COMMERCIALIZATION OF UNIVERSITY RESEARCH: 
THE CASE OF NANJING, CHINA

by

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Abstract

The Chinese government is propelling commercialization of university research as a strategy to boost industrial innovation and upgrade economic structure. Nanjing, the national third largest hub of science and technology (S&T) resources, was selected in 2009 as the only pilot city for comprehensive S&T institutional reform. Based on in-depth key informant interviews, site visits and documents collected from multi-sources, this study examines the framework conditions as well as specific mechanisms of university research commercialization in Nanjing. This research also strives to broaden and deepen the existent literature on university-industry liaison in China, which is detected as empirically narrow, theoretically thin and analytically shallow. Following an introduction (chapter 1) and a literature review (chapter 2), a China-specific model to analyze regional/local innovation is designed based on a critical review of the development trajectory of innovation theories (chapter 3). Employing this theoretical tool, the multi-layer policies, institutions and programs set up by multi-scalar governments to govern innovation and technology commercialization in Nanjing are depicted and interrogated (chapter 4). At a conceptual level, this multi-layer framework apparatus displays a pattern of “hierarchical amplification”, which the author argues has led to propensities of overcapacity, irrationality and “mission creep” in China’s efforts at boosting innovation. Empirically, four sets of university-affiliated research commercialization channels operating under the multi-layer framework in Nanjing are studied – 1) university technology transfer offices, 2) enterprise-college-institute cooperation platforms, 3) university science parks, and 4) university spin-off companies (chapter 5). This thesis concludes by summarizing the research and identifying impediments in the current university research commercialization regime (chapter 6).
Preface

This thesis is original, unpublished and independent work by the author, Xiao Fu. The fieldwork conducted for this study was approved by UBC Behavioral Research Ethics Board [certificate #H11-01020; project title: Commercialization of University-Generated Technologies: The Case of Nanjing, China].
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<th>Full Form</th>
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<tbody>
<tr>
<td>CADZ</td>
<td>Chinese Association of Development Zones</td>
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<td>CAE</td>
<td>Chinese Academy of Engineering</td>
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<td>CAS</td>
<td>Chinese Academy of Sciences</td>
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<td>CBRC</td>
<td>China Banking Regulatory Commission</td>
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<td>CETC</td>
<td>China Electronics Technology Group Corporation</td>
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<td>CEWC</td>
<td>Central Economic Work Conference</td>
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<td>CIRC</td>
<td>China Insurance Regulatory Commission</td>
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<td>CSRC</td>
<td>China Securities Regulatory Commission</td>
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<tr>
<td>DRC</td>
<td>Development Research Center</td>
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<tr>
<td>ECIC</td>
<td>Enterprise-College-Institute Cooperation</td>
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<td>EI</td>
<td>Engineering Index</td>
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<tr>
<td>EPZ</td>
<td>Export Processing Zone</td>
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<td>ETDZ</td>
<td>Economic and Technological Development Zone</td>
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<tr>
<td>FDU</td>
<td>Fudan University</td>
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<td>FTE</td>
<td>Full Time Equivalent</td>
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<td>FTZ</td>
<td>Free Trade Zone</td>
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<tr>
<td>HEI</td>
<td>Higher Education Institute</td>
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<td>HIDZ</td>
<td>High-tech Industrial Development Zone</td>
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<td>ICT</td>
<td>Information and Communication Technology</td>
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<td>IIS</td>
<td>International Innovation System</td>
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<tr>
<td>Innofund</td>
<td>Innovation Fund for Tech-based SMEs</td>
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<tr>
<td>IPO</td>
<td>Initial Public Offering</td>
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<td>IPR</td>
<td>Intellectual Property Right</td>
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<td>IT</td>
<td>Information Technology</td>
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<td>LME</td>
<td>Large- and Medium-sized Enterprise</td>
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<td>MII</td>
<td>Ministry of Information Industry</td>
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<td>MNC</td>
<td>Multinational Corporation</td>
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<td>MOA</td>
<td>Ministry of Agriculture</td>
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<td>MOC</td>
<td>Ministry of Commerce</td>
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<td>MOE</td>
<td>Ministry of Education</td>
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<td>Ministry of Finance</td>
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<td>MOH</td>
<td>Ministry of Health</td>
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<td>MOP</td>
<td>Ministry of Personnel</td>
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<td>MOST</td>
<td>Ministry of Science and Technology</td>
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<td>NAU</td>
<td>Nanjing Agricultural University</td>
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<td>NDRC</td>
<td>National Development and Reform Commission</td>
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<td>NIS</td>
<td>National Innovation System</td>
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<td>NIT</td>
<td>Nanjing Institute of Technology</td>
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<td>Abbreviation</td>
<td>Full Name</td>
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<tr>
<td>NJU</td>
<td>Nanjing University</td>
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<td>NNU</td>
<td>Nanjing Normal University</td>
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<td>NSFC</td>
<td>Natural Science Foundation of China</td>
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<tr>
<td>NTTC</td>
<td>National Technology Transfer Center</td>
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<tr>
<td>NUAA</td>
<td>Nanjing University of Aeronautics and Astronautics</td>
</tr>
<tr>
<td>NUS</td>
<td>National University of Singapore</td>
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<tr>
<td>NUST</td>
<td>Nanjing University of Science and Technology</td>
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<tr>
<td>NUT</td>
<td>Nanjing University of Technology</td>
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<tr>
<td>PC</td>
<td>Personal Computer</td>
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<tr>
<td>PKU</td>
<td>Peking University</td>
</tr>
<tr>
<td>PPC</td>
<td>Productivity Promotion Center</td>
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<tr>
<td>PRI</td>
<td>Public Research Institute</td>
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<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
</tr>
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<td>RIS</td>
<td>Regional Innovation System</td>
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<tr>
<td>S&amp;T</td>
<td>Science and Technology</td>
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<td>SCI</td>
<td>Science Citation Index</td>
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<tr>
<td>SETC</td>
<td>State Economic and Trade Commission</td>
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<td>SEU</td>
<td>Southeast University</td>
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<td>SEZ</td>
<td>Special Economic Zone</td>
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<tr>
<td>SHIP</td>
<td>Shenzhen High-Tech Industrial Park</td>
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<td>SIPO</td>
<td>State Intellectual Property Office</td>
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<tr>
<td>SJTU</td>
<td>Shanghai Jiaotong University</td>
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<tr>
<td>SME</td>
<td>Small- and Medium-sized Enterprise</td>
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<tr>
<td>SOE</td>
<td>State-Owned Enterprise</td>
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<tr>
<td>SPC</td>
<td>State Planning Commission</td>
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<tr>
<td>SSIPC</td>
<td>Shenzhen Science and Technology Industrial Park</td>
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<tr>
<td>STACO</td>
<td>S&amp;T Achievements Commercialization Office</td>
</tr>
<tr>
<td>STIP</td>
<td>Science and Technology Industrial Park</td>
</tr>
<tr>
<td>TBI</td>
<td>Technology Business Incubator</td>
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<tr>
<td>THU</td>
<td>Tsinghua University</td>
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<tr>
<td>TIM</td>
<td>Territorial Innovation Model</td>
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<td>TTO</td>
<td>Technology Transfer Office</td>
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<td>UIL</td>
<td>University-Industry Linkage</td>
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<td>URE</td>
<td>University-run Enterprise</td>
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<tr>
<td>URI</td>
<td>University and Research Institute</td>
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<tr>
<td>USP</td>
<td>University Science Park</td>
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<tr>
<td>VC</td>
<td>Venture Capital</td>
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<tr>
<td>WB</td>
<td>World Bank</td>
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<tr>
<td>ZGC</td>
<td>Zhongguancun Science Park</td>
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<td>ZJU</td>
<td>Zhejiang University</td>
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Chapter 1. Introduction

1.1 Research background

This research addresses China’s university research commercialization, both as a thematic segment as well as a materialization strategy of innovation. Joseph Schumpeter (1934, 1989), the guru of innovation research, defines innovation as new combinations of existing resources. Later scholars generally adopted a dichotomous division – “product innovation” and “process innovation”, with the former defined as the occurrence of new or improved goods and services, and the latter new or improved ways to produce goods and services (Edquist et al., 2001; Fagerberg, 2005). Innovation is believed to be a systematic phenomenon, catalyzing from an evolutionary network of mutually interacting innovation agents, all embedded in a broad institutional, politico-economic and socio-cultural environment (Van de Ven et al., 1999).

Many scholars consider scientific innovation desirable for national economic strength (e.g. Mowery & Rosenberg, 1989; Porter, 1990). For advanced industrial economies, where continual operational improvement and deployment of mature technologies are a given, economists argue that cutting-edge innovation is essential for maintaining global eminence (Porter & Stern, 2001). Countries such as the United States, Germany, and Israel are frequently cited to exemplify the power of innovation in sustaining competitiveness (e.g. Rosenberg, 1972; Legler et al., 2000; Davis & Davis, 2005). For industrial latecomers such as East Asia countries, innovation is often credited as the key of economic catching-up. Thanks to technological innovation, Japan, South Korea and Taiwan, countries that historically relied heavily on exporting low value-added marginalized commodities, have upgraded their economic structure and hence generated new growth momentums (Fagerberg & Godinho, 2005).

In the case of China, innovation is not only desirable but also urgent. China’s economic growth averaged 10 percent over the past three decades, and over 500 million people were lifted out of poverty (World Bank & Development Research Center of the State Council, 2012). It is now the world’s largest exporter and manufacturer, and its economic scale is second only to the United States (ibid.). Though staggering, China’s economic miracle has come at the expense of environmental degradation, resource depletion, and to some extent labor exploitation (e.g. Chan, 2001; Economy, 2004). Diminishing population dividends (rising labor costs coupled with an aging population), fluctuating energy and raw materials prices, currency appreciation pressure, demand slumps in overseas markets in an era of financial crisis and fiscal austerity, and a graduate pool
“overly-educated” for the contemporary job market, are among the many factors further exacerbating China’s urgency to restructure its low value-added export economy. While encouraging domestic consumption and enlarging government spending could to some extent appease some of these problems, the key to break the bottleneck of a labor-intensive and investment-driven economy is to climb the technological ladder via innovation. Indeed, *China 2030: Building a Modern, Harmonious, and Creative High-Income Society*, a recent report co-authored by the World Bank (WB) and the Development Research Center (DRC) of the State Council (China’s central official think-tank), urges China to accelerate its pace of innovation (WB & DRC, 2012). In fact, innovation has long been espoused by the Chinese central government. Starting from 2000, “innovation” and “economic restructuring” lingered as pivotal themes for 11 consecutive years in the annual Central Economic Work Conference (CEWC), a national economic tone-setting meeting (Wangyi Caijin, 2012). An entire chapter of China’s latest Five Year Plan (2011-2015) is centered on innovation promotion (Zhongguo Zhengfu Wapng, 2011). In addition, major political leaders, including Chairman Hu and Premier Wen, have urged innovation on various occasions.

How should China innovate then? Since an innovation system encompasses various organizations and institutions, efforts to promote innovation could target different agents and enlist myriad approaches. Over the past two decades, the fledging knowledge economy worldwide has accentuated one set of innovation strategies, that is fostering university-industry linkages (UILs) and commercializing university research (Hersheberg *et al.*, 2007; Yusuf & Nabeshima, eds., 2007). The development of an information technology (IT) cluster in Silicon Valley benefits substantially from Stanford University and the University of California-Berkeley, and the emergence of a biotechnology cluster around Route 128 (Boston) is similarly indebted to many nearby universities (Kenney & von Burg, 1999). Demonstration effects of US UILs are felt across both the Atlantic and the Pacific, as other countries are ramping up their innovation capacities by fertilizing and nurturing university-industry liaison (to be elaborated in the next chapter). A group of scholars, under the “Triple Helix” banner, explicitly advocate an entrepreneurial bend of universities – forming closer and deeper links with industry to maximize knowledge capitalization (Etzkowitz & Leydesdorff, 1997, 1999; Etzkowitz, 1998, 2002; Etzkowitz *et al.*, 2000).

In China, firms are generally low in technology level as well as research and development (R&D) capacities, technology intermediary agencies are largely underdeveloped, while the higher education sector itself is relatively robust (Eun *et al.*, 2006). Therefore, a university-centered approach to form UILs and commercialize technology is of particular relevance and viability for innovation promotion
in China. In other words, university research commercialization is both an important thematic segment and a pivotal implementation strategy of innovation in China. Actually, China’s efforts to mimic the Silicon Valley and Route 128 success has long been observed, as seen in ordinances made in the 1980s to encourage university engagement with industry, and the establishment of a national web of technology transfer offices and science parks (see chapter four). However, the dynamics of university-industry interaction in China are currently underresearched, and the existing literature is empirically narrow, theoretically thin, and analytically shallow (see the next chapter). This research aims to enrich this part of the literature and contribute to our understanding of this topic.

This research is conducted bearing a brief in mind that a thorough investigation of China’s university research commercialization, similar to any other grand national endeavors, should incorporate three elements: 1) a national perspective – since China is still highly centralized in grand project design, and top-level institutions, policies and programs exert premier influence on lower-level maneuvers; 2) an adequate regional/local focus – due to China’s significant geographical unevenness in both political and economic strength as well as resource and talent endowments, any overarching study could miss local nuances and lean towards over-generalization; and 3) an understanding of inter-layer governmental coordination dynamics – since while the central government helms national initiatives, local governments are the primary project implementers, therefore inter-governmental interaction shapes how policies materialize. This brief or “protocol” guides the design of this whole project and permeates throughout this thesis.

1.2 Research goals and objectives

The purpose of this study is to examine the framework conditions and specific mechanisms of commercializing university research in Nanjing, China. Towards this end, four objectives are identified: first, to build a theoretical framework for analyzing regional/local innovation in China, which fuses the strengths of available theoretical tools with the distinguishing features of the Chinese context; second, to survey the current multi-scalar institution, policy and program apparatus governing university research commercialization in Nanjing; third, to examine various agencies and mechanisms tasked with commercializing university research in Nanjing; and lastly, to perform a diagnosis of the current arrangement. At the conceptual level, the author proposes that UILs in China are best understood via a “hierarchical amplification” model, and this is tested through interviews conducted in Nanjing with a variety of agencies including technology transfer units and university science parks.
It is worth mentioning at this point that though the first two objectives shown above serve the investigation of the Nanjing case study (and thus seem auxiliary to the third objective), they also have their stand-alone purpose of streamlining future discussion of university research commercialization in China. Thus, chapters three and four are written in a detailed manner to fulfill the first and second objectives. The time frame of this study is 2000 to 2011, since 2000 is the year when the first set of university technology transfer offices (TTOs) were designated national status and the first set of university science parks (USPs) were launched in Nanjing (interview #1, Shangbing Jia). The survey of the science and technology (S&T) framework conditions, nevertheless, can be traced back to 1978 when initial S&T reform started. Fieldwork for this study was conducted on-site in Nanjing during May-June, 2011.

1.3 Study area – Nanjing

Nanjing, with an urban population of 5 million, is the capital city of prosperous Jiangsu Province (Figure 1). Sitting at the interaction of the Yangtze River (an east-west water transport artery) and the Nanjing-Beijing railway (a south-north land transport artery), Nanjing is the central city of the Yangtze River Delta and the second largest commercial center in East China, after Shanghai (Nanjing Government, 2009). Its economic base consists of both traditional industries inherited from the planned regime (1949-1978), such as electronics, petrochemical, automobiles, and steel, as well as newly expanded service industries, including trade, tourism, finance and logistics (Nanjing
Municipal Investment Promotion Commission, 2012). Modern industries, such as green energy, new materials, biopharmaceuticals, and integrated circuit designs, are targeted by the municipal government in its economic blueprint (ibid.). In 2011, Forbes magazine ranked Nanjing as China’s fifth best city for business, behind Guangzhou, Shenzhen, Hangzhou and Shanghai (Forbes, 2011). However, Nanjing has always been overshadowed by nearby Shanghai about 300 km away, and has vied for talent, investment and recognition with other economic powerhouses in Jiangsu Province, such as Suzhou, Wuxi and Changzhou. Distinguishing Nanjing from those neighboring rivals are a rich historical and cultural heritage, as well as its abundant S&T resources. With 53 higher education institutes (HEIs) enrolling some 760,000 students, and 540 various scientific research organizations accommodating about 530,000 research staff, Nanjing is a strategic national knowledge and talent hub, with wide-ranging technological expertise (Nanjing Government, 2009). Thus, UILs and university research commercialization are of particular importance for Nanjing. Furthermore, Nanjing was selected in 2009 by the national Ministry of Science and Technology (MOST) as the only pilot city for comprehensive S&T institutional reform (Nanjing Daily, 2009). This makes Nanjing an ideal case study city for this research, since successful Nanjing practices in commercializing university research will arguably be modeled by future followers. Besides, existent studies addressing UILs and technology commercialization in China focus exclusively on first-tier municipalities directly under the central government, e.g. Beijing and Shanghai, whose preferential political status are not typical of most Chinese cities. Nanjing, being a second-tier city nested administratively under the influence of both national and provincial authorities, is comparably more exemplar of Chinese cities than Beijing or Shanghai. Therefore, a Nanjing-focused investigation could shed light on the opportunities and constraints surrounding China’s research commercialization scenario in a broader context.

1.4 Research methodology

The primary method employed in this research is semi-structured key informant interview, plus statistical analysis of secondary data collected during fieldwork. Interviews were successfully arranged with 14 subjects: 1 officer at the Nanjing municipal-level S&T commission, 1 officer at the Nanjing district-level Gulou S&T bureau, 1 Nanjing Sci-Tech Square officer, 4 university TTO officers, 4 USP managers, 1 manager of the Nanjing University (NJU) – Lianyungang Government S&T cooperative platform, and 2 NJU faculty members involved in research commercialization (see Appendix A for details). Questions were pre-designed (attached in Appendix B), but they were only loosely followed during the interviews. Some pre-designed questions were either shunned or revised,
and extemporaneous questions were added during the conversation to better collect information. Since all interviews were held at the interviewees’ workplaces, site visits were rendered possible, and internal documents and organizational brochures were collected during the interviews.

1.5 Thesis outline

This thesis consists of six chapters. This introduction summarizes the topic, background, goals, objectives, study area, methodology as well as the thesis structure. Following is a literature review chapter, where existent studies pertinent to university research commercialization in China are critically reviewed. Chapter three aims to establish a theoretical grid guiding the investigation of China’s regional and local innovation systems, by surveying the development trajectory of innovation theories along the axis of scale debate. Employing this theoretical grid, chapter four examines the multi-scalar institution, policy and program apparatus set up in China to govern innovation promotion and research commercialization on the ground, and explores inter-layer governmental coordination. The concept of “hierarchical amplification” is proposed after the framework examination. Then comes an empirical chapter scrutinizing four sets of university-affiliated commercialization agencies in Nanjing – university TTOs, enterprise-college-institute cooperation (ECIC) platforms, USPs and spin-off companies. The thesis concludes with an summary of the research and an evaluative interrogation of deficiencies in the current system.
Chapter 2. A Survey of Literature: University-Industry Linkages (UILs) in China

2.1 Introduction

The rise of the knowledge economy has underscored the economic salience of universities as knowledge providers. It is now reasonably well established that “the presence of research-oriented universities - public or private - can assist geographically proximate firms directly through the provision of educated workers and indirectly by way of myriad externalities” (Hershberg et al., 2007, p. 932). To unleash universities’ economic externalities, national governments of both developed and developing countries have ushered policy initiatives to fertilize UILs and facilitate university research commercialization (Wu, 2007). UILs and commercialization take various forms, including contractual research, technology licensing, collaborative R&D, technology consulting as well as spin-off companies (Hussler et al., 2010). Correspondingly, a myriad of agencies are involved, such as TTOs, incubators and USPs (ibid.).

A substantial body of literature has been built up that surveys instances in the United States and Europe where research-oriented entrepreneurial universities, often through affiliated science parks, have supplied the underpinnings of dynamic clusters that are the backbone of regional growth spirals (e.g. Saxenian, 1994; Etzkowitz, 2002; Appleseed, 2003; Lenoir et al., 2003; Rosenberg, 2003; Siegel et al., 2003; Mowery et al., 2004; Lecuyer, 2005). Notable examples include the Silicon Valley which harbors Stanford University (e.g. Saxenian, 1994; Wonglimpiyarat, 2010), Route 128 around Boston which clusters multiple universities (e.g. Etzkowitz, 2002; Appleseed, 2003), as well as Cambridge and Oxford university science parks (e.g. Siegel et al., 2003). The United States is by all accounts the frontrunner in regard to UILs development and knowledge capitalization, exemplified by Stanford, MIT, UC Diego and UT Austin (Hershberg et al., 2007). Its superiority is embodied in: 1) the robust legal bedrock paved by the Stevenson-Wydler Act (1980), the Bayh-Dole Act (1980), the Small Business Research Innovation Program (1982), and the Small Business Technology Transfer Program (1992), 2) the wide range of channels through which its entrepreneurship-prone universities involve in economic activities, as well as 3) the effectiveness of university-industry cooperation, as gauged by revenues generated from technology licensing, contractual research and university spin-offs (ibid.). Western Europe had few instances of UILs until the US demonstration effect spurred universities and companies to interact, which now begun to bear fruit in places such as Cambridge and Oxford (UK), Munich (Germany), Grenoble Valley (France), and Sophia Antipolis (France) (Saperstein & Rouach, 2002; Aniello, 2004; Proudfoot, 2004; Cosh et al., 2006). Countries in other parts of the world, primarily in East and Southeast Asia, are also starting to shore
up themselves for the innovation race (see Edgington, 2008a, b), arguably in order to occupy more advantageous positions of the global value chain and cultivating new growth edges. Nonetheless, to the extent that university research commercialization has been examined, it is almost exclusively in the context of the developed world (Hershberg et al., 2007). Literature documenting UILs in non-western regions is in its early stage of accumulation.

Among Asian economies, Singapore is pursuing the US model of UILs most closely (ibid.). The role of the National University of Singapore (NUS) is underscored as it adopted a “Global Knowledge Enterprise” vision in the late 1990s, following the appointment of an industry-savvy vice-chancellor (Wong, 2006; Wong et al., 2007). A new university division called “NUS Enterprise” was established accordingly, which aimed to inject an entrepreneurial dimension in the university’s education and research and to derive more economic value out of the university’s intellectual assets (ibid.). The NUS Enterprise reorganized its TTO to be more inventor-friendly, expanded industrial liaison functions to broaden UILs, and launched a Venture Support Unit to assist start-ups. NUS has also modified its curriculum to instill an entrepreneurial and innovative mindset into its students. In addition, an NUS Overseas Colleges program was created to send students to the world’s most entrepreneurship-laden hubs for internship and apprenticeship (ibid.).

Japan followed a different path. The burst of its economic bubble at the beginning of the 1990s constituted a catch-up imperative, and the government’s ambition to re-make Japan as a “Nation based on Science and Technology” formalized into the Science and Technology Law (1995) and the first and second Science and Technology Basic Plans (1996-2000 and 2001-05; Hershberg et al., 2007; Edgington, 2008a, b). The legislation clarified the legal framework as well as offered governmental support for UILs. Universities and enterprises responded correspondingly (Jiang et al., 2006). Nevertheless, Japanese UILs differ from the US model as technology transfer often takes the form of an informal agreement between a faculty member and a private company for co-authorship, co-application of patents or a case-by-case R&D contract, rather than direct technology transfer grounded in legal/formal arrangements (Kodama & Suzuki, 2007). In addition, Japanese UILs also demonstrate a “receiver-active paradigm”, in which successful technology transfer depends more on firms’ proactive strengths to identify and absorb established technologies rather than universities’ technology marketing efforts (Kodama et al., 2006).

UILs in South Korea are currently sparse, as universities focus on teaching and exhibit limited entrepreneurship (Sohn & Kenney, 2007). Although Korean research institutes, such as the Korea Institute of Science and Technology, have developed technologies of importance to industry, the
major technology source for Korean firms is overseas licensing (ibid.). Once large Korean firms build up their technological expertise, they begin developing internal R&D, with little interest in the academia (ibid.). There are signs that this traditional model may be changing as universities and firms start to approach each other (Eom & Lee, 2010).

Taiwan’s technology catch-up in the 1990s, and the accompanying boom of export-oriented manufacturing, is indebted heavily to public research institutes (PRIs), especially the Industrial Technology Research Institute (Mathews & Hu, 2006, 2007). “PRIs played the role of technology capture agencies and technology diffusion managers, going abroad to seek the technologies needed by local firms and building capabilities in those technologies, which the PRIs then passed across to the private sector as rapidly as possible” (Mathews & Hu, 2006, p. 92). Entering the 21st century, Taiwan embarked on a new phase in developing its national innovation capacity, this time mimicking the US-model to cultivate entrepreneurial universities. Universities were dramatically upgraded in their roles in providing fundamental R&D, as well as in fortifying the economy’s innovative potential via various commercialization activities (Mathews & Hu, 2007).

Compared with the above-mentioned countries, UILs in Thailand are nascent, despite a general awareness of their economic importance (Brimble, 2006; Brimble & Doner, 2007). Three S&T actors – industry, academia, and the state – are all impeded in kick-starting UILs. Thai industry has historically been somewhat protected, resulting in low R&D and technology-absorbing capabilities, Thai universities are too bureaucratic and financially constrained to respond to industrial technology needs, and the Thai government has weak political incentives and administrative capabilities to strengthen UILs (ibid.). The situation in India is somehow similar (Basant & Chandra, 2006, 2007).

Basically all UIL studies concerning the above-reviewed countries take the nation state as a monolithic entity. This is where China stands out, since China exhibits significant geographical unevenness in governmental capabilities, politico-economic strength, as well as S&T and talent endowments. In addition, the Chinese government is arguably more heavy-handed than any above country. The Chinese government is capable of mobilizing enormous energy to achieve national targets once the political will is there. Further complicating the Chinese case is an intricate power structure between different layers of government. Therefore, as laid out in section 1.1, a research of UILs in China should incorporate a national perspective, a regional/local focus as well as intricacies of inter-layer governmental coordination. However, the innovation landscape of China is largely unclear at present, as there is an overall lack of studies (at least in the English literature) that document and interrogate China’s university knowledge commercialization efforts.
The existent handful of Chinese studies can be divided into three groups. The first group encompasses papers tracing the evolutionary role of universities in China’s national innovation system from the foundation of the People’s Republic of China in 1949 to the current, as well as the policy and institutional reforms underpinning the changes (e.g. World Bank, 1997; Zhang, 2003; Ma, 2004; Xue, 2006; Xue & Zhou, 2007; OECD, 2008). In sum, they indicate that China may be a distinctive case study of UILs because of its unique political legacies. Chapter four of this thesis is specifically dedicated to laying out the history and current status of China’s S&T framework in some detail, including institutions, policies, and programs, hence a detailed literature review at the national level is omitted here.

The second group of literature comprises several region/university-centered studies, with a focus on how specific universities contribute to regional economy via research commercialization and knowledge spillover (e.g. Liu & Jiang, 2001; Chen & Kenney, 2007; Wu, 2007, 2010; Hussler et al., 2010). Thus far, only selected eminent cities have drawn academic attention, including the national first and second largest S&T hubs – Beijing (Liu & Jiang, 2001; Chen & Kenney, 2007) and Shanghai (Wu, 2007, 2010), China’s biggest municipality and inland powerhouse – Chongqing (Hussler et al., 2010), and China’s first Economic Special Zone – Shenzhen (Chen & Kenney, 2007). Each of these case studies highlights the roles of local elite universities, including Tsinghua University (THU) and Peking University (PKU) in Beijing, as well as Fudan University (FDU) and Shanghai Jiaotong University (SJTU) in Shanghai.

The third group of literature comprises several agency/mechanism-centered studies, focusing on specific knowledge commercialization agencies or mechanisms, such as university TTOs, USPs, and university-run enterprises (UREs) (e.g. Mei, 2004; Xue, 2004; Eun et al., 2006; Tang, 2006a; Kroll & Liefner, 2008). The second and third groups of literature complement each other in the sense that while the former touches upon various agencies and mechanisms to provide a holistic local view, the latter enlists different regions and universities for empirical breath and mutual comparisons. The following is a review of the second and third body of literature, with some evaluative remarks closing this chapter.
2.2 Studies focusing on specific regions or universities in research commercialization (for locations see Figure 1)

Beijing

Among Chinese cities, Beijing – the political, educational and S&T capital of China – has arguably gained the most scholarly attention regarding research commercialization. Beijing is a government city with relatively little industry and weak commercial tradition (Chen & Kenney, 2007). Since the 1980s, severe pollution has also spurred a concerted effort to relocate industrial production out of the urban area (ibid.). Nevertheless, Beijing is exceptional in its S&T endowment. Beijing houses 71 universities and 371 research institutes, unparalleled both in number and quality (ibid.). Consequentially, official development plans prioritize knowledge economy sectors such as petrochemical material, integrated circuit, liquid crystal display, mobile communication, computer and software (Beijing Investment Promotion Bureau, 2004). The role of the Zhongguancun Science Park (or Zhongguancun, ZGC for short) is underscored when addressing innovation and knowledge economy in Beijing (Zhou, 2008). ZGC represents China’s first concerted efforts to mimic the Silicon Valley and is claimed to be the nation’s most innovative region (Zhou, 2005). Starting from an “Electronics Street” clustering several computer and IT firms hatched by the Chinese Academy of Sciences (CAS) in the early 1980s, ZGC was later formalized in 1988 by the State Council into a Beijing Experimental Zone for New Technology and Industrial Development (ZGC Science Park, 2012). In 1999 it was expanded to include five sub-parks and escalated administratively into the ZGC Science Park (ibid.). In 2009 this district was further enlarged to encompass ten sub-parks. The ten sub-parks, each with different technology specifications, now span different districts of Beijing and collectively cover a wide area (ibid.). Geographically speaking the entire area of Beijing is currently within the embrace of ZGC (Figure 2). However, the mere scope and locational patchiness of the current ZGC, coupled with differentiation among sub-parks regarding the presence of universities and research institutes (URIs), now render ZGC an improper scale for examining UILs. Haidian sub-park (the narrowly defined ZGC), which is the core and origin of the current ZGC as well as the hub of most Beijing URIs and multinational corporation (MNC) R&D headquarters, has been the focus of existent ZGC literature (e.g. Zhou & Xin, 2003; Cao, 2004; Zhou, 2005; Tan, 2006; Liefner et al., 2006). These studies emphasize government policy, institutional setting, and inter-firm interactions, with no specific advertence to UILs. The UIL-pertinent studies reviewed below are all conducted at a sub-ZGC, URI-centered scale, and are generally separate from the ZGC literature bloc.
Figure 2. A map of the ten sub-parks of Zhongguancun Science Park, Beijing (scale: 1:45,000)

One paper by Chen and Kenney (2007) compares Beijing and Shenzhen’s research commercialization paradigms, and provides a holistic view of the Beijing model, in which the role of research institutes and universities is accentuated. The authors note that CAS, founded in 1949 by the central government as a primary research undertaker, operates a national web of branches, but reserves some of the most prestigious ones in Beijing. During the course of national S&T reform in 1980s, CAS was corporatized and encouraged to pursue research commercialization (ibid.). In response, CAS launched in liaison with Beijing local government a Technology Licensing Office as well as an S&T Development Center, to facilitate technology transfer (ibid.). It also established the China Science and Technology Promotion and Economic Investment Company (a venture capital firm) to support and finance staff establishing start-ups (ibid.). Up until 2004, the CAS system had spun off more than 400 high-tech enterprises, including eight publicly listed ones (ibid.). One flagship CAS spin-off is the Lenovo group, which acquired IBM’s personal computer (PC) division in 2005, and subsequently grew to be the world’s second largest PC maker as measured by market share¹ (ibid.). As for universities in Beijing, contractual research, joint research projects, technology licensing, professional consulting and technology spin-offs have been the major commercialization channels. THU and PKU have been national commercialization leaders. In 1991, THU established an internal Technology Licensing Organization to coordinate university-industry liaison (ibid.). In 2001, “THU signed 828 research contracts worth RMB 432 million and 534 technology transfer contracts worth RMB 234 million” (ibid., p. 1066). Chen and Kenney (2007) show that university-affiliated firms in Beijing have a longer history than other UIL arrangements. THU founded its first firm in 1922, at that time mainly to provide students with internship and apprenticeship opportunities rather than to seek profits. In the wave of 1980s S&T reforms, THU established the Tsinghua Technology Service Company to assist faculty launch technology start-ups (ibid.). Spin-offs proliferated so much that THU had to build its own science park in 1994 to accommodate them, and to found the Tsinghua Enterprise Group² in 1995 to rationalize spin-off management and investment (ibid.). The THU science park was further equipped in 2001 with a professional incubator company – the Tsinghua Business Incubator Co., Ltd. (ibid.). By 2007, the park occupied 690 thousand square meters and housed 466 entities, including national research laboratories, regional MNC R&D centers (e.g. SUN Micro-systems, Proctor & Gamble, and NEC), headquarters of university enterprises (e.g. Tongfang, Unisplendour, and Zhicheng) and various technology

² Later restructured into the Tsinghua Holdings Co., Ltd. in 2003 (Song, 2004)
service firms (ibid.). Similarly, PKU has operated a science park and has commercialized research via spin-offs, among which the Founder Group is most renowned (ibid.).

Yet another study on UILs in Beijing by Liu and Jiang (2001, p. 183) examines THU more closely and claims it exhibits “some of the best practices of technology transfer in China”. According to these authors, three advantages make THU a frontrunner in technology transfer, namely “high quality research staff”, “first-class research conditions”, and a preferential recipient status for R&D projects and funds (ibid., p. 183-4). They categorize THU’s methods of technology transfer into five groups: 1) the “establishment of the University-Industry Cooperation Committee of THU”, which enlists various domestic and multinational companies and acts as a coordinating mechanism to facilitate UILs; 2) “technology transfer through collaboration with local government”, as exemplified by THU signing collaborative contracts with various provincial and municipal governments throughout the 1990s and 2000s, to facilitate establishment of R&D risk investment foundations as well as local technology transfer bases; 3) “establishment of high technology companies in partnership with enterprises”; 4) “building-up a Science and Technology Cooperation Network of Chinese Universities”, an online technology search and inquiry platform founded by THU together with six other universities and the S&T Development Center of the State Education Commission; and 5) “collaboration with enterprises”, which encapsulates joint research, technology sales, spin-offs and other forms (ibid., p. 184-6).

**Shanghai**

Shanghai, long seen as the production center and economic locomotive of China, is also the birthplace of China’s first modern HEIs (Wu, 2007). Shanghai is currently the home to a cluster of 66 universities enrolling around 515,700 students, 218 research institutes employing 32,500 S&T staff, and 1,750 large and medium-sized enterprises (LMEs) hiring 226,000 R&D personnel (Shanghai S&T Commission and Shanghai Statistics Bureau, 2011). Shanghai even outstrips the capital Beijing in several studies indexing the R&D strength and innovation potential of different Chinese metropolises (e.g. Jefferson & Zhong, 2004; Wang & Tong, 2005).

According to Wu (2007, 2010), Shanghai currently takes the national lead in responding to the central government’s appeal for university research commercialization. Wu’s 2007 Shanghai study leans more towards policy changes and initiatives at the national and municipal governments to promote commercialization, while her 2010 research assigns more weight on intra-university institutional arrangement and incentive scheme geared towards the same purpose. Two elite
Shanghai universities - FDU and SJTU - are used in a comparative manner in both studies to augment discussion and depict inter-university nuances. Four commercialization agents are touched upon – university TTOs, joint R&D collaboration with industry, USPs, and university spin-offs. SJTU, with a traditional distinction in engineering and applied sciences, outperforms arts and basic sciences-centered FDU, in both TTO competency and the extensiveness of collaborative R&D (ibid.). SJTU’s TTO is staffed currently with over 20 employees who proactively identify marketable innovations patented by faculty members, cultivate collaborations with local affiliates of well-known firms (e.g. Volkswagen, General Motors, and Baoshan Iron & Steel), and raise research funding from local government sources (ibid.). In comparison, FDU’s three-staff TTO, unable to engage closely with faculty members or firms, is limited to only providing general oversight regarding university–industry liaison (ibid.). As for collaborative R&D, SJTU operates joint laboratories with 40 MNCs and research institutions (the most notable example being a durable partnership with General Motors) and has extended linkages to Japan and Korea (ibid.). Comparatively, FDU’s collaborative industry liaison is more recent and less extensive (ibid.). Wu (ibid.) notes that each university runs a national-level USP. The SJTU one was originally composed of three high-tech incubators, but has expanded to include 7 sub-parks, each with a specific industry focus; and is buttressed by a venture capital management company co-established by SJTU and the Shanghai Venture Capital Corporation (Wu, 2007; SJTU USP, 2012). FDU Science Park now houses over 100 enterprises and consists of a software park, a business incubator, a “digital city”, an industrial estate and two branch parks (Wu, 2007; FDU USP, 2012). Regarding university spin-offs, the two major universities in Shanghai adopt distinctively different approaches. SJTU directly invests university money in technology start-ups and holds sole ownership of some enterprises; besides, its party secretary and president serve respectively as chairman and vice chairman of a university enterprise group overseeing all SJTU commercial entities, which arguably results in an intertwining of university administration with enterprise decision-making as well as university finance with corporate finance (Wu, 2007, 2010). In contrast, FDU shuns away from directly investing in or owning enterprises, but uses technology equities to form joint ventures with private partners (ibid.). A separate Commercialization and University Enterprise Management Office has also been established to handle and coordinate enterprises-related issues (ibid.). Wu (ibid.) favors explicitly the FDU approach since it creates a buffer zone between university and spin-offs, in terms of administration, finance as well as culture.
**Chongqing**

Chongqing is the youngest and largest Chinese municipality, located in the upstream of the Yangtze River and housing 28 million inhabitants (Hussler et al., 2010). It is not only a major inland economic center but also a strategic S&T hub, with around 376,200 students enrolled in 38 HEIs, 36,700 S&T staff employed in 715 research institutes, and 26,800 R&D personnel hired in LMEs. Hussler et al. (ibid.) present a case study of Chongqing, in tandem with Karlsruhe, Germany and Milan, Italy, in a paper which develops a taxonomy of knowledge transfer tools and compares the knowledge commercialization models of different regions. They conclude that different regions display both common features and idiosyncratic characteristics in research commercialization practices, and argue effective knowledge commercialization tools need to reflect local contexts and be tailored to regional needs (ibid.). In their survey of Chongqing, they highlight six commercialization actors – TTOs, technology market, S&T industrial parks (STIPs), technology business incubators (TBIs), productivity promotion centers (PPCs) and an innovation-supporting financial system (ibid.). As they observe, TTOs are “widely integrated in universities and research institutes, acting as double intermediaries between innovators and academia on the one hand, and between academia and industry on the other hand” (ibid., p. 514). The local technology market, operated by the municipal government, is the major platform where technology service and technology development contracts are hammered out (ibid.). Various STIPs have been set up in Chongqing since 1991 to “form clusters of innovation and cooperation between science, industry and education”, to “support technology-based start-up creation”, and finally to “industrialize high-tech products” (ibid., p. 515). In terms of TBIs, Chongqing currently hosts 27 of them (including 2 national USPs run respectively by Chongqing University and Southwestern University), supported by the National Torch Program to nurture new technology-based firms (ibid.). Chongqing has 18 PPCs, one of which was designated national demonstrative¹ (ibid.). The PPCs are financed by local government and managed by MOST together with the Chongqing S&T Commission, and comprise various intermediary and consulting organizations dedicated to supporting small and medium-size innovation-based firms (ibid). Regarding the financial framework, national and municipal innovation funds, government-backed venture capital firms and guarantee agencies, coupled with university venture capital agencies, together serve as the seed fund pool (ibid.). Hussler et al. (ibid., p. 517) consider that the Chongqing model is “quite comprehensive”, as it includes a diversified spectrum of commercialization tools. Nevertheless, they notice “a lack of interaction, and the absence of

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¹ For nationwide institutional arrangements or programs, Chinese central authorities routinely designate national demonstrative ones to exemplify best practices.
redundancy and overlap among valorization tools, [with] each tool being dedicated to one specific purpose” (ibid.).

Shenzhen

Located in southern China, Shenzhen is the closest mainland city to Hong Kong. Unlike Beijing, Shanghai and Chongqing, Shenzhen started with few S&T facilities or R&D capabilities when it was designated as a Special Economic Zone in 1980 following China’s “reform and open-up” policy (Chen & Kenney, 2007). The lack of S&T heritage, however, makes Shenzhen an especially valuable case to examine, since it exemplifies how cities with limited S&T resources wrestle with innovation cultivation, which differs significantly from resources-concentrated technopoles (e.g. Beijing, Shanghai, and Nanjing). Contributions come from the aforementioned Chen and Kenney’s (2007) study contrasting Beijing and Shenzhen in their UILs development trajectories. While Shenzhen’s ballooning economic growth after 1980 was based on labor-intensive assembly operations, the local government developed innovation policies soon after. To nurture local talents and accumulate S&T resources, Shenzhen authorities established Shenzhen University in 1983 and later Shenzhen Polytechnic in 1993 (ibid.). In 1985 the municipal government and CAS jointly established the first-ever S&T park in Mainland China – the Shenzhen S&T Industrial Park (or SSIPC, ibid.). It aimed initially at incubating firms out of CAS research, hence refracting knowledge spillover into Shenzhen, but in the late 2000s it adopted a broader strategy, targeting financial services and culture business (SSIPC, 2012). In 1996, Shenzhen established the national-level Shenzhen High-Tech Industrial Park (SHIP), covering an area of 11.5 square kilometers (SHIP, 2012). Though titled “High-Tech”, resembling its counterparts in other Chinese cities, SHIP welcomes companies from nearly every industry, every country and with every level of technology density (Chen & Kenney, 2007).

Nevertheless, UILs formation and technology commercialization are embedded in SHIP’s mission. Its way to commercialize research has been to attract URIs to set up branches within the park. THU, PKU, Hong Kong University of Science and Technology, CAS, the Chinese Academy of Engineering (CAE), and many more have all established their research bases and innovation platforms in SHIP (ibid.). Furthermore, in 2000 part of the SHIP was designated to be a Virtual University Park\(^1\), which currently hosts 43 branches of various URIs, 8 technology-based incubators as well as 78 research laboratories and centers (ibid.). In 2000, the Virtual University Park was packaged into a USP and promoted to national status (SHIP, 2012). In sum, Shenzhen’s way of

\(^1\) It is not an actual university in its tradition definition, but an R&D cluster dedicated to knowledge commercialization and entrepreneurship education.
overcoming its original S&T barrenness has been to fertilize research commercialization via channeling external S&T resources inward.

2.3 Studies focusing on specific agencies or mechanisms in research commercialization

University Technology Transfer Offices (TTOs)

Systematic research of Chinese university TTOs have yet to emerge. Tang (2006) takes a preliminary step towards this direction, though his work enlists only the first six National Technology Transfer Centers (NTTCs) authorized by the Ministry of Education (MOE) and the former State Economic and Trade Commission (SETC)\(^1\) in 2001. This embodies the central government’s attempts in the 1990s to strengthen UILs and university research commercialization (ibid.). The six universities selected are THU, SJTU, China East Polytechnic University, Huazhong S&T University, Xi’an Jiaotong University and Sichuan University (ibid.). The selection is more based on particularly strong industry-relevant disciplines and geographic consideration (to scatter the cohort all around China), rather than the overall prestige or commercialization performance of candidates (ibid.). For example, Sichuan University and Xi’an Jiaotong University benefit from being located in the West, while China East Polytechnic University, not a top university in China, benefits from having an outstanding chemical engineering department (ibid.). According to Tang (ibid., p. 2), NTTCs are tasked with five missions: 1) to “make joint R&D on general technology between university and industry”; 2) to “promote the construction of firm technology centers by taking use of university S&T advantages”; 3) to “accelerate the commercialization of university S&T achievements and diffuse them”; 4) to “act as a mediate to strengthen international technology cooperation between domestic firms and foreign firms”; and 5) to “provide various required services to firms”. Actually, Chinese universities have long integrated similar tasks in their operation, usually within the regime of the S&T division. Some also established specific TTOs, commonly named S&T Achievements Commercialization Office (STACO), to handle commercialization (ibid.). Thus, the national initiative to set up NTTC should not be read as initial launching of TTOs, but efforts to operationally revamp, financially bolster and administratively escalate the work of technology transfer. Combining telephone/personal interviews and questionnaire surveys, Tang (2006) compared the performance of all six NTTCs and derived some conclusions. According to him, their efficiency and effectiveness could be deterred by multiple factors: first, NTTCs are not smoothly integrated with corresponding S&T divisions, or even coexist with previous STACOs, leading to

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\(^1\) Later incorporated into the current Ministry of Commerce.
obvious administrative overlap; second, unlike the THU NTTC whose income is linked with commercialization revenue, other NTTCs operate on a not-for-profit base, seriously disincentivizing the usually low-salaried staff; and finally, NTTCs located away from the eastern coast suffer from weak local economic base as well as low technology absorbing capacities of local firms, which contradicts with the initial intention to scatter NTTCs geographically.

University Science Parks (USPs)

If university TTOs serve to radiate technological findings out of university campuses, then USPs act as the seedbeds to incubate technology start-ups. However, studies systematically examining China’s science parks have been sparse (e.g. Walcott, 2002, 2003; Sutherland, 2005), not to mention the subset USP group. Science parks, including USPs, were directed and funded by MOST in the 1990s under the auspices of the national Torch Program, as a maneuver to reform China’s national innovation system (Sutherland, 2005). USPs in China, according to Mei (2004, p. 1), “originated in the early 1990s, grew in the middle of the 1990s and enjoyed a booming development at the turn of the 21st century”. The government-supported proliferation of USPs all over China is often seen as efforts to emulate foreign practices, but it is also propelled by THU’s initial successful experiment. In 2001, a first cohort of 22 USPs were appointed by MOST and MOE as national USPs, and 2002 saw another 21 augment the list (Mei, 2004). By the end of 2002, the 43 national USPs had absorbed a total investment of RMB 29.7 billion and accommodated 5,500 enterprises, including 2,300 under incubation and 920 successfully graduated (ibid.). The under-incubation enterprises collectively had commercialized more than 1,860 high-level R&D achievements, obtained 1,923 patents, generated 4,116 new products, attracted 1,300 overseas returnee scholars, and created around 100,000 employment opportunities (ibid.). USPs are commonly co-located with universities, as to make university-enterprise interaction easy and prompt (ibid.). Mei (ibid.) believes that the USP system is an ideal mechanism of promoting knowledge commercialization in China, and is mutually beneficial for both universities and enterprises. On the one hand, via USPs universities could provide nascent companies with a wide range of support – subsidized offices and facilities, access to university laboratory equipment, access to faculty and student talent, an innovative cultural atmosphere, as well as value-adding technology and incubating services (ibid.). On the other hand, enterprises housed in USPs could provide the financial support and market vision to assist universities keep abreast with societal knowledge/technology demands (ibid.).
University-Run Enterprises (UREs)

UREs in China are enterprises “typically established, staffed, funded and managerially controlled by the mother institutions” (Eun et al., 2006, p.1332). Due to this particular ownership structure, UREs are usually endowed with the de facto right to exploit exclusively the mother institutions’ various assets, including physical spaces, manpower, research outcomes, financial resources, social links, even the university title as a commercial brand (ibid.). Unlike TTOs and USPs that are more or less modeled on Western practices, the URE system is almost uniquely Chinese, since direct ownership of a commercial firm may invalidate the tax-exempt status of a Western university (Chen & Kenney, 2007). Consequentially, Chinese UREs differ significantly from ordinary university spin-offs usually set up by individual academicians with off-duty inventions and personally raised funds (Roberts, 1991). Based on this, some scholars deny calling the Chinese UREs “spin-offs” but “spin-arounds”, which maintain a sort of “umbilical cord” with the mother institutions rather than being truly spun “off” (Eun et al., 2006, p.1332). Other scholars use “spin-offs” more inclusively, and view the Chinese UREs as “sponsored spin-offs” while the traditional spin-offs as “private spin-offs” (e.g. Pirnay et al., 2003; Wallin & Dahlstrand, 2006; Kroll & Liefner, 2008). The mere uniqueness of Chinese UREs attracts much academic attention, making UREs more thoroughly investigated in comparison with with TTOs and USPs. Before proceeding, it is worth mentioning that most studies discussing Chinese university spin-offs address the URE system (private spin-offs are excluded). Private university spin-offs do exist in China, but the absence of sound data and inventory have muted them in scholarly discourse, comprising an academic vacuum (Kroll & Liefner, 2008).

Extensive existence of UREs dates back to the 1950s when many Chinese universities used UREs to provide students with short-term internships or apprenticeship opportunities in a production environment (Xue, 2004). In addition, under the pre-reform “work unit system (danwei)”, which mandated enterprises, universities and other social institutions to engage in self-sufficient production, many universities also had their own service providers, such as print shops, publishers, guest-houses (ibid.). After China’s “reform and open-up” policy, the central government issued in 1985 a decree on structural reform of the education sector – “The resolution of the Central Committee of the Communist Party of China on the structural reform of the education system” – to encourage educational institutions to engage in the economic and social development of the general society (ibid.). This was the first institutional stimulus embraced by UREs. This 1985 action was amplified in 1991 as the State Council endorsed UREs through a document enacted by the then Commission on Education and S&T to provide URE guidelines, and was further strengthened in
1992 by Deng Xiaoping’s “southern tour” (indicative of solidified reform and marketization determination).

Letting universities establish their own technology enterprises was seen at that time as the most logical solution for technology transfer and knowledge dissimilation due to several reasons (Hussler et al., 2010). First, at that time the industry sector and the higher education sector in China differed too much in institutional set-up and mindset to allow effective direct cooperation (dampening the feasibility of university-industry collaborative research; Kroll & Liefner, 2008). Second, deficient contract law and intellectual property rights (IPRs) framework jeopardized extensive technology licensing and sales (ibid.). Third, “private ownership of firms and entrepreneurial activities by university personnel were then either officially prohibited or at least strongly frowned upon” (dampening the feasibility of private technology spin-offs; ibid., p. 302). Fourth, the industry sector lacked an interest in acquiring technologies from domestic universities. Giant state-owned enterprises (SOEs) endowed with market monopoly status and financed generously by state-owned banks were lukewarm to upgrade technology. Private enterprises in that era, mostly engaged in low-tech and labor-intensive production/service activities, were incapable of and disinterested in reaching out to universities. In addition, most MNCs operating in China then were technologically backed up by their patent companies, and did not see the necessity to seek local technology partnership (ibid.). These four reasons collectively overshadowed the feasibility of alternative commercialization mechanisms other than universities establishing their own UREs.

In terms of performance, UREs generated considerable optimism in the 1990s. By the end of 2000, there were 5,451 UREs in China, though only half of them were classified as S&T enterprises (Xue, 2004). About 40 of them were already listed on the stock markets in Mainland China and Hong Kong (Eun et al., 2006). 14 of the Chinese top 100 S&T firms in year 2002 were UREs (ibid.). The sales revenue and profits of UREs swelled throughout the 1990s, despite mediocre patenting activity (Kroll & Liefner, 2008). Success stories such as Lenovo, Founder, and Tongfang, spun off from CAS, PKU and THU respectively, were publicized widely (e.g. Gu, 1999; Lu, 2000; Xie & White, 2004). However, this early optimism dissipated in the new millennium. The total number of UREs decreased to around 4,500 in 2010 (Wu & Zhou, 2011). The contribution rate of UREs to national overall R&D revenues decreased from 10% in 2000 to 2.2% in 2006 (ibid.). The capital raised through initial public offering (IPO) by UREs dwindled and the financial performance of many listed UREs deteriorated throughout the late 2000s (Eun et al., 2006). As a result, the number of UREs in the list of Chinese top 100 S&T firms shrank to 7 in 2005 (ibid.). There were even reports
in 2007 suggesting that some universities implicated in the losses of their affiliated firms might end in bankruptcy (Chen & Kenney, 2007). Not only the overall performance of UREs soured, the picture within UREs also became highly polarized. In 2004, the top 10 universities captured 73.1% of all sales revenues by S&T UREs, with PKU and THU together accounting for 48.8% (Kroll & Liefner, 2008). Similarly, the 10 biggest S&T UREs accounted for 59.9% of the overall sales volume, with Founder and Tongfang collectively covering 37.5% (ibid.). Put differently, 51.3% of all S&T UREs’ sales volume concentrated in Beijing, and 90.3% in the 10 most active provinces (ibid.). It is easy to conclude that the encouraging performance of some URE stars is far from exemplar of the national average. Echoing enlarging economic losses of publicly funded universities in their private ventures, attitudes of the general public towards UREs turned from positive to negative (Wu & Zhou, 2011). Despite of the ebbs and flows of UREs, their genuine contribution to knowledge spillover has always been doubted. UREs are often seen as “cash cows” committed to profit seeking in low-tech sectors, or conveyors transferring personnel from universities to industry, all under the banner of technology commercialization but without truly doing so (e.g. Chen & Kenney, 2007; Wu, 2010).

Multiple studies tried to explain the underperformance of UREs (Young, 1999; Sunami, 2002; Sanders & Yang, 2003; Xue, 2004; Zhao et al., 2004; Eun et al., 2006), building on which Kroll and Liefner (2008) compiled a summary of causes. First, top managers of UREs are usually nominated by university administrators, and are frequently unqualified and lacking entrepreneurial spirit (ibid.). Second, the intended organizational integration between universities and UREs often result in inefficient overlaps in responsibilities (ibid.). Third, as state-owned enterprises, UREs are backed by universities and very often governments, and therefore could easily obtain loans from state banks, leading to indiscretionary project planning and implementation (ibid.). Fourth, UREs suffer from deficient incentive structure, where the rights of researchers, developers, and financial contributors are usually vaguely defined and loosely protected (ibid.). Fifth, university administrations tend to interfere excessively in UREs’ everyday business, disrupting sound decision-making (ibid.). Sixth, many large UREs lack clearly defined core capabilities and spare their resources over an unnecessarily wide range of activities (ibid.).

The aforementioned historical factors prioritizing UREs as a mechanism to commercialize university research gradually eroded over years. In other words, other mechanisms, such as technology licensing, affiliated science parks, collaborative R&D with industry, became more viable. Given this as well as the economic losses UREs brought to university budgets, the State Council in 2001 issued
the “Memorandum on the Experiment of Standardizing University-run Enterprises Management at Peking University and Tsinghua University”, which basically called for de-linking UREs from universities (Eun et al., 2006). Wu (2010) also observes that since the late 1990s, many UREs have begun to reform their governance structure to distance themselves from university administrations, and university departments have also gradually gave up control of enterprises, which caused a steady nationwide decline of wholly owned UREs since 2000. Decreasing in number, losing policy favor, alienated from universities, and rivaled by other commercialization channels, UREs seem to have lost their preeminence as university technology commercializers. Arguably, the URE system will no longer be a dominant actor in China’s research commercialization arena.

2.4 Summary and discussion

Pitting the above-reviewed studies against the three guidelines set out in section 1.1, the region/university-centered studies in section 2.2 pay insufficient attention to the national context, while the agency/mechanism-centered studies in section 2.3 lack local depth, and neither of them examine inter-layer governmental coordination. In addition, the existent literature on China’s UILs is problematic in three ways. First, the empirical scope is limited. Region/university-centered studies have concentrated largely on several high-profile Chinese metropolises, i.e. Beijing, Shanghai, Shenzhen, and Chongqing, whose S&T endowments or political capital are unparalleled in other cities. Indeed, a disproportional amount of ink has been spilled on ZGC, as if it is the only visible commercialization site in China. Even the ZGC literature hardly specifies the important university-industry interaction dynamics. With the exception of UREs, studies on specific research commercialization agencies/mechanisms are surprisingly limited. Overall, the growth of empirical documentary patently lags behinds the proliferation of UILs in China. An up-to-date comprehensive understanding of China’s efforts in advancing knowledge commercialization awaits more empirical studies.

Second, the UIL research on China is thus far lacking in theory. While in China university-industry liaison is a relatively new research domain, in the United States and to a lesser extent in Europe a much richer and nuanced block of literature is already in place (e.g. Saxenian, 1994; Appleseed, 2003; Lenoir et al., 2003; Rosenberg, 2003; Mowery et al., 2004). Accompanying accumulative empirical knowledge is also a process of theory diversification and fine-tuning (see the next chapter). However, thus far few efforts have emerged to infuse Chinese innovation studies with theories. Theory-guided studies can arguably generate more and deeper insights. Paying meager attention to theory, current
Chinese UIL studies also miss the opportunity of theory building and/or nuancing, as well as cross-fertilization with overseas UIL research.

Third, current works are more descriptive than analytical. Different commercialization mechanisms are frequently juxtaposed, with their objectives and responsibilities listed, and their performance laid out (as gauged by numbers of deals accomplished, revenues generated as well as patents filed and obtained). However, “how these mechanisms actually work”, “how governments, universities, enterprises, and innovators interplay at institutional interfaces”, “how commercialization is impeded by various obstacles” – these questions are rarely explored sufficiently. In this way, various commercialization mechanisms are presented as “black boxes” measured by outputs while leaving the internal dynamics unpacked. Analytically thin studies can hardly diagnose the deficiencies and limitations within the current system, paralyzing the formation of policy suggestions.

This study strives to address all the three identified limitations. First, Nanjing is selected as a case study to broaden empirical scope. Nanjing, the national third biggest S&T hub (Nanjing Government, 2009), so far has had little scholarly exposure. It differs from Beijing, Shanghai and Chongqing, since it has a provincial government to report to, rather than being directly under the central government. This additional layer of hierarchy adds nuanced dynamics that could not be uncovered in Beijing, Shanghai or Chongqing stories. Nanjing also differs from Shenzhen in both its rich S&T endowment, and its lack of any “Special Economic Zone” status – a token for political flexibility and decision-making autonomy. Subjective to both central and provincial planning and without special political designation, Nanjing is arguably administratively more representative of the majority of Chinese cities. Second, chapter three surveys major existent theoretical models for innovation studies, and based on an evaluation of them, proposes a China-specific model. This chapter is intended not only as a theoretical guide for this thesis, but also as a preliminary attempt for infusing Chinese innovation studies with theories. Third, attempts are made to weave together descriptive materials with analytical reflections in chapter four to six. Chapter four strives to uncover China’s innovation framework set-up in terms of multi-level institution, policy and program arrangement, which colors specific research commercialization approaches. This chapter introduces the concept of “hierarchical amplification” to explain the idiosyncratic features of China’s national innovation system. Chapter five scrutinizes four different university research commercialization agencies operating in Nanjing, combining empirical description with analytical discussion. The last chapter of this thesis summarizes the research and also examines the impediments in China’s commercialization system. In sum, with a case study on the neglected Nanjing, a rich theoretical
discussion, and elaborate analytical elements, this research aims to broaden and deepen the current literature.
Chapter 3. Building the Theoretical Grid: A Survey of Innovation Theories and a Quest for a China-Specific Model

3.1 Introduction

One objective of this research is to build a theoretical grid to scrutinize China’s regional/local innovation system, since existent studies are observed as largely theory-inadventent (see section 2.4). As discussed in section 1.1, China’s overall centralized political economy harbors intricate inter-level governmental interactions and significant geographical unevenness. This entails a multi-scalar theoretical instrument with a regional/local focus as well as a broad national perspective. This chapter seeks to achieve the objective of theory building by delineating the development trajectory of innovation theories, and based on this, proposing a China-specific theoretical model. This chapter is written in an elaborate manner because it not only anchors the theoretical grid guiding the rest of this thesis but also intends to fulfill its stand-alone (rather ancillary) purpose of contributing to the theorization of the Chinese innovation literature.

Ever since Joseph Schumpeter (1934) started systematic studies of innovation, the research archive has seen interlaced enrichment of both empirical knowledge and theoretical novelty. The historical conceptualization of innovation as a linear process – “pushed” by corporate internal R&D activities, and “pulled” by market demands – has long been phased out (Santos, 2000). Replacing it is an understanding that innovation is the outcome of systematic interaction of various organizations and procedures, localized in a territorial web of interconnected political, economic and social relations (Fromhold-Eisebith, 2007). In other words, innovation must be addressed in terms of “systems”, encompassing both organizations and institutions (Fagerberg, 2005). “Organizations are formal structures that are consciously created and have an explicit purpose”, such as firms, universities, public and private research institutes, venture capital organizations, public agencies responsible for innovation-related policy, and bridging institutes operating to facilitate interactions among other innovation agents (Edquist & Johnson, 1997, p.46-7; Edquist, 2005). “Institutions are sets of common habits, norms, routines, established practices, rules, or laws that regulate the relations and interactions between individual, groups, and organizations” (Edquist & Johnson, 1997, p.46; Edquist, 2005).

While innovation systems are sometimes delineated on the basis of technological, industrial, or sectoral characteristics, propagating specific technology-/industry-/sector-centered innovation systems (e.g. Hughes, 1983; Carlsson & Stankiewicz, 1991; Carlsson, 1995; Breschi & Malerba, 1997;
Malerba, 2002), a more policy-relevant and commonly adopted approach is to demarcate system boundaries along geographical (national or regional) borders. Accordingly many scholars have adopted the “National Innovation System (NIS)” or “Regional Innovation System (RIS)” analytical framework (for NIS, see Freeman, 1987; Lundvall, 1992; Nelson et al., 1993; for RIS, see Cooke et al., 1997; Braczyk et al., 1998; Cooke, 2001; Asheim & Isaksen, 2002). Over time, innovation systems have been discussed at a range of scales, from national to regional and international. Attempts have also emerged to bridge multiple scales and construct a cross- or multi-scalar methodology. Another theoretical school, which represents itself in contrast to the “system” discourse, contends that innovation is best to be understood as a scale-independent Triple Helix (Leydesdorff & Etzkowitz, 1996). Whereas understanding of innovative process has become more sophisticated and nuanced, the proper theoretical model for innovation research has become more blurry and contested. Though difficult to pin all pertinent theories within one survey map, the path of innovation theory development could be best traced along the debate of scale, or more specifically which geographical scale is the best to capture the full dynamics of innovative agents and their interplay. In the following, single-scalar theories of innovation systems are reviewed first, followed by an elucidation of emergent cross- and multi-scalar approaches. Then, the author examines the scale-independent Triple Helix model. Finally, based on a discussion of the three categories, a theoretical model tailored to the Chinese context is proposed.

3.2 Single-scalar systems of innovation

National Innovation System (NIS)

The first theory enshrining the systematic vision of innovation is NIS. This concept was proposed by Freeman (1987) in his study of Japan’s technology development, where he defined it as a network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies. A rich literature has accumulated along this strand of analysis (e.g. Lundvall, 1992; Nelson, 1993; Freeman, 1995; Metcalfe, 1995; and Edquist, 1997). The agents encompassed within an NIS include 1) public agencies formulating and implementing S&T policies; 2) enterprises (public and private, indigenous and foreign); 3) public and private research institutes; 4) higher education institutions; and 5) bridging institutes, operating to facilitate interactions and resolve mismatches among other innovation components (Chang & Shih, 2004). NIS studies explicitly adopt “nation” as the unit for innovation investigation.
Validating the NIS doctrine are two broad categories of nation-specific factors (Bunnell & Coe, 2001). First, national-level policies and institutions assert state influence upon innovation. Labor market, IPR regime, industrial policies, S&T policies, education and research funding for public universities – essential elements in an innovation system, are all subject to the influence of state regulation and coordination. OECD (2000) prescribes a list of national policy instruments conducive to innovation promotion: those favorable to start-ups and to financial corporations supporting start-ups; regulatory and institutional frameworks that facilitate links between science and industry; support of basic scientific research; and the education and training of necessary human capital.

Second, national-specific socio-cultural characteristics also bear on innovation. After examining a series of NIS case studies, Nelson (1993, p. 518) asserts that, “in all these cases, a distinctive national character pervades the firms, the educational system, the law, the politics, and the government, all of which have been shaped by a shared historical experience and culture”. Different nations are also believed to have different processes of learning (Andersen & Lundvall, 1997). The “nation” is contended to be the best scale to grasp the impacts of “cultural proximity” upon domestic innovation (Gertler, 1995).

NIS theory delivers important insights for sure, but the suitability of “nation” as a coherent analytical unit for innovation activity has been increasingly problematized by regionalization and globalization literature. On the one hand, NIS theory’s neglect of the uneven innovation geography within a nation as well as barely mobile locally bounded innovative assets has promoted a downscaling of innovation research (e.g. Bunnell & Coe, 2001). On the other hand, globalization of innovative resources (i.e. technologies, R&D facilities, and high-skill employees), facilitated via cross-border inter-firm interactions or orchestrated within a MNC conduit, triggered an upscaling of innovation analysis (ibid.). Nation, as a fundamental scale of innovation studies, has consequently been denaturalized (Taylor, 1996).

Regional Innovation System (RIS)

Unlike NIS research, which employs a more or less unified rhetoric, the discourse of localized innovation system bifurcates into various branches and proliferates a range of territorial innovation models (TIMs). Some examples are industrial districts (e.g. Scott, 1988), clusters (e.g. Porter, 1990), innovative milieux (e.g. Camagni, 1991), neo-Marshallian nodes (Amin & Thrift, 1992), technology districts (e.g. Storper, 1993), technopoles (e.g. Castells & Hall, 1994), learning regions (e.g. MacLeod, 2000), and RIS (e.g. Cooke et al., 1997, 1998). After a critical review of multiple TIMs, Moularst and Sekia (2003) conclude that despite their diverse theoretical genealogies, they share a common ground
– economics of agglomeration, endogenous development theory, innovation systems theory, and network theories. Here, the focus is put on the RIS model, for its clear antecedence to the NIS model and resemblance to other TIMs.

The RIS concept was introduced by Cooke et al. (1997, 1998) as a blending of the so-called “new” regional science (see for example Storper, 1997), and the evolutionary economic theories embedded in the NIS discourse. Borrowed from the former is a strong emphasis on notions such as “proximity, trust, institutions, norms, routines, conventions and learning in the regional context”, and from the latter comes a focus on innovation as a “dynamic, interactive and systematic process” (Bunnell & Coe, 2001, p. 575). Accordingly, Cooke et al. (1998, p. 1581) define RIS as a complex “in which firms and other organizations […] are systematically engaged in interactive learning through an institutional milieu characterized by embeddedness”. RIS theory explicitly puts its analytical lens upon localized clusters of tangible organizations – e.g. enterprises, research institutes, and universities, as well as locally bounded intangible assets circulating among these organizations – e.g. tacit knowledge, know-how, and conventions. Innovation-orientated cooperation among co-located innovative organizations, and exchange of innovation-fertilizing assets, are believed to happen on a territorial seedbed of socio-cultural commonalities, values, and friendships (Maskell & Malmberg, 1999). Therefore, “region” is argued to be the most appropriate scale for understanding systematic innovation as well as organizing policy interventions (Cooke, 1992). Empirical studies based on the European context validate the regional focus by showing that technology-intensive small and medium size firms are highly oriented towards regional collaboration as an innovation strategy (e.g. Koschatzky & Sternberg, 2000). A large portion of RIS research is specifically concerned with cities (Bunnell & Coe, 2001). Crevoisier (1999, p. 70) regards cities as the context where “the resources required in innovation process develop and come into contact with each other”. Whether adopting region or city as the analytical focus, the scaling down of NIS theory is designed to remedy its ignorance of patently uneven innovation landscape within one nation.

International Innovation System (IIS)

Besides the national and regional perspectives, there is a growing awareness that an international dimension needs to be incorporated into the systematic understanding of innovation (Howells & Wood, 1993; Niosi & Bellon, 1994; Hotz-Hart, 2000; Bunnell & Coe, 2001; Asheim & Herstad, 2005). Underpinning this assertion are two trends: cross-national technology circulation among

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1 Innovation actors are believed to interact with each other, and therefore keep the national innovation system in a dynamic status.
corporations, and internationalization of R&D activities within MNCs. First, facing an increasing rate of technology change and a decreasing product life cycle in the 1990s, firms were stressed to diversify and upgrade their technology base at a sufficient pace (Carlsson, 2006). Firms responded by exploiting foreign innovative capabilities and competence, usually in forms like financing foreign R&D laboratories, purchasing technology licenses, and establishing technological alliances (ibid.). Locals are no longer the sole providers of innovativeness, technologies can be sought and developed elsewhere, cross-region or cross-border. Second, MNCs are orchestrating innovation internationalization, by strategically reconfiguring their global R&D networks. A stream of empirical studies, based upon patent data, have demonstrated an increasing volume of MNCs’ overseas R&D activities (e.g. Cantwell, 1989; Howells, 1990; Zejan, 1990; Sigurdson, 1992). Patel (1997) throws in a twist by stating that the increase in technology internationalization is largely due to overseas mergers and acquisitions rather than means of organic growth. Also employing patent-based empirical investigations, other researchers confirm that the vast majority of MNC R&D still highly concentrates within the global triad of the United States, Europe and Japan (Patel & Pavitt, 1991; Patel, 1995; Pearce & Singh, 1992; Patel & Vega, 1999). Brockhoff (1998) contends that when various measures of international R&D are employed (beyond just patents), the increasing magnitude of R&D internationalization gets more obvious. Further complicating the discussion is the view that overseas MNC R&D activities tend to be less science-based than those in home countries, and tend to be in fields outside the companies’ core competencies (Carlsson, 2006). Despite controversies around the scope and nature of R&D internationalization, it is generally agreed that this trend does constitute extra-national innovation factors that both NIS and RIS frameworks fail to capture. Consequently, “nation” and “region” are rejected as inadequate scales for innovation research; the current globalization trend entails an international dimension (Bunnell & Coe, 2001). Fromhold-Eisebith (2007) coined the “International Innovation System (IIS)” to reflect this theoretical turn, in analogy to NIS and RIS.

3.3 Cross- and Multi-scalar approaches

The three single-scalar theoretical approaches reviewed above, albeit mutual recognition of insights from others, all privilege their respective analytical scale as the most appropriate to interrogate innovation and generally follow separate narrative lines. The mutual exclusiveness of different single-scalar innovation research started to spark concerns. For example, Hotz-Hart (2000, p. 444) realizes that “systems of innovation are increasingly complex and intertwined, with regional, national, and international levels of integration of innovation activities”. Oinas and Malecki (1999, p. 10) talk
about “spatial innovation systems” consisting of “overlapping and interlinked national, regional and international systems of innovation which all are manifested in different configurations in space”. Arguably, none of NIS, RIS or IIS functions in isolation; and researchers have probed to establish a framework to think across multiple layers and illustrate inter-layer dependencies. The two attempts identified come from Bunnell and Coe (2001) and Fromhold-Eisebith (2007). They both seek to interweave different scalar agents, but in contrasting ways – the former favoring a de-scaled horizontal network approach, whereas the latter interconnecting different scales to form a vertical multi-scalar model. For distinction, these two approaches are designated respectively as “Cross-scalar Innovation Network” and “Multi-scalar Innovation System”.

**Cross-scalar Innovation Network**

Bunnell and Coe (2001, p. 583) first problematize the systematic view of innovation by stating that “the very conception of a system suggests both an internal coherence and a more or less bounded distinction from other systems”, which they believe are out of tune with the current reality. They also take issue with NIS/RIS theory’s blindness to extra-national innovation factors. In contrast, a network view, emphasizing the construction of networks and the ability they give certain participants to “act at a distance”, could cut cross the local, regional and global, and offer insights about innovation processes that scale-restricted studies cannot. Local innovation agents should be treated as nodes in transnational networks rather than fragments restricted within any scalar containers (i.e. nations, regions). Accordingly, they propose “networks, with their associated attributes of connectivity, reciprocity, embeddedness and power relations, … to be brought to center stage” (ibid., p. 578). This epistemological shift from hierarchical scales to horizontal networks echoed a wider trend of descaling and flattening research in social sciences, which entangles with the rigidity and downward dominance presumed by hierarchical scales, and promotes a more fluid, contested and flat epistemology (e.g. Beauregard, 1995; Kelly, 1997; Swyngedouw, 1997; Cox, 1998; Marston *et al.*, 2005). This change also entails an analytical shift from territorial systems towards specific innovation actors as well as the flows and interconnectivity among them. Thus, Bunnell and Coe (2001) follow on to discuss what they view as the fundamental nodes in innovation networks - firms and individuals.

In addition to aforementioned cross-border inter-firm R&D circulation and intra-MNC transnational R&D deployment emphasized in the IIS literature, Bunnell and Coe (2001) introduce another dimension of innovation internationalization. Citing Thrift (1997, p. 59), they state “successful organizations will be those that are able to diffuse essentially local tacit knowledge over
space through limited amounts of codification and interaction”. In other words, what circulate along MNCs’ intra-firm conduits are not only codified knowledge and technologies, as gauged often by patent numbers, but also less measurable tacit local knowledge. Thus, the assumption in the RIS camp that tacit innovative assets are territorially attached and only locally exchangeable is refuted, and the distinction between mobile codified knowledge and immobile tacit knowledge is blurred. Innovation internationalization is more extensive and deeper than usually assumed, undermining the relevance of regional proximity and territorial specificity. Furthermore, the role of migrating individuals (high-skill employees, experts, and managers) in innovation internationalization has been insufficiently conceptualized (Bunnell & Coe, 2001; Fromhold-Eisebith, 2002). Highly mobile employees carry with them knowledge, expertise and socio-cultural familiarity to specific contexts when they migrate along both intra- and inter-corporate networks. Human migration acts as another manifestation of how innovation networks cut through bounded national or regional systems of innovation, and how innovative assets could be detached from territory, mobilized and transferred around the globe. In conclusion, technology, R&D activities, tacit local knowledge, and individual innovativeness carriers – innovation-related agents that are traditionally understood as territory-attached and local-bounded, are proved to be more and more globally mobile. It is based on this that Bunnell and Coe (2001) appeal for a cross-scalar and network-based epistemology.

Multi-scalar Innovation System

Fromhold-Eisebith (2007) cautions the descaling tendency in Bunnell and Coe (2001)’s network approach, and advocates a “National Supersystem of Innovation (NSSI)” model which bridges all three scales. The NSSI model is depicted in Figure 3, which illustrates two major points. First, NIS and RIS never operate independently. “Long-term evolution of regional industrial specializations, longstanding core-periphery differences within countries, the socio-cultural embedding of trustful knowledge-intensive collaboration, and the existence of particular regional government or governance structures and informal institutions” constitute regional particularities that speak in favor of a regional focus for innovation investigation (Fromhold-Eisebith, 2007, p. 222). However, these specificities militate under “nationally determined and constructed infrastructure, institutional and political settings” as well as a national socio-cultural milieu (ibid., Figure 3). On the other hand, NIS is not static, but also evolves partly to cater to local innovative demands or to maximize local innovation potentials. The national infrastructure, institution, policy and socio-culture framework, thus, is subject to the influence of regional innovative development as well. The performance of a
NIS is largely determined by its RISs and mutual interactions among them (Figure 3). In short, NIS and RIS are mutually constitutive.

Second, instead of floating aloft national and regional systems, international networks refract through them (ibid.). The argument that international networks could tap into local innovative assets bypassing the influence of NIS and RIS is an exaggeration. Since integrating and exploiting region-specific advantages is the primary drive of cross-border innovation collaboration and deployment, IIS influence could arguably be best examined at the regional scale (Figure 3). Furthermore, the extent and nature of R&D shift, technology transfer, employee migration and strategic technological alliance – channels of innovation internationalization, are all subject to the regulation of NIS and RIS (Figure 3). International impacts upon NIS and RIS are indisputable, but could be a double-edged sword. Innovation internationalization, to some nations could be a notorious hollowing-out of domestic innovation power and capacities, while to others an injection of fresh blood cultivating new innovation strengths and potential (Niosi & Bellon, 1994; Oinas & Malecki, 1999).

This NSSI approach has the advantage of focusing political attention on important inter-scalar questions submerged in single- and cross-scalar models, such as “To which extent and in which way do well-functioning RIS make up a successful NIS? Is a good NIS (policy) defined as explicitly enabling the development of effective RIS? Is the basic concept of ‘system’ the same in the case of NIS and RIS or not and what does this mean for policy design? How could international impulses be integrated best, on the scale of NIS or RIS?” (Fromhold-Eisebith, 2007, p. 222).

Figure 3. National Supersystem of Innovation
Source: Fromhold-Eisebith (2007)
3.4 Scale-independent Triple Helix Model

One increasingly influential school of innovation theory that presents itself in contrast to the innovation system doctrine is the Triple Helix model. This model aims to explain the formation and evolution of innovation by theorizing the interaction among three specific actors - academia, industry and government (each representing one helix). This theory emerged out of a workshop on “Evolutionary Economics and Chaos Theory: New Directions in Technology Studies” (Leydesdorff & Van den Besselaar, 1994), organized to fuse institutional analysis of the knowledge infrastructure (e.g. Etzkowitz, 1994) with evolutionary analysis of the knowledge base of an economy (David & Forey, 1994; Nelson, 1994). Later, Henry Etzkowitz and Loet Leydesdorff contributed significantly towards its maturation. As an innovation theory, it contrasts with the traditional “innovation system” rhetoric in several ways: it adopts a neo-network epistemology, it elevates the status of academia to be equivalent to state and industry as an economic player, it is neo-institutionalist in understanding the relationship among three helices, and it is neo-evolutionary in depicting the interaction among three helices.

- Neo-network Epistemology

Though the Triple Helix model does not explicitly address scale issues, it is de facto applicable at different scales, national or subnational. While it aligns somehow with the network method, its network only enlists same-scalar actors, differing from Bunnell and Coe’s (2001) cross-scalar approach which nests different scalar actors within one network. In addition, it differs from traditional definition of networks composed of interconnected nodes, since in a Triple Helix different nodes overlap with each other rather than relate at arm’s length (see the following). Thus, this author terms this new epistemology a “neo-network”.

- “Entrepreneurial University”

In sharp contrast to traditional configuration where the university is considered to be a talent, knowledge and idea provider, auxiliary to industrial or state interests, the Triple Helix model explicitly contends that the university is an equivalent player as state and industry in the current

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1 Key papers detailing the Triple Helix theory include Leydesdorff & Etzkowitz, 1996, 1998a, 1998b; Etzkowitz & Leydesdorff (eds.), 1997; Leydesdorff, 1997, 2000; Etzkowitz & Leydesdorff, 1998; Etzkowitz & Leydesdorff, 2000; Etzkowitz, 2003; Etzkowitz et al., 2000; Leydesdorff & Meyer, 2003, 2006; since they overlap extensively in explaining the Triple Helix theory, and sub-section 3.4 is based on a collective reading of them, sentences in this section will not be referenced on a one-by-one basis.

2 Ibid.
knowledge economy. This notion is based on three observations: first, as the knowledge economy escalated the importance of intellectual capital, the economic salience of universities is elevated accordingly; second, accompanying the proliferation of industrial and engineering sciences, universities are demonstrating an increasing entrepreneurial ethos which does not see fundamental discoveries as the end of scientific and technological inquires but their applications; third, government policies in North American and Western Europe, now increasingly in East Asia, are encouraging deeper university engagement in economic development, as demonstrated by a series of intermediate processes and institutions stimulated by government to accelerate the commercialization of university research. Based on this, Triple Helix theorists declare that universities are undergoing a second academic evolution which adds a third mission – socio-economic development – to their previous agenda of teaching and researching (researching is believed to be the second mission added around World War II). Universities that successfully integrate the three missions are called “Entrepreneurial University”, a concept first introduced in 1998 by the American sociologist Burton R. Clark in his study “Creating Entrepreneurial Universities: Organizational Pathways of Transformation” (Bratinu & Stanciu, 2010). Since the university is viewed as a central player, the Triple Helix model focuses its analytical lens on universities, different from the NIS/RIS approach where industry is placed at the forefront, or the “Triangle” model of Sabato (1975) where the state is privileged.

- Neo-institutionalist institutional relationship

The Triple Helix Model is neo-institutionalist in contending that the boundary between academia, industry and government is in flux, and the three institutional spheres are overlapping both in function and institutional setting. In terms of function, entrepreneurial universities not only perform traditional roles as talent training and research, but also take a proactive role in targeting demanded technologies, licensing research findings and nurturing start-ups; firms not only utilize their “absorptive capabilities” (Cohen & Levinthal, 1990) to recognize, assimilate and commercialize university-generated technologies, but also engage in higher levels of employee training and internal R&D; and governments go beyond their traditional regulatory role as policy makers to act as public entrepreneurs and venture capitalists. Therefore, universities, firms and the government all “intrude” into function domains traditionally perceived as out of their realms; in other words, the once one-to-one corresponding relation between functions and institutions is mixed. Speaking of institutional setting, technology transfer offices, science parks, incubators and other arrangements frequently involve and bring together all three parties, again blurring the once solid institutional boundaries.
This image of institutional overlapping is presented in contrast to two opposing paradigms: first, a statist model of government controlling academia and industry, and second, a laissez-faire model, with industry, academia, and government separate from each other, interacting only modestly across strong boundaries (Figure 4). The statist model is believed to represent the situations in the former Soviet Union as well as some European and Latin American countries, in the era when state-owned industries were predominant. The laissez-faire model intends to reflect the way the US is supposed to operate, at least in theory. The overlapping regime, where each actor maintains its special features and unique identity while also taking the role of the other, is deemed as the new norm.

• Neo-evolutionary interaction

According to traditional innovation system studies, the interaction among academia, industry and government is believed to be evolutionary, that is the inputs and outputs of each actor undergo changes over time. The Triple Helix model advances this understanding further to argue that not only the parameters of interaction are changing, but the ways of interaction and the institutional setting of each actor are also constantly changing. In other words, a Triple Helix is not synchronized a priori so that three helices interact with each other within a fixed setting and via fixed channels, but subject to constant and recursive reconfiguration. Sociological concepts such as “institutional retention”, “re-combinatorial innovation”, “reflexive controls” and “constructivist institutionalism” are all folded into this new understanding. Figure 5
indicates how three helices develop an emerging overlay of communications, networks and organizations among the helices, and form an eternally evolutionary triple helix. Each institutional strand is subject to its internal dynamics, and this one-dimensional fluctuation disturbs prior bi-dimensional equilibrium and exerts destabilizing efforts upon other two strands to co-evolve reflexively, and ultimately drives the entire three-dimensional constellation into transition. Because the emerging order of a new innovation regime is pending and exerting selection pressure, the interaction among the three institutional carriers is entrained in evolutionary drifts, striving to retain the hitherto best possible fits. The underlying assumption of this neo-evolutionary epistemology is that academia, industry and government all aspire to the same goal of optimizing the effectiveness and functionality of the triple helix; however, this may not be the truth, since there is strong belief that institutions act out of their specific volitions rather than a cross-institution common goal.

3.5 A theoretical model for China

As previously stated, a China-specific theoretical model should meet three criteria: 1) account for central-level innovation regime design, since China is still highly centralized in grand national endeavors; 2) maintain an adequate region/local focus, as China is especially uneven over geography both in terms of political and economic muscle as well as resource and talent endowment; and 3) remain attentive to intricate inter-layer governmental interaction and coordination, which influence how central arrangements materialize. Single-scalar innovation system theories, cross- and multi-scalar approaches, and the Triple Helix model have all been reviewed above. Which one or selective combination of them satisfies the three criteria?

The highly polarized national landscape of China (e.g. the S&T gaps between east and west) defies a single-scalar NIS approach, which inevitably misses regional and local nuances. A RIS approach focusing on local dynamics is also insufficient, lacking a thorough scrutiny of central-level S&T configurations. International technology transfer and cross-border talent migration are surely important elements, and are becoming more so as China further integrates itself into the global S&T web. A holistic panorama of China’s innovation paradigm should certainly incorporate international dimensions; nevertheless, this thesis focuses on research commercialization of Chinese domestic universities in which the role of international actors is barely visible, therefore international elements are neglected here. Then how can we bridge national and subnational actors, via a cross-scalar network approach (à la Bunnell & Coe, 2001) or a multi-scalar supersystem approach (à la Fromhold-Eisebith, 2007)? The author favors the latter. It is unrealistic to nest all innovation actors in one horizontal network, since different government layers in China demonstrate a rigid power
hierarchy, and non-government actors by no means possess “horizontal” relationship with government ones. In contrast, the multi-scalar approach aligns better with the Chinese reality.

Application of the Triple Helix model to China demands special caution. The three underlining features of the Triple Helix – 1) equivalent position of government, industry and academia, 2) overlapping institutional boundaries among the three, and 3) neo-evolutionary interaction among them – are not ubiquitous. In the case of China, universities are by no means at an equivalent decision-making position with the government; actually, one can argue that both universities and industry are within the grip of government in China’s highly-centralized regime, resembling the statist mode in Figure 4. Overlapping functions and institutional settings may be observable in both the West and the East; however, inter-institution interaction is hardly neo-evolutionary in either one. Configuration of each institution as well as the channels and norms of their interaction endure significant inertia and path dependency, constant and recursive reconfiguration to form a dynamic equilibrium is far from the truth. Besides, the latent assumption that industry, government and academia work towards the same goal of system optimization is unwarranted as well. In a nutshell, the Triple Helix model, though inspiring, is more like a theoretical imagination rather than an observable reality. Actually, Etzkowitz (2003, p.332) explicitly states: “the prerequisite for a viable Triple Helix model is a free and open democratic society”. The applicability of the Triple Helix to a country like China demands serious reconsideration.

Merging the multi-scalar philosophy à la Fromhold-Eisebith (2007; Figure 3) with the statistic government-industry-university relationship model (Figure 4), a China-specific theory model (see Figure 6) is proposed by the author. As shown, the lower-level innovation systems are nested in higher-level ones. Policies, institutions, and programs concerning innovation are followed and elaborated downward along administrative hierarchy, while local novel endeavors may receive the attention of central decision-makers. At the local level, universities and firms interact via various ways, but both maneuver within a government-orchestrated space rather than occupying equivalent positions. It is noteworthy that though Figure 6 uses three tiers of government to illustrate multi-layer space, the exact number of hierarchical layers may vary. For large municipalities directly under the central government, i.e. Beijing, Shanghai, Tianjin, and Chongqing, since they are administratively equivalent to provinces, there is no provincial intervention hovering above. For municipalities under provincial jurisdiction, S&T activities are influenced by at least three layers of government monitoring (i.e. national, provincial, municipal). County or district government may take a stake in certain S&T activities as well. Employing this theoretical model, the next chapter first
surveys the multi-layer institution, policy and program framework currently deployed in China to foster research commercialization, and explores inter-layer dynamics. The inter-layer relationship are observed to exhibit a “hierarchical amplification” pattern. After that, chapter five examines four sets of commercialization agencies operating under this multi-layer framework in Nanjing.

**Figure 6.** An innovation model for China
Chapter 4. Framework Apparatus of China’s University Research Commercialization Regime: Multi-Layer Institution, Policy and Program Framework and Inter-Layer Dynamics

4.1 Introduction

Employing the theoretical model developed in the last chapter and as a background to the elaborate Nanjing case study in the following chapter, this chapter aims to uncover the multi-layer institution, policy and program framework underpinning university research commercialization in China. Specific commercialization mechanisms all operate upon this framework. In other words, the framework apparatus surveyed here conditions the dynamics and sets the parameters for what is possible on the ground. The focus of this chapter is on the segment of framework pertinent to research commercialization, rather than the entire framework for China’s national innovation system, which embroils additional aspects such as basic research promotion, corporate internal R&D stimulation, human talent cultivation and foreign technology acquisition. The bulk of this chapter consists of three sub-sections scrutinizing respectively multi-layer institutions, policies, and programs (Jiangsu province and Nanjing municipality are used for illustrating subnational arrangements). Preceding that the evolutionary history of China’s S&T system is sketched to highlight historical legacies. An evaluative summary concludes this chapter by discussing inter-layer coordination patterns in the current multi-layer framework. The discussion introduces the concept of “hierarchical amplification” to denote the specific characteristics of China’s innovation regime.

4.2 China’s S&T system in transition

As mentioned in section 2.1, a large portion of the existent literature concerning university research commercialization in China aims to document the evolution of China’s S&T system from the foundation of the People’s Republic of China in 1949 to the contemporary period, as well as the policy and institutional reforms underpinning the evolution (e.g. World Bank, 1997, 2001; Gu, 1999; Sun, 2002; Zhang, 2003; Ma, 2004; Xue, 2006; Xue & Zhou, 2007; OECD, 2008). Figure 7 illustrates how China’s S&T system has transformed over time, with milestone policies and initiatives highlighted. Figure 8 and 9 constitute pictorial illustration and contrast of pre- vis-à-vis post-reform national S&T systems.

Shortly after the foundation of the communist regime in 1949, China imported a highly rigid and centralized Soviet S&T model (Xue, 1997; Sun, 2002; Liu & White, 2001; OECD, 2008). Within that
Figure 7. Reform of China’s S&T system
Source: OECD, 2008, p.72 (with modifications)
system, HEIs, PRIs and enterprises were all affiliated to different levels of government entities, i.e. the central government, ministries, and local governments (as shown in Figure 8, HEIs, PRIs and enterprises are classified into different categories based on their affiliation to different government bodies). In addition, HEIs, PRIs and enterprises undertook distinct and separate roles assigned by their authorities, and barely related to each other in a direct manner (see Figure 8). The designated task for HEIs was teaching (with marginal research involved) and supplying manpower to industry and academia (see the flow arrows in Figure 8 from the HEI sector to the other two). Colleges belonging to a certain industrial branch ministry catered to the personnel needs of that specific industry (Xue, 1997). For example, graduates from colleges affiliated with the Ministry of Agriculture found work only with agriculture-related research institutes and firms. PRIs were designated as research undertakers, with CAS in charge of the majority of basic research and some applied research (ibid.). PRIs affiliated with a certain industrial ministry also focused specifically on related research domains (ibid.). For example, PRIs affiliated with the Ministry of Agriculture concentrated on agricultural technologies. Manpower from HEIs and research findings from PRIs were channeled by their supervisory ministries to corresponding SOEs, which were responsible for production (ibid., see the flow arrows in Figure 8 into the industry sector). The central government planned teaching programs, student enrolments, research agenda, job/internship assignment, and industrial production, and orchestrated talent, technology and capital flows among the three sectors, all according to the contemporary five-year plan. The top-down centralized S&T system proved to be a failure, however, as demonstrated by China’s extreme economic hardship throughout the 1950s to the 1970s. Only after Deng Xiaoping came into power and initiated economic reorientation in the late 1970s could new policies be introduced.

The starting point of S&T reforms in China was the 1978 National Conference on Science and Technology, which marked an ideological departure from the Soviet model and stated that modernization of agriculture, industry and national defense entailed S&T modernization (OECD, 2008). In 1985, the “Resolution of the Central Committee of the Communist Party of China on structural S&T reform” trailblazed S&T reforms (Motohashi & Yun, 2007). After Deng’s 1992 South Talk demonstrating determination to continue market-oriented economic reform, national S&T reforms entered a new era (Motohashi, 2006). Changes accelerated further when in 1998 Deng’s successor – Jiang Zhemin – announced the “revitalizing the nation through science and education (kejiaoxingguo)” strategy at the fifteenth party congress (ibid.). In China’s fifteenth five year plan (2001-2005) and all successive ones, “economic development fueled by technological progress” remained a central theme, and “further stimulating innovation as well as reforming institutions to
abolish counter-innovation imperfections” constituted a pivotal priority in national agenda (World Bank, 2001). These top-level policy cornerstones paved the way for a decades long deepening of S&T reconfiguration that is still ongoing, as shown in the launch of various S&T directives and programs since then (Figure 7). As a result of policy reorientations, major S&T actors (i.e. PRIs, HEIs and enterprises) had all been significantly transformed after 1985, both in terms of their respective features as well as their mutual interactions (see the changes from Figure 8 to 9).

Indeed, following 1985 (see Figure 9) many PRIs (especially those affiliated to local authorities) were closed, or cut off from the government via either converting to private research institutes or merging into enterprises’ R&D units (OECD, 2008). PRIs remaining affiliated to governments were also instructed to diversify their financial sources through reaching out to the industry sector (Liu & White, 2001; Sun, 2002). As indicated by the changes from Figure 8 to 9, after S&T reforms research institutes started to perform joint research with both universities and firms and even set up affiliated enterprises, rather than solely providing research results demanded by SOEs.

HEIs also underwent large-scale adjustment, merging and decentralization. The majority of colleges affiliated to different ministries were transferred under the supervision of MOE to form a more streamlined management system¹ (World Bank, 1997; OECD, 2008). With the exception of a selective group of elite universities, other universities were granted administrative freedom, though MOE policies still weighed heavily on nationwide issues such as enrolment, tuition and faculty employment (Xue & Zhou, 2007). Student enrolment expanded, the total number of universities decreased, the portion of comprehensive universities increased, and the average teacher-to-student ratio improved (ibid.). As with research institutes, universities were also urged to seek alternative sources of funding, though the government still contributed the dominant share (ibid). Most importantly, HEIs were required to combine research with their previous sole task of teaching and encouraged to utilize their research outcomes by interacting with PRIs and enterprises (ibid). Over time, higher education overtook the PRI sector and became the major research sector in China (ibid.). The changes from Figure 8 to 9 indicate that instead of providing mere manpower to academia and industry as in the pre-reform period, post-reform HEIs conducted joint research with PRIs and enterprises, and even founded university-owned enterprises (a review of those enterprises is available in section 2.3).

¹ See the change from Figure 8 to 9 that the category of universities directly under ministries other than the Ministry of Education was eliminated.
Regarding enterprises, many were privatized and hence became responsible for corporate management, market competition, costs and benefits, as well as R&D. As shown in Figure 9, many enterprises were no longer affiliated with government bodies. Nevertheless, just stepping out of the planned system, the private sector remained underdeveloped in R&D capabilities, and needed research assistance from external R&D entities to tackle technological challenges (OECD, 2008).

Universities’ needs to seek non-governmental financing, coupled with enterprises’ needs to seek R&D assistance, opened up prospects of university-industry liaison. University research commercialization, though could be traced back to the pre-reform era in spontaneous forms such as university-affiliated work units (Xue, 2006), received increasing official endorsement after S&T reforms, and eventually constituted a policy priority (Xue & Zhou, 2007). The emergency of the need for a knowledge economy in China, the demonstration effects of successful knowledge clusters in the West (e.g. Silicon Valley, Route 128), and China’s urgency to upgrade its low value-added economy, has recently spurred concerted national efforts to engrave a “third mission” – research commercialization – into the higher education sector (Wu, 2007, 2010). The chapter now examines China’s major institutional arrangements for S&T, followed by policy frameworks and program initiatives at the national, provincial and municipal level.

4.3 Multi-layer institution framework

Three decades of S&T reforms have hatched a national infrastructure of institutions, policies and programs. This section seeks to uncover the institutional structures deployed at national, provincial and municipal levels to promote S&T development and university research commercialization.

National level

At the central government level, various government bodies are involved in innovation promotion (Figure 10). The highest-ranking coordination mechanism for S&T and education issues in China is the State Council (China’s Cabinet) Steering Group of S&T and Education (Guo Jia Ke Ji Jiao Yu Ling Dao Xiao Zu), founded in 1998. The Premier and the State Councilor in charge of S&T and education affairs serve as its chair and deputy head respectively (ibid.). This steering group is constituted of all ministers associated with S&T and education issues. It hosts China’s S&T and

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1 Section 4.3, 4.4, and 4.5 are mostly based on information collected and synthesized from OECD, 2008 (unless identified otherwise); thus, sentences are not referenced on a one-by-one base.
education system by making strategic decisions, coordinating all pertinent central-level government agencies, as well as drafting China’s Medium- and Long-term S&T Strategic Plans.

Under the steering group, MOST (see Figure 10) holds comprehensive responsibilities for the design and implementation of China’s S&T policies and programs. It is also the primary agency governing university research commercialization. Its main tasks include: 1) formulating strategies, priority areas, policies, laws and regulations for S&T; 2) conducting research on major S&T issues related to economic and social development; 3) guiding reforms of the S&T system; 4) formulating policies to strengthen basic research, high-tech development and industrialization; 5) designing and implementing programs to fund basic and applied research, to induce firms to innovate, to create science parks, incubators, and so on; 6) developing measures to increase S&T investments; 7) cultivating S&T talents; and 8) promoting international S&T cooperation and exchanges.

MOE (Figure 10) is another key national player in university research commercialization, since the majority of public universities in China are under its jurisdiction. It is currently responsible for designing and implementing policies related to higher education, university research, and the commercialization of research outcomes. MOE supervises and oversees, frequently in liaison with MOST, various commercialization measures concerning universities, such as university-run
enterprises, faculty start-ups, ownership of intellectual property, technology transfer, university science parks, and research collaboration with industry.

Another key stakeholder in innovation promotion as well as university research commercialization is the National Development and Reform Commission (NDRC, see Figure 10), which has wide-ranging administrative and planning control over all aspects of the Chinese economy, resembling to some extent its predecessor during the planning regime – the State Planning Commission (SPC). Its supreme authority in macroeconomic management has given it a critical role in formulating or approving measures for implementing national S&T plans as well as allocating resources for S&T programs. Among all the departments composing NDRC, the Department of High-technology Industry has a special role in innovation, since it is responsible for “monitoring the development of high-tech industries and technological development; for putting forward strategies, plans, policies, priority areas and investment projects for the development of new technology sectors and technological upgrading; and for recommending policies that support the development of key technologies” (OECD, 2008; p. 103). Other departments of NDRC, including the Department of Development Planning, the Department of Fixed Asset Investment, and the Department of Small and Medium-sized Enterprises (SMEs), also play an important role by adopting S&T development plans, approving investment for R&D infrastructure building, and formulating policies for SMEs.

In addition to MOST, MOE and NDRC, many other ministries and agencies are involved in innovation promotion and knowledge commercialization, but in a less direct manner (Figure 10). The Natural Science Foundation of China (NSFC), for example, is a specialized national agency for funding basic and technological research projects. The Ministry of Finance (MOF) has a key role in allocating capital resources to S&T programs and investing in R&D infrastructure. The Ministry of Personnel (MOP) works to foster talent for R&D and attracts returnee talent from overseas. The State Administration of Taxation designs various tax incentives to buttress the development of R&D, SMEs, science parks, high-technology development zones, and so on. The China Banking Regulatory Commission (CBRC), China Securities Regulatory Commission (CSRC) and China Insurance Regulatory Commission (CIRC) influence framework conditions for innovation financing and for stock market capitalization of innovation start-ups, and set up the regulatory framework for venture capital firms. The State Intellectual Property Office (SIPO) and the State Administration of Industry and Commerce both work to create a market environment with robust IPR protection and trademark protection that is conducive to fair competition. Furthermore, industrial ministries, such as the Ministry of Agriculture (MOA), the Ministry of Health (MOH) and the Ministry of
Information Industry (MII), all influence innovation policies in their respective area of competence: MOA is engaged in R&D and research commercialization in agricultural science and biotechnology, MOH in medical science, and MII in information and communication technologies.

In sum, an impressive number of agencies are involved in central-level S&T planning, which underscores the importance of effective horizontal coordination at the national level. For policy-making and priority-setting issues, the State Council Steering Group of S&T and Education (with its Medium- and Long-term S&T Strategic Plan 2006-2020) serves to provide overarching coordination; however, at the implementation level there are currently no institutionalized coordination mechanisms. Therefore, temporary coordination mechanisms are created on a case-by-case basis when performing high-level horizontal tasks. For instance, in 2007 NDRC, MOST, MOE, MOF, and MOP worked together with other above-listed agencies to draft the 99 detailed rules for implementing the Medium- and Long-term S&T Strategic Plan 2006-2020, and allocated among themselves the responsibilities of implementing these rules.

**Provincial level**

The S&T institutional structure at the provincial level is basically a replicate of the national one (Figure 11). In other words, national ministries and agencies all have their provincial (and municipal) branches, indicating a potentially strong vertical control over local S&T initiatives. Direct institutional parallels enable the allocation of responsibilities among central government agencies to be mirrored at the provincial level. In terms of S&T activities, the Provincial S&T Department is the direct regulator, while a range of other departments play supplementary and supporting roles. The responsibilities of each S&T actor at the provincial level resemble closely those of its corresponding ministry, but with a smaller jurisdiction area (a detailed description therefore is omitted here). Since national policies and ministerial directives only set orientation, targets and priorities for national endeavors rather than detailed action plans, provincial government bodies are in theory allowed to elaborate higher-level documents in a way that reconciles national requirements with regional particularities. When making S&T plans, the provincial S&T department usually consults other relevant government bodies; nevertheless, in terms of program implementation at the provincial level there is also a lack of horizontal coordination. Different provinces barely differ in their S&T institutional arrangement; therefore the set up in Jiangsu province (see Figure 11) is exemplar of other provinces in China.
Municipal level

The provincial S&T institutional structure is reproduced at the municipal level as well (Figure 11), and further at the district and county level. Accordingly, the allocation of S&T responsibilities among municipal agencies corresponds with that of central and provincial governments. For instance, the Nanjing S&T Commission\(^1\) oversees directly innovation issues, including university research commercialization. The municipal government adds another layer of policy elaboration into the development blueprint passed down along the administrative hierarchy. Compared with higher-level authorities, the municipal government has a smaller say in making grand S&T plans but a larger role in plan implementation. Insufficiency of horizontal mechanisms to coordinate implementation of S&T plans is a problem at the municipal level as well (interview #1, Shangbing Jia). S&T institutional arrangement in Nanjing municipality (as shown in Figure 11) is representative of other municipalities in China as well.

\(^{1}\) It was renamed from the Nanjing S&T Bureau in April, 2010 after Nanjing was selected to be the national pilot city for comprehensive S&T institutional reform, to assign it more horizontal coordination authority, see http://www.njutnsp.com/view.asp?id=535&class=823 [in Chinese].
4.4 Multi-layer policy framework

Since the 1980s, a wide range of plans, laws and regulations have been promulgated with the purpose of promoting innovation and S&T development. This section surveys China’s current multi-layer S&T policy framework, with a primary focus on policies concerning research commercialization.

National level

The Medium- and Long-term S&T Strategic Plan 2006-2020 is the top-level document guiding China’s S&T policy framework. The third of this kind since 1949, the current plan stipulates China’s S&T goal “to became an innovation-oriented society by 2020 and a leading innovation country in the long term” and lists four specific objectives – 1) R&D intensity to reach 2% of GDP by 2010, and 2.5% by 2020; 2) S&T and innovation to contribute 60% of GDP growth; 3) dependence on foreign technology to be reduced to less than 30%; and 4) to be among the top five worldwide in terms of the number of domestic invention patents granted and the number of international citations of scientific papers (MOST, 2012a). This plan is accompanied by a document of 99 detailed rules for its implementation (MOST, 2012b).

In addition, MOST makes five-year S&T plans in line with both the medium- and long-term S&T plan and China’s national five-year plans. The 12th S&T Five Year Plan (2011-2015), the newest one, sets targets in eight S&T indicators – 1) gross R&D expenditure to improve from 1.75% to 2.2% of GDP; 2) full-time equivalent (FTE) R&D personnel from 0.33% to 0.43% of total labor force; 3) the international rank of scientific paper citations from 8th to 5th; 4) the number of invention patents held by every ten thousand persons from 1.7 to 3.3; 5) the number of invention patent applications by every hundred FTE research personnel from 10 to 12; 6) the total volume of transactions in national technology market from 390.6 to 800 billion; 7) the percentage of total added value in manufacturing contributed by the high-tech sector from 13% to 18%; 8) the percentage of citizens with basic scientific qualifications from 3.27% to 5% (MOST, 2012c).

Buttressing grand S&T plans is a policy constellation covering science, technology, reform of S&T actors (e.g. PRIs, HEIs), infrastructure construction for scientific research, infrastructure

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1 FTE data is a measure of the actual volume of human resources devoted to R&D. One full-time equivalent can be thought of as one person-year. Thus, a person who normally spends 30% of time on R&D and the rest on other activities should be considered as 0.3 FTE. Similarly, if a full-time R&D worker is employed at an R&D unit for six months, this results in a FTE of 0.5 (OECD, 2002).
construction for technology commercialization, as well as framework conditions for innovation (e.g. IPR protection, higher education fortification, and rewards for S&T achievement and excellence). A comprehensive, though not exhaustive, survey of S&T policies based on the EU Trend Chart Innovation Policy Classification System is appended in Appendix C. Only the policies addressing research commercialization directly are listed here:

1. The Science and Technology Development/Progress Law (1993) designates S&T progress as one key component of China’s economic development, promotes the use of market mechanisms in innovation promotion, recognizes the status of S&T employees, and promises IPR protection and some freedom with respect to scientific research.

2. The S&T Achievements Conversion Enhancement Law (1996) is the basic law on technology transfer. It encourages the science sector to transfer its S&T findings more autonomously according to defined channels (self-investment, transfer to others, allow others to use findings, joint conversion, use findings as equity investment) and rules that secure IPR in transfer operations (ownership and share of technological right and interest).


5. The Regulation on Technology Transfer for PRIs (1998).


7. The Decision on Strengthening Technology Innovation, Developing and Industrializing High Technology (1999) sets fiscal and financial policies to support the industrialization of high technology. It is the starting point of the commercialization of high technology.


Elaborate policy analysis into each of the above-listed laws is beyond the scope of this thesis. The major point here is to demonstrate a relatively comprehensive web of policies to govern knowledge commercialization is already in place. Some researchers (Tang, 2006b; OECD, 2008) contend certain elements of the S&T Findings Conversion Law and the S&T Advancement Law are similar to the US Bayh-Dole Act (1980), which laid the regulatory bedrock for the fertile US environment of academia-industry interactions.

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1 The below bulleted policies are quoted from OECD, 2008, p. 191, with minor modifications.
Although China has gradually abandoned its traditional planning system with central planners’ direct top-down command and control over the society, planning documents and laws enacted at the central level continue to be key guides for public actions in all fields and at all levels. The Five-Year Plan is the single most important document that sets the perimeters for all social and economic development. In the S&T domain, the Medium- and Long-term S&T Strategic Plan 2006-2020 and the S&T Five-year Plan set framework conditions. Overall, national plans depict the broad strategic orientation, and leave space for elaboration and augmentation at subnational government levels. Provinces, municipalities and counties all work out their own social and economic strategies as well as S&T development plans, in line with higher-level frameworks and (in theory) in light of regional/local specialties. A depiction of the provincial S&T policies of Jiangsu province can illustrate the national-provincial relationship in policy-making; emphasis here is also put on policies related directly to university research commercialization.

The Jiangsu S&T Department drafts its own five-year S&T development plan in accordance with the medium- and long-term S&T strategic plan and the national-level five-year S&T plan. Its 12th provincial S&T development plan mimics its higher-level counterpart in structure and rhetoric but stipulates wider and more ambitious targets (all quantified into specific numbers). For example, the current provincial plan (2011-2015) proposes to double three S&T indicators – gross R&D expenditure, FTE R&D personnel, added value from the high-tech sector, and triple three other indicators – total number of granted patents, start-up investment, number of private technology firms (Jiangsu S&T Department, 2012a). Surpassing national goals is arguably a common practice for resource-rich provinces to demonstrate their administrative capability and political adherence (interview #1, Shangbing Jia).

Apart from the provincial five-year S&T plan, the Jiangsu S&T Department also enacts various policy documents and ordinances to supplement and guide the implementation of national laws and polices. The S&T department website lists 16 national S&T laws, 98 various regulatory notes from the state council or ministries, 46 provincial S&T policies, 100 provincial S&T regulations, and 21 explanatory notes of key national policies (Jiangsu S&T Department, 2012b). This numeric comparison of national- vis-à-vis provincial-level documents illustrates the existence of a more dense policy net at the provincial level. Basically every national law is paired with one or several provincial regulations (ibid.). For example, The S&T Development/Progress Law and The S&T Achievements Conversion Enhancement Law are paired respectively with The Provincial S&T
Development/Progress Ordinance and The Provincial S&T Achievements Conversion Enhancement Ordinance (ibid.). While national laws declare what are allowed and encouraged, the provincial ordinances lay out specific action directions (ibid.). Overall, the provincial policy framework is designed in strict abidance with national documents and with the intention to successfully implement national initiatives.

Municipal level

Municipal-level ordinances and regulations further concur and elaborate provincial-level documents, the way the latter concur and elaborate national-level ones. Nanjing municipality has its own five-year S&T plan, adopting the orientation, structure, rhetoric of corresponding national and provincial ones, only with minor modifications and specifications to cater to local reality. In terms of policies, since the municipal government is the direct implementer of S&T programs, a comprehensive and complex policy apparatus is put in place to guide implementation – the Nanjing municipal S&T commission’s website lists some 300 regulations and ordinances (Nanjing municipal S&T commission, 2012). Major national-level laws all have their municipal-level counterparts. The policy-making authority of sub-municipal governments, namely district or county government, is much constrained. They only draft documents guiding details of specific projects within their administrative areas.

4.5 Multi-layer program framework

In China, all policy-making agencies also carry responsibilities for implementation. S&T programs are the major vehicles with which government institutions (those mentioned in section 4.3) materialize associated policies (those mentioned in section 4.4). This section describes some major S&T programs shaping China’s innovation landscape, with a focus on those particularly pertinent to university research commercialization.

National level

As shown in section 4.3, S&T issues involve various national ministries and agencies. Arguably, a range of programs implemented by different central bodies all relate to innovation, such as the Knowledge Innovation Program run by CAS to strengthen its research institute branches, the 211 Program and 985 Program run by MOE to enhance the facilities and research capabilities of elite universities, as well as the Great Program, Key Program and Major Program run by NSFC to fund
scientific research. Nevertheless, MOST implements the most innovation-relevant S&T programs. Appendix D is created to provide the most up-to-date illustration of the MOST program tapestry, adopting the program typology of China’s 11th Five Year S&T Plan and compiling official information from various reports and websites. Here the focus is put on the Torch Program, one component of the “Environment Building for S&T Industries” program cluster, since it relates directly to technology commercialization.

The grand mission of the Torch Program is “reinforcing the overall environment for technology innovation and promoting high-tech industrialization”, which is broken into four objectives: “1) to perfect the support system for high-tech industrialization, focusing on promoting indigenous innovation; 2) to foster the growth of tech-based SMEs and boost technological innovation in enterprises; 3) to promote the development of innovation clusters and advance upgrades in high technologies; 4) to mobilize innovative resources including capital, technology and talent to reinforce support for innovation and industrialization” (Torch Program website, 2005). These mission and objectives are to be achieved through 10 pillar tasks, aggregated into three groups: Cultivating Tech-based SMEs, Developing Innovation Clusters, and Building an Innovative Environment (Figure 12). As hinted by the group names, these three task aggregations fulfill separate roles: the environment building group serves to fertilize the socio-economic environment for the origination and growth of tech-based SMEs, the SME cultivating group assists the early phase of commercializing research results into firms, while the innovation clusters group aims to fortify and cluster mature SMEs to form economic engines. This thesis puts its lens closer to the early stage of knowledge commercialization, thus the discussion here concentrates on the Innovation Fund for Tech-based SMEs (Innofund), technology business incubators (TBIs), and the technology market (shadowed in Figure 12).

The Innofund was set up by the State Council in 1999 as a central government funding reservoir for technology-based SMEs. This initiative was based on experiences from industrialized countries to remedy the “market failure” that projects with innovative technology and market potential may not be attractive to commercial capital at their early stages of commercialization. The ultimate goal of Innofund is to lever other financial capital towards innovative start-ups. To qualify for Innofund funding, applicants must fulfill the following conditions: 1) be an independent business entity; 2) be involved in high-tech activities; 3) have a ratio of R&D investment to sales greater than 5%; 4) 30% of its employees be R&D personnel; 5) employs fewer than 500 people; and 6) with Chinese equity exceeding 50% (Jiangsu S&T Department, 2010). Between 2006 and 2010, Innofund devoted a total
of RMB 11.5 billion to support 17,893 projects, with average fund of RMB 650,000 per project (see Figure 13 for time series changes; MOST, 2011). Of the 6,410 projects approved between 1999 and 2004, 35% were in IT, 20% in automation, 18% in biotechnology, 16% in material technologies, 6% in environment protection technologies, 4% in energy technologies, and 17% of the funded projects held IPRs (ibid.). At the end of 2005, over a hundred Innofund beneficiaries had been listed on domestic and overseas stock exchanges (Torch Program website, 2005).

Figure 12. Structure of the MOST Torch Program
Source: based on Torch Program website, 2005

Figure 13. Innofund funding amount & No. of funded projects (2006-2010)
Source: MOST, 2011
TBIs, an important instrument of the Torch Program, aim at nurturing tech-based start-ups, by providing physical facilities and comprehensive value-added services (see Figure 14 for an example of TBI). They are considered as seedbeds for commercializing research results, cultivating future entrepreneurs, as well as linking science with marketplace. The first TBI in China was the Wuhan East Lake Innovation Center established in June 1987, and after the launch of the Torch Program in the following year a vigorous nationwide proliferation started (OECD, 2008). Till the end of 2010, 896 TBIs had been set up around the country (346 national-level ones), which accommodated 56,000 under-incubation start-ups, graduated 36,485 firms, and employed 11,770,000 persons (MOST, 2011). Thus far, more than 150 graduated firms have been publicly listed, among which are some renowned international players, such as Lenovo, Huawai, Suntech Power, and so on.

According to OECD, TBIs have undergone three stages of development. At the outset, the government mainly used the incubators to provide physical facilities, and “more attention was given to social benefits rather than to direct economic ones” (OECD, 2008, p. 464). In the second phase, incubators started to provide a wider range of services directly to the entrepreneur. Industry-specific incubators were created and more attention was given to profit-oriented development. Nowadays, Chinese TBIs have diversified significantly in type (university science parks, incubators for returned overseas scientists, international business incubators, and so on) and ownership (fully government-funded public organizations, partially government-funded public organizations, independent public organizations, state-owned enterprises, private enterprises, public-private joint entities, and so on). In addition, various TBI networks have emerged, including local ones in Beijing, Shanghai, and Hubei, regional ones in west, north and mid-east China, as well as a Professional Committee on TBI under The China National Association of S&T Industrial Parks (STIPs).

Figure 14. Chengdu High-tech Business Incubator
Source: Torch Program website, 2005
The technology market in China is a virtual market to bring together technology producers and consumers, and thereof facilitate technology transfer and commercialization. It comprises a national inventory system (administered by various levels of government S&T agencies) registering on the one hand technological findings from universities, research institutes and R&D firms, on the other hand technological demands from enterprises. A large group of multi-type technology intermediaries, either public, private or dual-identity (i.e. public-private joint ventures), operate to file technology supply and demand information, register them into the inventory system, and/or broker between technology providers and consumers. The first technology market emerged in 1984 in Wuhan registering 60 technology offices in PRIs, universities and firms (OECD, 2008). Following that, central government endorsement spurred a national expansion. According to MOST’s 2011 annual S&T report, there are currently around 1,000 technology market management agencies, 800 technology contract registering and certifying agencies, 200 government run technology transaction centers, 40 technology IPR transaction centers, as well as 20,000 various organizations engaged in technology development, technology service, technology transfer, and technology consultation. The distinction among these organizations is a source of confusion. Technology intermediaries enjoy some tax incentives in return for their contributions to stimulating technology transfer, but the scope and geographical variation of such incentives are unclear. Despite the confusion and unclarity, the transaction volume through the national technology market increased 500 times since 1984 and reached RMB 390.6 billion in 2010 (MOST, 2011). Figure 15 gives a snapshot of the technology market development from 1998 to 2005, highlighting the increase of transaction volume, the diversification of technology sellers, as well as the transaction composition in 2005. Obviously, with an impressive business flow and a large number of agencies involved, the technology market is both critical and hybrid. The China Technology Market Association was established by MOST in 1992 and the 1987 Technology Contract Law was revised in 1999, to streamline and standardize its operation. Though frequently noted in innovation studies (e.g. Hussler et al., 2010), China’s technology market, together with associated intermediaries, is thus far underresearched.
Provincial level

As documented above, subnational governments roughly mirror central arrangement in both S&T institution setting and S&T policy-making. In terms of S&T program design and implementation, subnational governments nevertheless enjoy considerably larger autonomy. In fact, subnational authorities have the freedom to create and run their own S&T programs, as long as they are in alignment with national policies. That does not mean nationwide programs are overshadowed or deprioritized; successful implementation of national initiatives is still mandatory and of significant importance, but are often augmented with a rich range of extra provincial/local programs.

Figure 16 depicts the segment of S&T program repertoire orchestrated by Jiangsu provincial S&T department that addresses technology commercialization directly. This program cohort is grouped loosely under the banner of “Enterprise-College-Institute Cooperation (ECIC)”, and a specific ECIC bureau is set up within the S&T department to coordinate relevant work. When comparing Figure 16 with 12, it is easy to see the Jiangsu ECIC program cohort not only incorporates fully the portion of the national Torch Program that caters to earlier stages of technology commercialization, but also augments it with a wide range of additional initiatives. In other words, the national program apparatus geared towards promoting research commercialization is amplified significantly at the Jiangsu provincial level.

As shown in Figure 16, the Jiangsu provincial government designed four additional S&T funds to supplement the Torch Innofund. First is the provincial level Innofund, which was created in 2007 to subsidize promising SMEs in technology domains ("tech-SMEs" thereafter; Jiangsu S&T Department, 2010). The S&T Achievement Conversion Fund was initiated in 2004 to support the transfer, commercialization and industrialization of technologies in Jiangsu (Jiangsu ECIC Bureau, 2010a, 2010b). The Enterprise-College-Institute Cooperative Innovation Fund was created in 2009 with the main purpose of supporting 1) the construction of major innovation platforms, 2) foresighted enterprise-college-institute collaborative research, and 3) the development of university TTOs (ibid.). In 2009 alone, this fund allocated RMB 0.2 billion to support 79 projects (ibid.). The S&T Achievement Conversion Risk Compensation Fund was created to compensate financial institutions for losses in investing in tech start-ups (ibid.). It is noteworthy that only S&T funds targeted at ECIC activities and coming from the Jiangsu S&T department are identified above, and

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1 Several S&T personnel interviewed during the fieldwork suggested that “Government-Enterprise-College-Institute Cooperation” (they emphasized “government” should be put at the first) would be a more precise term since the public sector tended to play the most active and decisive role (interview #3, Peng Ding; #4, Jian Yu; #8, Jiang Yue; #12, Shaoming Pan).
many other subsidies from various government divisions are available for tech-SMEs to apply to. According to the manual of policy incentives for tech-SMEs complied by the Jiangsu S&T department, these supportive initiatives include tax exemptions, financial credits, recruitment assistance, incubation services, firm designation\(^1\), product certification\(^2\), and a range of special government funds. Regarding direct funds, the manual lists seven national ones and thirteen provincial ones (Jiangsu S&T Department, 2010).

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<tr>
<th>Supportive funds</th>
<th>ECIC platforms</th>
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<td>- Innovation Fund for Tech-based SMEs (Innofund) *</td>
<td>- Technology Business Incubators (TBIs) *</td>
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<td>- Provincial-level Innofund</td>
<td>- Start-up Centers</td>
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<td>- S&amp;T Achievements Conversion Fund</td>
<td>- University Science Parks (USPs)</td>
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<td>- Enterprise-College-Institute Cooperative Innovation Fund</td>
<td>- Overseas Returnee Start-up Centers</td>
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<td>- S&amp;T Achievements Conversion Risk Compensation Fund</td>
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<th>Technology transfer platforms/agencies/events</th>
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<td>- Technology Market *</td>
<td>- S&amp;T Strategic Alliance</td>
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<tr>
<td>- ECIC Website</td>
<td>- College-Enterprise Coalition</td>
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<tr>
<td>- Jiangsu Conference for ECIC Achievements Exhibition</td>
<td>- Industrial Technology Strategic Innovation Coalition</td>
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<tr>
<td>- Jiangsu Conference for International Technology Transfer and Commercialization</td>
<td>- Academician Corporate Workstation</td>
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<td>- S&amp;T Exhibition Tour</td>
<td>- Graduate Corporate Workstation</td>
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<td>- S&amp;T Township Officers Cohort</td>
<td>- Postdoctoral Corporate Workstation</td>
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<td>- Innovation Township</td>
<td>- Tech-agriculture Special Cooperation Unit</td>
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\(*\) programs designated by the national Torch Project.

Note: The Jiangsu ECIC Bureau does not explicitly categorize their programs, this taxonomy is created by the author for clarity.

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\(^1\) Firms granted special designation, e.g. high-tech firm, software firm and integrated circuit firm, enjoy special benefits.

\(^2\) Products granted special certification, e.g. indigenous innovative products, national/provincial major products, bring another layer of benefits.
Also comprising the ECIC program cohort is a group of technology transfer platforms/agencies/events (see Figure 16). The technology market is a provincial fragment of the aforementioned national technology market web. A provincial ECIC website (http://www.jsxy.cn) has been created to publicize work progress, ECIC-pertinent policies and regulations, technology supply and demand information, as well as biographies of S&T experts in Jiangsu. Two provincial ECIC conferences, the Jiangsu Conference for ECIC Achievements Exhibition (initiated in 2007) and the Jiangsu Conference for International Technology Transfer and Commercialization (initiated in 2008) are organized every other year alternatively to bridge technology providers and consumers. The former targets renowned domestic universities and research institutes as technology sources, while the latter targets foreign ones (Jiangsu ECIC Bureau, 2010a, 2010b). As reported, the second domestic conference (2009) brought together 2,698 technology offers and 1,552 requests, resulting in 889 transfer contracts anchored with a total investment of RMB 16.11 billion (Jiangsu ECIC Bureau, 2010b). The second international conference (2010) attracted 280 foreign participants from 25 countries and 450 domestic corporate representatives, and led to about 200 transfer deals sealed, totaling RMB 1.053 billion in investment (conference website: http://www.cittc.org). In addition to organizing its own ones, the ECIC bureau also participates in multiple S&T exhibitions/conferences/fairs/summits hold each year in various parts of China to promote both inward and outward technology transfer. Each attendance entails comprehensive preparation of compiling provincial technology supply and demand information, and is usually accompanied by delegates from academia and industry. Some major events are the Beijing International High-tech Expo, the Chongqing High-tech Fair, the Western China International Fair (hold in Chengdu), and the Jiangsu-Chongqing Economic Cooperation Conference (Jiangsu ECIC Bureau, 2010c). The S&T Township Officers Cohort is a bold administrative initiative to appoint a selective group of young talent in public URIs, SOEs and government S&T branches, into leadership positions at township governments (Jiangsu ECIC Bureau, 2010a, 2010b). They are expected to facilitate technology transfer from urban centers into industrial towns. Till the end of 2009, 84 candidates had been appointed via this program into 74 industrial towns in 8 prefectures (ibid.).

The last part of the ECIC program cohort is multiple ECIC platforms (see Figure 16). “Platform (Zaiti or Pingtai)” is an inclusive umbrella category used currently to denote any organizational arrangements aimed to bridge science and industry (interview #1, Shangbing Jia). The Torch TBI program is already a loose project container aggregating organizations set up with the purpose of accommodating and incubating tech start-ups, and Jiangsu has 199 of them (Jiangsu S&T Statistics Bureau, 2009a). Nevertheless, it is insufficient to satisfy the Jiangsu provincial government’ political
zeal and ambitions, which spurred a proliferation of multifarious platforms. The S&T Strategic Alliance (Figure 16) roughly refers to all kinds of efforts of the provincial and subordinate municipal governments to refract S&T results from major national R&D hubs inward, via signing strategic cooperation deals, and/or establishing cooperation factories/laboratories (ibid.). Sought-after hubs include elite universities and research institutes, such as CAS, CAE, PKU, THU, Zhejiang University (ZJU), and the China Electronics Technology Group Corporation (CETC, ibid.). Literally all Chinese provinces and municipalities are in a “scramble” to anchor connections with these eminent R&D hubs, not only for their rich S&T outputs but also due to their high political visibility (interview #1, Shangbing Jia). The Jiangsu ECIC bureau proudly itself explicitly for making Jiangsu the top cooperator with these R&D stars (Jiangsu ECIC Bureau, 2010a). At the end of 2009, Jiangsu had 544 strategic cooperation contracts, 280 co-established cooperation centers, and 20,800 cooperation projects, with some 940 domestic R&D entities (Jiangsu ECIC Bureau, 2010b). The College-Enterprise Coalition is a different project, initiated in 2009, to pair each selected S&T firm with a corresponding expert working at local URIs, from whom the firm can seek S&T consulting, R&D assistance or technology news (Jiangsu ECIC Bureau, 2010a, 2010b). At the end of 2009, 4,112 coalitions were formed, with 62 HEIs, 13 research institutes, 2,353 research groups and 20,000 S&T personnel participating (ibid.). The Industrial Technology Strategic Innovation Coalition is a mechanism to create legally binding partnerships between URIs and enterprises (Jiangsu ECIC Bureau, 2010c). 13 such coalitions were formed at the end of 2009, recruiting 53 colleges, 61 research institutes, and 481 enterprises, covering sectors such as IT, new energy and environment protection, bio-pharmaceutical, new materials, and advanced manufacturing (ibid.). The Tech-agriculture Special Cooperation Unit is a similar coalition mechanism that brings together business and URIs, but with its focus on agriculture development (ibid.). There were 116 of them at the end of 2009, involving 60 URIs and 5 agriculture-related commissions (ibid.). The Academician/Graduate/Postdoctoral Corporation Workstation project aims to set up workstations (i.e. offices or laboratories with equipment and facilities) for enlisted academicians, graduate students, and postdoctoral students to specifically work on firms’ technology problems (ibid.). At the end of 2009, there were 142 academician workstations, 32 graduate ones, and 401 postdoctoral ones (ibid.). Lastly, the Innovation Township initiative is a package of policy incentives to encourage towns to develop high-tech and specialized industry (Jiangsu ECIC Bureau, 2010a).
Municipal level

The Nanjing municipal government is engaged primarily in implementing the wide range of national and provincial S&T programs, with limited resources to launch additional ones. It is difficult to identify the exact origin of some local S&T programs, since in many cases, the program was first initiated by a local government, received the attention of the provincial or central authority, then was publicized province/country-wide as best practice or enlisted into provincial/national program agenda (interview #1, Shangbing Jia). For instance, as mentioned above, both the technology market and TBI were initiated first in Wuhan, and only proliferated nationwide after receiving central government endorsement via the Torch Program. This is also the case of USP, with its origin at Northeast University in Shenyang (Liu, 2006).

4.6 Inter-layer relations

As laid out above, subnational arrangements replicate the central-level S&T institution setting, elaborate and augment central-level S&T policies, as well as amplify and expand central-level S&T programs. In the realm of S&T activities, the multi-layer system is overall both centralized and decentralized, centralized in the sense of strict downward consistence of policy design, priority setting, and program orientation, while decentralized in the sense that local authorities have considerable autonomy in program creation and implementation. The author terms this vertical coordination pattern “hierarchical amplification”. This pattern is arguably observable in various other sectors other than S&T in China (e.g. Walcott, 2003).

This “hierarchical amplification” system has the merit of mobilizing enormous political energy from subnational governments to pursue national targets, but also carries three undesirable propensities. First, structural overcapacities could ensue when unbridled local energy pour into a uniform set of national-level targets. Second, there is the danger of “program irrationality” since local authorities have few incentives to tailor national programs to local contexts. There are also no formalized channels of “bottom up” feedbacks in terms of S&T policy making as well as program design (interview #1, Shangbing Jia). Third, a phenomenon termed “mission creep” by OECD (2008) is likely to happen where national programs are implemented in a way astray from their original

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1 “S&T industrial parks present an example of ‘mission creep’, in that they were initially created and supported under the Torch Program to provide a supportive environment for the development of indigenous innovation capabilities but have often become mere platforms for export-oriented manufacturing by affiliates of international corporations. Generous support policies, especially tax exemptions, have in fact encouraged production and exports rather than innovation” (OECD, 2008, p. 68).
intention. This is largely due to the absence of a sound program supervision/evaluation system in China (ibid.). Overall, despite three decades of S&T reforms, the current S&T system is still primarily “top down” and exhibits legacies and limitations of the pre-reform planning regime.

This section concludes the survey of the multi-level institution, policy and program framework of China’s NIS by interrogating how the inter-layer structure of “hierarchical amplification” is formed and why it induces the three propensities identified above (probing two questions as set out below). This pattern certainly colors the specific research commercialization mechanisms in Nanjing (to be detailed in the following chapter). The three identified “side effects” of the “hierarchical amplification” system will also be tested in the Nanjing case study (see Chapter 5).

“Hierarchical” - how the national S&T orientation is persevered downward in the administrative hierarchy

First, China is still a highly centralized regime at least at the strategy level with its heavy-handed central government and indisputable central authorities (OECD, 2008). According to China’s legal system, subnational regulations that mismatch or contradict national policies are automatically invalidated. This overall political system renders possible strict adherence in S&T orientation downward the administrative hierarchy.

Second, national S&T targets are set in a rigid and “objective” manner, making local defiance difficult (ibid.). As shown in section 4.4, the current Medium- and Long-term S&T Strategic Plan and S&T Five-Year Plan all quantify their S&T targets into specific figures. While one may argue there is still space for subnational authorizes to incorporate local particularities into policy-making, subnational policy makers do not always possess the capacities to do so, especially in the domain of S&T where they have insufficient experience (ibid.). The most efficient and politically safe approach then is to simply reproduce and amplify national policies. This leads to different regions adopting similar development agendas, targeting similar goals and prioritizing similar domains. As a result, the seeds of overcapacity and redundancy are already sown at this stage.

Third, in terms of evaluating subnational governments and officials, their performance in fulfilling national goals and implementing national programs is still the primary bar. In other words, efforts unmatching central requirements run the risk of not being credited or recognized, hence local authorizes have few incentives to stray away from what they are told to do directly.
Fourth, S&T programs are still primarily financed by the central government. Since China introduced a dual (central vis-à-vis provincial) tax system in 1994, subnational authorities have enjoyed considerable financial freedom (ibid.). Correspondingly, major spending responsibilities, such as education, health and social welfare, all fall to provincial governments. The subnational share of total public expenditure exceeds that of all OECD countries (ibid.). However, by contrast, funding decentralization is limited in S&T activities. In 2005, more than 60% of public expenditures for S&T programs were from the central budget (ibid.). The more subnational entities rely on financing from a higher level, the more they are likely to adhere to higher-level policy orientations. Taking advantage of central budgets constitutes another incentive for subnational governments to strictly parallel national arrangements.

Fifth, there is the influence of the centralized label system. National-, provincial-, municipal- or even county-level labels are attributed to projects, platforms, centers, parks, universities, firms, products, or even R&D personnel to reflect their position in a hierarchy of superiority. For example, Nanjing has 10 national-level TBIs, 13 provincial-level ones, and 8 municipal-level ones (Jiangsu S&T Statistics Bureau, 2009a). A label with a certain level denotes endorsement or favor from that level of government, and hence it could bring significant social and political capital; and the higher the designation level, the larger the capital. A highly ranked (i.e. with a high-level label) park, center, or firm may receive significant tax cuts, cheaper land, and easy access to bank loans, and highly ranked universities or S&T personnel are sought after as technology partners. This hierarchical labeling approach is not a Chinese invention, and is commonly marshaled in OECD countries to direct resources into priority areas, be they centers of excellence, clusters of firms or particular technologies (OECD, 2008). However, probably no OECD country can match China in terms of how many doors a label can open or how many resources a label can lever. To win labels as well as the attached political capital from higher-level authorities, low-level governments have a strong incentive to adhere to higher-level policy orientation. The credibility of the labeling process, however, is a serious concern. In China, the labeling process is much lamented for a lack of transparency, the potential of harboring rent-seeking activities, as well as the dubious qualifications of those who make the labeling decisions (frequently civil servants rather than qualified expects; interviews #3, Peng Ding; #4, Jiang Yue; and #14, Jiangfeng She).

Finally, the parallel of government structure along the power hierarchy (see Figure 11) could contribute to a downward consistence in plan making as well. Overall, all these factors prescribe a rigid adherence to national S&T configuration, hindering local governments’ ability and willingness
to tailor their S&T plans to any regional context. When this orientation adherence is coupled with local officials’ political ambition to amplify national targets, overcapacity ensues.

“Amplification” - how national commitment to innovation promotion is massively amplified at subnational levels

First, though central plans demand adherence, central authorities do not intervene directly into local implementation of S&T programs (OECD, 2008). In addition, central authorities mainly evaluate how much rather than how subnational governments achieve national targets (ibid.). Adding to local flexibility is the fact that a government bureau is under the direct supervision of its same level city government rather than its corresponding higher-level government division (ibid.). For example, the Nanjing S&T Commission is under the direct administrative leadership (xingzheng lingdao) of the Nanjing municipal government, not the Jiangsu S&T Department, which provides only business guidance (yewu zhidao). These two S&T bodies may meet to discuss thematic issues, but there are no formalized program supervision mechanisms, hence no watchdogs are in place for over-investing in S&T programs. Second, the centralized funding, evaluating and labeling regime mentioned above, leads to not only hierarchical orientation coherency but also a “project race”, since funds, labels and chances of political coronation are finite. As a result, same-level governments are in a restless competition for larger funding, more high labels and better performance evaluation. In institutional economics studies, it is also observed that the Chinese political system mobilizes enormous local energy in achieving national goals by engaging local governments in reckless competition (e.g. Cheung, 2009). This institutional “magic” of energizing or even frenzying local governments reminisces to some extent the “Great Leap Forward” period, and is observable in the domain of innovation promotion and knowledge commercialization. Such development mania could be more or less harnessed if a strong supervision system existed; nevertheless, the Chinese government is much more adept in “money-pouring”, “winner-picking”, and “scale expansion” than in program supervision and quality monitoring, and overall the S&T system exhibits considerate tolerance of reckless competition and unbridled program expansion.

4.7 Summary

In sum, while a rigid hierarchical coherency penetrates all levels of S&T strategy making, there is an unharnessed competition among government at the same level: this competition drives a process of program amplification. This is to say, provincial governments, municipal governments within one province, and even district governments within one municipality, are all engaged in a competition for achieving similar S&T goals. This unique vertical coordination pattern, termed “hierarchical
amplification” by the author, is conducive to massive expansion, but is prone to overcapacity, irrationality and “mission creep”. Problems are exacerbated if no proper evaluation and supervision mechanisms are in place. These features buried in China’s S&T framework could be detected more vividly in the following chapter, which focuses on four specific sets of university-affiliated research commercialization agencies in Nanjing.
Chapter 5. University-Affiliated Research Commercialization Agencies: A Nanjing Case Study

5.1 Introduction

An investigation of China’s university research commercialization regime, according to the theoretical model proposed in chapter three (Figure 6), entails screening the framework conditions as well as examining specific commercialization conduits. The previous chapter serves the first step by laying out the multi-layer S&T institutions, policies and programs currently in place, and this chapter is set to interrogate a group of commercialization agencies affiliated directly to universities, namely university TTOs, ECIC platforms, USPs, and spin-off companies. Discussion of spin-off companies will be brief and mostly based on secondary information sources, due to the failure to arrange interviews with spin-off company personnel during the fieldwork. The major universities in Nanjing include Nanjing University (NJU), Southeast University (SEU), Nanjing University of Science and Technology (NUST), Nanjing University of Technology (NUT), Nanjing University of Aeronautics and Astronautics (NUAA), Nanjing Normal University (NNU), Nanjing Agricultural University (NAU), and Nanjing Institute of Technology (NIT). Among them, the first four are most active and experienced in research commercialization, and are therefore visited during the fieldwork.

In broad-scale analysis the relationships between the four types of research commercialization agencies to their affiliated universities is depicted in Figure 17. As shown, the TTO is part of the university’s administrative organ, and is usually nested under the S&T division. The ECIC platform is a cooperative R&D entity co-established by a university/research institute with a government or enterprise partner, which is often facilitated and coordinated by the corresponding TTO. The USP is a business incubator usually located adjacent to university campus, which accommodates technology start-ups. The university may hold equities of some of these start-ups, either via capital or technology investment. The USP may also have branch parks, sometimes located in a different city from the university. Apart from the start-ups under USP incubation, two other types of spin-offs could be affiliated to a university – the wholly owned ones (i.e. UREs) as well as the private spin-offs founded and owned by faculty members but located outside of USPs. The rest of this chapter comprises four sections examining each set of commercialization agency respectively, and ends with a discussion of their mutual interactions.

1 The content of this chapter is mainly based on interviews (see Appendix A&B), unless indicated otherwise.
5.2 University technology transfer offices (TTOs)

5.2.1 History, scope and hierarchy

As discussed in section 2.3, the TTO system is not new to Chinese universities. Before MOE and the former SETC authorized six universities to establish NTTCs in 2001, various universities had long operated their technology transfer offices (usually named STACOs) in a spontaneous manner to facilitate knowledge spillover (Tang, 2006a; OECD, 2008). Thus, the 2001 project should be viewed as an attempt to fortify and formalize existing efforts, rather than any groundbreaking initiative. The first batch of six authorized universities were THU, SJTU, China East Polytechnic University, Huazhong S&T University, Xi’an Jiaotong University and Sichuan University, scattered in different parts of China to reach a geographical balance (ibid.). As observed by Tang (2006), these newly established NTTCs sometimes coexisted with previous STACOs, and resulted in institutional redundancy and operational overlap.
Later on, the initiative to authorize launching NTTCs was replaced by granting existing TTOs national status. At the end of 2010, national status was granted to 134 TTOs, affiliated not only to universities but also research institutes, companies and various other S&T entities (MOST, 2010). According to the 2010 China S&T Development Report, these 134 TTOs employed 10,438 staff, facilitated 316,602 technology transfer projects worth RMB 79 billion, organized 3,284 technology transfer events, launched 14,637 technology transfer training sessions, served 104,397 firms, and responded to 112,285 corporate requests (ibid.). In 2011, another batch of 68 TTOs were designated as national-level, enlarging the list to include 202 (MOE S&T Development Center, 2012).

The Jiangsu provincial government has a parallel initiative to shore up TTOs. At the end of 2011, there were 17 provincial-level university TTOs\(^1\) (385 staff employed) in Jiangsu, which had organized 705 technology transfer events, and facilitated 4,992 technology transfer deals totaling RMB 1.65 billion (Jiangsu ECIC Bureau, 2012c). Nanjing held eight such TTOs, located in NJU, SEU, NUST, NUT, NUAA, NAU, NNU and NIT, the first three of which were national-level ones. According to interviews (interviews #4, Jian Yu; #5, Yao Wang; #6, Shengxiang Hu; and #7, Mingcai Pan), various other Nanjing colleges had established TTOs as well, and were competing to obtain provincial and ultimately national status/labels. As indicated in the previous chapter, a higher position in the TTO hierarchy could lever larger recognition and support (both monetary and non-monetary) from multi-level governments into the associated university (ibid.). Thus, to climb up the ranking hierarchy constituted a major objective for most established TTOs. University TTOs were largely homogenous all over Nanjing or even China in terms of their operation, functions and impediments, therefore the rest of this section is written with a level of generalization, even through it is based on interviews carried out with specific Nanjing university TTO managers.

5.2.2 Operation and functions

Within a university, the TTO is usually an administrative organ nested under the S&T division. Administrative bodies in public Chinese universities are forbidden from moneymaking dealings; thus, university TTOs in Nanjing provided technology services for free (interviews # 4-7, various TTO officers in Nanjing). The daily expenses of a TTO were covered directly by university budgets. In addition, TTOs at public universities lack recruitment flexibility, since they are part of the university and all public university recruitment in China is subject to the bianzhi quota system. Bianzhi is an employment status granted to regular staff formally employed in the government sector or

\(^1\) National-level ones usually carry provincial status as well, and hence are counted in.
government-affiliated organizations (shiye danwei), and is tied with better social welfare and larger employment stability than average private sector employees. Since the annual bianzhi quota for any public institute is quite limited, universities tend to reserve such quota for attracting renowned professors rather than staffing their administrative units. As a result, university TTOs in Nanjing were generally understaffed: the four university TTOs (NJU, SEU, NUST & NUT) visited during the fieldwork each comprised only 1-3 full time employees. Even employed staff might cross-hold teaching, researching or other administrative posts. For example, the head of the NJU TTO was also a department dean and professor. This employment constraint has lead to a major issue, as TTO staff may lack the time or qualifications for full and effective engagement in technology transactions and subsequent commercialization.

Nevertheless, all university TTOs were responsible for facilitating and streamlining various UIL forms, such as contractual research, technology licensing, cooperative projects, co-establishing R&D, technology consulting, and launching start-ups. Contractual research happens when an external organization, an enterprise or a government body, contracts an R&D project to a university researcher or research team. Technology licensing is selling an existing technology licensed by a university researcher to an external body. At the time of this study, contractual research and technology licensing constituted the dominant share of technology transfer in Nanjing (interviews #1, Shangbing Jia; and #4, Jian Yu). Cooperative projects are those when an industrial R&D entity partners with one or several university researchers to bid and undertake a research project, may it be a government commissioned one or an industrial one. Co-establishing R&D entities encompasses a wide range of arrangements leading into some sort of co-founded organizations between a university and a government/enterprise. In addition to the ECIC platforms to be discussed below, those co-founded R&D entities include various other organizations established under provincial ECIC initiatives (see Figure 16, p. 58). Technology consulting refers to cases where university researchers are hired to provide consulting service to industrial entities or governments. Launching start-ups comprises assisting university faculty members to establish firms based on their research findings.

In Nanjing, research commercialization projects are usually called “horizontal projects” to differentiate them from government commissioned scientific research projects, which are called

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1 zhenfu bianzhi for government employees, and shiye bianzhi for employees at government-affiliated units
2 They may report a larger number to government inventory by counting in S&T staff not actually involved in technology transfer to buoy the scale of their TTOs, for the sake of more government support and recognition. This is a common practice according to interviews (interviews #4, 5, 6 & 7, university TTO officers).
3 For example the S&T Strategic Alliance, College-Enterprise Coalition, Industrial Technology Strategic Innovation Coalition, and the Academician/Graduate/Postdoctoral Corporate Workstation
“vertical projects”. To be precise, vertical projects comprise those funded or commissioned by central ministries (including the specific research fund dispenser - NSFC) or national S&T programs, while horizontal projects encompass those initiated by industrial entities or local government bodies. This rhetoric differentiation reflects intricate power relationship among different S&T actors in China, as universities generally view central government bodies as dominant, superior and more important (thus “higher” in power hierarchy and forging a “vertical” top-down relationship), while enterprises and local authorities are seen as approachable, negotiable and less important (thus “equal-level” or “horizontal”). University TTOs are primarily responsible for facilitating and coordinating horizontal projects. Other offices under the university S&T division oversee vertical projects.

The core of boosting horizontal cooperation is to bridge internal technology supplies with external demands, and to achieve this requires university TTOs to marshal multiple resources and work in different frontiers. Table 1 indicates the working contents of a typical university TTO in Nanjing. As shown, a TTO needs to work with at least three sets of S&T actors: university researchers, governments, and enterprises.

<table>
<thead>
<tr>
<th>Table 1. The major working contents of a typical university TTO in Nanjing, China</th>
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| university researcher | • track and inventory research outcomes  
                      • assist faculty members in technology licensing, patenting and other paperwork  
                      • advise faculty members in various forms of cooperation with industry or government |
| government | • report technology achievements for government inventory  
               • report technology transfer results and statistics for government inventory  
               • participate in various government organized S&T events and initiatives |
| industry | • run a website to publicize S&T information as well as gather online technology requests  
             • organize specific S&T exhibition tours  
             • nurture and maintain long-term R&D cooperation linkages with blue-chip firms  
             • receive on-site technology inquiries from enterprise visitors |

_Source: based on interviews #4, 5, 6 & 7, various university TTO officers_

Regarding researchers, a TTO needs to keep abreast with their research status and progress (see Table 1), which is usually done by keeping close communication with research secretaries of each university department, from whom research information can be gathered. Researchers may solicit assistance from the associated university TTO, when they intend to license or patent research discoveries. They may also resort to the TTO for advice regarding contracts, taxes and other legal issues when they enter into technology transfer deals or R&D cooperation projects with industrial partners. The TTO could also be the first place to visit when a faculty member wants to set up a research-based firm. However, university researchers can seek assistance from external S&T service
agencies as well, and may sometimes shun university TTOs deliberately (for reasons to be explained later).

Regarding governments, university TTOs are their major S&T information portals (see Table 1). Municipal or provincial governments, often their S&T divisions, may run their own TTOs and S&T information websites; nevertheless, they are not technology creators themselves, and hence they reply on TTOs affiliated to URIs to feed them important S&T information. This is the case in Nanjing city, which runs its own official municipal TTO – the Nanjing S&T Achievements Conversion Center. In addition, statistics bureaus under municipal or provincial governments request technology transaction information from university TTOs for their data inventory. Lastly, as technology providers, universities are required to participate in various government-initiated S&T events and programs (these are listed in Figure 16). University TTOs are the managerial bodies to organize personnel and resources for participation.

Regarding enterprises, TTOs run websites to publicize the research strengths and researcher information of their associated institutes (see Table 1). The website of the NUST TTO (http://cg.njust.edu.cn) even incorporates an electronic form for enterprises to submit technology research requests. A TTO also targets specific local blue-chip companies, whose technology domain matches with university expertise, for nurturing long term R&D cooperation. For instance, the NUT TTO maintains close R&D partnership with the Sinopec Yangzi Petrochemical Company Ltd. – a major local player in the petrochemical industry (interview #6, Shengxiang Hu). Due to limited resources and capabilities, university TTOs rarely approach small firms proactively, and small firms need to initiate on-site visits for technology inquires. Preceding such visits, small firms may first contact the local government to solicit an introduction to the university. For example, a firm in Suzhou that has no bonds with NJU, may contact the Suzhou municipal S&T bureau for an introduction before reaching out to NJU on its own. Sometimes local S&T bureau officers even accompany company delegates during their initial visits to university TTOs. Similarly, universities may also contact associated government agencies to pave the way before seeking cooperation with unfamiliar firms. The involvement of the government in university-enterprise contacts is due to the specific Chinese political ecosystem, in which a government introduction or endorsement is often deemed an effective way to lever attention from or establish bonds with an unfamiliar organization. One interviewee (#3, Peng Ding) likened the government as the matchmaker that fabricates the
In addition to proactively approaching strategic partners and receiving visiting firms, university TTOs may also organize information sessions in targeted cities to publicize research advantages and probe cooperation opportunities. These kinds of events are usually solicited or endorsed by local officials, assisted by local alumni groups, and attended by local entrepreneurs (usually convened by the local government).

5.2.3 Comparison with government and private TTOs

In terms of function, university TTOs are part of the technology intermediary community working to match technology supply with demand. As discussed in section 4.5, the technology intermediary community in China comprises multifarious members and is thus far underresearched. MOST (2011) estimates there were about 22,000 such intermediaries in China at the end of 2010. The 2010 Nanjing S&T Yearbook estimates there were 161 such intermediaries in Nanjing at the end of 2009, which employed 22,029 persons and generated a revenue of RMB 8.1 billion (Nanjing S&T Commission, 2010). These intermediaries generally lack clear functional specialization, rendering an accurate function-based classification difficult. Nevertheless, they can be roughly grouped into three cohorts: university TTOs, government TTOs and private TTOs. Table 2 dissects the strengths, limitations and major service fields of each category. This comparison may shield some light into the mottled and obscure picture of China’s technology intermediary market.

As stressed above, the key of facilitating technology transfer is to match university technology supplies with corporate demands. Therefore, the success of a TTO hinges upon its access to both ends of the supply-demand link. Such accessibility is the major factor differentiating three types of TTOs (see Table 2). In terms of technology production, a university TTO has privileged and exclusive access to pertinent information from its associated university, but is generally blocked from other universities. A government TTO has the political power to request information from any university located within its jurisdiction to feed its technology database, but may in reality face a perfunctory response. That is to say, when requested to report technology-related information (hereafter “tech-info”), universities may respond in a selective and reluctant manner. By reporting tech-info to supervisory local S&T authorities, universities could utilize government information disclosure channels (e.g. government run TTOs and S&T information websites) to publicize their

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1 According to a Chinese folk story, when the lunar god (yuelao) ties together the ankles of two persons with an invisible red string, the two will marry each other. Therefore, “red-string” is used in China as a metaphor of marital relationship.
2 Government and private technology intermediaries may take various names, but they are all called TTO here for convenience.
research findings at no costs. Nevertheless, a university TTO generally views its exclusive access to tech-info as an asset, which it has few incentives to share freely. Furthermore, the involvement of government players is sometimes seen as unnecessary or even troublesome (interview #4, Jiang Yu). A private TTO has the theoretical flexibility to gather tech-info from any university, but is frequently turned off due to disinterest and distrust (interview #3, Peng Ding). Regarding the other side of the supply-demand link, i.e. corporate technology demands, a government TTO has advantageous access to those from firms within its jurisdiction. Nevertheless, its political power is less helpful in areas outside of its jurisdiction. For example, the Nanjing government TTO can request companies within Nanjing to report their technology demands, but cannot do so to companies outside. In other words, a government TTO faces locational confinement in accessing corporate technology needs. By contrast, a university TTO could survey technology demands proactively from any firm regardless of where it is located in China, but in reality they generally lack the resources and capacities to do so (interviews #4-7, various university TTO officers). Lacking both the political power of government TTOs and university TTOs’ close affiliation to researchers, private TTOs have a rather weak appeal to companies as technology needs collectors, even though they are free from locational restrictions (interview #3, Peng Ding).
In addition to different degrees of access to technology supply and demand information, another difference between the three types of TTOs is their employment flexibility and associated level of professionalism (see Table 2). As noted earlier, government and university TTOs are constrained by the bianzhi system to recruit the right people into technology transfer posts. Private TTOs stand out in this regard because they have the freedom to recruit talented staff and experts in technology transaction, and being the closest to the final market they arguably have more “business savvy” (interview #3, Peng Ding). Unfortunately, private TTOs’ limited access to universities and corporates leaves little space for this advantage to play out.

The strengths and limitations of three types of TTOs discussed above result in their difference in major service fields (see Table 2). Private TTOs are squeezed into a narrow set of business activities, mainly legal consulting and paperwork involved in the process of research contracting, technology licensing, S&T program application, and patent application. By contrast, government TTOs mainly gather technology information, both in terms of supply and demand, from various sources, as well as handle procedural jobs involved in the process of technology contract registration and S&T program applications. University TTOs, with exclusive access to university tech-info, engage in inventorying and publicizing technology productions as well as hands-on management of technology transfer projects (the onerous paperwork part is frequently outsourced to private TTOs). University TTOs arguably play the most significant role in the commercialization of university technologies, since they grip the upstream R&D resources. Nevertheless, their operation is fraught with difficulties.

5.2.4 Impediments faced by university TTOs

University TTOs in Nanjing face multiple structural impediments. First, they were financially constrained. University TTOs, once designated national status, receive a direct state subsidy in the amount of RMB 1 million (interviews #4-7, various university TTO officers; this is consistent with what is observed by Tang, 2006a and Wu, 2010). However, this sum is far from sufficient to turn a university TTO into a fully-fledged technology services provider. As a result, university TTOs generally lacked the capability to survey corporate technology demands in a comprehensive manner (see Table 2). Second, they had staffing difficulties. As noted previously, public university TTOs were restricted by the bianzhi system to recruit technology transaction experts from outside the university, and were frequently understaffed or staffed with unqualified and cross-appointed university employees. This resulted in questionable professionalism and service quality. Third, there was a notable lack of incentives. As aforementioned, university TTOs, forbidden from
moneymaking as part of the university administrative body, charged no fees for their services. TTO staff received no commissions from successful technology transfer deals they brokered or facilitated, and as a result they were afforded little more than a meager salary. Since incomes did not correlate with performance, their enthusiasm often dipped.

The financial, staffing and incentive difficulties boil down to an institutional conundrum. On the one hand, university TTOs enjoyed privileged and exclusive access to university technologies only because they were directly part of the university system. On the other hand, being part of the university system, they were restricted in revenue generation, recruitment and incentive creation. In a nutshell, the public identity of university TTOs has brought opposing advantages and disadvantages.

Interviews (#4, 5, 6 & 7, various university TTO officers) revealed the central government encouraged university TTOs to embark upon marketization approaches to emulate western counterparts. In other words, they were urged to develop revenue generation mechanisms, gain financial self-sufficiency and operate as private entities. The RMB 1 million state subsidy provided to each national-level TTO was meant to help cover its operation costs before achieving self-sufficiency. The marketization approach adopted by the four interviewed university TTOs was to set up an affiliated firm in the form of a university URE to circumvent their prohibition from commercial activities\(^1\) (ibid.). This way TTOs maintained their associations with universities as well as accesses to university technologies, while at the same time gained legitimacy to engage in profit-making (through their URE affiliates). This arrangement also created an institutional buffer zone between the university budget and the income derived from technology transaction deals (i.e. monetary issues induced in technology transactions will be recorded in the URE corporate balance sheet rather than the university balance sheet so that the university will not be exposed directly to potential financial risks; interview #5, Yao Wang). In theory, the affiliated URE provided an effective channel for university TTOs to operate in the private market. In reality, nevertheless, the path towards marketization via URE was still hindered in Nanjing due to a lack of financial resources. At the time of this research, the UREs of the four interviewed university TTOs had no capital to rent/build offices or employ staff. In other words, they were the so-called “hollow shell” companies existing on a normative base, simply to provide the legitimacy needed by corresponding TTOs for commercial engagement (interviews #4-7, various university TTO officers). Elsewhere in

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\(^1\) As mentioned in section 2.3, public universities in China are prohibited from engaging in commercial activities directly, but are allowed to do so via their affiliated UREs.
China, THU and SJTU have to some extent overcome this problem by bringing in venture capital (VC) to finance their TTO operation (interview #4, Jian Yu). Whether this same approach will be adopted in Nanjing remains to be seen, as the VC market in Nanjing is much less developed compared with Beijing and Shanghai, and Nanjing universities were to some extent more conservative in probing market-minded maneuvers (ibid.). Interviewed TTO officers in Nanjing (interviews #4-7) generally expected investments to come from various levels of governments.

Apart from the problems discussed above, university TTOs in Nanjing also suffered a lack of patronage from university researchers. Researchers may even deliberately shun university TTOs in their horizontal\(^1\) R&D engagement (interview #4-7, 13 & 14, university TTO officers and researchers). Underlining such disinterest are three major reasons. First, some researchers deem the services provided by university TTOs unnecessary. Researchers with an entrepreneurial mindset and rich experiences of industrial engagement could anchor horizontal projects on their own without involving any third party player such as the university TTO (interviews #3, Peng Ding; #13, You Peng Xu; and #14, Jiangfeng She). In some cases, their personal industry linkages, business savvy and social capital can help them sharpen visibility, market research results and attract R&D deals (ibid.). Some university researchers argue that the paperwork part of horizontal projects can be contracted conveniently to a private technology service provider, and even by offering free services, university TTOs are not always attractive enough as they are generally perceived as bureaucratic (ibid.).

Second, involving a university TTO in technology transfer runs the risk of landing the researcher in technology ownership disputes. According to the Article 6 of the Chinese Patent Law, technology achievements made by researchers utilizing university resources and facilities or as side products of conducting government commissioned projects are categorized as “service invention”, which belong to the university unless stipulated otherwise, while the rest of technology findings are “non-service invention” which belong solely to researchers\(^2\) (OECD, 2008). However, in reality the boundary

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\(^1\) As explained in section 5.2.2 (p. 68), “vertical projects” refer to those funded or commissioned by central ministries or national S&T programs, while “horizontal projects” refer to those initiated by industrial entities or local authorities.

\(^2\) “An invention-creation (in this law ‘invention creation’ means inventions, utility models and designs), made by a person in execution of the tasks of the entity to which he belongs, or made by him mainly by using the material and technical means of the entity, is a service invention-creation. For a service invention-creation, the right to apply for a patent belongs to the entity. After the application is approved, the entity shall be the patentee. For a non-service invention-creation, the right to apply for a patent belongs the inventor or creator. After the application is approved, the inventor or creator shall be the patentee. In respect of an invention-creation made by a person using the material and technical means of an entity to which he belongs, where the entity and inventor or creator have entered into a contract in which the right to apply for and own a patent is provided for, such a provision shall apply.” (Article 6 of the Chinese Patent Law)
between services and non-services invention could be blurry and controversial. For financial incentives, researchers tend to declare their research outcomes as “non-service findings” and thus they claim full ownership. Since the university TTO is a university administrative organ, to involve it in technology transfer is to expose the technology in question directly to the university administration, which could sometimes result in disputes or even lawsuits regarding ownership and revenue allocation (interview #8, Jiang Yue). For some researchers, the best way to avoid controversy or (in dishonest cases) to veil university-held research findings as their own, is simply to shun the university TTO. Some researchers even transferred their technological findings deliberately to firms in distant cities (from their universities) for lower visibility (ibid.).

The third reason why researchers tended to shun university TTOs was to circumvent the university management system of commercialization revenues. For vertical projects, funds from the funding authorities to a certain researcher are deposited to her individual research account trustees by the university. The researcher could only take income in the form of reimbursement to cover expenses induced in research activities. Each reimbursement required receipts, and all expenses needed to be proved legitimate and necessary. In other words, the project undertaker (the researcher) owned the funds, but the usage of funds was subject to the scrutiny of the university administration, and money withdraws entailed cumbersome reimbursement procedures. Researchers interviewed (interviews #13, Youpeng Xu; and #14, Jiangfeng She) lamented that their research funds for projects undertaken decades ago still resided in the university depository, waiting to be reimbursed to them. Unfortunately, this strict management system of vertical project funds is applied to horizontal projects as well. The common practice in Nanjing at the time of this research was that out of the total revenues generated from horizontal projects, the university and the associated department took 10%-20%, the researcher could withdraw roughly 20% as a service fee directly, while the rest (60% to 70%) was deposited to the researcher’s individual account and subject to future reimbursements (the exact share varied from university to university; interviews #4-7, various university TTO officers; and #13, Jiangfeng She). This mandated revenue trusteeship disgruntled many, and dampened researchers’ zeal for horizontal projects. To channel the money directly and fully into their own pockets, capable researchers prefer to sign R&D contracts with industrial partners directly and avoid the involvement of a university TTO.

In addition to institutional barriers and low patronage from researchers, another problem impeding the development of university TTOs is insufficient enthusiasm of university researchers in undertaking horizontal projects in the first place. This stemmed from several causes. The first was
the superiority of and preference for vertical projects vis-à-vis horizontal ones. In terms of funding, university researchers found that projects commissioned by central authorities came with generous amounts of funding, while horizontal projects might require extensive bargaining with specific industry contractors or partners (interviews #13, Youpeng Xu; and #14, Jiangfeng She). University authorities also tended to discriminate against horizontal projects because the current Chinese university evaluation system prioritized academic output, and that was evaluated primarily by the number of published papers indexed in the Science Citation Index (SCI) and Engineering Index (EI; ibid.). This type of academic output was considered essential since it dictated the national ranking and hence eminence of a university, which was tied with attractiveness to student applicants as well as the financial support a university could lever from the state (ibid.). This excessive emphasis on academic output have cast major Chinese universities in a so-called “publication mania”, and resultantly horizontal projects, which usually lead to no indexed publications or measurable academic achievements, are viewed by some universities as unworthy (ibid.). Universities’ disfavor of horizontal projects infiltrated into the evaluation of university faculty members. Interviews in Nanjing (ibid.) concur with Wu’s (2007, 2010) observation in Shanghai that horizontal accomplishments were not valued as high as vertical ones in evaluating the academic performance as well as deciding the promotion of faculty members. This undermined significantly university researchers’ interests to orient their research towards industrial application or explore commercialization prospects of their scientific endeavors. In addition to institutional discrimination, entrepreneurial research faculty may also face the cultural bias that they are sometimes viewed as business-focused, money-oriented, and hence disingenuously committed to core responsibilities of teaching and researching. This appears to have marred their reputation and has lead to their alienation from university colleagues (interviews #13, Youpeng Xu; and #14, Jiangfeng She).

5.3 Enterprise-college-institute cooperation (ECIC) platforms

5.3.1 General status of ECIC platforms

“China is now seeking to strengthen relationships among firms, universities and research institutes through what are referred to as platforms. These may take a variety of forms. The 11th Five-year National S&T Plan (2006-10) explicitly recognizes this platform concept for the first time. Given the novelty of the strategy, few resources have so far been dedicated to building such platforms. Provincial and local actors are also struggling with the modalities and incentives for building such platforms. As in OECD
countries, these platforms can be anything from a website to joint R&D projects. Platforms may be initiated by the national or provincial level but may also be supported by municipalities or smaller units of government such as counties and districts. Some platforms are sector-specific and link actors in a similar sector or value chain. Others are general support mechanisms open to all actors.” (OECD, 2008, p.371)

Fieldwork in Nanjing echoes the above observation. The “platform” concept is used loosely to denote a wide range of initiatives that lead to some kind of physical establishment (e.g. offices, laboratories, research institutes, working stations, and so on) to bring URIs and enterprises together. Though such platforms are usually grouped under the ECIC banner, they can differ vastly from each other in terms of scope, organizational structure, functions and other aspects. As shown in Figure 16 and discussed in section 4.5, the Jiangsu “ECIC platforms” cohort includes programs such as TBIs, S&T Strategic Coalitions, College-Enterprise Coalitions, Industrial Technology Strategic Innovation Coalitions, and Academician/Graduate/Postdoctoral Corporate Workstations. Except for TBIs, which are institutionalized in the national Torch Program, all the others are provincial-level arrangements designed to augment national endeavors.

These programs differ from national ones in several aspects. First, subnational governments play a substantial role in financing them. For example, during the 11th five-year period (2006-2010), 80% of the Jiangsu S&T Achievement Conversion Fund and 70% of the Jiangsu Enterprise-College-Institute Cooperative Innovation Fund went into ECIC-related projects (Jiangsu ECIC Bureau, 2010a).

Second, unlike national programs that are mandated all over China, subnational ones are voluntary. Though municipalities with richer S&T endowments are at an advantageous position to launch these voluntary initiatives, interviews (interviews #1, Shangbing Jia; #4, Jian Yu; and #6, Shengxiang Hu) revealed that cities poor in S&T resources were particularly keen and forceful in initiating and implementing such programs. Within Jiangsu province, prosperous cities such as Wuxi, Suzhou, and Changzhou devoted enormous resources to establish ECIC platforms as a way of fortifying their local innovation systems (ibid.). In addition, Huaian city designated the year 2008 as the “ECIC Year”, Yangzhou city designated the May of each year as “ECIC promotion month”, Zhenjiang city ushered comprehensive ECIC guidelines for two consecutive years (2009 & 2010); and Nantong city launched the “ECIC Hundred-Thousand-Hundred of Thousand (the more the better)” campaign (Jiangsu ECIC Bureau, 2010a). In contrast, Nanjing, the city with the densest net of S&T actors, was
commented by interviewees (interviews #1, Shangbing Jia; #4, Jian Yu; and #6, Shengxiang Hu) as “laid-back” in executing its ECIC initiatives. As a regional S&T hub, Nanjing had a relatively larger chance of obtaining national approvals to launch TTOs, USPs and other large-scale S&T projects, thus the ECIC platform was just one of the many options in its UIL “arsenal”. Other cities, however, relied more heavily on ECIC platforms to seek knowledge capitalization achievements. This pattern resembled what has been documented in the literature review (section 2.3) that S&T hub cities such as Beijing and Shanghai focused on tapping into their local S&T capital, whereas Shenzhen devotedly brought in external resources to beef up its S&T infrastructure.

Third, if national programs are top-down, subnational ones could be seen as bottom-up, opening the theoretical possibility of incorporating more contextual conditions in program design. This explains why subnational S&T projects are often heterogeneous, differing from national ones such as TTOs and USPs, which need to adhere to national regulations and consequentially appear more standardized. However, when local governments are eager to compete with each other for S&T achievements and fear falling behind regional leaders (hence politically disfavored), they may emulate blindly others’ approaches without much modification (interviews #1, Shangbing Jia; and #3, Peng Ding). This adds a degree of irrationality and redundancy, and may dilute the advantages of bottom-up approaches.

Different from university TTOs (see the preceding section 5.2), the description of ECIC platforms can hardly be written with much generalization, as the ECIC platform category contains highly diversified forms and features. Furthermore, due to their idiosyncratic nature, ECIC platforms are rarely surveyed in national/provincial studies and statistical reports, making it difficult to present aggregate description or numeric measurements. One commonality of ECIC platforms is that rather than emerging out of spontaneous URI-industry liaison, they are generally designed, initiated, financed and promoted by subnational governments (interview #1, Shangbing Jia). Another observation is that the current proliferation of ECIC platforms outpaces the development of corresponding legal and policy framework, hence harbors much flexibility, novelty and diversity (interviews #1, Shangbing Jia; and #12, Shaoming Pan). The following subsection addresses specifically the S&T Strategic Coalition – an essential component of ECIC platforms in Jiangsu, and then an example of ECIC platforms will be scrutinized.
5.3.2 General status of the S&T strategic coalition program

The S&T Strategic Coalition is a priority domain of ECIC. As defined in section 4.5, it roughly refers to all kinds of efforts of the provincial and municipal governments in Jiangsu province to refract intellectual assets from major national R&D hubs inward, via signing strategic cooperation deals, and/or establishing cooperation factories/laboratories. CAS, CAE, PKU, THU, ZJU, and some premier SOEs are among the highly sought-after R&D partners. One reason is their superior R&D productivity that opens up more cooperation opportunities, but an implicit cause is the unparalleled visibility of these elite institutes in China’s S&T landscape. Anchoring a cooperation deal with a national R&D star is arguably among the most notable achievements that a local municipal government can make. The coalition web of CAS, PKU or THU, according to interviews, reaches every corner of China (interviews #1, Shangbing Jia; and #2, Zhihui Li).

Amid the national scramble for establishing strategic coalitions with top R&D institutes, the Jiangsu provincial government is explicitly proud of itself as a frontrunner. At the end of 2009, Jiangsu had signed 544 strategic cooperation deals with S&T partners, and 941 URIs (inside and outside Jiangsu) had established durable cooperation relations with Jiangsu companies, together leading to some 20,800 projects with a total investment of RMB 918 billion (Jiangsu ECIC Bureau, 2010a). The CAS system had a strategic alliance with every city in Jiangsu, and established research institute branches in many of them. At the end of 2010, around 5,000 CAS research personnel were working for the Jiangsu province, and this dense web of coalition concluded 1,000 projects, generating a revenue of RMB 316 billion (ibid.). The 110 ECIC projects with PKU or THU, according to interviews, generated a revenue of RMB 7 billion (out of RMB 1 billion investment) in Jiangsu province in 2010 (ibid.). In the same year, THU had 334 ECIC projects in Jiangsu (profit unclear), and CETC had 94 generating RMB 3.3 billion out of RMB 0.5 billion investment. Platforms and projects spun off the S&T strategic coalition program were also heterogeneous, defying an overarching discussion, and the following presents one specific platform example.

5.3.3 An example of ECIC platforms – “The Research Institute of NJU in Lianyungang”

As noted, unlike TTOs and USPs, each ECIC platform is idiosyncratic. The case study here aims to shed some light into this largely uncovered UIL mechanism rather than to provide a holistic picture. NJU has 24 ECIC platforms in total. A brief profile of each of them is sketched in Appendix E, we can see these platforms take three organizational forms (with the first being the most popular) – 1) research institutes co-established with a city government, 2) incubators/USPs, and 3) R&D centers
launched together with industry giants such as Sinopec and the Jinchuan Group. Most of these platforms were set up very recently, and some are still under construction. Their physical scope varies, ranging from a massive science park to a mere single building or a couple of offices. They are frequently located in existing industrial parks, high-tech parks, or development zones, which generally cluster multiple firms and so present the largest R&D demands. Another pattern is that each ECIC research institute is usually hosted by one NJU school or department, which provides specific technology matches. “The Research Institute of NJU in Lianyungang”, hereafter referred to as “the LYG institute”, is selected as an example here, but it should speak only to the first form of research institutes co-established with a city government, and a following section will address the case of incubators/USPs.

• Launch, organizational nature and rationale

The LYG institute was launched at the beginning of 2010, and it started full operation in July 2010 (interview #12, Shaoming Pan). It is located on the third floor of a building in the Lianyungang S&T and Education Park (Figure 18), a municipal level S&T park (about 330kms from Nanjing) which accommodates multiple research and education institutes. It is a wholly owned research subsidy of NJU, in other words it belongs entirely to NJU even though it is located outside of the city. However, it is also listed as a unit under the Lianyungang S&T Bureau, to denote its nature as a co-established ECIC platform between NJU and the Lianyungang government. Being a research subsidy of NJU means it is a public unit (since NJU is a public university), or in China called Shiyé Danwei.

The Lianyungang government provided all the initial assets for the institute, including RMB 5 million working capital, 2,000m² office space (together with land use permit), research facilities, 10 standard hotel rooms for accommodating visiting experts, and 15 shiyé bianzhi headcounts (ibid.). NJU only contributed to this institute in terms of

![Figure 18. Research Institute of NJU in Lianyungang Source: NJU TTO website, 2012](image-url)
arranging recruitment, management, and R&D resources.

The ultimate rationale for the LYG institute is to promote UILs, and specific incentives are myriad. For NJU, it provides an institutional base and physical space for streamlining research commercialization in Lianyungang. Before the launch of this institute, NJU researchers were already involved in cooperation with Lianyungang enterprises, but mostly on an individual basis and in informal forms (ibid.). Through the LYG institute, NJU researchers now could have a formal work place to meet and work together with local industrial partners. This could arguably boost NJU’s local prospects of UIL development and research commercialization. For Lianyungang, the LYG institute channels in S&T resources from NJU, opening possibility of satisfying local industrial technology needs and upgrading private sector R&D level. Lianyungang is a city poor in S&T assets; consequently this institute could also retain local R&D talent who otherwise would migrate to other cities for commensurate jobs, therefore preventing a brain-drain loss. In addition, since this institute incorporates an education and training function, it could assist Lianyungang city in R&D talent cultivation. Besides these objectives, there are other implicit reasons. For example, Lianyungang government is under political pressure to make S&T achievements. Moreover, NJU has no reason to reject a physical asset that comes at marginal costs on its side as the funding comes solely from the Lianyungang government. Actually, the primary way for local governments to encourage eminent URIs into co-establishing ECIC platforms and strategic alliance is to offer perks such as buildings, research facilities, land use rights and bianzhi quota that turn into the targeted institute’s assets. Due to the relative scarcity of R&D sources and the pervasive pressure for local governments to make R&D achievements, eminent URIs are on the higher end of the power balance in the UIL scramble.

- Leadership and structure

Figure 19 depicts the organizational structure of the LYG institute. The leadership body is composed of members from both the Lianyungang government and NJU. The Board of Governors consists of nine members: 1) the vice-party secretary of the Lianyungang government, 2) the vice-director of the NJU S&T Division, 3) the vice-director of the Lianyungang S&T Bureau, 4) the director of the Lianyungang S&T and Education Park, 5) the vice-mayor of the Lianyungang Donghai county, 6) a standing committee member and the district governor of Lianyungang Guannan county, 7) the party secretary of the NJU School of Earth Sciences and Engineering, 8) the vice-director of the NJU School of the Environment, and 9) the department director of the NJU School of Geographical and Oceanographic Sciences (LYG Institute website, 2010). This leadership
body makes top-level decisions regarding the development of the LYG institute. Its composition reflects not so much the intention of bringing different interests and perspectives together but the mechanism of building up political capital. In the case of most Chinese dual-identity (i.e. joint ventures between public and private agencies) and sometimes even private organizations, party leaders, government officials, key persons in public institutes are often invited to hold nominal governing or supervisory posts to lever political support and capital. Under the governing board, the department director of the NJU School of Geographical and Oceanographic Sciences (interviewee #12, Shaoming Pan) is the primary person in charge of the institute’s daily operation.

Regarding the operation structure, as shown in Figure 19, the institute is made up of two wings – the management wing and the R&D wing. The R&D wing comprises three research centers, one education and training center, and two outpost service branches. The three research centers focus respectively on marine resources development, new materials development, and environmental protection technology. The education and training center provides entrepreneurship training to local businessmen. The two service branches are each located in one port county to provide industrial planning, technology consulting, as well as environment protection services.
• Operation, functions and revenue composition

The LYG institute is mainly a platform to bring NJU researchers and Lianyungang industrial leaders together for technology cooperation. Cooperation can take a variety of forms. For example, a company in Lianyungang could contact the institute for help tackling technological challenges. The institute would then identify a NJU researcher competent in relevant technology domain and arrange for contractual research or cooperative R&D (interview #12, Shaoming Pan). NJU researchers and Lianyungang enterprises could co-apply for national research projects, and co-apply for patents, with the assistance of the institute (ibid.). The institute could also assist a NJU researcher to license out a technology or launch a spin-off company in Lianyungang (ibid.). The institute provides some basic research facilities, and could also arrange researchers and industrial clients to use facilities and equipment in NJU campuses. Overall the LYG institute functions like an outpost branch of the NJU university TTO. Its major purpose is to facilitate various forms of UILs, but with a specific location focus.

In terms of personnel, the institute held at the time of this research about 20 full-time employees, including both managerial and R&D staff (ibid.). NJU experts were invited to hold part-time positions only, since they usually undertook multiple obligations both in the university as well as in other regions (other than Lianyungang city). As aforementioned, NJU held the responsibility of recruitment and the Lianyungang government had allocated 15 shiye bianzhi to staff the institute. The bianzhi were used mainly to recruit exceptional researchers, since its associated benefits and social status constituted an appeal.

The office space provided by the Lianyungang government was free for only three years after the institute’s initial commencement. Rents would be charged after that. The institute, like other ECIC platforms, was expected to marketize itself and develop revenue generation mechanisms within three years (ibid.). The RMB 5 million government seed fund was meant to be assistance during the marketization transition. Here ECIC platforms resemble university TTOs in that they are both encouraged to gain financial self-sufficiency. At the time of interview, the LYG institute had only been in operation for roughly one year, thus its revenue scheme was still unclear and in the process of experimentation. According to the interview (#12) with Shaoming Pan, income during the first year mainly came from government sources: RMB 3 million from being selected as a provincial-level major ECIC platform, RMB 1 million from successfully applying for 9 Lianyungang municipal-level S&T projects, RMB 0.5 million from the talent recruitment program organized by the Jiangsu
Provincial Personnel Department, and RMB 1 million from education and training as well as technological consulting. It is therefore safe to say the institute was primarily government-financed during its debut year. Expenses were mainly spent on staff salaries and daily operations. The interviewee (ibid.) commented that one viable revenue stream should be commission fees from NJU researchers who, via the help of the institute, successfully anchored horizontal projects with Lianyungang industrial partners. However, the institute charged no commission fees at the time of fieldwork, for fear of discouraging NJU researchers and dampening UIL performance. How revenue generation would be achieved in the future was unclear.

• Impediments

As a public unit of NJU, the LYG institute faced similar problems as the university TTO. It was constrained in finance, recruitment and incentive formation due to its organization identity (a public unit while tasked with revenue generation). It also faced lukewarm interest from NJU researchers. Few were willing to work in a distant city on a long-term base, which entailed extensive traveling (it took about four hours to drive from Nanjing to Lianyungang). Resembling the situation with university TTOs, projects channeled via ECIC platforms also come with the risk of provoking technology ownership disputes as well as cumbersome revenue trusteeship, since the associated university may claim ownership of technologies generated from the ECIC platform as well as deposit research commercialization incomes into funds trusteeship accounts (see subsection 5.2.4 for detailed discussion). As for local enterprises, since the institute was fairly recent, the market confidence for its usefulness still awaited nurturing. As shown in revenue composition, local industry barely contributed to the institute’s first year income. Overall, it was too early to comment on the strengths and weakness of such platforms, as most of them were nascent and in a fluid process of institutional building.

5.4 University science parks (USPs)

5.4.1 A typology of cluster designations in China

China actively uses various types of clusters to bring firms and other actors together for agglomeration effects (OECD, 2008). This is seen as an attempt to replicate the success of clusters in OECD countries, though clusters in China may occupy much larger space, exhibit mightier governmental influence, and harbor a more complex set of overlapping structures (ibid.). Designations of these clusters are confusing, particularly so for external observers. A thorough
understanding of USPs, the author believes, needs to be preceded by a clarification of the
designation typology (Figure 20).

First is the “Special Economic Zone (SEZ)” category, which denotes a city granted special
economic policies, flexible government measures as well as larger decision-making autonomy to
make it more market-oriented and business-conducive. There are currently five SEZs in China –
Shenzhen, Zhuhai, Shantou, Xiamen and Kashgar. Next is the national “Development Zone”
category, which includes six sub-categories: 1) the Economic and Technological Development Zone
(ETDZ, 127 national-level ones in China) – mainly for attracting foreign direct investment; 2) the
High-tech Industrial Development Zone¹ (HIDZ, 56) – mainly for industrializing high and new
technologies; 3) the Free Trade Zone (FTZ, 13) – mainly for international trade and bonded
businesses; 4) the Border Economic Cooperation Zone (BECZ, 14) – mainly located along the
northern and northeastern border of China to develop border trade and export-oriented processing
business; 5) the Export Processing Zone (EPZ, 60) – mainly to promote the development of
processing trade; and 6) other national-level development zones (29) – for various economic
development such as tourism, finance, and logistics (Chinese Association of Development Zones,
CADZ, 2012). The sixth category of development zones may use variegated titles including “park”,
“hub” or “base”, causing difficulty in identifying their true designation. There are two other types of

¹ same as the S&T Industrial Park in Figure 12
clusters that are generally of smaller scale than development zones – the Specialized Industrial Base and the Software Park. They are both components of the national Torch Program.

TBIs (Technology Business Incubators), affiliated with the Torch Program as well, constitute another major category (see Figure 12). TBIs differ from other clusters as they are tasked specifically with incubating nascent start-ups, while the rest are responsible for clustering mature enterprises. TBIs also include three categories: 1) USPs – incubators affiliated with universities; 2) Start-up Centers – various entities for nurturing start-ups; and 3) Overseas Returnees Start-up Centers – organizations incubating start-ups launched by overseas returnees. All the above-mentioned cluster categories are national-level ones, and the Chinese “hierarchical amplification” system has paralleled each of them with countless counterparts at provincial, municipal, county, district or even township levels. Subnational clusters often use titles in an uncoordinated and arbitrary fashion, hence making it difficult to detect a certain cluster’s hierarchical position or institutional nature from its title. Further adding to the complexity is that small clusters may locate within higher-level larger clusters. For example, a HIDZ could contain several TBIs and software parks.

All clusters enjoy some form of preferential polices, including cheap land, tax cuts, subsidies and/or free services, and so on (OECD, 2008). However, the magnitude of government support varies between different cluster categories as well as hierarchical rankings (i.e. national, provincial, municipal or other levels). TBIs, according to interviews (interviews #1, Shangbing Jia; and #2, Zhihui Li), enjoy the most generous support since they have weaker revenue generation abilities. High-level clusters (i.e. those designated as national- or provincial-level) lever a higher share of central government support, while low-level ones are primarily subsidized by local authorities. This constitutes an incentive for lower-level clusters to compete for high-level designations. Besides, status promotion of a cluster marks management excellence, hence can bring political rewards for local officials in charge. In addition, zones and parks are the economic backbone and major tax contributors to local governments; therefore, local officials have a strong desire to buttress their proliferation, expansion and promotion. To curb excessive reliance on public finance, the central government has restricted local government input into zones and parks (OECD, 2008). The establishment of a large-scale cluster requires provincial and national level authorization. Nanjing currently holds four national-level development zones (1 HIDZ), seven provincial-level development zones, four Torch Program specialized industrial bases, one Torch Program software park, and 10 national-level TBIs (4 USPs; Jiangsu S&T Statistics Bureau, 2009a, 2009b).
5.4.2 Rationale, history, scope and hierarchy

As unraveled in the above designation typology, USPs (as a category of TBIs) are mainly tasked with incubating technology start-ups. Different from other TBI types, USPs aim to achieve this via capitalizing university knowledge. China’s initiative to establish USPs is said to be inspired by western practices (Wu & Zhou, 2011). According to interviews (interviews #2, Zhihui Li; and #8, Jiang Yue), USPs are also expected to rejuvenate existent development zones and other industrial clusters via feeding them with high-tech graduate firms, since after decades of growth industrial clusters are becoming stagnant, particularly in technological competence as well as R&D intensity.

China’s first USP – the Northeast University Science Park – was established in 1989 in Shenyang city, followed soon by THU and PKU (Xue, 2004). The USP program was institutionalized by MOST under the Torch Program in the 1990s as a maneuver to reform China’s NIS (Sutherland, 2005). In 2000, the central government recognized the economic contributions of USPs and decided to establish more (Liu, 2006). Mei (2004, p. 1) concludes USPs in China “originated in the early 1990s, grew in the middle of 1990s and enjoyed a booming development at the turn of 21st century”. At the end of 2010, the total number of national-level UPSs in China reached 86 (MOST, 2010). Table 3 summarizes major numeric figures gauging their status. Resembling other national programs, USPs are also established at provincial and municipal levels, and outstanding ones among them aim to get promoted to the national-level.

Nanjing currently has six USPs – four national-level ones, one provincial level and one municipal level (Jiangsu S&T Statistics Bureau, 2009b). The four national-level USPs are the NJU-Gulou colleges USP (referred to as the NJU USP hereafter), the SEU USP, the NUST USP and the NUT USP. A numerical depiction and comparison of the first three is provided in Table 4, compiling information from the Jiangsu

| Table 3. A numerical profile of Chinese national-level USPs at the end of 2010 |
|---------------------------------|------------------|
| **Indicator**                   | **Figure**       |
| Total No.                       | 86               |
| Total area                      | 8,144,900 km²    |
| Total capital volume            | RMB 12.571 billion (56.93% self-help, 2.73% government appropriation, 28.58% loans) |
| Fixed asset value               | RMB 4,867 million |
| Incubation fund                 | RMB 812 million  |
| No. of USP services employees   | 2,343            |
| No. of employees of under-incubation firms | 127,600 (20,600 fresh graduates) |
| No. of firms under-incubation   | 6,617            |
| No. of 2010 intakes             | 1,858            |
| Accumulative No. of graduated firms | 4,634 (21 public listed) |
| No. of graduated firms in 2010  | 683              |
| No. of government S&T projects undertaken by under-incubation firms in 2010 | 1,728 (345 state-level) |
| No. of patent applications filed by under-incubation firms in 2010 | 5,603 (2,333 invention patents) |
| No. of patents granted to under-incubation firms in 2010 | 2,857 (872 invention patents) |
| No. of technology transfers into under-incubation firms in 2010 | 4,606 |
| Total income of under-incubation firms | RMB 22.163 billion |
S&T Statistics Bureau’s 2008 TBI survey (data for the NUT USP is not available). The four national-level USPs in Nanjing are different from each other, though they are not as idiosyncratic as ECIC platforms, since as national-level parks they are subject to heavier central government scrutiny and regulation. As shown in Table 4, the listed three USPs demonstrated poor revenue-making abilities and weak financial strength. None of the three USPs generated any income in 2008, and the NJU USP and NUST USP had accumulated no financial capital for incubation use. These USPs were large – the smallest of the three occupied an area of 50,000 m\(^2\) and the NJU USP covered an area eight times of that. Nevertheless, till 2008 the NJU USP had incubated only a limited number of start-ups (see the accumulative No. of graduated firms in table 4). The revenue generation abilities of firms under the incubation of the NJU USP and the SEU USP were poor, as indicated by their average income and profit levels (see table 4). The technology strength of firms under USP incubation was also lackluster, according to the number of filed and granted patents (ibid.).

The NJU USP is a web of 12 branch parks located separately in different parts of the Gulou district (see Figure 21 for a district map of Nanjing), with its management office in a building inside the NJU campus (NJU USP website, 2012). It is affiliated nominally with 9 colleges in the Gulou district, though NJU is the primary one involved. Enterprises located in the same branch park generally share a similar technology focus, such as information and communication technologies (ICTs), biopharmaceuticals, new materials, new energy and environment protection (ibid.). SEU has branch campuses or research institutes in five districts of Nanjing as well as in nearby Suzhou city and Yangzhou city. The SEU USP also consists of seven sub-parks each co-located with one branch campus (SEU USP website, 2012). Each sub-park is designated with a particular technology domain, and at the time of this research four of these sub-parks were still under construction or expansion (ibid.). The NUT USP has three divisions, one located in the urban Gulou district (inside the NUT campus) and the other two in the suburban Pukou district (NUT USP website, 2012). Unlike the
previous two, the three divisions of the NUT USP were differentiated by function rather than technology focus. Thus, the Gulou division was designated to be a “seed” zone for incubating nascent start-ups, one Pukou division was designated as a “sprout” zone for further nurturing small firms graduated from the seed division, and the other Pukou division located in the Nanjing HIDZ was designated as a “talent” zone for accommodating domestic and overseas S&T experts (a residency community rather than a business area). The NUST USP does not adopt a branch structure, and comprises a very large park in the Baixia district located adjacent to the NUST campus (NUST USP website, 2012). Appendix F comprises pictures (Figures 23-26) that depict the majestic exterior of the four USPs. The site visits in 2011 revealed that some buildings were overly spacious and many of them were mostly vacant.

Table 4. A numerical depiction and comparison of three state-level USPs in Nanjing, 2008

<table>
<thead>
<tr>
<th>Indicator</th>
<th>NJU USP</th>
<th>SEU USP</th>
<th>NUST USP</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of managerial staff</td>
<td>24</td>
<td>15</td>
<td>52</td>
</tr>
<tr>
<td>Area (m²)</td>
<td>410,000</td>
<td>50,000</td>
<td>69,625</td>
</tr>
<tr>
<td></td>
<td>(600 office area)</td>
<td>(380 office area)</td>
<td>(1,375 office area)</td>
</tr>
<tr>
<td>Capital volume (RMB million)</td>
<td>5.36</td>
<td>141.16</td>
<td>141.633</td>
</tr>
<tr>
<td></td>
<td>(2.88 government approval)</td>
<td>(0 government approval)</td>
<td>(0.5 government approval)</td>
</tr>
<tr>
<td>Income (RMB yuan)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fixed asset value (RMB million)</td>
<td>0.48</td>
<td>57.45</td>
<td>462.11</td>
</tr>
<tr>
<td>Incubation fund (RMB million)</td>
<td>0.48</td>
<td>57.45</td>
<td>462.11</td>
</tr>
<tr>
<td></td>
<td>0.48</td>
<td>57.45</td>
<td>462.11</td>
</tr>
<tr>
<td>No. of firms under incubation</td>
<td>679</td>
<td>39</td>
<td>52</td>
</tr>
<tr>
<td>No. of 2008 intakes</td>
<td>110</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>Accumulative No. of graduated firms</td>
<td>42</td>
<td>35</td>
<td>62</td>
</tr>
<tr>
<td>No. of graduated firms in 2008</td>
<td>42</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>Income of under-incubation firms in 2008 (RMB million)</td>
<td>Total</td>
<td>3,684</td>
<td>5.43</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>5.43</td>
<td>19.49</td>
</tr>
<tr>
<td>Profits of under-incubation firms in 2008 (RMB million)</td>
<td>Total</td>
<td>176</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>0.26</td>
<td>-5.00</td>
</tr>
<tr>
<td>No. of employees of under-</td>
<td>9,685</td>
<td>14.26</td>
<td>1,349</td>
</tr>
<tr>
<td>incubation firms</td>
<td></td>
<td>14.26</td>
<td>34.59</td>
</tr>
<tr>
<td>No. of patent applications in 2008</td>
<td>190 (39 invention patents)</td>
<td>0.28 (0.06)</td>
<td>172 (107 invention patents)</td>
</tr>
<tr>
<td>No. of patents granted in 2008</td>
<td>78 (21 invention patents)</td>
<td>0.11 (0.03)</td>
<td>60 (27 invention patents)</td>
</tr>
</tbody>
</table>
5.4.3 Operation and functions

In terms of their institutional nature, the USPs were all public units, as they belonged to public universities (interviews #8-11, various USP officials). As public units they were not supposed to be profit-driven though financial self-sufficiency was encouraged (ibid.). At the same time, they were expected to adopt market mechanisms to maximize efficiency and professionalism. This dual-identity led to a two-layer management structure composed of a supervisory committee comprising university principals and/or party secretaries as well as government S&T officials, and nested under it a company incorporated by the university in the form of a URE. The supervisory committee was in charge of making strategic decisions, and more importantly weaving together political capital. The management company handled daily operation, and was staffed mostly with university employees. The identity conundrum observed earlier in the case of university TTOs and ECIC platforms was present in USPs as well, since they primarily ran on public assets while at the same time desired financial, recruitment and incentive freedom similar to private firms.

The composition of initial input into the establishment of USPs varied. In the case of the NJU USP, the entire input was from the Gulou district government with marginal contributions from NJU. According to interviews (interviews #1, Shangbing Jia; and #8, Jiang Yue), the majority of branch parks in the NJU USP consisted of previously obsolete factory bases left by bankrupted SOEs. The Gulou district government invested in their refurbishment and later transferred their land usage rights into the NJU USP (interview #8, Jiang Yue). The Gulou district is the central area of Nanjing (see Figure 21), thus its land commands a high price and this district was too congested for new development. But by transforming obsolete factory buildings into a USP, vacant buildings could be reutilized and additional construction was avoided. This is why the NJU USP comprised a loose web of separate branch parks (mainly high-rise buildings, see Figure 23 in Appendix F). The Gulou district government also purchased facilities and office supplies to prepare these branch parks for business incubation (ibid.). Other USPs were different. Thus, the SEU USP was founded primarily on university investment, with support from various district governments (interview #10, Xiucheng Guo). The NUT USP levered a large amount of bank loans into USP building (interview #9, Hongxi Chen). The NUST USP was co-established by NUST and the Baixia district government with investment from both sides, as well as bank loans (interview #11, Yong Shan). The exact amounts of capital obtained by this project from each party were difficult to uncover.

The level of government involvement in these various science parks was embodied not only in their initial investment but also in their daily operations. Government infiltration into the NJU USP was
particularly notable. Thus, except for an NJU-appointed manager, all the employees at the NJU USP were appointed by the Gulou district government (interview #8, Jiang Yue). Therefore, the NJU USP was viewed by some as a government science park operating under the banner of a USP (interviews #9, Hongxi Chen; and #11, Yong Shan). The NUT USP accommodated a branch office of the Gulou S&T Bureau (interview #2, Zhihui Li). In contrast, the NUST and SEU USPs arguably had a larger managerial autonomy.

Firms located in USPs enjoyed considerable preferential policies, including tax cuts, subsidies, low or free rents, free facilities, free services, free training, as well as easier access to university laboratories and talent (OECD, 2008; interviews #1, 2, 3, 8, 9, 10 & 11). Regarding services and training, the USP management company would typically familiarize start-ups located in the park with industrial policies, tax codes, financial market practices, as well as help these start-ups resolve technological, managerial, financial and recruitment difficulties. In addition, firms located in USPs had a larger chance to win various government S&T funds and projects, because of their USP affiliation. USPs also assisted start-ups in applying for patents, government R&D contracts, firm and product designations (e.g. high-tech firm, certificated software firm, high and new-tech products, major products, and so on) and various other government supports. These “perks” of locating in a USP are what define “incubation”, since they shield start-ups from fierce market competition, which may smother promising start-ups at an early stage. The scope and quality of such support determine incubation effects. At the time of the research, preferential policies for start-ups under the incubation of USPs in Nanjing were quite complicated, as four layers of governments – national, provincial, municipal, and district – all propagated some tentative policy supports. Interviewees (#8, 9, 10 & 11, USP officers) expected national authorities to formulate a more uniform and well-designed support framework soon. Though the picture was unclear, overall USPs were believed to be more favorable than development zones and other clusters regarding the generosity of government support (interviews #1, Shangbing Jia; and #8, Jiang Yue).

According to the typology of S&T programs in China (see Figure 12, 16 or 20), USPs constitute a category of TBI, thus their premier mission was to nurture start-up firms with strong R&D elements. To safeguard their mission, clear entrance and exit standards needed to be enforced. In other words, USP management had to stipulate clearly what types of firms could be allowed in and when they should move out. SEU has a stringent entrance requirement. Thus, eligible firms should meet the following criteria: 1) registered in the SEU USP; 2) newly incorporated or incorporated for less than three years; 3) have a registered capital less than RMB 5 million; 4) its yearly income prier
to move-in must not exceed RMB 2 million; and 5) should be tech-firms concentrated on R&D and technology commercialization (SEU USP website, 2012). However, the other three USPs do not have strict move-in thresholds. According to interviews, firms with a mature business or with limited R&D activities are also sometimes allowed into USPs (interviews #1, Shangbing Jia; #3, Peng Ding; and #8, Jiang Yue). In addition, move-in requirements also do not necessarily mandate any association with the “mother institute” (interviews #8-11, USP officers). For example, a firm founded based on a NJU technology or by an NJU alumni is certainly welcome in the NJU USP, but the door is basically open to all technology start-ups regardless of whether or not they relate to NJU. It is the intention of national policies that USPs serve the wider society rather than their affiliated universities (ibid.).

Preferential polices and services given to firms at USPs are supposed to be time-limited as they are expected to grow and graduate (move out) within a specific period. Otherwise they will be simply exploiting USP benefits. The SEU USP again has a stringent exit requirement that a firm can stay in its USP for no more than three years; any firm failing to graduate within this period will be forced out (SEU USP website, 2012). However, this time limit is not enforced universally in Nanjing. Interviews unveiled some enterprises that overstayed their incubation periods and grew too mature to be counted as start-ups still stayed in their USPs (interview #8, Jiang Yue). In such cases, the USP management and the district government in charge turned a blind eye on these overstaying firms deliberately, as they eyed the larger rentals, R&D contractual bills and taxes that a mature enterprise could offer (ibid.). One interviewee said local district governments were particularly reluctant to let go successful graduate firms, since it would entail a loss of tax sources if they moved to other districts (ibid.). USPs with their appealing policy perks were therefore used sometimes by district governments to detain so-called “tax cows”. Loose entrance and exit enforcement defies the original institutional agenda of USPs, causing the problem of “mission creep” (discussed in section 4.6).

At the time of this research, the income sources for USPs were largely two-fold. The first comprised rentals from start-ups, which tended to be much below market average, hence very meager. The other was equity interests from firms invested by the USP via an incubation fund. In this way, the USP basically took the role of a venture capitalist. Recent data gauging the financial performance of Nanjing USPs were unavailable. However, according to Table 4, their revenue generation capabilities were rather weak in 2008. Currently, the government (at various levels) was the primary financer of USPs. Since incubation is a risky activity with positive social and economic externalities, USP managers interviewed for this research did not conceal that securing government finance constituted
What was the rationale for universities to engage in a USP and why did so many universities vie for launching USPs, if the financial return seemed dismay, at least for now? The answer resembles the case of ECIC platforms discussed earlier. First, public universities, lacking autonomy in China, were pressured to respond to central authorities. Since MOST and MOE encouraged the development of USPs, any inactive response ran the risk of being interpreted as defiance. Elite institutes all braced themselves to “jump into this race”, for fear of losing eminence and political status if they were seen to fall behind. Second, multi-scalar governments have put together enticing packages in return for universities’ engagement. Under the banner of USP, universities can significantly expand their campus space as well as their physical asset portfolio. As demonstrated by the four USPs in Nanjing (shown in Appendix F), these universities secured a tremendous amount of land and buildings through USP development, sometimes even larger than their campuses. Without the legitimacy lend by USP development, they would never be allowed to make such an expansion. Besides, since at the present various levels of government were the primary financers of USP development, the burden did not fall on the shoulder of universities anyway. At the end of the day, elite universities are seem as “too big to fail”, since the government will always bail them out no matter where their USPs lead them to. With the title of a USP, it is also easier to bargain for government support in the future. Overall, there is no institutional brake for engaging in USP, just like the situation decades ago when numerous universities proliferated their UREs with a stunning zeal (Xue, 2004).

Then what is the rationale for local government engagement if USPs seemed to be a financial drag (as shown in table 4, USPs have limited abilities to generate revenues for themselves and therefore relied largely on government finance)? Just as an USP development project is a legitimate cause for universities to lever government support, it is also a sound cause for lower-level government to lever input from high-level authorities. A well-established USP, thanks to its visibility, is an effective achievement marker and could bring political rewards for the specific government in charge. In addition, local governments also have the incentive of securing tax sources. Start-ups, though enjoying significant public “spoil” during their incubation, will pay taxes in full amount once they graduate. Local governments are not only incubating tech-firms, but also future tax contributors. All in all, behind the enthusiasm over USPs is intricate inter-actor and inter-government gambling of political and economic interests, which is not always aligned with the original rationale of establishing USPs – knowledge commercialization and industrial modernization.
5.4.4 Problems

- financial uncertainty

Firm incubation is a notoriously risky endeavor, since many firms may not survive market competition after graduation. This means investment devoted into incubating nascent start-ups often brings no return, at least in the short-term. In western economies, such risky behavior is often left to venture capitalists. However, in China, governments and universities play such a role and invest in USPs with public money. This could spur political controversy if USPs fare poorly. As discussed in section 2.3, the public once lamented UREs for implicating their affiliated universities into financial losses and entailing government bailouts. The Chinese central government recognizes abundant financial input was essential for USPs to develop, but is also wary that the development of USPs may derail just like previous UREs. One possible solution to share and dilute the financial and political risks involved in USP development is to channel in private capital. Nevertheless, at the time of this research, a uniform national regulatory apparatus regarding USP was still pending in China, and the USPs in Nanjing were unsure about the flexibility they possessed in diversifying their financial sources. Interviewed USP managers in Nanjing (interviews #8-11) all claimed they were waiting for national USP policies to become clearer.

- “mission creep” and insufficient supervision

The problem of “mission creep”, one side effect of the Chinese “hierarchical amplification” system as discussed in section 4.6, is observable in Nanjing USPs. As aforementioned, USP management in Nanjing lacked effective entrance and exit enforcement. Firms either too mature or too limited on R&D to be classified as technology start-ups are sometimes allowed in. This carries the purpose of filling giant and spacious USPs (see Appendix F) and hence creating the appearance of success. Regarding post-incubation exit, firms exceeding the incubation time limit or mature enough to leave sometimes remained. Unlike nascent start-ups which demand various investments to grow, mature firms were in general financially strong, and could contribute much heavier to the associated university and district government in forms of rent, tax, investment, and job creation. These “unqualified residents” in USPs were detained deliberately to offset the financial burden brought by nascent start-ups (interview #8, Jiang Yue). Of course, these firms were also more than happy to prolong their stay in the preferential policy zone. This “mission creep” deformed the original mission bestowed on USPs, and blurred the boundary between USPs and industrial zones (see Figure 20). Jiang Yue (ibid.) bluntly stated the functional division between the two – USPs for
incubation and zones for clustering mature firms – was to some extent lost.

This “mission creep” phenomenon underscores the problem of an underdeveloped USP policy framework and an inadequate supervision scheme of S&T programs. At the end of 2011 (after the fieldwork), a nationwide evaluation of national-level USPs orchestrated by MOST and MOE was concluded, the first of this kind. The evaluation result was published in early 2012, which classified 86 current national USPs into three levels based on performance – A (17), B (47), and C (19). One USP was deprived of its park permit and dismantled, and two others were put on pending status for them to rectify and reform (MOE Department of S&T website, 2012a). Three Nanjing USPs – the NUST USP, the NJU USP and the NUT USP got into B level, while the SEU USP fell into C level. A five-year plan outline for USP development (2011-2015) was also ushered at the end of 2011, which is quite coarse and abstract (MOE Department of S&T website, 2012b). To some extent, these two maneuvers reflected that the problematic status of USP management at local level had attracted central level attention. They could also be viewed as a signal from the national government to centralize, formalize and streamline the management of USPs. More detailed regulations were expected to follow.

- others

Other problems include similar ones faced by university TTOs and ECIC platforms. For instance, USPs’ public identity caused staffing difficulty. USP management companies in the form of UREs could circumvent the bianzhi quota, but they were financially constrained when trying to recruit the best talent in managing science parks. Current employees of USPs were generally university administrative staff, professors or government officials whose managerial skills and professionalism were in doubt. Incentive creation was also problematic as current USPs were not financially rewarding. Overall, USPs in Nanjing were still in the process of expanding their business, but based on site visits, it is safe to say USPs tended to be overly massive in scale (see Table 4). State endorsed projects in China all tend to be suffused with excessive investment at the local level, a trait reflecting the “hierarchical amplification” pattern and rooted in China’s unique political economy, and the reasons have already been explored at various occasions in the previous text. Finally, notwithstanding the enticing preferential policies, USPs are not necessarily the preferred destination for university researchers to launch start-ups for the same reason they shun university TTOs and ECIC platforms.
5.5 University spin-off companies

Adopting a loose definition, university spin-off companies in China currently encompass three major categories: 1) UREs that are wholly owned and run by universities, 2) start-ups under incubation within USPs, and 3) private firms founded by university faculty members or students but not located in USPs (see Figure 17). Due to time and resources constraint, interviews conducted for this research failed to enlist any spin-off personnel, thus the discussion here is preliminary.

The existent literature regarding Chinese university spin-offs have focused exclusively on the first category, UREs wholly owned and run by universities, since it is a unique Chinese mechanism of commercializing university research (though the initial rationale of UREs was to buttress university budgets) and data are more readily available. This literature was surveyed in chapter two. The central government body overseeing UREs is MOE, or more specific its S&T Development Division. As stated in section 2.3, UREs enjoyed a boom in the 1980s and 1990s, backed up by government endorsement. This was because at that time alternative channels rather than URE to capitalize university research and fortify university budgets were underdeveloped. However, apart from some exceptional successes, the majority of UREs performed poorly and incurred financial losses. As a result, universities were urged by the central government to delink most UREs and consolidate remaining ones. Overall, UREs lost policy favor and shrunk significantly in scope, undermining its eminence as a university research commercialization mechanism. At the university level, the remaining UREs are now generally controlled via an asset management company, headed by a supervisory committee composed of university party secretaries and principals. For example, NJU manages its 11 UREs through the Nanjing University Capital Management Co. Ltd.¹ and its management structure is shown in Figure 22.

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¹ See the company website: http://ndzcgs.nju.edu.cn/index.php, and in addition to the 11 wholly-owned UREs, the capital management company holds equities in 52 other firms.
The second category of spin-offs, start-ups under incubation within USPs, presents an unclear picture. They are not all strictly university spin-offs, as many of them are not founded on specific university-generated technologies. However, located in a USP, they have more or less connections with the university, thus they could be loosely counted in the spin-off category. There are some aggregate national data regarding this cohort. At the end of 2010, 4,634 start-ups had graduated from the 86 national-level USPs, and 6,617 were under incubation with 1,858 as 2010 new intakes (see Table 3). In 2010, firms under USP incubation undertook 1,728 government commissioned S&T projects, acquired 2,857 patents, and made a total income of RMB 22.163 billion (ibid.).

However, regional and local data are scarce; the industrial/sectoral composition, R&D intensity and strength of under-incubation start-ups, as well as the ability of graduated firms to survive the rigor of market competition are all unclear. Since USPs and incubators are relatively new S&T programs, firms within them thus far received little academic attention, and sound data gauging their status are yet to emerge. Jiang Yue (interview #8) contended firms under the incubation of USPs did not always possess high technology relevancy, as a result of the “mission creep” phenomenon mentioned above.

The status of private spin-offs is even blurrier. Every interviewee from visited universities claimed it was a common practice for faculty members, especially those in applied science and engineering departments, to establish firms based on their research findings, and some researchers might own a number of firms. The general impression is that private spin-offs are pervasive, at least for elite universities. However, private spin-off is a controversial topic to bring up within universities. Founders of private spin-offs are generally careful to avoid exposure of their firms, for the fear of resulting in technology ownership disputes with the university, or being perceived by colleagues as money-oriented hence disingenuously committed to research and teaching (see discussion in section 5.2.4). Researchers may deliberately shun USPs in locating their start-ups, for much of the same reason they circumvent university TTOs and ECIC platforms to transfer technologies. Since these private spin-offs generally veil their university affiliation, they are difficult to identify or survey; therefore, it is not surprising private spin-offs in China comprise a data and research vacuum. One proposition that can be drawn is that the extent and magnitude of university research commercialization in China could be underestimated due to the unclear volume of “invisible” technology transfers and private spin-offs.
5.6 Summary and discussion

This chapter has reviewed all the four university-affiliated research commercialization agencies operating in Nanjing: university TTOs, ECIC platforms, USPs and spin-off companies (Figure 17). University TTOs are university administrative organs operating to match university technology supplies with market demands. ECIC platforms function more or less similar to outpost branches of their associated university TTOs, bringing university researchers and local entrepreneurs in touch. USPs are business incubators run by universities, in liaison with district governments, to hatch spin-off companies and guide their early growth. Spin-off companies include three categories. UREs have been marginalized as a mechanism of commercializing university research, whereas firms under USP incubation and private spin-offs are poorly understood and demand further investigations.

For agencies affiliated to the same university, in terms of their mutual relations, the TTO provides some largely nominal coordination on ECIC platforms. The TTO is nested under the university S&T division, whereas an ECIC platform is usually headed by one or several academic department directors. The USP and UREs are both under the governance of the university asset management committee. A portion of spin-off companies are under the incubation of the USP. Theoretically, these myriad commercialization agencies could cooperate horizontally to forge a holistic apparatus. For example, the TTO and ECIC platforms, with their strengths in accessing technology information, could identify promising technologies for spinning off companies and recommend them to the USP. The USP could possibly tap into the technology transaction expertise developed in the TTO and ECIC platforms to train and educate managers of start-ups under incubation. Different commercializing agencies affiliated to the same university could also negotiate and prioritize technology focuses together, to cultivate particular strengths in certain technology domains and hence establish core technology competence. However, as reflected in fieldwork, few cross-agency horizontal communication and coordination channels were explored in reality in Nanjing. This echoes what has been documented by Hussler et al. (2010) in Chongqing that different commercialization tools tend to be dedicated to one specific purpose without mutual interaction and organizational overlap. It will be interesting to probe some institutional synergy among various commercialization tools.

Different commercialization agencies may function separately, but they all work under China’s unique national innovation system as depicted in Figure 6. As a result, university TTOs, ECIC platforms and USPs in Nanjing more or less exhibited similar traits. First of all, their establishments were mostly government-driven rather than spontaneous. As discussed in chapter two, TTOs, USPs
and UREs were spontaneous forms of research commercialization at the very beginning and emerged only in specific places. However, the central government (through the policies, targets and programs described in chapter four) initiated their countrywide proliferation and this proliferation was made extensive by the “hierarchical amplification” system. As mentioned previously, most universities in Nanjing aimed to establish their own university TTOs. Nearly every city in Jiangsu, despite their economic base and S&T infrastructure, promoted ECIC platforms aggressively. National key S&T players were sought after by numerous municipal governments to establish R&D liaison and launch cooperative projects. Major universities in Nanjing built and expanded their USPs with stunning zeal, even though few buildings were fully occupied. The “flourish” of various S&T platforms, science parks, centers and other entities was artificial and abnormal. Not every university specializes in applied technologies and possesses abundant intellectual assets for commercialization, not every city has the potential or necessity to cultivate high-tech sectors, and overall innovation and knowledge commercialization cannot be mass-produced. The seemingly energetic response of local S&T actors to national innovation appeals were not out of genuine desire to meet “organic” demands but the political consideration to meet national targets, lever financial inputs from central-level authorities and gain political capital. All innovation theories reviewed in section three admit the strategic role of the government sector in a country’s NIS, but the role should be cultivating rather than manufacturing university-industry linkages. The Chinese government should reflect upon its old-style “top-down” and “out of the plan” strategy in promoting research commercialization.

Second, multi-level governments not only initiated but also intervened directly into different aspects of various commercialization agencies. University TTOs, USPs and ECIC platforms, as discussed previously, mostly relied on government funds for their operation. Through a hierarchal label system that is tied with valuable socio-political capital, the government also deployed a winner-picking mechanism to monitor the business orientation of commercialization agencies. Thus, the government rather than the market dictates resource allocation. In addition, the commercialization units surveyed in Nanjing were staffed frequently with government officials, usually at supervisory positions. The management team of the NJU USP included only one person that was not a government employee. The Nanjing municipal government also ran its own TTO and requested from university TTOs information that were viewed as strategic assets. As discussed earlier, university TTOs, USPs, ECIC platforms in Nanjing more or less struggled with a common paradox that they were on the one hand all public units and therefore restricted from operating like private entities, but on the other hand required by the government to adopt marketization approaches to gain financial self-sufficiency as well as professional efficiency. The contradiction of public identity
with market mentality imposed a range of difficulties on finance, recruitment and incentive creation. The ultimate lesson the Chinese central government learned from the disastrous planning regime is to cease direct economic participation. The disappointing performance of UREs also indicates the problematic nature of direct government involvement in the private sphere. Nevertheless, this study witnessed an extensive and excessive government infiltration in the domain of university research commercialization.

Lastly, various commercialization agencies were not only initiated and interfered by the government sector, but also oriented to meet government rather than market demands. Securing governmental recognition and supports constituted a major priority for university TTOs, USPs and ECIC platforms in Nanjing. TTOs devoted a large portion of their work to participate in various government-convened S&T events. The NJU Lianyungang Institute was engaged primarily in applying to government projects and attracted little interest from local industry during its initial year of operation. Driven by a desire to impress higher-level authorities, local S&T actors tended to create excellence makers of high visibility. As observed by OECD (2008, p.80), “policies aimed to promoting commercialization reveal a tendency, by national and local authorities, to focus on creating the physical infrastructure for commercialization by establishing big buildings or state-of-the-art facilities in big science parks and setting up technology transfer offices. At the same time, they appear to focus insufficiently on the more intangible aspects of commercialization and science-industry cooperation, such as attitudes, culture, communication, and perhaps more importantly, social capital”. The spacious but empty USPs in Nanjing attested vividly to this proposition. When the objective is to impress high-level authorities, it is also not surprising that USPs tended to fill their space with unqualified firms to create superficial success. The entire commercialization endeavor is distorted when the orientation is to serve the government rather than the market economy.

Government-initiated, government-financed, government-controlled, and government-oriented, the entire chain of university research commercialization seems self-fulfilling. When researchers deliberately shun university TTOs, USPs and ECIC platforms to transfer their technologies, when USPs have difficulty filling up their buildings with eligible start-ups, and when ECIC platforms spur little industrial interests, the question to ask is not how effective but how relevant the current commercialization apparatus is.
Chapter 6. Conclusion

6.1 A summary of the thesis

China’s staggering economic growth has lasted for three decades. However, the year 2012 witnessed waning of momentum. A “middle income trap” now looms around the corner. A loss of traditional comparative advantages (e.g. cheap labor, low material and land prices), exacerbation of environmental and resource challenges, coupled with a deteriorating external market has alarmed the urgency for China to upgrade its low value-added economy (WB & DRC, 2012). Technological innovation is believed to be the key to economic restructuring, and a feasible avenue towards innovation is university research commercialization. While China has devoted massive resources in this regard, academic efforts, at least in the English literature, have failed to keep up with the pace. Existent studies are detected as empirically narrow, theoretically thin and analytically shallow.

To enrich the current literature and enhance our understanding of China’s research commercialization system, this thesis sets the aim of examining its framework conditions, commercialization channels, as well as effectiveness and deficiencies. This aim is achieved in a three-step process. Chapter three proposes a China-specific theoretical tool for guiding empirical inquires, after a scale-traced interrogation of available innovation theories. Employing this theoretical tool, chapter four surveys the multi-scalar institution, policy and program apparatus deployed by Chinese authorities to stimulate and govern research commercialization. Operating under this multi-scalar framework are various commercialization mechanisms and agencies, among which four university-affiliated sets (i.e. university TTOs, ECIC platforms, USPs, university spin-off companies) are scrutinized in chapter five, largely based on information and materials collected during fieldwork. The methodology for this research is a combination of semi-structured key informant interviews with some statistical analysis based on government documents gathered from various sources.

The multi-scalar S&T institution, policy, program framework is found to demonstrate a pattern of “hierarchical amplification”. National-level S&T orientation and policies are strictly followed downward the administrative hierarchy; in addition, subnational governments tend to amplify national targets and requirements aggressively and blindly to win financial and political rewards. As a result, enormous local energy was devoted into a narrow set of centrally designed targets and priority domains. Under this overall framework setting, the Nanjing case study revealed pervasive government involvement in university research commercialization. The government sector was the primary initiator of various commercialization agencies, i.e. TTOs, USPs, and platforms. The
government sector also played the role of investor, evaluator, and direct manager of different agencies. Instead of cultivating genuine science-industry collaboration, this government-sponsored commercialization apparatus was skewed towards gaining political recognition and credits. As a result, USPs leaned towards excessive office building and deviated from their mission of incubating nascent start-ups into accommodating mature and low-R&D enterprises. In addition, various platforms were primarily engaged in applying to government funds, instead of catering to industrial technology needs. Subnational governments have their specific interests that are not always aligned with the genuine needs of the market economy. However, the Chinese “hierarchical amplification” system has mired all levels of governments in a reckless innovation and commercialization competition. In sum, the biggest problem in China’s current research commercialization regime is a misdefined government role.

The contribution of this research is three-fold. First, by conducting a survey of innovation theories and proposing a China-specific model, this thesis tries to fuse Chinese innovation studies with theories. This is not an ad-hoc move to theorize research for the sake of theorization itself. The author believes theory-guided investigations are better positioned than pure empirical documentaries to uncover the holistic picture, dynamic inter-actor interactions and systematic deficiencies of China’s innovation regime. Second, this study sheds light upon Nanjing, a second-tier municipality that has been largely neglected by existent Chinese innovation research, but is administratively more representative of most cities in China. Third, by probing the inter-layer governmental coordination pattern and the complex implications of governmental involvement in commercialization agencies, this study adds more nuance and depth into the current discussion of research commercialization in China (which tends to be overly descriptive).

6.2 Policy implications

The author identifies the most serious factor impeding China’s research commercialization is a misdefined government role, and accordingly calls for a strategic government withdrawal. First, the government sector should decrease direct participation in commercialization activities and open up space for more private players. TTOs, science parks, and technology transfer platforms constitute a nation’s research commercialization infrastructure, and this infrastructure is of high positive externalities but low short-term profitability. It is therefore legitimate for the government to invest in these infrastructure agencies. Nevertheless, instead of dispensing the money downward the government hierarchy and thereof creating an incentive for lower-level governments to impress higher-level authorities, the central government could provide the money in the form of subsidies to
private actors who endeavor to commercialize academic knowledge. Furthermore, local government officials should leave posts in commercialization agencies to industrial experts, and refrain from dictating the function of other stakeholders. Overall, in the research commercialization regime, government actors should change their role from direct participants to rule makers.

Second, the current efforts to boost commercialization are overly concentrated on the supply side, and the technology absorbing ability at the receiver-end is overlooked. Research commercialization is a two-way street, with the academia as the technology sender and the industry as receiver. According to Hussler et al. (2010), fruitful UILs entail three sets of transfer measures: 1) measures enhancing the visibility of university discoveries; 2) measures strengthening the private sector’s absorptive capacities of available technologies; and 3) measures monitoring the knowledge demands of the private sector and informing universities of such demands. The current university research commercialization regime in Nanjing suffices in the first set, to a lesser extent in the third, but falls short on the second. Tang (2007) points out indigenous Chinese regional firms generally lack technology “absorptive capacities”, which is defined by Cohen and Levinthal (1990) as the ability to recognize, assimilate and commercialize existent technologies. The OECD (2008) contends that S&T managerial ability is as much an issue as S&T qualities for Chinese companies. “Urged to reinforce their technological capability and to build on it to meet the ‘indigenous innovation’ goal assigned to the NIS, Chinese enterprises need to combine different modes of acquisition and development of knowledge dynamically: undertake R&D activities, co-operate for common creation of knowledge assets, buy technology on the technology market, nurture and/or fund spin-offs companies, etc.”(ibid. p. 242). Effective technology management in a rapidly evolving technological, legal, institutional and competitive environment is seen beyond the current capabilities of most Chinese enterprises (ibid.). To remedy this situation, the government needs to assist and encourage the private sector to enhance its absorptive capabilities of technologies. Once the private sector can better reap the benefits of knowledge spillover, it may participate more actively in research commercialization and thereof dilute the current excessive role of the public sector.

Third, another field the government could retreat and cede more autonomy to the market is finance. Policies should be put in place to make it easier for technology start-ups and commercialization agencies to secure investments from banks and venture capitalists. Less dependent upon government funds and direct subsidies, commercialization actors will be more oriented to the interests of market investors. Under China’s current largely state-controlled finance system, SMEs find it hard to secure loans and must often depend on self-funding (Allen et al., 2006). The situation
could be more unfavorable for tech-SMEs that are perceived riskier. A 2006 research from the All China Federation of Industry Commerce shows S&T firms in the Beijing Zhongguancun district were only able to finance one-quarter of their RMB 120 billion working capital with bank credits; more than half was funded through informal sources (OECD, 2008). The capital drainage is equally severe for new ventures. Start-up firms, particularly those in developing cutting-edge technology, are risky adventures which lack appeal on large creditors. In countries with a mature capital market, they depend on VC to underwrite their early costs. The flourish of Silicon Valley as a hub of innovative start-ups is credited much to the existence of a dense web of venture capitalists (Kenney & Florida, 2000; Hellmann, 2000). However, in China the VC market is underdeveloped and dominating the market are government-backed ones (Rothman, 2006; Wu, 2007). Segal (2003) found a number of enterprises set up by Fudan professors had to rely on personal and informal funds to finance initial operations. To build a more marketized commercialization market, the government should open more entries for private investors.

Lastly, instead of direct involvement in research commercialization, the government should focus on and improve its performance in framework setting. The central government should first strengthen its project supervisory capability to ensure local commercialization agencies and platforms do not “creep” from their missions. The IPR regime should also be streamlined and better enforced so that university researchers can involve commercialization agencies in their technology transfer without worrying about ownership disputes. When a sound IPR system is in place, university TTOs will also feel more secure to loosen their grip on university technology information, and invite private agencies to handle technology transfer transactions. The evaluation scheme of public universities and faculty members should also be revised so that both universities and researchers can receive fair credits for their efforts in knowledge capitalization. A better balance needs to be reached between basic research, long-term mission-oriented research, and R&D activities aimed at addressing industrial needs; this way universities and research faculties can better reconcile their mission of “researching” and “commercialization”. A sensible solution is to encourage university differentiation. Elite universities strong in research and scientific disciplines should be assigned a heavier research role, larger national program fund, and more research credits in evaluation; whereas universities with an orientation and strengths in applied science should be encouraged and credited to undertake more commercialization projects. Currently, the management and evaluation of universities is largely homogeneous, detrimental to unleashing their specialized advantages. The management of commercialization revenues also needs modifications to stimulate more researcher engagement.
6.3 Further research directions

It will be the author’s great honor if to some extent this thesis contributes to our understanding of China’s university research commercialization system. Extensive further research is needed to form a well-rounded literature bloc addressing this topic. First of all, due to time and resources limit, the investigation of local commercialization agencies in this thesis is necessarily limited. The research archive awaits more in-depth examinations of Nanjing university science parks as well as the start-ups under their incubation. Various platforms and local ECIC programs also need more elaborate depiction and analysis. Private spin-offs as well as private S&T intermediary agencies, largely absent from the current academic discussion, need to be thoroughly researched as well. Second, this study adds the so far neglected Nanjing city into discussion, but many more other case studies are needed, as China is so diversified geographically. The policy implications discussed in the preceding section are preliminary, and more studies aimed at proposing policies to reform and improve China’s research commercialization regime should be conducted. Cross-nation comparison studies or applicability analysis of best practices deployed in other nations will contribute in this regard. Finally, future attempts of fine-tuning and enriching innovation theories based on observations in China would also be interesting.
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Jiangsu ECIC Bureau (2010c). Summary report of major work progress in 2010 and work priorities in 2011 [in Chinese], Jiangsu ECIC Bureau, collected during fieldwork.


## APPENDIX_A

### List of interviewees

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<th>Index</th>
<th>Name</th>
<th>Affiliation</th>
<th>Interview Date</th>
<th>Interview Location</th>
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<td>1</td>
<td>JIA, Shangbing</td>
<td>Nanjing S&amp;T Commission</td>
<td>2011/05/19</td>
<td>Nanjing S&amp;T Commission meeting room</td>
</tr>
<tr>
<td>2</td>
<td>LI, Zhihui</td>
<td>Gulou District S&amp;T Bureau</td>
<td>2011/06/09</td>
<td>Gulou District S&amp;T Bureau branch office at Nanjing Sci-Tech Square</td>
</tr>
<tr>
<td>3</td>
<td>DING, Peng</td>
<td>Nanjing Sci-Tech Square</td>
<td>2011/06/07</td>
<td>Nanjing Sci-Tech Square</td>
</tr>
<tr>
<td>4</td>
<td>YU, Jian</td>
<td>Nanjing University technology transfer office</td>
<td>2011/05/20</td>
<td>Nanjing University technology transfer office</td>
</tr>
<tr>
<td>5</td>
<td>WANG, Yao</td>
<td>Southeast University technology transfer office</td>
<td>2011/05/25</td>
<td>Southeast University technology transfer office</td>
</tr>
<tr>
<td>6</td>
<td>HU, Shengxiang</td>
<td>Nanjing University of Technology technology transfer office</td>
<td>2011/05/31</td>
<td>Nanjing University of Technology technology transfer office</td>
</tr>
<tr>
<td>7</td>
<td>PAN, Mingcai</td>
<td>Nanjing University of Science and Technology technology transfer office</td>
<td>2011/06/07</td>
<td>Nanjing University of Science and Technology technology transfer office</td>
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<tr>
<td>8</td>
<td>YUE, Jiang</td>
<td>Nanjing University science park</td>
<td>2011/06/01</td>
<td>Nanjing University science park management office</td>
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<td>9</td>
<td>CHEN, Hongxi</td>
<td>Nanjing University of Technology science park</td>
<td>2011/06/02</td>
<td>Nanjing University of Technology science park management office</td>
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<td>10</td>
<td>GUO, Xuanchen</td>
<td>Southeast University science park</td>
<td>2011/06/12</td>
<td>Interviewee’s personal office at Southeast University</td>
</tr>
<tr>
<td>11</td>
<td>SHAN, Yong</td>
<td>Nanjing University of Science and Technology science park</td>
<td>2011/06/21</td>
<td>Nanjing University of Science and Technology science park planning office</td>
</tr>
<tr>
<td>12</td>
<td>PAN, Shaoming</td>
<td>The Research Institute of Nanjing University in Lianyungang</td>
<td>2011/06/22</td>
<td>Interviewee’s personal office at Nanjing University</td>
</tr>
<tr>
<td>13</td>
<td>XU, Youpeng</td>
<td>Nanjing University Department of Land Resources and Tourism Sciences</td>
<td>2011/06/09</td>
<td>Interviewee’s personal office at Nanjing University</td>
</tr>
<tr>
<td>14</td>
<td>SHE, Jiangfeng</td>
<td>Nanjing University Department of Geographic Information Sciences</td>
<td>2011/06/10</td>
<td>Interviewee’s personal office at Nanjing University</td>
</tr>
</tbody>
</table>
APPENDIX B
List of pre-designed interview questions

1. Questions for officials at the Nanjing S&T Commission

1) What are the existing laws, policies, regulations and programs associated with promoting and managing commercialization of university-generated technologies in Nanjing?
2) What are the incentives provided by national, provincial, municipal and local district governments for commercializing university-generated technologies in Nanjing?
3) How the responsibilities of commercializing university-generated technologies are allocated among national, provincial, municipal and local district governments? What are their specific roles and mutual relations? What are the vertical coordinating mechanisms between different government layers?
4) At the municipal level in Nanjing, which government divisions are involved in the commercialization of university-generated technologies? What are their specific roles and mutual relations? What are the horizontal coordinating mechanisms among them?
5) Which technology domains does the Nanjing municipal government seek to encourage? And why?
6) From 2000 to 2010, what are the annual numbers of patent applications and grants in Nanjing? Among them, how many can be attributed to universities? What is the technological composition of these applicants and grants?
7) From 2000 to 2010, what are the annual numbers and revenues of technology licensing in Nanjing? Among them, how many can be attributed to universities? What is the technology composition of these licensed technologies?
8) How many high-tech companies are there in Nanjing? Among them, how many are established as a result of university-generated technologies and how many are university spin-off companies?
9) What is the ownership structure of these companies established based on university-generated technologies?
10) From your perspective, what are the strengths and weakness of the technology commercialization system in Nanjing, and how do you think the system could be improved?

2. Questions for officials at the China Sci-Tech Center

11) How and when was this center initiated?
12) What is the governance structure of this center?
13) What is the funding scheme of this center?
14) What is the land ownership status of this center?
15) What are the objectives and responsibilities of this center?
16) What programs does this center run and what kinds of services does it provide?
17) What are the achievements of this center since its foundation?
18) What is the role of this center in commercializing university-generated technologies?
19) How does this center cooperate with various universities?
20) From your perspective, what are the strengths and weakness of the technology commercialization system in Nanjing, and how do you think the system could be improved?

3. Questions for officers at University Technology Transfer Centers

21) How and when was this center initiated?
22) What is the governance structure of this center?
23) What is the funding scheme of this center?
24) How many staff does this center have?
25) What are the objectives and responsibilities of this center?
26) What programs does this center run and what kinds of services does it provide?
27) What kinds of assistance do different layers of governments provide for the operation of this center?
28) Which government agencies does this center cooperate with in commercializing university-generated technologies? What are their specific roles?
29) How does this center approach faculty members and how can this center be approached by faculty members?
30) What incentives does your university provide to encourage and facilitate faculty engagement with industry?
31) How does this center approach private sectors and how can this center be approached by private sectors?
32) After foundation, how many technology patent applications did this center submit annually? Among them, how many have been granted patents? What are the technological composition of these applications and grants?
33) After foundation, how many technology licenses did this center issue annually? What is the technological composition of these licensed technologies?
34) After foundation, how much revenue was generated by technology licensing annually? How the money was distributed among the center, the university and the faculty creating the technology?
35) From your perspective, what are the strengths and weaknesses of the technology commercialization system in Nanjing, and how do you think the system could be improved?

4. Questions for officers at University Science Parks

36) How and when was this park initiated?
37) What is the governance structure of this park?
38) What is the funding scheme of this park?
39) What is the land ownership status of this park?
40) What are the objectives and responsibilities of this park?
41) What programs does this park run and what kinds of services does it provide?
42) What kinds of assistance do different layers of governments provide for the operation of this park?
43) Which government agencies does this park cooperate with in commercializing university-generated technologies? What are their specific roles?
44) How does this center approach universities and private sectors to facilitate technology commercialization?
45) What are the companies and institutes located in this park?
46) What is the relationship between the park management office and various organizations located in this park?
47) What are the technological levels of the companies located in this park?
48) What are the operational and financial statuses of the companies located in this park?
49) How were the companies located in this park initiated? What kinds of assistance did they receive from the park management office, affiliated universities and public agencies?
50) After foundation, how many technology patent applications did this park (i.e. organizations in this park) submit annually? Among them, how many have been granted patents? What are the technological compositions of these applications and grants?
51) From your perspective, what are the strengths and weaknesses of the technology commercialization system in Nanjing, and how do you think the system could be improved?

5. Questions for managers of University Spin-Off Companies

52) How and when was your company established?
53) What is the relationship between your company, and universities & public agencies in Nanjing?
54) What is the ownership structure of your company?
55) What kinds of assistance has your company received from universities, public agencies and/or science parks, during its initiation and operation?
56) Which technology domain does your company focus on?
57) How many annual patent applications has your company submitted (and grants received) since its foundation?
58) What is the operational and financial status of your company since foundation?
59) Since foundation, has your company ever been approached by university faculty members, university technology transfer offices and/or university-based science parks? And for what?
60) Since foundation, has your company ever approached faculty members, universities technology transfer offices and/or university based science parks? And for what or why not?
61) From your perspective, what are the strengths and weaknesses of the technology commercialization system in Nanjing, and how do you think the system could be improved?
APPENDIX_C
China’s innovation policies according to the EU trend chart innovation policy classification system

<table>
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<tr>
<th>The EU Trend Chart Innovation Policy Classification System</th>
<th>Examples of Chinese laws, government policies and measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Policy category</strong></td>
<td><strong>Examples of Chinese laws, government policies and measures</strong></td>
</tr>
<tr>
<td><strong>Policy priority</strong></td>
<td><strong>Examples of Chinese laws, government policies and measures</strong></td>
</tr>
<tr>
<td>Mobility of students, research workers and teachers</td>
<td>Policy co-developed by Ministry of Education and Ministry of Personnel to support foreign experts to work in China, to attract overseas Chinese students and scholars to return, and to encourage the placement of Ph.D. graduates in post-doctoral research in enterprises, etc.</td>
</tr>
<tr>
<td>Raising the awareness of the larger public and involving those concerned</td>
<td>Enacted the Law on the Dissemination of Science and Technology Knowledge (2002). The government offers tax incentives for intermediary agencies whose main function is disseminating S&amp;T knowledge. Grants were provided to fund the project of increasing public awareness of S&amp;T.</td>
</tr>
<tr>
<td>Fostering innovative organizational and management practices in enterprises</td>
<td>Not available.</td>
</tr>
<tr>
<td>Public authorities and support to innovation policy makers</td>
<td>Not available.</td>
</tr>
<tr>
<td>Promotion of clustering and co-operation for innovation</td>
<td>Examples of regional clusters developed under the initiative of local governments, include the Yangtze River Delta Initiative by Shanghai and neighboring provinces to coordinate the development of the industrial clusters in the region, and the Pearl River Delta Region embracing Guangdong province and Hong Kong and Macau, China.</td>
</tr>
<tr>
<td>Administrative simplification</td>
<td>Regulations to simplify administration were launched, e.g. to encourage the creation of technology-based start-ups and to attract FDI.</td>
</tr>
<tr>
<td>Amelioration of legal and regulatory environments</td>
<td>China’s legislation in the field of IPR, S&amp;T development, education, and market competition, etc.</td>
</tr>
<tr>
<td>Innovation financing</td>
<td>The Innovation Fund for Small Technology-based Firms was established. New measures are under way.</td>
</tr>
<tr>
<td>Taxation</td>
<td>Tax incentives were provided to encourage the creation of new technology-based start-ups and to attract FDI. However, the past tax incentive policy for encouraging innovation in the established enterprises did not achieve satisfying results.</td>
</tr>
<tr>
<td>The EU Trend Chart Innovation Policy Classification System</td>
<td>Examples of Chinese laws, government policies and measures</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Policy category</strong></td>
<td><strong>Policy priority</strong></td>
</tr>
<tr>
<td>Strategic vision of research and development</td>
<td>Preferential tax policies for some industry sectors were implemented, such as the policy encouraging investment in the integrated circuit manufacturing sector. The 863 Program increasingly supports industrial R&amp;D. New tax incentives enacted since 2006.</td>
</tr>
<tr>
<td>Strengthening research carried out by companies</td>
<td>Numerous national and local government policies aim to promote science parks and incubators and attract overseas Chinese to set up start-ups in China.</td>
</tr>
<tr>
<td>Start-up of technology-based companies</td>
<td>Four R&amp;D and innovation consortia in steel, energy, agriculture and coal mine exploration were established in 2007 with the coordination of the central government agencies.</td>
</tr>
<tr>
<td>Intensified cooperation by research, universities and companies</td>
<td>Enactment of Small and Medium Enterprise Promotion Law (2002) and regulations on venture capital development. Establishment of the Innovation Fund for Small Technology Based Firms (Innofund).</td>
</tr>
</tbody>
</table>

*Source: OECD, 2008*
## APPENDIX_D
Inventory of MOST’s S&T programs based on the 11th National S&T Five Year Plan
(Four core programs and Two program clusters)

<table>
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<tr>
<th>Program</th>
<th>Initiating Year</th>
<th>Objective</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>National S&amp;T Major Projects / Mega-projects of Science Research <em>(Guo Jia Ke Ji Zhong Da Zhan Xiang)</em></td>
<td>2006</td>
<td>Achieve leapfrog technological progress and to achieve significant technological breakthroughs, leading to industrialization in major fields related to national socio-economic development within 3-5 years.</td>
<td>This program aims to concentrate resources on 12 mega-projects.</td>
</tr>
<tr>
<td>National Key Technologies R&amp;D Program <em>(Guo Jia Ke Ji Zhi Cheng Ji Hua, or Guo Jia Ke Ji Gong Guan Ji Hua before 07/2006)</em></td>
<td>1982</td>
<td>Foster key technologies to upgrade traditional industries and create new ones.</td>
<td>This is the first national S&amp;T program in China, and has been implemented through 5 five-year plans. The major goal of this program is to address pressing major S&amp;T issues in national economic and social development. The program concentrates on the R&amp;D of key and common technologies that drive technical upgrading and restructuring of industries that promote sustainable social development.</td>
</tr>
<tr>
<td>National High-tech R&amp;D Program (863 Program) <em>(Guo Jia Gao Ke Ji Yan Jiu Fa Zhan Ji Hua)</em></td>
<td>1986</td>
<td>Foster China’s overall innovation capacity and enhance its international competitiveness in high technologies.</td>
<td>This program is concentrating on mid- to long-term development in both civilian and military areas. This Program is co-managed by MOST and the Commission of S&amp;T and Industry for National Defense. The program covers 10 priority areas: information technology, biotechnology, new materials, advanced manufacturing, advanced energy, resources and environment technologies, marine technologies, modern agriculture, modern transportation, earth observation and navigation.</td>
</tr>
<tr>
<td>National Basic Research Program (973 Program) <em>(Guo Jia Zhong Dian Ji Chu Yan Jiu Fa Zhan Ji Hua)</em></td>
<td>1997</td>
<td>Support basic research.</td>
<td>Specific tasks are to support the implementation of key basic research in important scientific areas related to agriculture, energy resources, information, resources &amp; environment, and population &amp; health; to provide a theoretical basis and scientific foundation for innovation; to foster human resource; and to establish a number of high level scientific research units.</td>
</tr>
<tr>
<td>Program</td>
<td>Initiating Year</td>
<td>Objective</td>
<td>Characteristics</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>-----------------</td>
<td>------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>National S&amp;T Infrastructure Program</td>
<td>2005</td>
<td>Solidify national S&amp;T infrastructure to fortify R&amp;D.</td>
<td>Focus on building six infrastructure platforms: major S&amp;T equipment, natural sciences resources (e.g. species, samples), scientific data, scientific research archive, technology transfer, and internet facilities. 81 projects were funded (2010).</td>
</tr>
<tr>
<td>• R&amp;D Infrastructure and Facility Development Program</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Guo Jia Ke Ji Ji Chu Tiao Xian Ping Tai Jian She Zhuo Xiang)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• State Key Laboratories Development Program</td>
<td>1984</td>
<td>Support selected laboratories in universities, public research institutes and firms.</td>
<td>Promote advanced training and breakthrough research in 306 laboratories (2010).</td>
</tr>
<tr>
<td>(Guo Jia Zhong Dian Shi Yan Shi)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• National Engineering Technology Research Centers Development Program</td>
<td></td>
<td>Support selected engineering technology research centers in universities, public research institutes and firms.</td>
<td>Promote advanced training and breakthrough research in 264 engineering technology research centers (2010).</td>
</tr>
<tr>
<td>(Guo Jia Gong Cheng Ji Shu Yan Ji Zhong Xin)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• S&amp;T Basic Work Program</td>
<td></td>
<td>Support scientific expeditions, S&amp;T standards setting, inventorying and processing scientific materials, as well as other S&amp;T basic work.</td>
<td>During the 11th five-year plan period (2006-2010), 109 projects were funded with RMB 473 million.</td>
</tr>
<tr>
<td>(Ke Ji Ji Chu Xing Yan Ji Zhuan Xiang)</td>
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</table>

Environment Building for S&T Industries
(Zheng Ce Yin Dao Lei Ji Hua Yu Zhuo Xiang)

<table>
<thead>
<tr>
<th>Program</th>
<th>Initiating Year</th>
<th>Objective</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Spark Program</td>
<td>1986</td>
<td>Support technology transfer to rural area to promote the rural area development.</td>
<td>During the 11th five-year plan period (2006-2010), 57,087 projects were implemented, using RMB 193.9 billion, with the central government contributing RMB 871 million. The projects sponsored by this program attain government credits for bank loan application.</td>
</tr>
<tr>
<td>(Xing Huo Ji Hua)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>• Torch Program</td>
<td>1988</td>
<td>Support high technology industry sector development through setting up science parks and incubators, funding projects, and human resource training, etc.</td>
<td>During the 11th five-year plan period (2006-2010), 7,409 projects were funded, with RMB 846 million from the central government.</td>
</tr>
<tr>
<td>(Huo Ju Ji Hua)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Soft Science Research Program</td>
<td></td>
<td>Provide reliable scientific advice to national and local policy makers.</td>
<td>During the 11th five-year plan period (2006-2010), this program funded 1,122 projects with RMB 103.35 million.</td>
</tr>
<tr>
<td>(Guo Jia Ruan Ke Xue Yan Ji Ji Hua)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Program</td>
<td>Initiating Year</td>
<td>Objective</td>
<td>Characteristics</td>
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<tr>
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</tr>
<tr>
<td>National Key and New Product Program (Zheng Ce Yin Dao Le Ji Hua Yu Zhan Xiang)</td>
<td>1988</td>
<td>Compile the annual list of new and high technology products and fund those products selectively through grants and subsidiaries.</td>
<td>During the 11th five-year plan period (2006-2010), 10,043 applications were filed, with 64.33% approved. Among the approved ones, 1,316 won program funds, totaling RMB 829 million.</td>
</tr>
<tr>
<td>Program on Key International S&amp;T Cooperative Projects (Guo Ji Ke Ji He Zuo Ji Hua)</td>
<td></td>
<td>Use global S&amp;T resources to develop critical technologies; provide a platform for international cooperation.</td>
<td>During the 11th five-year plan period (2006-2010), this program funded 1,462 projects with RMB 2.8 billion.</td>
</tr>
<tr>
<td>Agriculture S&amp;T Transfer Fund (Guo Jia Nong Ye Ke Ji Cheng Guo Zhuan Hua Zi Jin)</td>
<td>2001</td>
<td>Foster the development and diffusion of agricultural technologies.</td>
<td>Priority given to new products, technologies and equipment. During the 11th five-year plan period (2006-2010), this program funded 2,719 projects with RMB 1.8 billion.</td>
</tr>
<tr>
<td>Innovation Fund for Technology-based SMEs (Ke Ji Xing Zhong Xiao Qi Ye Ji Shu Chuang Xin Ji Jin)</td>
<td>1999</td>
<td>Support the establishment and activities of high-tech SMEs.</td>
<td>This financial support includes subsidiaries, grants and capital investment. This fund connects to Key Technology R&amp;D Program, 863 program and Torch Program to facilitate technology transfer from the R&amp;D projects funded by them.</td>
</tr>
<tr>
<td>Program on Research for Public Good (Ke Ji Yu Min Qiang Xian Zhan Xian Ji Hua)</td>
<td>2005</td>
<td>Strengthen the S&amp;T capabilities of prefecture-level cities.</td>
<td>During the 11th five-year plan period (2006-2010), 884 prefectures were enlisted in this program, with 79.3% located in the middle or western region.</td>
</tr>
<tr>
<td>Special Technology Development Project for Research Institutes (Ke Yan Yuan Suo Ji Shu Kai Fa Yan Jin Zhan Xian Ji Jin)</td>
<td>1999</td>
<td>Support central government-affiliated technology development research institutes.</td>
<td>During the 11th five-year plan period (2006-2010), this program supported 1,268 projects, with RMB 1.2 billion government input and RMB 2.4 billion self-generated fund.</td>
</tr>
<tr>
<td>International Thermonuclear Experimental Reactor (ITER) Project (Guo Ji Re He Ju Bian Shi Yan Dui Ji Hua Zhan Xiang)</td>
<td>2007</td>
<td>To fulfill China’s research obligations as a member of this joint international project.</td>
<td>As of the end of 2010, 1,254 researchers participated in this project.</td>
</tr>
</tbody>
</table>

APPENDIX_E
A brief profile of NJU’s 24 ECIC platforms

<table>
<thead>
<tr>
<th>Platform Name</th>
<th>Founding Year</th>
<th>Founding Partner(s)</th>
<th>NJU branch in charge</th>
<th>Major R&amp;D domain</th>
<th>Staff No.</th>
<th>Building Area</th>
<th>Institute Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Institute</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 NJU-Yixing Environment Protection Research Institute</td>
<td>2010</td>
<td>Yixing Gov. &amp; YiXing Environment Protection Technology Park</td>
<td>School of the Environment</td>
<td>water pollution management</td>
<td>27</td>
<td>3,900 m²</td>
<td><a href="http://www.nyer.com">http://www.nyer.com</a></td>
</tr>
<tr>
<td>2 NJU-Taizhou China Medical City R&amp;D Center</td>
<td>2006</td>
<td>Taizhou Gov.</td>
<td>School of Life Sciences</td>
<td>biopharmaceuticals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 NJU-Changzhou High-tech Research Institute</td>
<td>2006</td>
<td>Changzhou Gov.</td>
<td>School of Chemistry &amp; Chemical Engineering</td>
<td>chemical sciences</td>
<td></td>
<td>4,000 m²</td>
<td><a href="http://www.njucz.cn">http://www.njucz.cn</a></td>
</tr>
<tr>
<td>4 NJU Biopharmaceutical Engineering Research Center</td>
<td>2008</td>
<td>Suzhou Industrial Park</td>
<td>NJU Molecular Medicine Research Institute</td>
<td>biopharmaceuticals</td>
<td>80+</td>
<td>11,000 m²</td>
<td><a href="http://www.njucz.cn">http://www.njucz.cn</a></td>
</tr>
<tr>
<td>5 NJU Suzhou High-tech Research Institute</td>
<td>2009</td>
<td>Suzhou Industrial Park</td>
<td>School of Earth Sciences &amp; Engineering</td>
<td>multiple</td>
<td></td>
<td></td>
<td><a href="http://www.njucz.cn">http://www.njucz.cn</a></td>
</tr>
<tr>
<td>6 NJU-Yangzhou Photoelectricity Research Institute</td>
<td>2009</td>
<td>Yangzhou Economic Development Zone</td>
<td>School of Physics</td>
<td>photoelectricity</td>
<td></td>
<td>2,000 m²</td>
<td></td>
</tr>
<tr>
<td>7 NJU-Jiangyin IT Research Institute</td>
<td>2008</td>
<td>Jiangyin Gov. &amp; Jiangyin Software Park</td>
<td>School of Computer Science &amp; Technology</td>
<td>IT</td>
<td>1,300 m²</td>
<td><a href="http://www.njuij.cn">http://www.njuij.cn</a></td>
<td></td>
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<tr>
<td>8 NJU-Huaiai High-tech Research Institute</td>
<td>2008</td>
<td>Huaian Gov.</td>
<td>School of Chemistry &amp; Chemical Engineering</td>
<td>chemical sciences</td>
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<td>9 NJU-Yangzhou Chemical Science &amp; Engineering Research Institute</td>
<td>2008</td>
<td>Yangzhou Chemical Industry Park</td>
<td>School of Chemistry &amp; Chemical Engineering</td>
<td>chemical sciences</td>
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<td>11 NJU-Nanjing Biopharmaceutical Research Center</td>
<td>2009</td>
<td>Nanjing Gov. &amp; Nanjing New and High Technology Development Zone</td>
<td>Model Animal Research Center</td>
<td>biopharmaceuticals</td>
<td></td>
<td>20,000 m²</td>
<td><a href="http://www.nbri-nju.com">http://www.nbri-nju.com</a></td>
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<tr>
<td>12 NJU Smart City Research Institute</td>
<td>2010</td>
<td>Nanjing Gov.</td>
<td>College of Engineering &amp; Applied Sciences</td>
<td>urban technologies</td>
<td></td>
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<tr>
<td>Platform Name</td>
<td>Founding Year</td>
<td>Founding Partner(s)</td>
<td>NJU branch in charge</td>
<td>Major R&amp;D domain</td>
<td>Staff No.</td>
<td>Building Area</td>
<td>Institute Website</td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
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<td>Research Institute of NJU in Lianyungang</td>
<td>2010</td>
<td>Liyungang Gov.</td>
<td>School of Geographical &amp; Oceanographic Sciences</td>
<td>marine sciences</td>
<td>33</td>
<td>2,000 m²</td>
<td><a href="http://www.nju-lyg.com">http://www.nju-lyg.com</a></td>
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<tr>
<td>NJU-Zhenjiang High-tech Research Institute</td>
<td>2010</td>
<td>Zhenjiang Gov. &amp; Zhenjiang New District</td>
<td>School of Electronic Science &amp; Engineering</td>
<td>multiple</td>
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<td>NJU-Yanchen Environment Protection Technology &amp; Engineering Research Institute</td>
<td>2011</td>
<td>Yanchen Gov.</td>
<td>School of the Environment</td>
<td>environment protection</td>
<td></td>
<td>6,000 m²</td>
<td><a href="http://cn55044.chinaw3.com">http://cn55044.chinaw3.com</a></td>
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<td><strong>Incubator or University Science Park</strong></td>
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<tr>
<td>NJU-Wuxi ECIC Base</td>
<td>2007</td>
<td>Wuxi Gov. &amp; Wuxi New District</td>
<td>S&amp;T Bureau</td>
<td>multiple</td>
<td></td>
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<td>NJU-Gulou College National University Science Park</td>
<td>2001</td>
<td>Gulou District Gov.</td>
<td>multiple involved</td>
<td>multiple</td>
<td></td>
<td>15,000 m²</td>
<td><a href="http://ndkjygwh.njgl.gov.cn">http://ndkjygwh.njgl.gov.cn</a></td>
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<td>NJU-Wuxi Ganghi Shengming Technology Park</td>
<td>in process</td>
<td>Wuxi Gov. &amp; Jiangsu Nandasoft Technology Co., Ltd.</td>
<td>multiple involved</td>
<td>multiple</td>
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<tr>
<td>NJU Xianlin Science Park</td>
<td>in process</td>
<td>Xianlin District Gov.</td>
<td>multiple involved</td>
<td>multiple</td>
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<tr>
<td>NJU Jiangning S&amp;T Industrial Park</td>
<td>in process</td>
<td>Jiangning District Gov.</td>
<td>multiple involved</td>
<td>multiple</td>
<td></td>
<td></td>
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<tr>
<td><strong>Industrial R&amp;D Center</strong></td>
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<td></td>
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<tr>
<td>NJU- Sinopec (Shanghai) Cooperative R&amp;D Center</td>
<td></td>
<td>Sinopec (Shanghai)</td>
<td>School of Chemistry &amp; Chemical Engineering</td>
<td>petrochemistry</td>
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<td>Green Power PV-NJU Photovoltaics Research Institute</td>
<td>2008</td>
<td>Jiangsu Green Power PV Co., Ltd.</td>
<td>multiple</td>
<td>photovoltaics</td>
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</tbody>
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Source: NJU TTO website: http://ttc.nju.edu.cn/ttc/xf.php
APPENDIX F
Pictures of university science parks (USPs) in Nanjing, 2011

Figure 23. Some branch parks of the NJU USP
Source: NJU USP website: http://www.scipark.com
Figure 24. Branch parks of the SEU USP  
(architect drawings are used for branch parks still under construction at the time of this research)  
Source: SEU USP website: http://sp.seu.edu.cn
Figure 25. Branch parks of the NTU USP (architect drawings are used for branch parks still under construction at the time of this research)

Source: NTU USP website: http://www.njutrsp.com
Figure 26. Layout of the NUST USP
(the original map came with no scale)
Source: NUST USP website: http://www.njutmsp.com