาณการผลิตที่สูงขึ้น ซึ่งสิ่งเหล่านี้ไม่อาจเกิดขึ้นได้โดยปราศจากความพยายาม แต่เป็นเพราะการให้การสนับสนุนทางเทคนิค หรือ การถ่ายทอดเทคโนโลยีนั่นเอง แต่เนื่องจากเรามีงานวิจัยในประเด็นนี้น้อยมาก จึงทำให้เราไม่เห็นตัวอย่างที่เป็นรูปธรรมของการถ่ายทอดเทคโนโลยี ดังนั้นงานวิจัยในประเด็นนี้จึงยังคงมีความสำคัญต่อแวดวงวิชาการและฝ่ายกำหนดนโยบาย เพื่อที่เราจะได้มีความเข้าใจที่ดีขึ้นต่อบทบาทของผู้ให้เทคโนโลยี และ สถานะ รวมถึง

บทบาทของผู้รับ ว่าควรจะเป็นอย่างไรจึงจะส่งเสริมให้การถ่ายทอดเทคโนโลยีนั้นสัมฤทธิ์ผลตามที่เรามุ่งหวัง

อย่างไรก็ดี อุตสาหกรรมการผลิตรถยนต์ของไทยได้มีการเปลี่ยนแปลงอย่างมากในช่วงสี่ห้าปีมานี้ ดังที่เราทราบดีว่าอุตสาหกรรมนี้ได้รับผลกระทบอย่างมากจากวิกฤตเศรษฐกิจเมื่อปี 2540 ที่ทำให้บริษัทต่างๆ ต้องทำการปรับตัวเพื่ออยู่รอด ประกอบกับการยกเลิกการบังคับใช้ชิ้นส่วนในประเทศในปี 2543 แต่การเปลี่ยนแปลงที่สำคัญที่ถือได้ว่าเป็นจุดหักเหของอุตสาหกรรมยานยนต์ของไทยคือการที่บริษัทต่างๆ ที่ลงทุนในประเทศไทยทั้งรายเก่าและรายใหม่ได้ตัดสินใจใช้ประเทศไทยเป็นฐานการผลิตและส่งออกในภูมิภาคเอเชีย ซึ่งเหตุผลส่วนหนึ่งของปรับเปลี่ยนกลยุทธ์การผลิตนี้มาจากการการเปลี่ยนแปลงเชิงโครงสร้างอุตสาหกรรมของโลก (Terdudomtham et al 2002) ด้วยเหตุนี้เองจะทำให้อุตสาหกรรมรถยนต์ของไทยจะพัฒนาไปเป็นส่วนหนึ่งในโครงข่ายการผลิตระดับโลก (Global Production Network; GPN) ของผู้ผลิตหลายค่าย ซึ่งจะส่งผลให้ประเทศไทยกลายมาเป็นฐานการผลิตรถยนต์ (โดยเฉพาะอย่างยิ่งรถกระบะ) ที่ใหญ่ที่สุดในโลกทันที ดังนั้นในช่วงที่โครงการวิจัยนี้เริ่มต้นขึ้น นับเป็นช่วงที่กล่าวได้ว่าเป็นจุดเปลี่ยนแปลงที่สำคัญอีกครั้งของอุตสาหกรรมยานยนต์ไทย เพราะจากงานวิจัยในอดีตเช่น Techakanont (2002) สะท้อนให้เห็นว่าการที่มีการโอนการผลิตใหม่ๆ มายังประเทศไทยนั้นจะทำให้บริษัทต่างชาติเหล่านั้นต้องถ่ายทอดเทคโนโลยีในระดับที่สูงขึ้นกว่าที่เคยถ่ายทอดมา และ ในประเด็นนี้ ผู้วิจัยเชื่อว่าเทคโนโลยีใหม่ที่จะมีการถ่ายทอดคือเทคโนโลยีการพัฒนาผลิตภัณฑ์ใหม่ เทคโนโลยีวิศวกรรมผลิตภัณฑ์ (Product engineering technology) เทคโนโลยีการออกแบบ (Design technology) และ แม้กระทั่งกิจกรรมการวิจัยและพัฒนา (Research and Development activity) เป็นต้น

ความเข้าใจต่อธรรมชาติและลักษณะของคลื่นเทคโนโลยีลูกใหม่ที่สูงกว่าที่เคยมีการถ่ายโอนมาสู่ฐานผลิตในประเทศไทยนี้มีนัยสำคัญต่อวงวิชาการและฝ่ายกำหนดนโยบายอย่างน้อยสองประการ ประการแรก รูปแบบการถ่ายทอดเทคโนโลยีที่จะเกิดขึ้นใหม่นี้เป็นระดับที่สูงกว่าที่เคยมีมาในอดีต ดังนั้นจึงเป็นที่น่าศึกษาค้นคว้าต่อไปโดยเริ่มจากปัญหาพื้นฐานว่าผู้ผลิตรถยนต์เหล่านี้มีเป้าหมายอะไร กล่าวคือเขาต้องการจะพัฒนาความสามารถทางวิศวกรรมการผลิตและการออกแบบของบริษัทในเครือของเขาไปถึงระดับใด พนักงานของไทยจะมีบทบาทอย่างไร และ บริษัทต่างชาติจะทำอย่างไรเพื่อพัฒนาความสามารถเหล่านี้ การศึกษาเพื่อตอบคำถามเหล่านี้จะช่วยขยายพรมแดนความรู้เกี่ยวกับสถานะทางเทคโนโลยีการผลิตรถยนต์ที่ประเทศไทยมีอยู่ ซึ่งจะช่วยให้ผู้กำหนดนโยบายของประเทศสามารถออกนโยบายที่จะส่งเสริมการพัฒนานี้ให้เป็นไปอย่างเหมาะสมยิ่งขึ้น

ประการที่สองคือ การปรับเปลี่ยนกลยุทธ์การลงทุนที่ทำให้ไทยกลายเป็นส่วนหนึ่งของเครือข่ายการผลิตระดับโลกนี้จะมีผลกระทบต่อผู้ผลิตชิ้นส่วนในประเทศ แต่เราต้อง

ศึกษาว่าผลกระทบที่เกิดจะอยู่ในรูปแบบใด ซึ่งผู้วิจัยคาดว่าการเปลี่ยนแปลงนี้จะมีผลต่อโครงสร้างความสัมพันธ์ระหว่างผู้ผลิตรถยนต์กับผู้ผลิตชิ้นส่วน ทั้งนี้เป็นผลจากการที่ผู้ผลิตรถยนต์มุ่งที่จะส่งออกเป็นหลักซึ่งรถยนต์ที่ผลิตนั้นจะต้องมีคุณภาพและระดับความปลอดภัยที่ได้มาตรฐานสากล ดังนั้นจึงสามารถคาดได้ผู้ผลิตชิ้นส่วนของไทยจะต้องถูกเรียกร้องให้มีการพัฒนาระดับคุณภาพมากขึ้นอย่างแน่นอน นอกจากนี้ ผู้ผลิตชิ้นส่วนอาจจำเป็นต้องทำการลงทุนเพิ่มเติมเพื่อขยายกำลังผลิตให้เพียงพอต่อสั่งซื้อใหม่ๆ ที่จะเพิ่มสูงขึ้นอย่างมหาศาลในเร็วๆ นี้ อย่างไรก็ดี การศึกษาในส่วนนี้จะอยู่ในระยะที่สองของงานวิจัยชิ้นนี้ เนื่องจากในระยะแรกนั้นจะเป็นการค้นคว้า รวบรวมข้อเท็จจริงจากภาคสนามเพื่อประมวลภาพในประเด็นการถ่ายทอดเทคโนโลยีในระดับวิศวกรรมผลิตภัณฑ์และการออกแบบก่อนว่ามีลักษณะอย่างไร ความเข้าใจในเรื่องนี้จะช่วยให้เราพิจารณาได้ว่า ปัจจัยใดคือโอกาส อะไรคืออุปสรรคของผู้ผลิตชิ้นส่วนต่อไป ซึ่งบทเรียนที่จะได้นี้คาดว่าจะช่วยให้ภาครัฐรวมถึงสถาบันต่างๆ เข้าใจถึงข้อเท็จจริงเกี่ยวกับสถานะทางเทคโนโลยีของผู้ผลิตในอุตสาหกรรมยานยนต์ของประเทศอันจะนำไปสู่การกำหนดนโยบายที่เหมาะสมเพื่อสนับสนุนการพัฒนาอุตสาหกรรมยานยนต์ที่ครบวงจรอย่างยั่งยืนต่อไป

งานวิจัยชิ้นนี้วัตถุประสงค์ดังต่อไปนี้

1. เพื่อศึกษาถึงกระบวนการถ่ายทอดเทคโนโลยีในระดับวิศวกรรมผลิตภัณฑ์และการออกแบบที่บริษัทรถยนต์ต่างชาติจะถ่ายทอดแก่บริษัทลูกในประเทศไทย

2. เพื่อศึกษาถึงผลกระทบของการเปลี่ยนแปลงนโยบายการผลิตและการถ่ายทอดเทคโนโลยีดังกล่าวต่อผู้ผลิตชิ้นส่วนในประเทศ ในประเด็นเกี่ยวกับโครงสร้างความสัมพันธ์กับผู้ผลิตรถยนต์ ความต้องการทางเทคนิคที่อาจจะเปลี่ยนแปลงไป

ระเบียบวิธีวิจัย

การวิจัยชิ้นนี้เน้นการวิจัยภาคสนามเป็นสำคัญ เนื่องจากข้อมูลที่จำเป็นต่อการวิเคราะห์นั้นเป็นข้อมูลใหม่ซึ่งไม่ปรากฏในรูปของเอกสารชั้นสอง การนำเสนอผลการวิจัยจะเป็นเชิงพรรณนา และ จัดเป็นงานวิจัยเชิงคุณภาพ ผู้วิจัยจะทำการขอความอนุเคราะห์จากบริษัทรถยนต์ที่มีแผนการผลิตที่ใช้ประเทศไทยเป็นศูนย์กลางการผลิตเพื่อขอสัมภาษณ์เชิงลึกกับบุคคลที่เกี่ยวข้องในกระบวนการถ่ายทอดเทคโนโลยีทั้งชาวไทยและชาวต่างประเทศ (โดยที่บริษัทเป้าหมายคือ โตโยต้าเพราะเป็นบริษัทที่มีโครงการใช้ไทยเป็นศูนย์กลางการผลิตในฐานะเครือข่ายการผลิตอย่างชัดเจนที่สุด) นอกจากนี้ ผู้วิจัยทำการศึกษาผลกระทบที่มีต่อผู้ผลิตชิ้นส่วนโดยการส่งแบบสอบถามเพื่อรับทราบข้อมูลเกี่ยวกับผลกระทบอันเนื่องมาจากการที่อุตสาหกรรมรถยนต์ไทยพัฒนาขึ้น และ สำหรับบริษัทที่ตอบแบบสอบถามและให้ความร่วมมือผู้วิจัยได้เข้าเยี่ยมชมโรงงานและสัมภาษณ์เชิงลึกกับบุคคลากรที่เกี่ยวข้องด้วย ในช่วงปี 2545 ถึง 2548 ผู้วิจัยได้เข้าสัมภาษณ์ผู้ผลิต

รถยนต์ห้าราย และ บางรายผู้วิจัยเข้าสัมภาษณ์มากกว่าหนึ่งครั้ง รายละเอียดของบริษัทที่เข้าสัมภาษณ์นำเสนอในบทที่ 3 ของรายงานฉบับนี้

การนำเสนองานวิจัย

รายงานวิจัยนี้มีทั้งสิ้น 6 บท โดยในบทที่ 1 เป็นการนำเสนอความสำคัญของปัญหา วัตถุประสงค์ของการศึกษา และโครงร่างเนื้อหารายงาน

ในบทที่ 2 เป็นการทบทวนวรรณกรรมในอดีตและนำเสนอแนวคิดพื้นฐานที่สำคัญ พร้อมกับกรอบการวิเคราะห์สำหรับการศึกษานี้ แนวคิดทางทฤษฎีที่งานวิจัยนี้ใช้ในการวิเคราะห์การถ่ายทอดเทคโนโลยีคือการมองว่าแก่นของการถ่ายทอดเทคโนโลยีคือการเรียนรู้ในฝ่ายผู้รับ โดยความพยายามและความเต็มใจในการถ่ายทอดของผู้ให้ (ผู้ผลิตรถยนต์) อันจะมีการระบุถึงเนื้อหาของความร่วมมือและเทคนิคการผลิตที่เจ้าของเทคโนโลยีจะต้องถ่ายทอดให้ด้วย เทคโนโลยีหรือความรู้อาจแบ่งได้เป็นสองประเภทใหญ่ๆ คือ ความรู้ที่ชัดแจ้ง (explicit knowledge) เช่นความรู้ที่อยู่ในรูปเอกสารหรือรูปแบบอื่นที่สามารถแลกเปลี่ยนได้ง่าย และ ความรู้ที่แฝงอยู่ในคน (tacit knowledge) ซึ่งเป็นความรู้ที่ไม่สามารถถ่ายทอดออกมาเป็นคำพูดหรือเอกสารได้ง่าย แต่ต้องถ่ายทอดโดยการแบ่งปันประสบการณ์หรือร่วมทำงานด้วยกัน

การศึกษานี้ประยุกต์แนวคิดการสร้างความรู้ในองค์กรของ Nonaka and Takeuchi (1995) เข้ากับการถ่ายทอดเทคโนโลยีข้ามกิจการ โดยพิจารณาว่าการตัดสินใจผลิตรถยนต์รุ่นใหม่ของผู้ผลิตรถยนต์ต่างชาตินั้นจะต้องมีการถ่ายทอดเทคโนโลยีการผลิตแก่พนักงานของตัวเองและในขณะเดียวกันก็ต้องมีการประสานกับผู้ผลิตชิ้นส่วนอย่างใกล้ชิดในช่วงการเตรียมการผลิตด้วย ด้วยเหตุนี้ทำให้แบบแผนการเรียนรู้ของผู้ผลิตชิ้นส่วนจึงขึ้นกับการช่วยเหลือจากผู้ผลิตรถยนต์และความพยายามสร้างความรู้ขึ้นในองค์กรของตัวเองด้วย ในตอนท้ายของบทนี้นำเสนอกรอบการศึกษาสำหรับการถ่ายทอดเทคโนโลยีทั้งในระดับภายในกิจการ (intra-firm technology transfer) และ ระดับข้ามกิจการ (inter-firm technology transfer)

ในบทที่ 3 ได้นำเสนอวิธีการศึกษา การเก็บข้อมูล และ ได้อธิบายถึงข้อมูลพื้นฐานของบริษัทที่ได้รวบรวมข้อมูลจากการใช้แบบสอบถาม การสัมภาษณ์ และ ข้อมูลทุติยภูมิอื่นๆ การเก็บข้อมูลเพื่อการวิจัยชิ้นนี้แบ่งออกได้เป็นสามช่วงด้วยกัน คือ ช่วงแรกเป็นการศึกษาสถานะปัจจุบัน (ในขณะนั้นปี 2546) เพื่อดูว่ามีการเปลี่ยนแปลงในอุตสาหกรรมอย่างไรบ้าง และ ความต้องการทางเทคนิคของผู้ผลิตรถยนต์ที่มีต่อผู้ผลิตชิ้นส่วนเป็นอย่างไร ผู้วิจัยได้เยี่ยมชมโรงงานและสัมภาษณ์ผู้ผลิตรถยนต์ 5 ราย (ทั้งหมดเป็นผู้ผลิตรถยนต์ญี่ปุ่น) และสัมภาษณ์ผู้ผลิตชิ้นส่วนอีกจำนวนมากเพื่อยืนยันความถูกต้องของข้อมูล ข้อค้นพบนี้ยืนยัน

ว่าแนวโน้มการเปลี่ยนแปลงของอุตสาหกรรมรถยนต์ไทยจะมุ่งเน้นการส่งออกมากขึ้น และความต้องการทางเทคนิคก็จะสูงขึ้น

ดังนั้นจึงได้ทำการออกแบบสอบถามเพื่อศึกษาประเด็นนี้เพิ่มเติมกับผู้ผลิตชิ้นส่วน (ซึ่งเป็นช่วงที่สองของการเก็บข้อมูล) ในขณะเดียวกันผู้วิจัยได้ติดต่อขอเข้าสัมภาษณ์กับผู้ผลิตรถยนต์เพิ่มเติม พร้อมกับศึกษาข้อมูลทุติยภูมิที่มีการเผยแพร่ ทำให้สามารถเลือกโครงการที่เหมาะสมได้ คือ บริษัทโตโยต้า ประเทศไทย ที่ได้ประกาศแผนการผลิตรถเอนกประสงค์ในประเทศไทยเมื่อปี 2545 และเริ่มดำเนินการผลิตจริงในปี 2547 โครงการนี้ถูกเลือกเนื่องจากเป็นโครงการที่ใหม่ และ มีการวางแผนแบบการผลิตเชิงเครือข่ายที่ชัดเจน อย่างไรก็ดี การที่โครงการนี้ยังอยู่ในช่วงเตรียมการผลิตและช่วงต้นของการผลิตจริง ทำให้ไม่สามารถได้ข้อมูลในเชิงลึกได้เพราะเป็นความลับทางธุรกิจ ด้วยเหตุนี้ผู้วิจัยจึงอาศัยข้อมูลที่มีการเผยแพร่แล้วมาประกอบกับการสัมภาษณ์เจ้าหน้าที่ของบริษัทโตโยต้าที่ให้ความอนุเคราะห์เพื่อนำมาวิเคราะห์ตามกรอบการศึกษาที่ตั้งไว้ (เป็นช่วงที่สามของการเก็บข้อมูล) เพื่อให้สามารถตอบวัตถุประสงค์ของการศึกษานี้ได้

ในบทที่ 4 นำเสนอผลการศึกษาเกี่ยวกับความพยายามของโตโยต้าในการถ่ายทอดเทคโนโลยีสู่ฐานผลิตในประเทศไทย โดยให้ข้อมูลพื้นฐานของโครงการและแนวคิดเกี่ยวกับการพัฒนาผลิตภัณฑ์ใหม่เนื่องจากเป็นประเด็นที่เกี่ยวข้องและมีความสำคัญต่อการเข้าใจสถานะของโครงการที่ศึกษา ข้อค้นพบสำคัญในส่วนนี้คือการที่โตโยต้าวางแผนให้ประเทศไทยเป็นศูนย์กลางการผลิตและส่งออกนี้ทำให้มีความจำเป็นต้องถ่ายทอดเทคโนโลยีในหลายระดับ ไม่เพียงแต่เทคนิคการผลิตเท่านั้น แต่ยังรวมถึงเทคโนโลยีระดับการออกแบบ, วิศวกรรมผลิตภัณฑ์ (product engineering), วิศวกรรมกระบวนการผลิต (process engineering), และ การบริหารระบบการผลิตด้วย อย่างไรก็ดี ผู้วิจัยไม่สามารถได้ข้อมูลในรายละเอียดเกี่ยวกับทรัพยากรที่โตโยต้าใช้เพื่อโครงการนี้ แต่เชื่อได้ว่าจะมีการใช้ทรัพยากรอย่างมหาศาล การที่บริษัทสามารถส่งออกได้ตามเป้าหมายพร้อมกับการขยายการผลิตอย่างต่อเนื่องในปี 2548 นี้ ก็เป็นที่เชื่อได้ว่าการถ่ายทอดเทคโนโลยีนั้นสำเร็จตามที่วางแผนไว้

ในบทที่ 5 นำเสนอผลการวิจัยด้วยแบบสอบถามเพื่อดูผลกระทบของการเปลี่ยนแปลงต่อผู้ผลิตชิ้นส่วนและเพื่อศึกษาว่าผู้ผลิตชิ้นส่วนไทยสามารถพัฒนาความสามารถทางเทคโนโลยีหรือไม่ จากการมีความสัมพันธ์ทางธุรกิจกับผู้ผลิตรถยนต์ ผลจากแบบสอบถามบ่งชี้ว่าหลังจากที่มีการยกเลิกการบังคับการใช้ชิ้นส่วนในประเทศในปี 2543 แล้ว การแข่งขันทวีความรุนแรงขึ้น และ ผู้ผลิตรถยนต์ต้องการให้ผู้ผลิตชิ้นส่วนพัฒนาความสามารถทางเทคโนโลยีเพิ่มอย่างมาก โดยเฉพาะในเรื่องวิศวกรรมกระบวนการผลิตและการออกแบบ

อย่างไรก็ดี ในประเด็นเรื่องความช่วยเหลือทางเทคนิคที่ได้รับจากผู้ผลิตรถยนต์นั้น มีผู้ผลิต 3 รายที่ตอบว่าได้รับความช่วยเหลือมากเป็นพิเศษ คือทางผู้ผลิตรถยนต์มีการส่งพนักงานเข้ามาร่วมเตรียมการผลิตด้วย ซึ่งโดยปกติแล้วผู้ผลิตรถยนต์จะให้ความช่วยเหลือ

ในลักษณะเพียงการให้คำแนะนำทางเทคนิคที่ทำระหว่างการเข้าเยี่ยมชมโรงงานเพื่อติดตามความก้าวหน้าเท่านั้น อย่างไรก็ดีผู้ผลิตชิ้นส่วนส่วนใหญ่เห็นด้วยว่าการมีความสัมพันธ์กับผู้ผลิตรถยนต์เป็นเพียงช่องทางหนึ่งของการพัฒนาความสามารถทางเทคโนโลยีได้ ในขณะที่การลงทุนด้านการฝึกอบรมและการสะสมประสบการณ์ของพนักงานมีความสำคัญในการพัฒนาตัวเองมากกว่า

ข้อค้นพบจากแบบสอบถามยืนยันถึงพลวัตของการเรียนรู้ของบริษัทผู้ผลิตชิ้นส่วนไทย ดังนั้นเพื่อที่จะเข้าใจในประเด็นนี้และเพื่อตอบคำถามการวิจัยข้อที่สอง ผู้วิจัยจึงศึกษาสามบริษัทที่ได้รับความช่วยเหลือจากบริษัทผู้ผลิตรถยนต์ โดยการเยี่ยมชมโรงงานและสัมภาษณ์เชิงลึกกับบุคลากรที่เกี่ยวข้องในกระบวนการเรียนรู้เทคนิคการผลิตจากผู้ผลิตรถยนต์ ซึ่งทั้งสามบริษัทนี้มีลักษณะเด่นเหมาะสมกับการศึกษานี้ เพราะทั้งสามรายนี้เป็นบริษัทที่ถือหุ้นโดยคนไทยเป็นหุ้นใหญ่ และมีหนึ่งบริษัทที่กลายเป็นบริษัทต่างชาติล้วนเพราะปัญหาการดำเนินธุรกิจและข้อจำกัดทางเทคโนโลยี

ในแต่ละกรณีศึกษา ผู้วิจัยอธิบายในเชิงประวัติศาสตร์โดยเน้นถึงความสัมพันธ์กับบริษัทผู้ผลิตรถยนต์อันนำมาซึ่งการพัฒนาระดับความสามารถทางเทคโนโลยีและพยายามค้นคว้าว่าผู้ผลิตชิ้นส่วนทั้งสามรายมีกระบวนการเรียนรู้ การลงทุนทางเทคโนโลยี และการบริหารความรู้อย่างไร ซึ่งข้อค้นพบสอดคล้องกับกรอบการศึกษาที่งานวิจัยนี้ใช้ กระบวนการเรียนรู้เกิดขึ้นในสองระดับคือระหว่างการมีปฏิสัมพันธ์กับผู้ผลิตรถยนต์ในช่วงการเตรียมการผลิตในอดีตและปัจจุบัน และ การแลกเปลี่ยน ปรับปรุงฐานความรู้เดิมภายในองค์กร ทั้งนี้การลงทุนในการฝึกอบรมและรับเอาเทคโนโลยีใหม่ๆ ก็มีความสำคัญต่อการพัฒนาระดับความสามารถทางเทคโนโลยีของผู้ผลิตชิ้นส่วนมาก

เมื่อศึกษาพัฒนาการของผู้ผลิตทั้งสามรายในรายละเอียดทำให้ทราบถึงการเปลี่ยนแปลงในความต้องการทางเทคนิคของผู้ผลิตรถยนต์ว่ามีการปรับสูงขึ้นไปอย่างมาก และทำให้เข้าใจถึงการเปลี่ยนแปลงของเนื้อหาทางเทคโนโลยีที่ถ่ายทอดแก่ผู้ผลิตชิ้นส่วน โดยพบว่า ในปัจจุบันและในอนาคตอันใกล้นี้ ผู้ผลิตชิ้นส่วนต้องมีความสามารถในระดับวิศวกรรมกระบวนการผลิต (process engineering) และวิศวกรรมผลิตภัณฑ์ (product engineering) มากขึ้น ซึ่งเป็นกลยุทธ์การผลิตที่ผู้ผลิตรถยนต์ทุกรายทำอยู่เพื่อให้แข่งขันได้ในระดับโลก (เพราะผู้ผลิตรถยนต์ในไทยต้องผลิตเพื่อส่งออก)

ในบทสุดท้าย เป็นบทสรุปการศึกษาและให้ข้อเสนอแนะเชิงนโยบาย จากข้อค้นพบในบทที่ 4 และ 5 ทำให้เราเห็นทิศทางการเปลี่ยนแปลงในกลยุทธ์ของผู้ผลิตรถยนต์และสภาพการแข่งขันที่ทวีความรุนแรงขึ้น ดังนั้นการลงทุนทางเทคโนโลยีใหม่ๆ เช่น เกี่ยวกับการออกแบบด้วยคอมพิวเตอร์ (computer aided design and computer aided manufacturing; CAD/CAM) และ ด้านวิศวกรรม (computer aided engineering: CAE) จึงจะมีส่วนช่วยให้ผู้ผลิตชิ้นส่วนไทยสามารถตอบสนองต่อความต้องการของผู้ผลิตรถยนต์ได้มากขึ้น อย่างไรก็ดี ความเข้าใจพื้นฐานเพื่อที่จะออกแบบชิ้นงานแบบครบวงจรการ

พัฒนาผลิตภัณฑ์ คือเริ่มตั้งแต่ออกแบบชิ้นงาน ออกแบบฟังก์ชั่นการทำงาน ออกแบบกระบวนบวนการผลิต จนถึงผลิตได้ตามคุณสมบัติที่ผู้ผลิตรถยนต์ต้องการนั้น ยังเป็นสิ่งที่ผู้ผลิตชิ้นส่วนไทยยังถือว่าอยู่ในช่วงเริ่มต้น ดังนั้นจึงจำเป็นที่ภาครัฐจะต้องให้การสนับสนุนด้านต่างๆ เช่น สาธารณูปโภคพื้นฐานทางเทคโนโลยีเช่นการฝึกอบรม การทดสอบชิ้นส่วนรวมทั้งหลักสูตรการศึกษาเพื่อที่จะตอบสนองต่อความต้องการของอุตสาหกรรมในระยะยาวต่อไป

Table of Contents

List of Tables

List of Figures

Chapter 1

Introduction

1.1 Significance of the Study

In the initial stages of the industrialization of virtually all developing countries, capital and technology (production and managerial technology) are scarce. A promising means of promoting economic development to overcome these bottlenecks is attracting foreign direct investment (FDI). Apart from its direct effects in terms of the expansion of domestic output, capital formation, employment, and export, FDI can bring about indirect benefits through technology transfer and diffusion, skills upgrades and the development of local ancillary industries through the creation of backward linkages (Dunning 1983, Borensztein et al 1995, Blomström and Kokko 1999, Markusen and Venables 1999). Multinational firms can play a crucial role in international technology transfer because they undertake a major part of the world's research and development (R&D) efforts to create and then own most of the world's advanced technology (Blomström and Kokko 1999). When making direct investments abroad by establishing overseas affiliates, these multinational firms inevitably must transfer technology to and upgrade the existing skills of the local population to assure the efficiency of their foreign operations (Sedgwick 1995). Therefore, FDI can act as a catalyst for knowledge diffusion and the provision of local capability formation in the recipient countries of FDI.

Nonetheless, prevailing understandings of the ways technology is transferred are far from complete. The existing literature has focused on the issue of international technology transfer through formal and voluntary forms such, as intra-firm technology transfer and arm's-length trade of technology (Reddy and Zhao 1990). However, very few studies have investigated the dynamic process of technology transfer and technological capability-formation in developing countries (e.g., Kim 1997, Cyhn 2002), and even they have not focused directly on technology transfer through informal mechanisms, such as the incidence of 'inter-firm' technology transfers.[1] Moreover, progressive global competition, driven by trade liberalization, deregulation of trade and investment, and the revolution of information and communication technology (IT), have changed global competition by making it more dynamic. These changes have prompted multinational firms to view their global production as a network rather than as "stand-alone overseas investment projects" (Ernst and Kim 2002). This trend is expected to proliferate, and the host countries of FDI stand ready to adapt appropriately to benefit from such changes. However, there is still a lack of understanding of the impacts of being a global production network on technology transfer; and how and in what forms local suppliers will be affected by such developments. Hence, the principal motivation of this research is to investigate the issue by looking at Thailand's automobile industry as a case in point.

Thailand provides an instructive model because its industrialization is of relatively short duration historically, and, throughout that process, it has relied heavily on FDI. In addition, among manufacturing industries that have been promoted there, the automobile industry is probably the only industry that the Thai government has had specific and clear goals to promote. Among important

[1] Inter-firm technology transfer is defined as a relationship between a supplier and an assembler that encourages knowledge transfer to make suppliers meet the assembler's quality requirement. This is sometimes referred to as 'buyer-supplier' relationship (Capannelli 1997), or 'technology partnering' (Beecham and Cordey-Hayes 1997).

rationalized policies imposed by the Thai government, the Local Content Requirement (LCR) regulation was regarded as the most influential policy for the development of supporting industries in Thailand. In 1975, a LCR of 25 percent for passenger cars and 20 percent for pickups was introduced. Later on, in 1987, it had been increased to a level of 54 percent for passenger cars and 70 percent for pickups, the level of which was maintained until the end of 1999. A series of rationalized policies, including LCR, high tariff protection, import ban on small cars, etc., has forced foreign assembling firms to become catalysts in promoting the growth of local supporting industries. From a virtual nonexistence of manufacturing expertise, in less than 40 years, the Thai automobile industry has been transformed from an import-substitution industry to a more export-oriented one, and currently it has been integrated into part of the global production network of some specific models by many world manufacturers. Foreign assembling firms have played an important role in disseminating important technology that has enhanced the technological capability formation and growth of Thailand's supporting industries (Techakanont and Terdudomtham 2004a).

Because the current trend continues in the direction of globalization, significant changes in car manufacturers' strategies, in particular, the requirements they impose on and the relationships they forge with local suppliers can be expected. In other words, technology transfer is evolving at both 'intra-firm' and 'inter-firm' levels; thus, it is necessary to investigate to what extent these strategies affect the content of technology transfer, how automobile manufacturers respond to such changes, how local firms adapt to these changing environments and how they utilize inter-firm relationship with assemblers as a means to develop their own technological capabilities. Research on technology transfer is scarce and there are few studies that set out to explain the process of technological capability formation (Ernst and Kim 2002). Therefore, this study contributes to the literature by examining the current technology transfer activities by a Japanese assembler and offering the evolution of inter-firm technology transfer and how local parts firms develop their technological capability.

1.2 Objective of the Study

1) To investigate the practices of technology transfer in product engineering and design capabilities by Japanese assemblers to their affiliates and to suppliers.

2) To study the effects of changes in strategy of assemblers to use Thailand as their export base on the 'inter-firm' relationship and to analyze the evolution of inter-firm technology transfer.

1.3 Organization of the Study

The organization of this report is as follows: Chapter 2 discusses the conceptual background and provides an analytical framework relevant to this study. Chapter 3 explains the research methods and reports general information of firms studied. Chapter 4 will present research findings on the roles and practices of a Japanese assembler in transferring technology to its affiliate and their suppliers in Thailand. This chapter focuses mainly on the 'intra-firm' technology transfer. In Chapter 5, the focus shifts to 'inter-firm' technology transfer. It discusses the technological capabilities formation in the local parts firms and their relationship with assemblers. Three case studies of local parts-making firms that have received direct assistance have been made to set the stage for the drawing of general observations about the evolution of inter-firm technology transfer and the dynamic process of capability formation. Chapter 6 provides conclusion and some policy recommendations.

Chapter 2

Conceptual Background and Analytical Framework

Firms in developing economies can acquire technology or develop technological capability by many means. They can develop the technology through their own efforts, through a systematic research and development program; they can learn technology from other firms; or they can accumulate it through experience (learning by doing) (e.g., Kim 1997). However, from the early stages of economic development, technology transfer from foreign countries seems to have been the most important channel for technology acquisition. Technology transfer is deemed to have been successful when the transferred technology is translated and internalized into the overall capability of the recipient. The following sections will discuss three important concepts pertinent to this study: 'technology', 'channels' and 'forms of technology transfer', in order to develop an analytical framework for studying the technology transfer and local capability formation.

2.1 Types of Technology

Technology can be defined in many ways, but researchers normally refer to the words "technology" or "technological knowledge" as "a way of doing something" (Nelson and Winter 1982, p. 60), "a collection of physical processes that transforms inputs into outputs and knowledge and skills that structure the activities involved in carrying out these transformations" (Kim 1997, p. 4). Some of them maintain that "technology" refers to people's knowledge of how to use "techniques," and defines as specifications of products or production systems that may or may not be embodied in particular physical goods such as machines or instruments (David 1997).

Previous literature has discussed the nature of technology, noting that it typically takes two main forms, "explicit" and "tacit" (Polanyi 1962).[2] Sometimes, these two forms are referred to as 'hardware' and 'software' technology. Explicit knowledge, which corresponds to 'hardware' technology, refers to knowledge that can be codified and is transmissible in formal or systematic language, e.g., production manuals, academic papers, books, technical specifications, designs, and the like. It is knowledge that can be shared, transmitted, retrieved and reused relatively easily. Tacit knowledge corresponds to 'software' or 'skill', which, by contrast, is difficult to codify, communicate or transfer. Explicit technology is useful only when tacit knowledge enables individuals and organizations to use it. Otherwise, it is confined to individual human minds, which makes it difficult to codify and communicate. Tacit knowledge can be exchanged through action, commitments and kinds of involvement that allow people to share experience, such as face-to-face communication or on-the-job or apprenticeship-type training (Ernst and Kim 2002).

In this study, the term "technology" refers to 'tacit knowledge' or 'software' technologies, which are necessary to perform activities or to achieve good quality in the production of a part. "Performing an activity" refers to the ability to use tools and/or equipment to perform a particular stage of production, to test the

[2] This concept is adopted by many studies, such as Hayashi (1990), Nonaka and Takeuchi (1995), Kim (1997), David (1997), and Ernst and Kim (2002).

quality of the part produced, or to manage the inventory, production flow, delivery, and other such things.[3]

2.2 Channels and Forms of Technology Transfer

International technology transfer may be classified into three main types, according to the characteristics of the business relationship between the source and the recipient. The three types are 1) "arms'-length" trade of technology, 2) intra-firm technology transfer, and 3) inter-firm technology transfer (Capannelli 1997). However, the literature has thus far paid greater attention to the first two channels, since they are considered to be important means of upgrading the technological capabilities of developing countries (Reddy and Zhao 1990).

"Arms' length" trade of technology refers to cases in which technology is acquired through market-mediated channels, and the recipient must pay for technology by, for example, paying technological fees or royalties or simply paying the monetary value of the machine in question. Intra-firm technology transfer refers to cases in which foreign firms supply the necessary information and train local workers in their overseas affiliates or joint ventures. Foreign firms, who own the technology, receive dividends as the return on their transfer of the technology.[4] With respect to the forms of technology transfer, previous studies have used slightly different terms to define them. In these studies, the three major forms of technology transfer can be distinguished as follows: 1) operation

[3] Many scholars emphasize the importance of 'skill' or 'tacit' knowledge. For example, see Nelson and Winter (1982), Nonaka and Takeuchi (1995), Shin (1996), Lall (1996), Kim (1997), David (1997), Ernst, Ganiatsos, and Mytelka (1998), and McKelvey (1998).

[4] In this view, Kim (1997) identifies these two modes as market-mediated transfer, in which transferee and transferor need to negotiate the terms and conditions involved. However, for the FDI and foreign licensing, the technology supplier plays an active role in transferring the technology, while in the case of the selling of the machine, the role is comparatively passive.

technology, 2) improvement technology, and 3) development technology (the creation of new knowledge). Each category can include several sub-types, depending on the researchers' observations.[5]

Inter-firm technology transfer is defined as technology transfer between large, foreign and smaller, local-based firms in the manufacturing sector. It has long been recognized that informal technology transfer occurring through this non-market-mediated route provides opportunities for local parts suppliers to learn new technology from foreign finished-product assemblers (e.g., Lall 1980, Mead 1984, Hill 1985, Wong 1991, and Capannelli 1997). Wong (1991) divided forms of inter-firm technology transfer into two types, direct and indirect. These writers all found that direct assistance, forms of which have included training local suppliers' employees, giving advice about quality control or management practices, performing plant audits and troubleshooting some production problems, or loaning equipment, had not been frequently observed; however, Wong (1992, p. 53) has noted that the importance of technology transfer through "inter-firm" linkages such as spillover, learning facilitation, and investment inducement are more important. However, there is significant evidence that confirms that local parts suppliers have improved their technological capabilities through inter-firm technical linkages, even in cases in which they have not received direct assistance (e.g., Capannelli 1997, Techakanont 1997, 2002).[6]

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[5] For instance, Yamashita (1991 p. 14-20) classifies technology transfer in 'nine stages', while Kuroda (2001, p. 38-40) divides the technology into ten categories. Stages or levels of technology may exhibit the degree of difficulty that the recipient has to master, from simple technology to the most advanced kind.

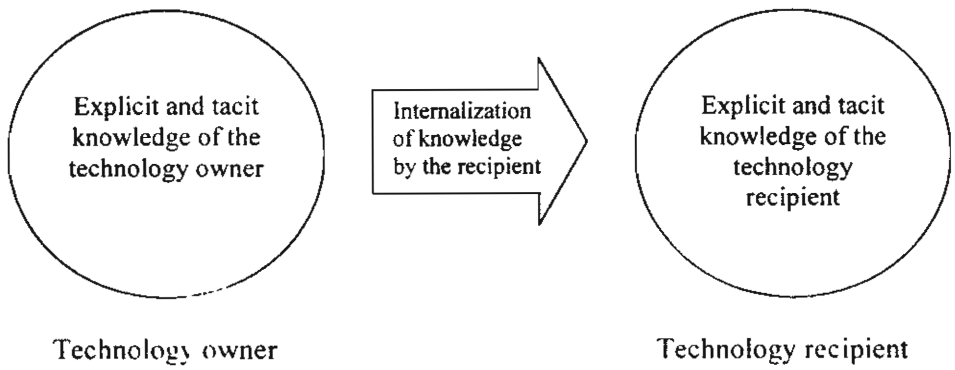
[6] Local suppliers can improve their capabilities because they are exposed to new, specific knowledge or information from the customers.

2.3 Technology Transfer as a Knowledge Conversion Process: Analytical Framework

As discussed above, irrespective of the mode of technology transfer, researchers have found the transfer of 'tacit' knowledge or 'software' technology more important than that of its 'explicit' or 'hardware' counterpart. Accordingly, the term technology transfer refers to the process of skill formation as experienced by the recipient as a direct result of the contributions of the technology source. The transfer process is said to be complete only if the recipient of the technology understands and is able to operate, maintain, and make effective use of the technology that has been transferred (Cohen and Levinthal 1989). Therefore, evidence of the success of any technology transfer would be an increase in the technological capabilities of the employees of the recipient firm and the enhancement of the efficiency of the firm's production process as a whole. On the recipient side, the process of technology transfer can be regarded as a learning process, i.e., the process of the internalization of knowledge (both explicit and explicit elements) from the owner (or transferor) to the recipients own businesses at the organizational level, see **Figure 1** below. However, only capable organizations can translate individual learning and acquired capabilities into organizational routines.

Although the concept of technology transfer is easily illustrated in **Figure 1**, it is not easy to ascertain what is going on inside this 'black box'. A concept that helps explain this complex issue can be found in the analysis of how Japanese companies create knowledge (Nonaka and Takeuchi 1995). They maintain that knowledge (or technology) is not restricted to an individual but must be shared by all of the human resources within the firm, an idea that is comparable to the "routines" concept of Nelson and Winter (1982). It is reasonable to apply this concept to the technology-transfer process because it is the process of one party's imparting a skill to another, after which the recipient needs to absorb or convert the knowledge transferred, both 'tacit' and 'explicit', into its own 'tacit' and 'explicit' knowledge. This concept is also supported by McKelvey (1998, 161-162), who maintains that the recipient is said to have successfully learned a technology if it can transform the codified knowledge (which is similar to explicit knowledge) into its tacit knowledge at the organization level.[7]

Figure 1 Technology Transfer as a Knowledge-Internalization Process



Source: Techakanont (2002, p. 27)

Nonetheless, our understanding of the ways that knowledge is transferred and that local suppliers can benefit from such relationship is far from complete. International technology transfer has been studied extensively, but the existing literature has focused on the transfer through formal mechanisms, such as joint ventures, foreign licensing and technical assistance agreements (Reddy and Zhao 1990). Very few studies have investigated the dynamic process of technology transfer and technological capability-formation in developing countries (e.g., Kim

[7] However, it should be noted that such successful transformation process requires purposeful effort and resource allocation (Lall 1996, Kim 1997).

1997, Cyhn 2002). A main distinction between 'inter-firm' relationship and other formal ones is that inter-firm relationships emerge only after a supplier has been selected and approved by an input buyer. The supplier needs to have sufficient technological capacity to respond efficiently to the specific needs of the input buying firm; otherwise, the buyer has no incentive to finalize a business agreement with that supplier (Asanuma 1989; pp. 21-25). This is completely different from the case of intra-firm technology transfer in which the transferor has clear incentive and willingness to transfer technology. Thus, direct technical assistance is rarely observed. Moreover, the issue becomes more complex simply because inter-firm technology transfer is not, logically, the main source of acquired technology. Local suppliers acquire and develop their own capabilities in several ways, such as acquiring technology from joint ventures, foreign licensing or technical assistance agreements; in other cases they rely on the importation of machinery to strengthen their technological capabilities. Accordingly, to explore this issue thoroughly, this study will analyze technology transfer as a process of knowledge conversion, which takes into account dynamic factors such as time, space and the environments in which firms operate.

Therefore, the analytical framework for this study has been developed by relating the idea of technology transfer to the idea of knowledge conversion put forth by Nonaka and Takeuchi (1995). From Figure 1, two diagrams have been developed to represent the technology transfer at two levels, the intra-firm and the inter-firm levels. In each diagram, it proposes two major categories of knowledge, i.e., explicit and tacit knowledge, and two major performers within the technology transfer process, i.e., the technology source and the technology recipient to show the various channels through which knowledge can be communicated and created.

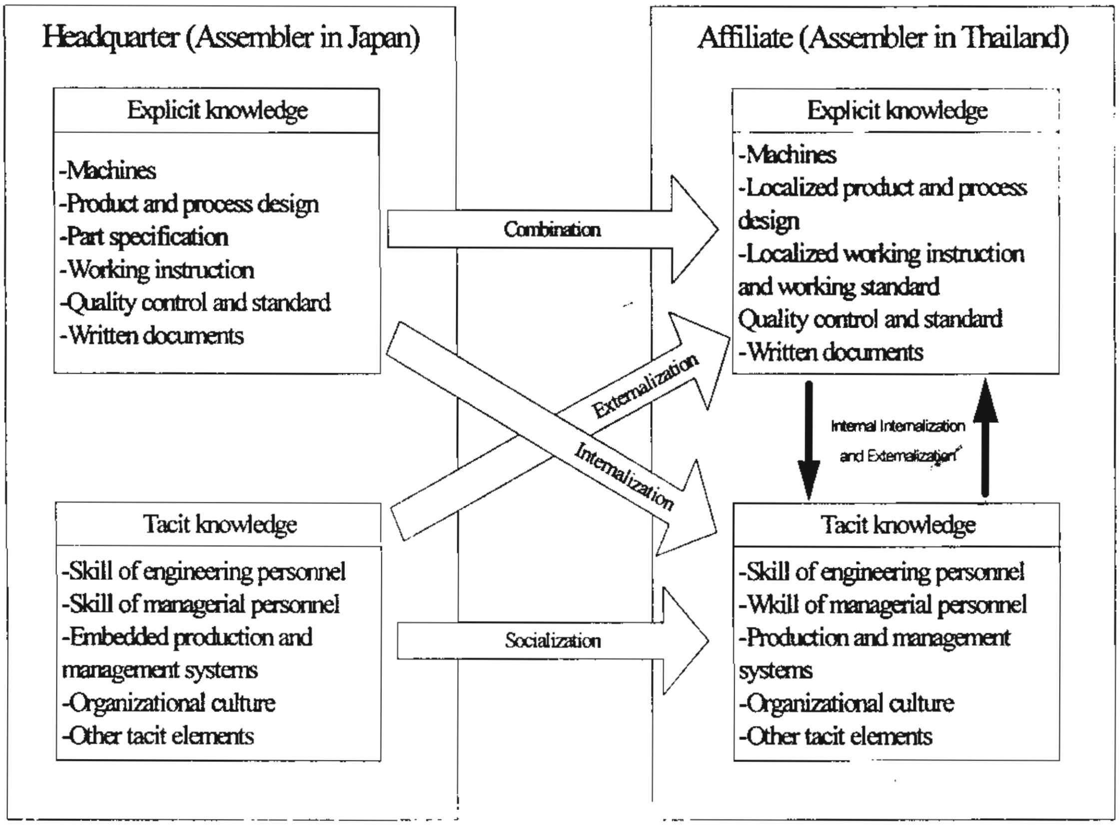
At the intra-firm level,[8] the source, in this example, is a Japanese assembler (headquarter in Japan) and the recipient is its affiliate company in Thailand (see Figure 2). At the inter-firm level, the technology source is Japanese assembler in Thailand and the recipient is local suppliers (see Figure 3).

Theoretically, assembling plant in Thailand will receive full 'intra-firm' support from its parent company, therefore, it can be argued that the technology transfer and learning process of the recipient side of these two levels are different. It is reasonably to believe that the learning process at the inter-firm level would be more complicated. Also, the conceptual background described above indicates that local suppliers can acquire technology in two major ways, by creating or improving their own knowledge (i.e., knowledge created inside the company) and/or by learning or expanding upon technology that has been transferred from its source (knowledge created from having a relationship with an external entity). In other words, for suppliers, internal efforts and specific investments to expand their absorptive capacity are crucial factors for the efficacy of knowledge conversion. That is, local parts firms can internalize knowledge through the creation of both explicit and tacit knowledge and through the dynamic process of conversion between two dimensions of knowledge; i.e., explicit and tacit knowledge (Nonaka 1991). This is the main reason for including the absorptive capacity only in the framework of inter-firm technology transfer (as shown in Figure 3).[9]

[8] Intra-firm technology transfer is defined as a situation in which technology is intentionally transferred by the technology source, a foreign-parent company, to its overseas affiliate. Intra-firm technology transfer is crucial because the success or failure of its overseas affiliate is determined by the quality of its transfer attempt (Sedgwick 1995). Typical transfer practices involve provision of training to the affiliate's local people, at home and/or in the host country, and instruction and training at the work site (or on-the-job training).

[9] This is by no mean to neglect the importance of absorptive capacity of the Japanese affiliate. The author did not include it because it will more complicate. Technological capability of the affiliate

Figure 2 Intra-firm Technology Transfer and Knowledge Conversion



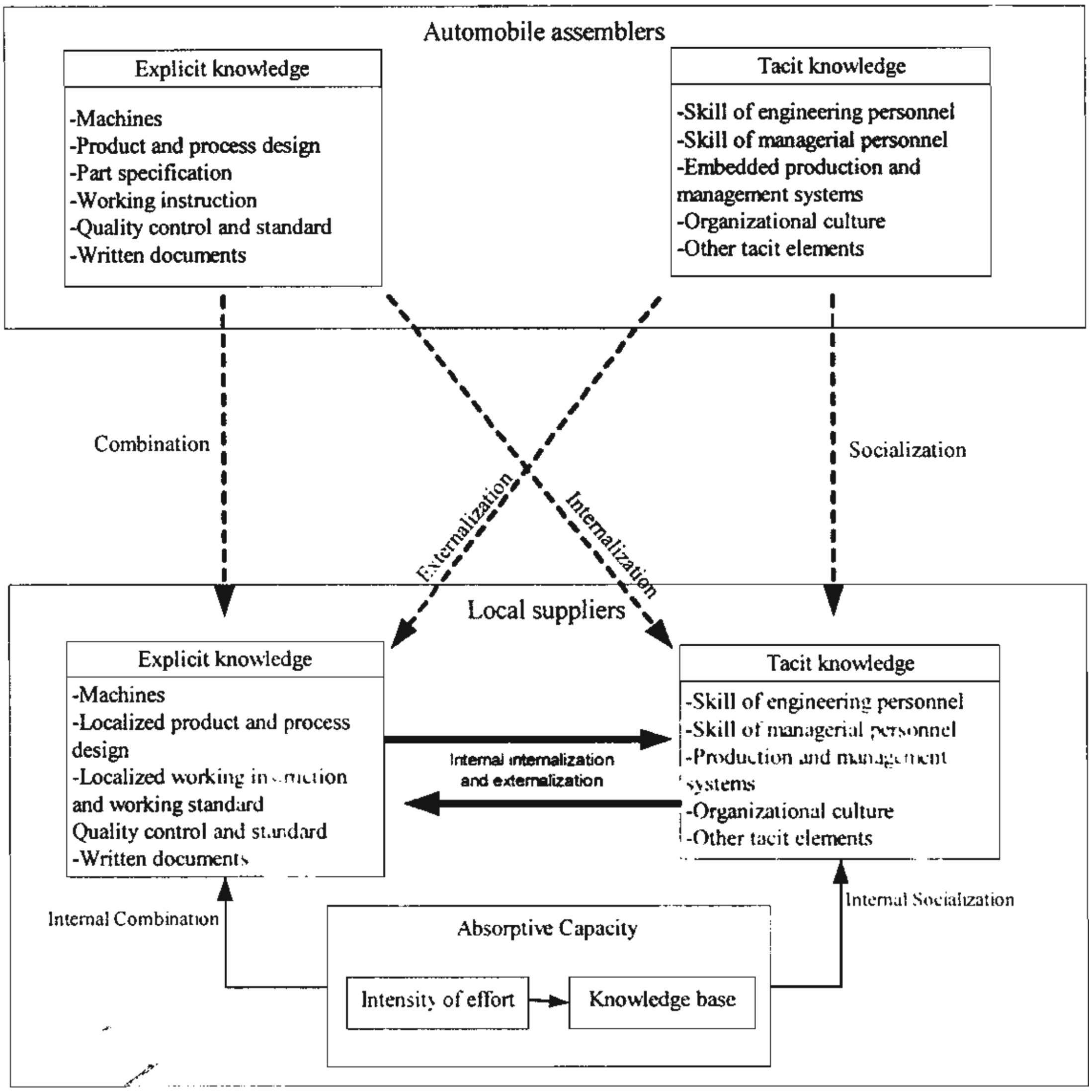
Note: ⇨ Knowledge transferred from the headquarter (Assembler in Japan)

→ Knowledge conversion within the companies (Assembler in Thailand)

Source: By the authors, based on ideas of Nonaka and Takeuchi (1995), Kim (1997) and Ernst and Kim (2002)

company in Thailand can be improved by the technical support from the parent company. Discussion about this issue will be given in Chapter 4.

Figure 3 Inter-firm Technology Transfer and Local Capability Formation



Note: - - - - → Knowledge transferred from automobile assemblers

——→ Knowledge conversion within the companies (local suppliers)

Source: By the authors, based on ideas of Nonaka and Takeuchi (1995), Kim (1997) and Ernst and Kim (2002)

The knowledge conversion process that takes place in both levels can be described as follows; conversion from tacit to tacit (called socialization) takes place when one individual's tacit knowledge is shared with another individual through training or face-to-face communication, whereas conversion from explicit to explicit (combination) takes place when discrete pieces of explicit knowledge are combined and made into a new whole. Conversion from tacit to explicit (externalization) occurs when an individual or a group is able to articulate his or her tacit knowledge into an explicit format, while conversion from explicit to tacit (internalization) occurs when new explicit knowledge is internalized and shared throughout a firm and other individuals begin to utilize it to broaden, extend and reframe their own tacit knowledge. As more participants in and around the firm become involved in the process, such conversions tend to become both faster and larger in scale (Nonaka and Takeuchi 1995). Nevertheless, effective knowledge conversion requires two important elements: an existing knowledge base (especially the tacit element) and an intensity of effort to develop that knowledge base. This is known as 'absorptive capacity', and it is crucial in determining how fast and successfully local suppliers can internalize the transferred technology and make it their own. Intensity of effort and commitment to the process are more important than the knowledge base because the former creates that latter, but not vice versa. Thus, intensity of effort enables a firm to improve its absorptive capacity, which in turn helps it achieve technology transfer from its customers effectively.

Chapter 3

Research Methodology and General Information about Firms Studied

The main purpose of this research is to examine the evolution of technology transfer in the Thai automobile industry, by investigating roles of automobile assemblers in promoting the technological capability of their affiliate and their local parts suppliers. This research relies on both primary and secondary data. To enrich our understanding of the current issue, the primary data seems to be more appropriate. Thus, the author tries to obtain the 'first hand' information. If that was not available, secondary data will be used for analysis. In order to fulfill research objectives, the author conducted three-phase of field survey, during 2002 and 2005. The details are given below.

The first phase was conducted in 2002 and 2003 to gain a deeper understanding of this issue. A series of exploratory interviews were undertaken to gauge the extent to which the changes within the industry would have an impact on the automobile-supplier relationship. This author visited five major assemblers and interviewed their management staff. Basic information, obtained in 2003, about these companies is shown in Table 1. The survey results suggested that car manufacturers were changing their purchasing and production strategies in the direction of globalization, i.e., the adoption of global sourcing policy and the integration of Thailand into their global production network. This had created substantial pressure on parts suppliers, especially in the area of engineering capability, and resulted in changes in the inter-firm relationship.

Table 1 Basic Information about Automobile Assemblers Interviewed

Assemblers	Establishment	Ownership	Main products	Production Capacity (in 2003)	Market orientation
Auto T	1960s	Japanese	Passenger cars and pickup trucks	200,000	Domestic
Auto I	1960s	Japanese	Pickup trucks	147,000	Domestic
Auto M	1960s	Japanese	Passenger cars and pickup trucks	174,000	Export
Auto A	1990s	Japanese	Pickup trucks	135,000	Export
Auto H	1990s	Japanese	Passenger cars	50,000	Domestic

Note: All firms currently export their products; however, if they export more than 50 percent of total production, they are classified as Export, otherwise, as Domestic firms.
Source: Information obtained from field survey during 2002 and 2003

In the second phase (during 2003 and 2004), the author designed a set of questionnai[illegible]d sent them to about 100 suppliers in August 2003. These suppliers were in the same sample to which a similar type of questionnaire had been sent in 2000.[10] The questionnaires were distributed in this way to take advantage of existing information about the inter-firm technology transfer, which is believed to provide a clearer picture to the evolution of inter-firm relationship in the Thai automobile industry. The main questions were designed to obtain general information, the characteristics of the suppliers' relationships with their customers and the status of their technological capability. The questions also asked how the companies had acquired their production technology and the sources of the improvements to their technology, the kinds of technical linkages their customers had provided, and the technological benefits that had been derived from having established and maintained inter-firm relationship with automobile assemblers in Thailand. As will be reported in the Chapter 5, 15 questionnaires were returned; six were from foreign suppliers, seven from joint ventures, and two

[10] Details about the structure of questions and sample firms surveyed in 2000, please refer to Techakanont (2002).

were pure Thai companies (see **Table 2**).[11] Then, during December 2003 and February 2004, the authors conducted in-depth, follow-up interviews with local suppliers who reportedly had received direct technical assistance from customers. These interviews were undertaken to examine the dynamic process of technological capability formation through inter-firm relationships and the intensity of their efforts. The survey findings and an analysis of them are provided in Chapter 5.

Table 2 Characteristics of Parts Suppliers that Answered the Questionnaire

Type of firms	Foreign firms (6 firms)	Joint venture firms (7 firms)	Thai firms (2 firms)	Total (15 firms)
Establishment				
1960-1970	1	2	1	4
1980s	1	1	1	3
1990-1995	2	4	-	6
1996 onwards	2	-	-	2
Employment				
Less than 100	1	-	-	1
100 - 199	-	1	-	1
200 - 499	4	4	-	8
More than 500	1	2	2	5
Sales (in 2002)				
Sales less than 100 mB.	-	-	-	-
100-499.9 mB.	2	2	-	4
500-999.9 mB.	3	3	-	6
1000-3 [illegible]	1	1	-	2
more th[illegible] B.	-	1	2	3
Percentage [illegible] export				
0%	4	1	-	5
0.1 - 10 %	-	2	2	4
10.1 - 20 %	-	-	-	-
20.1 - 50 %	2	4	-	6
More than 50%	-	-	-	-
Total	6	7	2	15

Source: Questionnaire survey in 2003

[11] Note that foreign firms refer to companies which have foreign equity not less than 80%, joint ventures to companies which have foreign equity between 20 to 79%, and Thai firms to companies which have foreign equity less than 20%

The third phase, during 2004 and 2005, was devoted to in-depth interview with automobile assemblers in order to learn the practice of technology transfer in product engineering and design capabilities. In order to select the appropriate case, this author relied on secondary information, such as the plan for export and the investment strategies of assemblers in Thailand. By comparing the export of automobile from Thailand in 2004 and 2005, interesting evidence has been observed. In 2004, it was reported that export of automobiles was 332,053 units, growing 41 percent from 2003. Mitsubishi was the largest exporter, followed by Auto Alliance, Toyota, General Motors, and Isuzu (see Table 3). However, in 2005, according to export projection by assemblers, Toyota will become the largest exporter, around 150,000 units of its new HILUX VIGO, new models of pickup trucks. VIGO is a part of the Innovative International Multi-purpose Vehicle (IMV) project that was launched in 2004. Mitsubishi would be the second largest exporter, follows by Auto Alliance (Thailand), Isuzu and General Motors.

Table 3 Exports of Automobiles during 1997 and 2004 (classified by assemblers)

	1997	1998	1999	2000	2002	2004
Mitsubishi Motor	40,072	63,797	60,986	63,541	75,581	88,033
GM	-	-	-	6,283	33,276	45,248
AAT	-	1,213	42,785	49,977	47,333	73,842
Toyota	1,563	1,819	12,151	16,031	11,882	52,682
Honda	570	2,910	6,361	6,183	10,371	44,564
Isuzu	-	20	516	5,689	1,348	26,954
Nissan	-	-	1,912	4,590	555	301
Others	-	48	380	541	n.a.	n.a.
รวม	42,205	69,807	125,091	152,835	180,553	332,053

Source: Mori (2002), Prachachart Thurakij, February 10-12, 2003, and Thai Automotive Industry Association.

Table 4 Production Capacity and Export Plan from Thailand in 2005

Company	Year of announcement to use Thailand as export base	Annual production capacity (units)	Estimated export in 2005	Main export market
Toyota	2002	350,800	150,000	Asia, Australia, New Zealand, Ocenea
Mitsubishi	2003	170,200	100,000	EU, Africa, Middle East
Auto Alliance (Ford & Mazda)	1996	135,000	65,000	EU , Australia, New Zealand, Ocenea
Isuzu	2001	200,000	50,000	Middle East and EU
GM		115,000	50,000	Australia, New Zealand, and Asia

Source: Compiled by the author, Thai Automotive Industry Association

To a certain extent, rapid expansion of production and export, as shown in Table 3 and Table 4, can confirm the success of the industry and the effort of foreign assemblers (especially Japanese firms) in transferring technology to their affiliates. Based on several interviews with assemblers, and secondary data published by many associations as well as in newspapers, the IMV project of Toyota emerges as the most interesting case for several reasons, such as the newness of the project (which needs additional investment), the surge in production and export in the past few years, and these newly designed models are launched first in Thailand. The success of this project leads us to expect the massive of technology transfer by Toyota, hence, studying this project will contribute to the literature by adding new evidence and improve our understanding of the issue. In the Chapter 4, the characteristics of the IMV project and the roles of Toyota in promoting engineering and design technology at the Thailand plant will be discussed, while the report on questionnaire survey and case studies on technological formation of part suppliers will be provided in Chapter 5.

Chapter 4

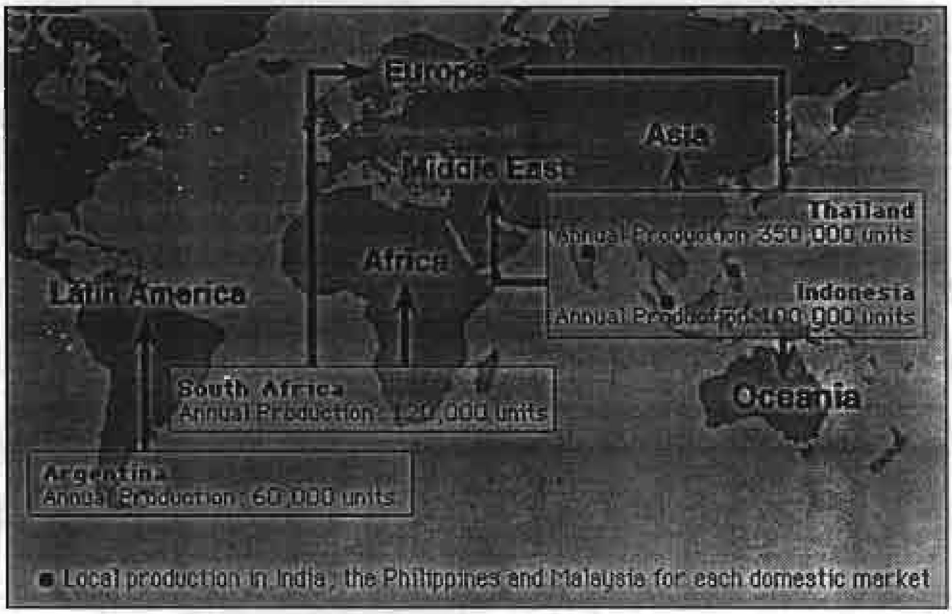
Roles of a Japanese Automobile Manufacturer in Transferring of Product Engineering and Design Technology

4.1 Background of Innovative International Multi-purpose Vehicle (IMV) Project

Toyota Motor Corporation (TMC) announced the Innovative International Multi-purpose Vehicle (IMV) Project in 2002 by launching sales of a new-type pickup truck in Thailand. The project includes 5 models newly designed for sale in more than 140 countries and customer demands for high levels of durability and comfort. In addition, an increase in production capacity is announced in Thailand and Indonesia, in April, 2005. It was reported in the Toyota's website that this project represents an unprecedented approach under a "Made by Toyota" banner that will rely fully on the resources and potential of outside-Japan global production and supply bases for both vehicles and components. It is also remarkable for fact that production will start almost at the same time at its four main production bases of Thailand, Indonesia, Argentina and South Africa, which will supply vehicles to countries in Asia, Europe, Africa, Oceania, Latin America and the Middle East. In addition, the project also includes the production of some major components in various locations, such as diesel engines in Thailand, gasoline engines in Indonesia and manual transmissions in the Philippines and

India, and their supply to the countries charged with vehicle production (See Figure 4 and Table 6).

Figure 4 Toyota's Production and Supply Network (IMV project)



Source: http://www.toyota.co.jp/en/strategy/imv/

Table 5 IMV Project Production Plan

Country	Type	Start-up	Capacity (units per year)	Export market
Thai	Pickup	Aug 2004	280,000	EU, Asia, Oceania, Middle East,
	SUV	Nov 2004	(140,000 export)	and others.
Indonesia	SUV	Sep 2004	80,000 (10,000 export)	Asia, Middle East
South Africa	Pickup	2005	60,000	EU, Africa and others
	SUV		(30,000 export)	
Argentina	Pickup	2005	60,000	South America
	SUV		(45,000 export)	

Source: Summarize from www.toyota.co.jp

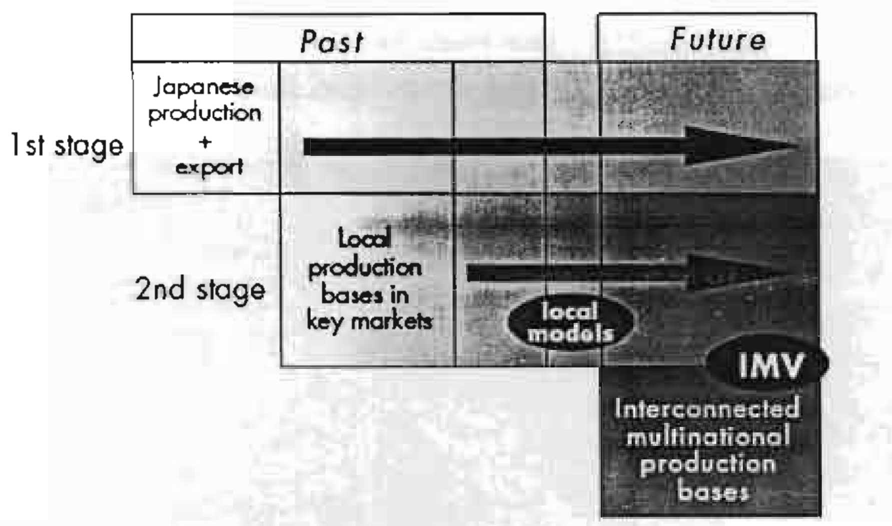
Table 6 Main Production Countries of Parts Related to IMV

Country	Main Production Item
Thailand	Diesel Engine
Indonesia	Gasoline Engine
Philippines	Manual Transmission
India	Manual Transmission

Source: http://www.toyota.co.jp/en/strategy/imv/

On a geographical and historical scale, the IMV project represents the third stage of manufacturing for Toyota (see Figure 5). In the first stage, Toyota made vehicles only in Japan and exported the units to world markets. This was followed in the second stage by local manufacturing in key market areas. Now, supported by trade liberalization, such as CEPT (Common Effective Preferential Tariff) in the ASEAN countries, Toyota has entered the third stage by taking up the challenge of building a more efficient production and supply system on a global scale. With this initiative, the globalization of Toyota's attitude towards "making things" and "quality" is becoming more important than ever. Therefore, it is essential for Toyota to transfer technology, not only the operative levels, but also management, engineering and design capabilities to its affiliate and supplier network in Thailand. The roles of Toyota in transferring technology will be discussed in the subsequent sections.

Figure 5 Stages of Toyota's Global Production



Source: http://www.toyota.co.jp/en/special/imv/imv.html

4.2 From Product Development to Mass Production: Basic Concepts

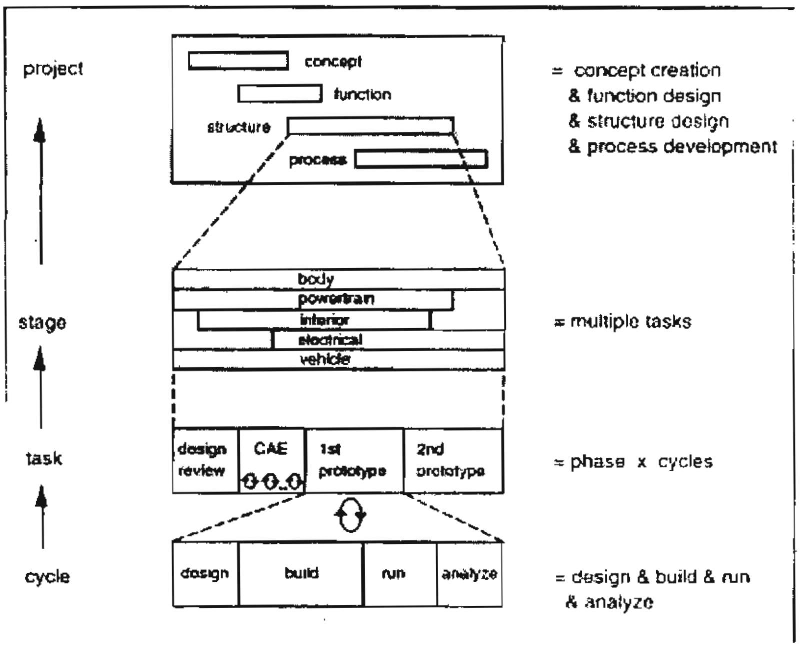
This section will provide basic information for understanding why technology transfer is necessary when a foreign assembling firm plan to launch a new model of automobile in another country. This fact lies on the most important task, i.e., product development, that must be accomplished before transferring the manufacturing of automobiles abroad. Product development activity may be divided into four major stages, namely, concept generation, function and structure design,[12] process development (or process engineering), and, finally, when these activities were complete, mass production will be launched (as shown in Figure 6).

According to Aoki (1988) and Clark and Fujimoto (1991), Japanese automobile manufacturers normally develop new products and/or new models in Japan, at their R&D center, in close collaboration with many part suppliers, both

[12] According to Clark and Fujimoto (1991), these two stages may be referred to as "product planning" and "product engineering." In a recent study, Thomke and Fujimoto (2000) explain the these two stages were normally carried out simultaneously, hence, it is sometimes known as "simultaneous engineering."

Japanese and foreign firms. Intensive information exchange between the assembler and parts suppliers normally takes place at this stage, because the assembler relies on engineering capability of the suppliers in both parts design and development. This process is usually performed in Japan because the assembler can maintain an efficient flow of information with all the suppliers.[13] Mass production would have no serious problem if it were launched in home country, because of the proximity to its suppliers and similarity of management routine. However, if this product will be produced in another country, problem and difficulty generally arise, which in turn requires the assembler to spend more resource to transfer technology to its affiliate as well as to local suppliers.

Figure 6 Stages of Product Development Activities



Source: Thomke and Fujimoto (2000), Figure 2, p. 131

[13] According to a study, Kimbara (1996) reported that a supplier with design capability spent about eight months designing and developing the first prototypes for the customer, and it needed about six months for adjustments and to make the second prototype. This example can express the high degree of collaboration between the two parties, and it supports why this process still remains in Japan.

In the case of Toyota's IMV project, as mentioned earlier, there were 5 newly designed models. From its formal announcement, it took less than three years for launching all models in 2004, which was considerably shorter than other projects in the past. In addition of intensive technological transfer and support, improvement in information technology, such as computer-aided design (CAD) and digital engineering, is one main factor accounting for this success.[14] Based on interviews with many assemblers, the transfer of production to overseas facilities normally occurs when the technical issues of the product engineering stage were almost complete. The most important task is to prepare for the mass production at the affiliate and to follow up all suppliers to meet the overall project schedule.[15]

For the sake of simplicity, the contents of technology transfer to Thailand may be classified into three parts, namely, 1) product development (which includes concept generation, product planning, product engineering, and engineering changes) 2) process preparation (or process engineering) and 3) mass production, as shown in Table 7. In this section, roles of Toyota in transferring engineering and design capabilities will be explained.

[14] According to Liker (2004), Toyota could shorten lead time to market, i.e., time required from product development to mass production, to only 12 months. However, the author did not explain or give information about general characteristics or design complexity of such projects. It is believed that for the IMV project, it would require more time and resources because Toyota would have to provide technical assistance not only to its affiliates but also for suppliers in the host countries.

[15] In a similar investment project, Techakanont (2002) observed that Japanese assemblers need to provide technical support to suppliers in Thailand. A main reason is the geographic isolation between product development and production activities. Therefore, many local suppliers that had no participation in the development stage could not understand some technical requirements, and, hence, technical assistance was necessary. Currently, assemblers require that suppliers should provide some development or engineering services, thus, supply chain management becomes more critical to maintain competitive advantage. As stated in a report, Vaghefi (2001) notes that engineering and development reliance on suppliers tend to be more important for assemblers because it accounts for about 85 percent of direct production cost. This strategy can provide some benefits to assemblers, such as avoiding investment, lower associated risk, and lower costs of development and production, especially when suppliers gain more specialization. (see http://www.toyota.co.jp/en/special/toyota_philosophy/)

4.3 Technology Transfer in Product Engineering and Design Capabilities

In 2002, there was a report about the strategic changes in investing policies of Japanese assemblers in Thailand (Mori 2002). The change was that they would transfer higher level of technology to their affiliates, especially product development, design, product and process engineering technology (see Table 7). In 2003, Toyota and Mitsubishi announced the plan to establish a research and development center in Thailand (Business Day, January 16, 2003, Krungthep Thurakij, June 16, 2003), which confirms Mori's observation. However, at that time, it was not clear if that would entail a new and higher wave of technology transfer.

Based on several interviews by this author, since 2002, there was evident that some assemblers already made the progress in transferring some aspects of product and process engineering to their employees, such as capability to revise some engineering design of body parts and some components that are not safety parts.[16] Under the IMV project, Toyota took the lead by setting up a research center, called "Toyota Technical Center Asia Pacific Thailand" or TTCAP-TH, which is one of the two research centers (the other one is in Australia). The center is located at Amphur Bangbo, Samutprakan Province. It was reported that Toyota invested more than 2,700 million baht and commenced operation in April 2005. There are about 290 staff, most of them are engineers. After recruitment, they were train in Thailand on average three to six months, then they were sent to Japan to work with Japanese engineers in product development division about one

[16] An interview with Thai engineers of a Japanese assembler who were being trained at the headquarter plant in Japan indicated that they were able to do analysis and revise some engineering changes. Although each case needs to receive final assessment and approve by engineering division at headquarter, every 'engineering change notice' has to be written systematically and thoroughly evaluated before submission. Without sufficient knowledge transferred, this could not be possible (Interview on March 16, 2004, in Japan)

to two years (http://www.toyota.co.jp/en/news/05/0511.html and Prachachart Thurakij, June 16, 2003).

Table 7 Processes that are Likely to be Transferred to Thailand

Process Stages	Individual processes	Before 2002	2002 onwards
Product Development	Concept generation	J	J
	Product Planning	J	J
	Product Engineering	J	T
	Engineering change for local specification	J	T
Process engineering		J/T	J/T
Production stage	In-house production management	T	T
	Supplier management	T	T

Note: Product engineering is a process consisting of repeated engineering, prototype making, testing cycles that lead to the completion of formal drawings for products and parts. J = Japan; T = Thailand.

Source: Adapted from Mori (2002); Fig. 2, pp. 33, and from interviews by the author.

Normally, each assembler has its own way to develop new product, i.e., it is the company's specific knowledge. Most of technologies and skills are embodied in organization routine and human resources, which are difficult to transfer. For Toyota, it has its own development system, called "Toyota Development System."[17] Therefore, it is necessary for TTACP-TH to have their engineers worked and trained in Japan. On-the-job training is probably the most effective method to transfer 'tacit' skill of Japanese expert to Thai engineers through 'socialization' process. After learning such skills, Thai engineers have to transform their skill into a more explicit form, such as to develop documents into Thai language (externalization) or to improve the knowledge they have learned

[17] For details about product development of Toyota, see Fujimoto (1999), Amasaka (2002) and Liker (2004)

into a new standard (combination). This set of explicit knowledge would then be crucial for sharing with and training to other staff at TTCAP-TH (internalization).

Examples of technology that need to be transferred to Thai engineers are Toyota's development software such as CATIA (Computer-Aided Three-Dimensional Interactive Application), and digital engineering software that Toyota collaborated with Delmia (Digital Enterprise Lean Manufacturing Interactive Application), in which the project is called V-Comm (Virtual & Visual Communication). Thomke and Fujimoto (2000) reported that this software help Toyota to shorten lead time for product development because it can efficiently simulate and analyze the feasibility of design, which is the Design-Build-Run-Test cycle in Figure 6 at the very early stage of product development.[18] This digital manufacturing is changing the way Toyota and other larger manufacturers develop and create new products with advanced 3-D simulation, promising to dramatically speed the time-to-market for new products while cutting manufacturing costs considerably. Thus, these are areas that Thai engineers have to comprehend, and training in Japan was crucial in determining the success.[19]

[18] However, it is also because of Toyota's systematical record about the success and failure of design, development and engineering related issues, which enables Toyota to avoid 80% loss from inappropriate design in prior to the production of the first prototype. Accordingly, Toyota could shorten time to market by 33 percent, avoid the engineering changes after releasing the first drawing by 33 percent, and lower development cost by 50 percent. DELMIA Press release (2004), available at http://catiaworld.com/cwnews/view.asp?msgID=67

[19] Nonetheless, it can be expected that the main function of R&D activity will be performed in Japan. The centers in Thailand and in Australia would play supportive roles, as indicated in a company's document, (An introduction to Toyota factory in Thailand) that TTCAP-TH's functions included "survey and research about consumer preference about style, technology, color, and material for parts. Then this information will feed to the R&D center in Japan to develop and design new automobiles."

4.4 Technology Transfer in Process Engineering Capability

The steps and procedures of technology transfer in process engineering are similar to the transfer of product and design capabilities explained earlier. The difference lies in the content of technology and the location. Because Toyota has long operating experience in Thailand, this preparation process usually takes place at both in Japan and at the plant in Thailand (as also indicated in Table 7). Due to the advancement in design technology, Toyota can perform product engineering and process engineering simultaneously at the early stage of design and development. Toyota uses "digital mock-ups" software to do experiment on virtual assembly and simulate the working environment in 3 dimensions. Also, this software can analyze the ergonomics and the working condition between workers and machines digitally, so that Toyota can design safe and efficient assembly lines before the construction of the 'real' production lines at the factory.[20]

Even though the design of production line could be done in Japan, dispatching experts to perform the preparation in Thailand was essential because the installation of machines and equipment had to be done in Thailand. At the same time, some Thai engineers were sent to Japan for training at the production site, so that they could learn how to perform and manage the production line (tacit skills) from Japanese experts. Then, these trainees had to codify and transform their accumulated tacit knowledge into a more 'explicit' form of knowledge, which is easier to share with other staff, such as working manual or standard for operation. These documents were then studied and improved by Thai and

[20] This is a part of the V-Comm project, in which engineers of Toyota can perform the simulation from V-Comm rooms in different locations simultaneously.

Japanese engineers. A set of new explicit knowledge such as working manual for the operation in Thailand would be developed (combination). Finally, all of these documents will be used to train and to embed the skill into all employees (internalization). Because the transfer of this technology usually requires 'time' and 'space' for workers to 'socialize', the presence of Japanese experts in Thailand is one crucial factor in determining the success of technology transfer.

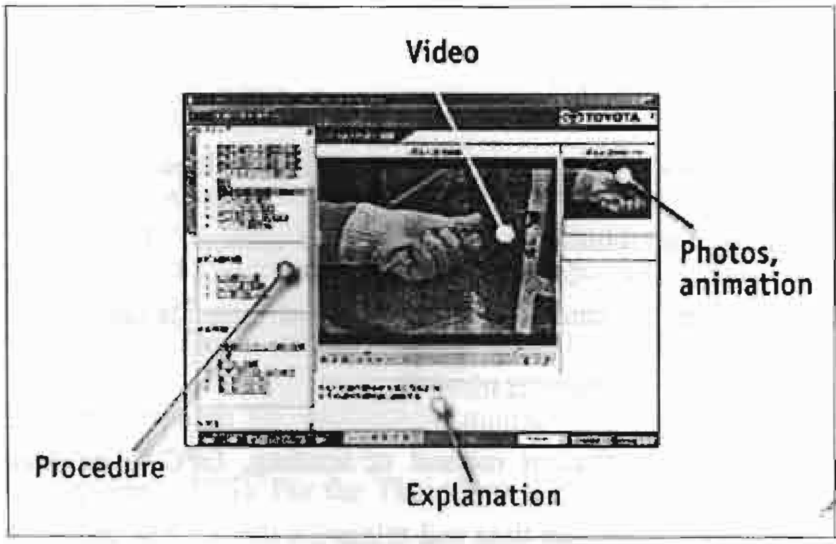
The SECI process explained above is the task that Toyota has to accomplish. The process is similar to the observation of a previous study by Techakanont (2002) in a sense that Japanese assemblers aim to develop the skill of "trainers," which will be crucial in passing on the skill to their peers and/or subordinates. Usually, the preparation stage requires enormous supports from headquarter in forms of man-hour of experts and training program for local staff, for instance. With this projection and the intense competition in the global market, Toyota responded by establishing "Toyota Global Production Center" (GPC) in July 2003. The mission of GPC is to rapidly instruct large numbers of mid-level plant managers from overseas and Japan in best practices. A reason behind this establishment is because of globalization strategy of Toyota; as can be seen in the following statement;

> Toyota sees increased self-reliance for overseas affiliates as essential to successful worldwide expansion. With over 50 manufacturing sites in 26 countries and locations worldwide, Toyota's traditional "mother plant" system of support has been stretched. Toyota's overseas vehicle production posted a year-on-year increase of 18.7% in CY2003 and is on course to rise another 20% in CY2004. "We must advance our competitiveness by developing more efficient training to support overseas manufacturing efficiency and quality," explains Toyota Executive Vice President Kosuke Shiramizu.[21]

[21] http://www.toyota.co.jp/en/special/gpc/gpc.html

The GPC has an objective to reduce resources and costs that the headquarter has to support their overseas facility, at the same time, it aims to provide 'best practice' operation skill to middle class managers. Toyota emphasizes the importance of tacit knowledge of its employees, as it is the key element of the Toyota Production System. One of the main achievements to promote this is the development of "visual manuals." Visual manuals are created because Toyota sought a "common base" for manufacturing at Toyota plants worldwide. Also, this means that Toyota has to find and organize the best practices and eliminating individual methods that rarely written down. In doing so, Toyota "selected and organized the best practices for each skill and applied digital technology to compile these methods into 'visual manuals,' keeping text to a minimum, while using photos along with short animation and video clips to facilitate rapid comprehension." The manuals also have slow-motion videos clips which enable trainees to grasp skills of experts who tend to demonstrate too rapidly. The use of animation with necessary explanation can be regarded as an attempt to 'decode' the 'tacit' skills of experts into a new form of 'explicit' knowledge that can be efficiently shared and learned by other staff. As a result, Toyota can reduce the time and resources spent on support its overseas plants and on training their staff globally. In 2003, it was reported that GPC had about 2,000 visual manuals in stock, covering a vast repertoire of automotive assembly processes.

Figure 7 An Example of Visual Manual



Source: http://www.toyota.co.jp/en/special/gpc/gpc.html

For efficient and effective skills training, trainees will be trained through four stages at GPC (see also Figure 8):

(1) Trainees acquire basic knowledge using visual manuals.

(2) They practice fundamental skills — such as how to tighten screws so they are not too loose or too tight — at specially designed work tables.

(3) They progress to "element work" training, such as joining a door lock rod and door handle.

(4) They learn the basics of standardized work, including how to start and end an operation, the *kanban* system of just-in-time parts ordering and how to use the *andon* system to halt the line if there is a problem.[22]

Figure 8 Training Steps at GPC

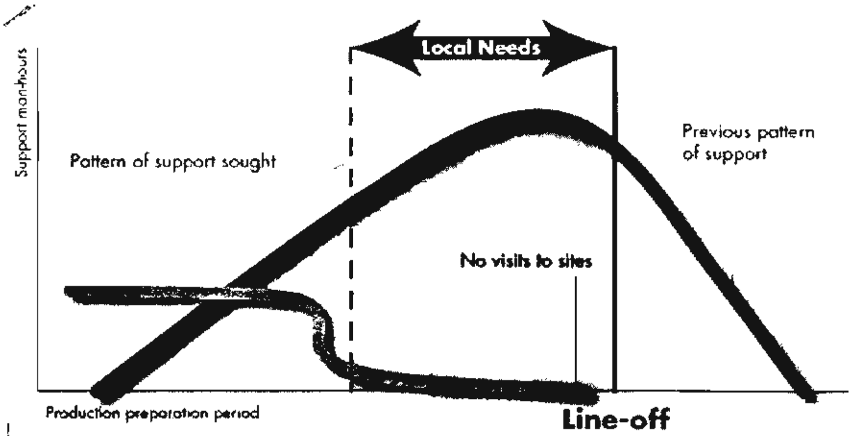
Source: http://www.toyota.co.jp/en/special/gpc/gpc.html

[22] Kanban, Just-in-time, andon are some basic skills of the Toyota Production System (TPS).

Carefully considered, the training practice of GPC is consistent with the SECI process of Nonaka and Takeuchi (1995). It begins with the assembly of experts in manufacturing skill (socialization) in order to create best practice manual (externalization). Then, each manual will be developed into a new form of explicit knowledge (combination), i.e., the 'visual manual.' This manual is then used in training. Trainees can learn from the visual manuals and then assimilate such skill into their skill (internalization).[23]

Because of this efficient method of training, GPC is augmenting this capability to reduce preparation time and minimize the need to send personnel to overseas sites to supervise training for new-model assembly. It is reported that Toyota can reduce training costs by 50 percent, while improving the training effectiveness by 6-7 times. The aim of GPC to reduce support resource can be seen in Figure 9. However, the GPC was established after the announcement of the IMV project. Thus, it is believed that the GPC was not fully utilized for this project, then, sending Thai trainees to train in Japan and dispatching Japanese expert to train staff in Thailand was necessary.

Figure 9 Aim in Reduction in Support during the Preparation Stage



Source: http://www.toyota.co.jp/en/special/gpc/gpc.html

[23] However, the participation with Japanese experts, or trainers, during the training is important for the transfer such skills.

4.5 Technology Transfer in Production Management: the Toyota Production System

After the launch of IMV project, Toyota Motor Thailand expanded their annual production capacity from 200,000 units in 2003 to 350,000 units in 2005. This calls for a more systematic production management system of its operation and of its suppliers. Therefore, it is essential for Toyota Motor Japan to transfer and spread its strength in production management system, called "Toyota Production System" (TPS). For the Thai plant, TPS has been initiated since 1998 and it is known as "Toyota Way." At first, Toyota tried to implement only in its factories. Since 2001, this activity has been promoted to suppliers, as will be explained later in this section. In essence, TPS consists of three main activities;[24]

1. Just-in-Time: produce right parts, right amount, at the right time.
2. Jidoka: in-station quality control – making problem visible and never letting a defect pass into the next station.
3. Kaizen: continuous improvement that encourage employees to suggest new ideas to reduce waste and improve productivity.

It should note that the "Toyota Way" is not merely a tool that anyone can adopt and utilize efficiently without effort. There are other issues, such as corporate culture, organizational routine, and vision. The gist of the system is the 'kaizen' mind and the core factor is the company's human resource. The TPS can be prevailed in organization that had well-trained staff with kaizen mind. Without that, JIT and Jidoka will be meaningless. For instance, if an operator found a

[24] TPS was developed by Taiichi Ohno and was applied not only to the shop floor of Toyota plants but also spread to suppliers (Liker 2004, p. 32). In fact, TPS consists of many sub-activities under these three main activities. For reference about the TPS, see Ohno (1988), Fujimoto (1999), Liker (2004).

defect in the line and did not hold the 'andon,' the line will not stop, the problem will not be corrected, hence, the utmost quality of product cannot be achieved. Therefore, the human resource department of Toyota is important to provide training to their employees and to develop evaluation scheme in order to ensure the effectiveness of training.

For TMT, to maintain and improve its competitiveness, it needs to spread the application of TPS to cover not only its own staff, but also the manufacturing of parts (i.e., its suppliers) and the sales units (i.e., its dealers). The company initiated two main courses of action for this. On the one hand, it has been promoting the TPS at the manufacturing level, i.e., at the production site of suppliers. This activity is conducted by a team of specialists in the purchasing department. They will rove from time to time to instruct and assist the suppliers to implement a TPS model line in their operation. This program is run on a voluntary basis. Suppliers in the "Toyota Cooperation Club" can apply for this program. It is expected that all members will join TPS activity by 2007.[25] On the other hand, it promotes the TPS at the management level. For this purpose, in 2004, "Toyota Academy" was established as the training center for promoting TPS. It offers several courses for senior executives and executives of its affiliates, suppliers and dealers. In 2004, it offered 6 courses. In 2005, the number of courses increases to 15 courses. The number of courses and attendees are expected to increase in the future, indicating the long term commitment of Toyota to diffuse its technology to all parties involved in its supply chain in Thailand.

[25] Interview with a staff of Toyota's purchasing division, March 7, 2004.

Chapter 5

Inter-firm Technology Transfer and Local Capability Formation: Case Studies

As discussed in Chapter 3 and Chapter 4, the Thai automobile industry has recovered from the economic crisis and has been transformed into an export oriented industry in the past five years, as indicated by the surge in both production and export amounts. Because the automobile manufacturing requires large number of parts and components, the rapid expansion makes assemblers to have close relationship and even require higher technological level from their suppliers. Thus, in this chapter, we will turn our focus to the suppliers' side and study how the changes in the industry affect their relationship with automobile assemblers, whether or not the technological linkage has been changing and how it evolves. Field survey results will be presented and three case studies will be discussed.

5.1 Evidence of Inter-Firm Technology Transfer in the Thai Automobile Industry

This part presents the field survey findings regarding the existence of inter-firm technology transfer in the Thai automobile industry. The questionnaire asked the firms to specify three important buyers (in terms of value of order) over the previous three years (2000 – 2003), to investigate the types of inter-firm relationship they had had with them. The assistance reported was of two types: 1) direct assistance, referring to the cases in which suppliers reported having some customers' staff staying on as support for a period of time, and 2) indirect assistance, referring to situations in which the respondents received some other form of advice from customers. Those who answered neither were regarded as having received nothing. The questionnaire results showed that, of the 15 firms, only three reported having received technical assistance as well as technical advice from their customers; 11 firms reported having received technical advice, while the rest appeared to have received nothing (see Table 8).

Table 8 Number of Respondents Receiving Technical Assistance from Customers (during 2000 and 2003)

Degree of inter-firm technical assistance	Foreign	Joint venture	Thai	Total
Received direct assistance from customer	1	-	2	3
Received only technical advice	4	7	-	11
Not at all	1	-	-	1
Total number of firms	6	7	2	15

Source: Questionnaire survey in 2003

However, the follow-up interviews with the assemblers revealed that all of them had teams that periodically visited and followed up on the work of the suppliers to ensure the quality and timing of all parts ordered. In many cases, their staffs merely visited and provided technical advice on specific problems found during the visit or on areas for improvement. Thus, the suppliers had received various kinds of technical advice from their customers.[26] The questionnaire noted four types of such technical linkages, including advice about quality control, maintenance, design drawings for the making of dies or tooling and advice about project management. As shown in Table 9, almost all suppliers had received advice about quality control, while about half of them received advice about

[26] Some firms may have realized that they had received nothing, despite having been visited. In this survey, there was only one case of a firm that had not received any advice from an automobile customer; hence, this firm was considered to have received nothing.

project management. Only few of them received advice about maintenance and design.[27]

Table 9 Technical Advice Suppliers Received from Customers

Types of technical advice	Foreign	Joint venture	Thai	Total
Quality control practice	5	7	2	14
Advice about project management practice	3	3	2	8
Maintenance	1	1	1	3
Design drawing to make die or tooling	-	-	2	2
Total number of firms	6	7	2	15

Source: Questionnaire survey in 2003

By rearranging the information obtained from the questionnaires, the authors were able to correlate the technical linkages the car assemblers had created with these suppliers. As regards their answers about who their main customers were, they mentioned eight car assemblers, six of them Japanese firms and two non-Japanese firms. As shown in Table 10, the Japanese assemblers seemed to have played a more active role in providing inter-firm support, while non-Japanese firms provided only advice about quality control. The more active roles of the Japanese firms could be explained by the larger scale of their production and their longer experience in Thailand.[28]

[27] Based on the information obtained from the survey, only six suppliers (two are Thai firms) reported having performed design activities. As seen in the table, only two Thai firms received this assistance, while foreign and joint-venture firms did not receive it. This implies that an inter-firm technical linkage is likely to be created with suppliers that have limited opportunities. In foreign and joint ventures, this is accomplished through 'intra-firm' support.

[28] Production capacity of Auto B was about 10,000 units, while Auto G about 40,000 units per year. While that of Japanese firms were larger than 100,000 units a year, see also Table 1. Nonetheless, this information should be interpreted with care because it is derived from suppliers' answers that they receive what kind of support or advice from their main customers. Interview with assemblers indicate that each firm has its own plan and program to support suppliers. However, this is beyond the scope of this paper. Future research may be taken by investigating in details about supplier development program of these firms to yield clearer understanding.

Table 10 Technical Advice Assemblers Provided to Suppliers

Types of technical assistance that each car assembler provided to suppliers	Japanese firms						Non Japanese firms	
	Auto T	Auto M	Auto I	Auto N	Auto A	Auto H	Auto B	Auto G
Quality control practice	5	5	8	1	6	5	1	1
Advice about project management practice	3	-	2	-	2	1	-	-
Design drawing to make die or tooling	-	-	1	-	1	-	-	-
Maintenance	-	-	-	-	1	-	-	-
Total number of suppliers that supply parts to each assembler	5	5	8	2	7	5	1	1

Source: Questionnaire survey in 2003

The findings presented thus far confirm the existence of and reveal the current state of inter-firm technology transfer in the Thai automobile industry. The suppliers acknowledged that these linkages with automobile assemblers provided benefits in several ways, such as improving their quality-control and problem-solving capabilities and teaching them new production processes and management practices. They added that all of these had led to improvements in their technological capabilities.

All firms in the sample reported that, compared to three years previously, they had experienced technological improvements such as reductions in defect rates, shortening of time cycles and reductions in production costs. However, as discussed in the previous section, in addition to inter-firm technical linkages, there are several other possible sources of such improvements, such as internal efforts, the adoption of newer machinery, longer-term worker experience, the creation of linkages with suppliers and institutions, and even the hiring of skilled workers from other companies. Accordingly, it was also necessary to inquire about the sources of the improvements noted.

The questionnaire asked all suppliers about the importance of several potential sources of technological improvement. Theoretically, firms could improve their productivity in several ways, such as 1) acquiring new machinery (newer models of machines that were technologically more sophisticated), 2) in-house training efforts, such as training or technological activities, 3) the build-up of employees' experience (the learning-by-doing effect), 4) the hiring of skilled workers from other companies, 5) technical assistance resulting from having a relationship with the customers (inter-firm relationship with customers), 6) the improvement of the quality of the suppliers (inter-firm relationship with suppliers), and 7) technical linkages with institutions in Thailand (domestic sources of technology).[29]

In Table 11 and Figure 10, the responses are displayed in accordance with their average values, from high to low. In-house efforts and the improved experience of employees were regarded as the most important sources of technological improvement. It is interesting to observe that those improvements came from their suppliers, inter-firm technical relationships with customers, and the adoption of new machines that were expected to have a stronger impact. Technical linkages with institutions in Thailand such as universities, government laboratories, or technical training institutions were found to be less important to foreign and joint venture firms than it was for Thai firms. This finding provides evidence to support the argument that firms with foreign ownership have considerable opportunities to obtain necessary technology (both for manufacturing and for improving productivity) from their parent companies. Such opportunities are not already available to Thai firms; therefore, it is not surprising to observe that a domestic source of technology is regarded as an important source of

[29] They were asked to state the degree of importance of each factor, based on a Likert-scale from 1 to 7, in which 1 means that the particular source is not important at all, while 7 means that the particular source is extremely important, that it contributed to their improvement.

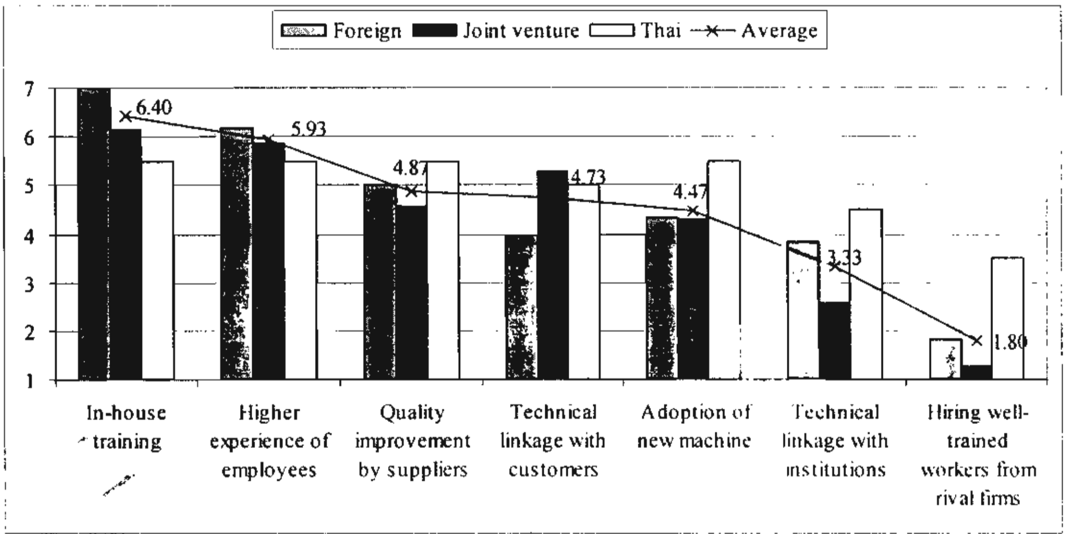
technological improvement for independent Thai firms. As regards the last factor, head-hunting was found not to be an important factor for technological improvement; however, it received a high evaluation by Thai firms.

Table 11 Sources of Technological Improvement

Sources of technological improvement	Foreign	Joint venture	Thai	Average
In-house training	7	6.14	5.5	6.4
Higher experience of employees	6.17	5.86	5.5	5.93
Quality improvement by suppliers	5	4.57	5.5	4.87
Technical linkage with customers	4	5.29	5	4.73
Adoption of new machine	4.33	4.29	5.5	4.47
Technical linkage with institutions	3.83	2.57	4.5	3.33
Hiring well-trained workers from rival firms	1.83	1.29	3.5	1.8

Source: Questionnaire survey in 2003

Figure 10 Sources of Technological Improvement



Source: Questionnaire survey in 2003

5.2 Inter-firm Technology Transfer and Local Capability Formation: Case Studies

Field survey results presented earlier clearly show that automobile assemblers created inter-firm technical linkages, which made local suppliers realize that that was an important source of technological improvement. However, the process of technology transfer is not static. Once the environment in which firms operate has changed, e.g., the changes in the assemblers' production and purchasing policies that were discussed previously, those changes would affect the content of the inter-firm technology transfer as well as the capability formation of local suppliers. Thus, in this section, the results of the follow-up surveys regarding the three cases that reported inter-firm technical support from assemblers over the previous three to five years will be discussed. Then, an analysis and some general observations about the evolution of inter-firm technology transfer and technological capability formation within these three firms will be provided.

5.2.1 Case 1

Supplier A is a joint venture between a Japanese motorcycle manufacturer (62%) and a Thai firm (38%). In 2003, its main products were motorcycle parts (50%) and automobile parts (17%) and others (die cast molds and machining services). However, the equity ratio at its establishment, in 1990, was Thai (72%) and Japanese (28 %) businesses. The ownership structure was changed after 2000, due to liquidity problems (after the economic crisis), changes in the production technology and intense competition.

From 1990 to 2000, during which time the main source of the production technology was its Japanese partner, the Thai owners had management authority. The company's main products were casting parts for motorcycles. After 1995, the company has diversified its business to include the casting of auto parts; this was possible because of the Thai majority ownership. However, the Japanese partner was passive about providing technology to assist this supplier because its business was unrelated to the firm's main business. Supplier A acquired technology through a technical assistance (TA) agreement with a Japanese casting company to produce parts for Auto I. In 1996, it received approval to supply casting parts to Auto A. It believed that it could utilize the know-how it had acquired earlier to produce the same product for new customer. However, due to the difference in production techniques and specifications of the casting product, this supplier could not simply follow the production technique of Auto I. In fact, Auto A required that Supplier A take full responsibility for production preparation. Once it was clear that Supplier A could perform such activities to a tight deadline, Auto A needed to provide technical support. That technical support included sending experts to assist, work with and train local staff members (socialization) in the preparation stage (which lasted about two years) and the provision of designs for the new production line (transfer of explicit knowledge); in addition, all expenses were borne by the buyer (Auto A).[30]

Why did Auto A have to bear this costly activity when it could not gain any monetary benefit from doing so? There are two main reasons for this. One was that this obligation was on the mandatory list of the LCR regulations. Thus, Auto A had to procure the parts locally. Another reason was that it was impossible to switch to another supplier because of lead-time constraints. Hence, to avoid the setback of the entire project because of a delay on the part of a supplier, Auto A determined that providing intensive technical assistance in the technical area that the supplier lacked was both more economical and more efficient. This is a clear example of technology transfer through a buyer-supplier relationship, in which the

[30] Details about the inter-firm technology transfer activity by this firm to suppliers in Thailand, including the case study of this supplier, were provided in Techakanont (2002). However, in that report, this assembler was named 'T-firm'.

buyer enhanced the local supplier's capability, especially in the area of its quality-control and project-management capabilities, without receiving any monetary payment for providing such assistance.

However, because of the economic crisis, the supplier faced a severe liquidity problem. This called for a rescue plan by its Japanese investor, which had also planned to make this supplier its regional base. Since the Japanese company became the majority party, 'intra-firm' technology transfer has become the main source of technology. As a result, Auto A changed its view of this supplier, in that it no longer considered it necessary to provide direct technical assistance, as it had done from 1997 to 1999.[31] In the event that quality problems arose, the Japanese partner was responsible for solving them and supplying the counter-measure.

Intra-firm support took the form of increasing numbers of Japanese expatriates from one to six to provide coordination, technical advice, and training to enhance the technological capability of the supplier. The role of the Japanese partner in assisting this supplier included a short- and long-term plan. To overcome the low utilization capacity in the short-run, due to the economic crisis, it transferred orders from Japanese headquarters to Thailand. This included the transferring of molds and machinery for producing the parts and exporting them to Japan. This process is still ongoing. As its longer-term plan, it installed a new production line for a new product, low-pressure casting for cylinder heads (for motorcycles). In addition, it set up another casting process whose production technology was somewhat similar to that of the production of cylinder heads for a new generation of diesel engines (made from aluminum, instead of using ferrous casting). This was considered part of its plan to develop the production skills of

[31] Interview with a top management of Auto A on March 12, 2001.

Supplier A for future orders by some automobile assemblers in Thailand. This new technology is much more difficult to carry out than ferrous casting; hence, it was disclosed that without the Japanese partner, it would have been impossible for Supplier A to acquire this technology.

Moreover, in 2001, local engineers were sent to the headquarters plant in Japan to learn about mold design. Two groups were sent; each group consisted of three engineers, and the duration of their training was about three months. They were trained on the job, and the target was to make the Thai engineers understand the details of mold design so that later they could collaborate with mold-makers in Thailand. The Japanese firm made additional investments in computer aided design (CAD) and computer aided manufacturing (CAM) technology to support this activity. As a result, the design capability of Supplier A has been enhanced and developed. Previously, Supplier A lacked the knowledge about how to make a mold. It just gave a drawing of the part to mold-makers for them to produce. The mold-makers then proceeded to make 'as cast' drawings and mold drawings, after which they produced the mold. There was always the chance that some problem might arise due to the improper mold design and that Supplier A would not realize it until the trial of the finished mold. Thus, it took longer to have a perfect mold complete. After their training in Japan, local engineers came to understand the hidden technical issues specific to the part drawing and could translate and develop the drawing into an appropriate 'as cast' drawing. It was unable to do so in the past and lacked sufficient technical knowledge to collaborate with mold-makers in the process of mold design. As a result, a complete mold could now be finished within a shorter time span, as sometimes required.[32] In 2003, Supplier A was able to produce about 50 to 60 molds, half of which were exported to its Japanese affiliate in other countries. Hence, this is clear evidence of the technological development of this supplier, and the active role of the Japanese experts should be acknowledged.

5.2.2 Case 2

Supplier B, an independent Thai firm, was established in 1986. It belongs to S-group, the largest auto parts group in Thailand, which consists of more than 30 companies. The origin of S-group can be traced back to the establishment of the S-firm, which was founded in 1972 as an Original Equipment Manufacturing (OEM) producer for motorcycle seats, trimming parts and other parts. It began business as an OEM supplier because it had a close business relationship with, and been receiving considerable assistance from, Auto M from the beginning. The inter-firm relationship benefited S-firm by allowing it to acquire manufacturing technology. As an example, Auto M had introduced S-firm to its Japanese suppliers for the purpose of strike technical assistance deals with them, and, at the same time, Auto M had dispatched Japanese experts to work, assist, and to transfer technology, particularly in the area of stamping and die-making technology, to S-firm. Since then, its production and technological capability has been developed.

In the mid-1980s, Auto M requested S-firm to expand its production of auto body parts and other stamping parts. Auto M recognized that S-firm had investment capability but not technical expertise; therefore, it decided to provide

[32] It could complete the design process about 5% faster than it could three years previously. Currently, for a similar type of mold, the lead time for making a mold used by Supplier A is about 30% longer than at the best practice plant of the Japanese firm.

technical support.[33] In 1986, S-firm established Supplier B and received a technical assistance agreement with Auto M for the stamping die-manufacturing technology. Since then, Supplier B has developed its technological capability and become an indispensable supplier for Auto M. It currently produces a wide range of products, such as stamping dies, press parts, bumpers, chassis frames, door hinges, fuel tanks, car bodies and exhaust pipes and mufflers; it also supplies products to almost all automobile manufacturers in Thailand. This company acquired technology through technical agreements with many foreign companies (almost all of them Japanese firms) that specialize in particular products; however, for stamping and die-making technology, it mainly received technical advice from Auto M.

It has been reported that Auto M transferred substantial technology, especially in the area of metal-stamping and die-making technology, to assist Supplier B in acquiring the necessary operational capabilities to produce good-quality parts. From the beginning, in addition to setting up the production line and installing machinery, Auto M shared information assets, such as the standards for die-making (explicit knowledge), and sent a number of Japanese experts to work with Supplier B.[34] Supplier B's engineers shared experience through 'socialization' with Japanese experts and assimilates such explicit knowledge into their own tacit knowledge (internalization). Auto M's die-making standard has

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[33] In fact, there were three options for Auto M to localize stamping parts: 1) to import, 2) to produce in-house, or 3) to outsource from local suppliers. The first option might not be justified because of its bulkiness and in part because of the LCR regulations; hence, the firm had to choose between in-house production or subcontracting out. However, it was the company's strategy to outsource stamping parts and to develop local suppliers, such as Supplier B. At present, it also outsources outer panels, a practice that is completely different from other car makers, which usually produce these parts in-house.

[34] It has been reported that there have always been Japanese staff people working with this supplier, but the total number has varied from time to time. Over the past three years, there were on average four Japanese experts working at Supplier B.

been revised, adapted, and developed to local working conditions.[35] The revision of this die-making standard was done through brainstorming by the responsible engineers and technicians to find the solution (internal socialization). Once they found that solution, the standard was revised and added to the stock of explicit knowledge (externalization). Over time, localized versions of the company's own die-making standard have been established (combination).

An important step of inter-firm collaboration came in the years 1993 to 1995, when Auto M requested that Supplier B conduct an engineering study of stamping parts of competitors' vehicles in order to feed that information back to Auto M's design center, which was developing a new model of pickups to be launched around 1995. This activity is called 'tear down', and essentially it is very similar to 'reverse engineering,' i.e., disassembling all the stamping parts of existing competitors' products to analyze the specifications of the raw material, stamping processes, parts designs, and, in total, the stamping technology. Supplier B had to make an enormous investment in computerized software, such as computer-aided design (CAD) and computer-aided manufacturing (CAM) programs, as well as in much testing equipment. A designated group of engineers worked closely with experts from Auto M (socialization). Close supervision and guidance from the Japanese experts helped Supplier B broaden and deepen its capacity in very important basic engineering area, e.g., raw materials, die design and process engineering technologies, all of which added to its own stock of knowledge (socialization and then externalization). Combining the intensity of Supplier B's

[35] It should also be noted that die-making standards have been revised because Supplier B was supplying stamping parts for other automobile assemblers whose design standards were slightly different. Technical advice from automakers has been acknowledged as an important source of information as well.

efforts with the technical support from Auto M, Supplier B could achieve significant technological development.[36]

After 1996, the firm experienced a significant change in customers' technical requirement, when it received a new order from a newly established car maker, called Auto A, which had just transferred all of its pickup production to Thailand.[37] It planned to produce and export new models of pickups, the upper bodies of which were newly designed; thus, no master model was available. This reflected a departure from the previous production experience of Supplier B. The information assets that Supplier B received were by way of the parts drawings of 87 ordered parts; this was based on the fact that it needed to accomplish all the 'process engineering' tasks[38] on its own. However, because of Supplier B's limited experience in the preparation the entire engineering process and the tight schedule, Auto A realized that there was a possibility that this supplier might not be able to finish that preparation on schedule; hence, it decided to provide intensive technical assistance.[39]

On average, there were seven Auto A staff members working at Supplier B's factory for about two years, and nearly 40 experts came to provide support on a short-term basis at each stage of preparation (socialization). The content of the

[36] This reflected the commitment of top management and the intensity of the effort in expanding its technological capability, induced by the inter-firm relationship. Many senior engineers have acknowledged this collaboration as the most important step, and it marked the milestone in achieving greater self-reliance in the engineering capability of Supplier B. It should be noted that, in addition to this activity, Supplier B also invested in a new stamping plant at Laemchabang, immediately next to the Auto M plant. The main activity of this new plant was to provide a stamping service mainly for Auto M, while Supplier B placed more emphasis on supportive activities, such as die and tooling design and production-process development.

[37] The details regarding the inter-firm technology transfer activity by this firm to suppliers in Thailand, including Supplier B, has been reported in Techakanont (2002). See also footnote 30.

[38] Process engineering tasks include a series that consisted of planning, designing, drafting a drawing, die-making, finishing, and stamping, trouble shooting and trying out, prior to the launch of mass production.

[39] Although Japanese experts from Auto M were working at Supplier B's plant, they played no role in filling other firms' orders.

inter-firm technology transfer by this company was in the area of 'process engineering' capability.[40] Supplier B benefited from Auto A's intensive technical assistance by learning new project management practices and improving its die design standards, which became acceptable to many other assemblers thereafter.[41]

Since the industry became more liberalized, in 2000, many assemblers have pursued a strategy to make Thailand their production and export base, and that has resulted in significant changes in purchasing and supplier relationship policies. The practice of Auto A, i.e., requiring suppliers to take full responsibility for process engineering activities, apart from quality, cost, delivery (QCD) criteria, has become a basic requirement for other makers. They have increasingly adopted a global sourcing strategy to obtain good parts at the lowest price. Moreover, they now demand higher technological involvement from parts suppliers, to provide full component design and development capabilities, or, at least, to respond to engineering changes in design that could take place during the process leading up to mass production.

In 2000, after about 15 years' experience in providing stamping services, Supplier B's first challenge in the area of product development and engineering activity was the order from Auto I. Supplier B won the bidding as a Tier-1 supplier for front bumpers and reinforcements of this global model. It received

[40] The process of knowledge conversion took place through interactions between Japanese and Thai staff members. Technical support was provided through the OJT method, to provide training in all the processes step by step. First, they transferred tacit skills through OJT (socialization), and assisted Supplier B in developing working and quality standards (externalization). Then, they revised and improved it to create a new standard (combination) and used that to train local staff member to acquire basic operation skills (internalization). Technical assistance effectively enhanced local workers' skills. Improvement of the operators' skill resulted in a significant reduction in the defect rate. Moreover, Supplier B has made exceptional improvements in its project-management capabilities, and it has acknowledged that it was accredited QS9000 because of the knowledge acquired from working with Auto A experts. Clearly, the content of the knowledge conversion was in the area of 'process engineering'.

[41] Interview with a senior engineer of Supplier B, on August 25 and December 4, 2003.

only a sketch drawing of the bumper and some minimum states of the requirement regarding the engineering specifications from Auto I.[42] Because of the limitations of this information, Supplier B needed to develop finished parts and supply them to the customer on the planned schedule.

Nevertheless, Supplier B found that, given its existing level of explicit and tacit technology, it would not be able to meet Auto I's schedule. Hence, purposeful investment (of more than 50 million baht) in computer aided engineering (CAE) and simulator software necessary for the development task was approved by the top management and made during 2001 and 2002. This new investment enabled Supplier B to simulate and test its design and allowed it to have its first 3-D design finalized. That process required some 'guest engineers' to be sent to Auto I's headquarters to collaborate throughout the entire process of 'product engineering', including the development of detailed blueprints for each component and major systems; after that, prototypes of components and vehicles were built based on those preliminary drawings, following which, prototypes were tested against established targets; finally, the tests were evaluated and the designs modified as necessary. The cycle was repeated until an acceptable level of performance was achieved.[43]

In total, Supplier B sent 'guest engineers' to Auto I three times, until the final parts drawings were approved. Each time, it sent two to three veteran engineers who stayed in Japan about one week. All expenses were borne by Supplier B. The guest engineer system exposed the company to the real product-development activities of Auto I (socialization). It enabled this company to understand how the

[42] This is normal practice for Japanese or other Tier-1 suppliers, because they have design and development capability. However, for Thai firms, this reveals significantly higher technical requirements by suppliers than in the past.
[43] This definition is from Clark and Fujimoto (1991, pp. 116-117).

activities were managed and made it possible to help Supplier B to translate the knowledge gained from direct experience into actual product-development activities (internalization of embedded knowledge). After the guest engineers returned to Thailand, the knowledge they had acquired was shared with local staff members (socialization) and then incorporated into the company's design standards (externalization). Clearly, despite the absence of direct technical support from the customer, the combining of its existing knowledge base with purposeful investment and increasing the intensity of its in-house efforts to perform the 'product engineering' activity, Supplier B was able to benefit from the inter-firm technical linkage, and its technological capabilities were enhanced.

In 2003, it was disclosed that Supplier B already had about seven parts designed and developed in-house that met the customer's requirements. It was also able to produce for export two sets of transfer dies, weighing 23 tons, to Germany. In addition, to improve productivity at its Laemchabang plant, it installed a new, automated production line. Although it purchased machines from a Japanese machine maker, it had the ability to evaluate and select the appropriate equipment and could design the production line by itself. Hence, it can be said that within less than 20 years, inter-firm technology transfer and internal effort synergistically made Supplier B attain appreciable technological capability development. Thus, it is reasonable to expect that, as Supplier B gradually becomes more self-reliant in manufacturing technology, direct support from Auto M would be diminished. Internal efforts to develop technological capability will become the most important element in the sustaining of the business.

5.2.3 Case 3

Historically, Supplier C had had a relationship with the S-firm. The presidents of Suppliers B and C are brothers and established the S-firm together. Five years later, in 1977, the younger brother, the founder of Supplier C, decided to establish his own company. Its main business lines were plastic and metal products for motorcycle parts, auto parts, and electronics and electrical parts. Its development started with an order from two Japanese motorcycle manufacturers to produce seats. Similarly to the case of Supplier B, at the time it was established, it had investment capability; thus, the buyers provided the technical assistance necessary for the production technology. Later on, this supplier diversified to produce other plastic parts for motorcycles and electronics and electrical appliances parts, and auto parts. It acquired the necessary technology through technical assistance agreements or by forming new businesses through joint ventures with Japanese firms that specialized in particular products. The company has grown and gone on to become one of the biggest Thai auto parts groups, the T-group business.

The history of the development of Supplier C's technological capability is that, from its early stage, it acquired technology through various channels, from purchasing state-of-the-art machinery, forging technical assistance agreements in some areas of production technology (plastic parts), and having inter-firm relationship with automobile assemblers. Inter-firm relationships with motorcycles buyers and Auto M were important for acquiring the technology related to stamping and die-making. Supplier C has developed its capability mainly through inter-firm relationships with motorcycle manufacturers in Thailand and with Auto M.

In the early 1990s, the automobile industry grew rapidly, and the demand for auto parts surged significantly. Because of their close relationship, Supplier C established a new factory at Laemchabang industrial estate at the request of Auto M. Auto M dispatched Japanese experts to work at this plant and played a role similar to the one it played in the case of Supplier B, giving advice and assisting the supplier to prepare for the production of new product and to improve its daily operations through greater attention to detail. The main role of the Laemchabang plant was to perform the mass production and deliver the parts to the customer on time. Most of the large and bulky parts have been produced there.

To respond quickly to the surge in demand and the rapid changes in the technological requirements from automobile customers, Supplier C's president decided to divide the engineering and mold-making sections to form three new companies, still located in the same area, however. Two companies perform the stamping die and tooling-making for metal parts, while the other one attends to injection molds, blow molds, and die-cast molds to make plastic and aluminum parts.[44] An interview with a manager of Supplier C indicated that, prior to 1992, customers normally provided the data about the part, part drawings, die designs and die drawings. Using these information assets, Supplier C made the dies and prepared the production process, which it was able to do quite easily. In the process, if some problems arose, customers normally sent engineers to provide advice and troubleshoot problems.

From early 1990s on, the technical requirements customers imposed on suppliers changed drastically. In 1993 and 1997, customers provided sample parts,

[44] Since 1998, for the company that attends to plastic molds, it has used a Japanese company to obtain technical consultant and assistant service in the fields of operation, design, and obtaining information about tooling, machine, and equipment. Thus, it can be said that Supplier C utilized a TA agreement in order to supply some technical knowledge that it did not possess.

part drawings, and inspection jigs, but not the die drawings.[45] This meant that Supplier C needed to design the die itself. Inter-firm technical assistance came by way of advice given during periodic factory visits, which were made to ensure that the supplier could accomplish the preparation process on time. During this time, Supplier C had to invest in computerized software such as CAD and CAM and hardware such as a new CNC machine and testing equipment to enhance its technological capabilities sufficiently to meet the higher requirements of its customers. After 1998, almost no customers provided sample parts or inspection jigs. Supplier C received only the data about the part in CAD data format. Using this data, it needed to design and make the dies, establish the production processes and make the inspection jigs to produce the part to the exact specifications. The knowledge it accumulated and its previous investment in CAD/CAM helped this supplier meet the customer's higher technical requirements. However, apart from assistance from Auto M at its Laemchabang plant, it did not receive any direct assistance from other makers. It received only some technical advice regarding quality control and die and tooling design.

After 2000, the industry became more liberalized, and automobile assemblers required that suppliers be able to develop their own drawings, which meant that suppliers needed greater design capabilities. In some of the new orders, Supplier C won the bidding as a Tier-1 supplier. Similarly to the case of Supplier B, it received only sketch drawings of the parts with statements of the requirements. It had to design and develop the part drawings, which need to be approved by Auto I. It has been reported that, during the preparation process, Auto I sent some engineers to follow up and to give advice on the part-design process. Thus,

[45] Inspection jigs were provided because the customers wanted to ensure the quality of the parts.

Supplier C was able to learn some specific technical information about die design through a socialization process with Japanese experts. Also, it has been learned that Supplier C had made an additional investment of more than 60 million baht for CAD and CAE software to improve its design and engineering capabilities.

However, in many cases, Supplier C still lacked sufficient capabilities to provide full service from design and part development as a global Tier-1 supplier. To overcome that limitation, a TA partner that had such design capability played a collaborative role in the development stage in Japan, to finalize the design of parts. After the part drawings were finalized, Supplier C designed the dies and prepared the production process based on the part drawings developed by its TA partner. This is the process by means of which it has now accumulated sufficient capability. Hence, it can be said that it is vital to make continuous internal efforts to develop technological capability and that some external source of technology, such as a TA agreement, can be used to supplement knowledge in a technical area that the supplier still lacks.

5.3 Evolution of inter-firm technology transfer and technological capability formation of local parts firms

On the basis of these three prominent case studies, this paper has found that the changes in assemblers' technical requirements affected the pattern of inter-firm relationships and technology transfer. This complex issue is summarized in Table 7. This section analyzes the matter and offers general ideas about the evolution of inter-firm technology transfer.

This study has found that inter-firm technology transfer in the Thai automobile industry began during the early stages of the introduction of LCR regulations (after 1970). To make the required use of locally made parts, assemblers both produced them in-house and subcontracted them out. During the period between1970 and 1990, when they subcontracted, they sometimes helped suppliers establish production facilities, as is clearly seen in the case of Suppliers B and C, both of which needed only to have only sufficient investment capability and fair operations capabilities.

Moreover, prior to 1990, almost all of the car models produced in Thailand were the same models produced in other countries. When production of a model was transferred to Thailand, Japanese automakers normally sent experts to perform all of the tasks that were critical in preparing for the production, until the quality of the tryout parts was acceptable. Then, local staff members were trained in how to operate the machinery and how to control quality during mass production. The implication from this is that information assets such as sample parts, parts and die drawings, production process (and in some cases even the stamping dies) were available to local suppliers. Suppliers did not need to do the whole preparation process, ranging from designing the facility to designing the tooling and designing the production process; thus, they did not have opportunity to perform the whole series of engineering activities, but only the operations.[46] Therefore, it can be argued that the content of inter-firm technology transfer was to a large extent at the operational level. However, it should be noted that, apart

[46] In fact, it has been found that other car assemblers used the same strategy, i.e., sending Japanese experts to prepare the production process and simply use Thai suppliers as service providers (Techakanont 2002). There are at least two reasons that accounted for this practice. On the one hand local suppliers were in the initial stages of acquiring the requisite technology; as a result, Japanese assemblers preferred to complete the preparation in order to meet the scheduled deadlines. On the other hand, the industry was still protected by LCR regulations and high import tariffs; therefore, it was possible that assemblers would have to bear this high-cost activity in order to comply with the regulations, while still keeping the operation profitable. For details about government policies, please see, for example, Doner (1991), Buranathanang (1995), Terdudomtham (1997), and Techakanont and Terdudomtham (2004).

from receiving technology from assemblers, suppliers also acquired technology from other channels, such as technical assistance agreements or joint ventures.

Between 1990 and 1995, the situation changed slightly. Assemblers generally required that suppliers have investment, operational and some aspects of process engineering capabilities. A main reason for this was that information assets that assemblers provided suppliers were reduced. Suppliers were required to have the capability to design dies, toolings, and production processes. The technical collaborations between Auto M and Supplier B confirm this fact. Supplier B was able to improve its engineering capabilities by obtaining inter-firm technical assistance through 'socialization' with Japanese experts, 'combination' of the explicit knowledge of the assembler, and, finally, 'internalization' and 'externalization' of that knowledge into its own knowledge base. However, the intensity of the effort of local firms that were important for such knowledge assimilation, conversion and formation should not be overlooked.

Between1995 and 1999, some assemblers started producing new models first in Thailand. The relevant information assets were drastically reduced. As can be seen in Table 7, no part drawings or master parts was available to suppliers; instead, only CAD data was distributed. Thus, suppliers had to prepare all the production process by themselves. The cases of Supplier A and B in dealing with Auto A show that the contents of inter-firm technology transfer had gone beyond the operational and QCD to include 'process engineering' capabilities. The 'socialization' process between local staff and Japanese experts was essential for suppliers to assimilate the technology effectively.

As the industry became more liberalized, after 2000, many assemblers pursued the strategy of making Thailand their production and export base. Global sourcing and competitive bidding systems were adopted, and assemblers demanded their Tier-1 suppliers in Thailand to provide a full component design and development capability, or, at least, to respond to engineering changes in the designs that might occur during the process prior to the mass production. In this respect, the research findings in Section 3 and the case studies reveal that inter-firm technology transfer became less intensive than it had been in the past. The more active role of suppliers and their increased ability to take part in the product engineering process have become increasingly important. In other words, local suppliers must show their strong will to participate in such processes and must possess sufficient engineering capability; otherwise, they will not be selected as Tier-1 suppliers and cannot benefit fully from inter-firm relationships.

Table 12 Evolution of Assemblers' Requirements and the Contents of Inter-firm Technology Transfer

Years	Types of car model assembled	Characteristics of ordered parts and information assets provided to suppliers	Assemblers' requirements on suppliers	Supplier responsibilities	Contents of inter-firm technology transfer
1970-1990	Copy model	Sample and data of a part. part drawings, die designs. die drawings. inspection jigs.	Investment and (fair) operational capabilities	No need to change the drawing. In some cases, suppliers could obtain die drawings or dies and direct technical assistance from assemblers.	Operational capability and QCD
1990-1995	Copy model	Sample and data of a part. part drawings, inspection jigs.	Investment. operational, and (fair) process engineering capabilities	No need to change the drawing. In some cases, suppliers could obtain die drawings or dies and advice about technical or problem solving from assemblers.	Operational, QCD, and some areas of process engineering capabilities
1995-1999	Start production of new models	Data of a part (online). no master model. no sample part.	Investment. operational. and sufficient level of process engineering capabilities	Suppliers needed to make some engineering changes based on the drawing. to design dies, production processes and develop inspection jigs by themselves.	Operational, QCD, and process engineering capabilities
2000 onwards	Many new models will be produced in Thailand	Part concepts	Investment. operational. and sufficient level of process and (fair) product engineering capabilities	Suppliers needed to develop part drawing, design dies, establish production processes, develop inspection jigs, and perform tests by themselves. Internal effort becomes increasingly important.	QCD, process and product engineering capabilities

Source: By the author, based on in-depth interview with suppliers

Given the rapid changes in the automobile industry, suppliers need to have design capability. Nevertheless, it takes time and resources to develop that capability, as confirmed by the case of Supplier B. Thus, suppliers have needed to be aware that there were also other ways to respond to the heightened technical requirements, especially as regards design and product development capabilities, of automobile assemblers. Local suppliers may acquire technology from technology partners, which can be either by striking joint venture deals (case of Supplier A) or technical assistance agreements (case of Supplier C) to supply and assimilate the knowledge in the particular technical area that had been lacking and to retain their customers' business. This will allow them to benefit from inter-firm technology transfer and provide them with the opportunity to take part in the product-development stage with customers in the future.

Chapter 6

Conclusion and Policy Recommendations

Progressive global competition has made international investment more dynamic and has led multinational firms to consolidate their dispersed operations as a network. This research investigates the Thai automobile industry's relatively recent integration into the global production network and examines how this situation has affected the pattern of knowledge transfer and assembler-supplier relationships, in particular, through the inter-firm linkages that have evolved in the process.

In examining the roles of foreign automobile manufacturers to transfer technology, this research selects the case of Toyota's IMV project as a case study. In response to intense competition, Toyota has integrated Thailand into a part of the global production network of its multi-purpose vehicles. Research findings on IMV project and recent Toyota's activities confirm that higher technological capabilities, such as product engineering and design activity, have been transferred to their affiliates in Thailand. Analysis on these activities is based on an analytical framework that integrates the essence of technology transfer with that of knowledge-conversion processes. All the main findings are presented in Chapter 4.

In addition, this research also investigates the effects of such changing environments on local parts suppliers. It evolution of inter-firm technology transfer and the dynamic process of local capability formation are explained and analyzed with case studies of three prominent firms. The case studies show that inter-firm technology transfer has undergone significant evolution as regards its contents and the roles and the degrees of intensity of effort of both the transferors and the transferees. It has been found that over the previous 20 years, the content of the technology transferred has increased the degree of difficulty of the transfer, in areas from the operational to process engineering and product engineering. There is ample evidence that local suppliers had been able to start business with appropriate levels of investment capability but significantly less technical capability. Their viability as businesses was made possible because of the intensive inter-firm technology transfer initiated by the assemblers. Local firms were then able to improve and develop their technological capabilities through a variety of means, the most important of which has been their internal efforts to improve their capabilities. Over time, during each stage – i.e., from the operational to process engineering and product engineering – the level of effort of the transferor has become less intensive, while it has taken a greater degree of effort on the part of local suppliers to keep up with the accelerating pace and heightened technical requirements of the assemblers, particularly with respect to design and engineering capabilities. Assemblers are demanding a higher level of engineering capability from their suppliers to improve their own competitiveness.

Throughout this process, the suppliers have to upgrade their QCD to survive and grow, and in some cases their engineering to become more profitable and finally to become Tier-1 suppliers, at which point they are eligible to benefit from a higher level of technology transfer including 'product engineering' capabilities. In some instances, internal efforts and endeavors may not have been sufficient to reach the desired levels; thus, alliances with foreign partners may turn out to be a good way to attain these targets.[47] Overall, the suppliers' own efforts in human-resource development seem to have been the most crucial factor in maintaining and continuously developing their technological capabilities; that, in turn, opens them to the benefits of inter-firm technology transfer.

It is undeniable that, given the rapid pace of development, local parts firms may not be able to upgrade themselves quickly enough to meet the higher technological requirements of assemblers and the trends of globalization. It has been reported that most local suppliers have not been able to deal well with these changes and have stepped down to a lower tier; some may lose orders in the future if they remain at the same technological level they currently maintain (Techakanont 2003). Thus, the role of the state should be changed to facilitate and support the fields of knowledge that local firms lack. There are many areas in which the Thai government and its institutions can play key roles, for instance, human resource development (graduation systems and training centers) and the enhancement of particular technological capabilities, such as the implementation of testing facilities. All of these efforts should be extended to sustain and expand the development of the supporting industries.

[47] In the short run, local firms should remain focused on and attempt to retain the business they have, i.e., to maintain the orders from assemblers as global Tier-1 suppliers. Since they lack both the financial resources and some of the technology, they should not be over-concerned about being Tier-1 or Tier-2 suppliers, or attempt to maintain their majority ownership if their financial and technology status is fragile. In the long run, because many Thai firms still do not have their own indigenous production technology, they inevitably must search for an appropriate technology partner, even if that entails entering into forms of acquisitions such as striking deals regarding technical assistance or entering joint-venture agreements.

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Appendix

Outputs of the Research Project

1. Evolution of Inter-firm Technology Transfer and Technological Capability Formation of Local Parts Firms in the Thai Automobile Industry, published in ***Journal of Technology Innovation*** Vol. 12, No. 2, pp. 151-183.

2. Transferring of Product Engineering and Design Technology in the Thai Automobile Industry, a paper presented at ***"The First National Conference for Economist"***, Thammasat University, Bangkok, Thailand, October 28, 2005

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Evolution of Inter-firm Technology Transfer and Technological Capability Formation of Local Parts Firms in the Thai Automobile Industry

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Summary

This paper investigates the evolution of 'inter-firm' technology transfer in the Thai automobile industry, which has gradually been integrated into global production network of some specific automotive models (one-ton pickups). This paper discusses the linkage between the role of automobile assemblers in transferring technology and the way their strategic changes bring about heightened demands on the technological capacity of suppliers and the contents of technology transfer. With higher competition at the global level, local suppliers are required to improve their technical and managerial skills, especially in the area of 'product engineering' capability. The authors examine the ways local firms have adapted to these changes in their environments, as well as the ways they utilize inter-firm relationship with automobile assemblers as a means to improve their own technological capabilities. The dynamic process of capability formation in local parts firms, through intensive efforts and learning inducements brought about by inter-firm relationships, are also discussed.

Key words : technology transfer, automobile industry, inter-firm relationship, capability formation, local suppliers

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1. Introduction

In the initial stages of the industrialization of virtually all developing countries, capital and technology (production and managerial technology) are scarce. A promising means of promoting economic development to overcome these bottlenecks is attracting foreign direct investment (FDI). Apart from its direct effects in terms of the expansion of domestic output, capital formation, employment, and export, FDI can bring about indirect benefits through technology transfer and diffusion, skills upgrades and the development of local ancillary industries through the creation of backward linkages (Dunning, 1983; Borensztein, et al., 1995; Blomström and Kokko, 1999; Markusen and Venables, 1999). Multinational firms can play a crucial role in international technology transfer because they undertake a major part of the world's research and development (R&D) efforts to create and then own most of the world's advanced technology (Blomström and Kokko, 1999). When making direct investments abroad by establishing overseas affiliates, these multinational firms inevitably must transfer technology to and upgrade the existing skills of the local population to assure the efficiency of their foreign operations (Sedgwick, 1995). Therefore, FDI can act as a catalyst for knowledge diffusion and the provision of local capability formation in the recipient countries of FDI.

Nonetheless, prevailing understandings of the ways technology is transferred are far from complete. The existing literature has focused on the issue of international technology transfer through formal and voluntary forms such, as intra-firm technology transfer and arm's-length trade of technology (Reddy and Zhao, 1990). However, very few studies have investigated the dynamic process of technology transfer and technological capability-formation in developing countries (e.g., Kim, 1997; Cyhn, 2002), and even they have not focused directly on technology transfer through informal mechanisms, such as the incidence of 'inter-firm' technology transfers.[1] Moreover, progressive global competition, driven by trade liberalization, deregulation of trade and investment, and the revolution of information and communication technology (IT), have changed global competition by making it more dynamic. These changes have prompted multinational firms to view their global production as a network rather than as "stand-alone overseas investment projects" (Ernst and Kim, 2002). This trend is expected to proliferate, and the host countries of FDI stand ready to adapt appropriately to benefit from such changes. However, there is still a lack of understanding of the impacts of being a global production network on technology

1) Inter-firm technology transfer is defined as a relationship between a supplier and an assembler that encourages knowledge transfer to make suppliers meet the assembler's quality requirement. This is sometimes referred to as 'buyer-supplier' relationship (Capannelli, 1997), or 'technology partnering' (Beecham and Cory-Hayes, 1997).

transfer; and how and in what forms local suppliers will be affected by such developments. Hence, the principal motivation of this paper is to investigate the issue by looking at Thailand's automobile industry as a case in point.

Thailand provides an instructive model because its industrialization is of relatively short duration historically, and, throughout that process, it has relied heavily on FDI. In addition, among manufacturing industries that have been promoted there, the automobile industry is probably the only industry that the Thai government has had specific and clear goals to promote. Among important rationalized policies imposed by the Thai government, the Local Content Requirement (LCR) regulation was regarded as the most influential policy for the development of supporting industries in Thailand. In 1975, a LCR of 25 percent for passenger cars and 20 percent for pickups was introduced. Later on, in 1987, it had been increased to a level of 54 percent for passenger cars and 70 percent for pickups, the level of which was maintained until the end of 1999. A series of rationalized policies, including LCR, high tariff protection, import ban on small cars, etc., has forced foreign assembling firms to become catalysts in promoting the growth of local supporting industries. From a virtual nonexistence of manufacturing expertise, in less than 40 years, the Thai automobile industry has been transformed from an import-substitution industry to a more export-oriented one, and currently it has been integrated into part of the global production network of some specific models by many world manufacturers. Foreign assembling firms have played an important role in disseminating important technology that has enhanced the technological capability formation and growth of Thailand's supporting industries (Techakanont and Terdudomtham, 2004).

Because the current trend continues in the direction of globalization, significant changes in car manufacturers' strategies, in particular, the requirements they impose on and the relationships they forge with local suppliers can be expected. In other words, inter-firm technology transfer is evolving; thus, it is necessary to investigate to what extent these strategies affect the content of inter-firm technology transfer, how local firms adapt to these changing environments and how they utilize inter-firm relationship with assemblers as a means to develop their own technological capabilities. Research on inter-firm technology transfer is scarce and there are few studies that set out to explain the process of technological capability formation (Ernst and Kim, 2002). Therefore, this paper contributes to the literature by examining the evolution of inter-firm technology transfer and the role of automobile assemblers in promoting the technological capability of local parts suppliers in Thailand. The organization of this paper is as follows: Section 2 discusses the conceptual background and provides an analytical framework relevant to this study. Section 3 explains the research methods and reports the evidence of inter-firm technology transfer collected.

Section 4 discusses the technological capabilities formation in the local parts firms and their relationship with assemblers. Three case studies of local parts-making firms that have received direct assistance have been made to set the stage for the drawing of general observations about the evolution of inter-firm technology transfer and the dynamic process of capability formation. Section 5 provides concluding remarks.

2. Conceptual Background and Analytical Framework

Firms in developing economies can acquire technology or develop technological capability by many means. They can develop the technology through their own efforts, through a systematic research and development program; they can learn technology from other firms; or they can accumulate it through experience (learning by doing) (e.g., Kim, 1997). However, from the early stages of economic development, technology transfer from foreign countries seems to have been the most important channel for technology acquisition. Technology transfer is deemed to have been successful when the transferred technology is translated and internalized into the overall capability of the recipient. This section will discuss three important concepts pertinent to this study: 'technology', 'channels' and 'forms of technology transfer', in order to develop an analytical framework for studying the inter-firm technology transfer and local capability formation.

2.1 Types of Technology

Technology can be defined in many ways, but researchers normally refer to the words "technology" or "technological knowledge" as "a way of doing something" (Nelson and Winter 1982, p. 60), "a collection of physical processes that transforms inputs into outputs and knowledge and skills that structure the activities involved in carrying out these transformations" (Kim, 1997, p. 4). Some of them maintain that "technology" refers to people's knowledge of how to use "techniques," and defines as specifications of products or production systems that may or may not be embodied in particular physical goods such as machines or instruments (David, 1997). Previous literature has discussed the nature of technology, noting that it typically takes two main forms, "explicit" and "tacit" (Polanyi, 1962).[2] Sometimes, these two forms are referred to as 'hardware' and 'software' technology. Explicit knowledge, which corresponds to 'hardware' technology, refers to knowledge that can be codified and is transmissible in formal or systematic

2) This concept is adopted by many studies, such as Hayashi (1990), Nonaka and Takeuchi (1995), Kim (1997), David (1997), and Ernst and Kim (2002).