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TECHNICAL REPORT

Creating an Innovation System for Knowledge City

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Sponsored by the Guangzhou Development District



Environment, Energy, and Economic Development

A RAND INFRASTRUCTURE, SAFETY, AND ENVIRONMENT PROGRAM

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Preface

China's Guangzhou Development District (GDD) is focused on creating an environment conducive to innovation in Sino-Singapore Guangzhou Knowledge City, a new project being carried out by GDD with Singbridge of Singapore. Knowledge City is to be a new environmentally and technologically advanced city that hosts innovative industries and their associated knowledge workers.

GDD has commissioned the RAND Corporation to help GDD succeed in its efforts. The results of RAND's work are published in a companion volume, *An Outline of Strategies for Building an Innovation System for Knowledge City* (MG-1240-GDD). That report presents specific actions that GDD should undertake in three broad areas: attracting and retaining high-technology companies; attracting and retaining highly skilled, innovative workers; and ensuring the availability of innovation-oriented financing. It then ranks them by importance, ease of implementation, and timing. The outline provides GDD with a roadmap for working toward the success of Knowledge City. The companion report is available at <http://www.rand.org/pubs/monographs/MG1240.html>.

This technical report presents RAND's detailed analysis of innovation systems, existing conditions in GDD, and the steps GDD will need to take to make Knowledge City a success. It consolidates interim analyses conducted for GDD on which *An Outline of Strategies for Building an Innovation System for Knowledge City* is based. This document will be posted on the GDD and RAND websites so that the interested public may download either the Chinese or English language versions. It is designed to help the interested reader understand how RAND arrived at its recommendations in the companion report, *An Outline of Strategies for Building an Innovation System for Knowledge City*.

The report consists of three parts. Part I provides an introduction to innovation systems and clusters, Knowledge City, GDD, and Guangzhou. It also compares Guangzhou with other innovative regions of China. These will provide the most important competition for innovative firms and knowledge workers.

Part II describes the factors leading to success for three innovative clusters: Silicon Valley, the life sciences corridor in Maryland, and the information and communications technology corridor between Tel Aviv and Haifa in Israel. It describes the history of these clusters and identifies key factors in their success.

Part III applies lessons learned from the three case studies, other international experience, and the broader literature on entrepreneurship and cluster formation to GDD and the development of Knowledge City. The lessons learned are compared with existing conditions in GDD, initially focusing on taxes, nontax incentives, and intellectual property rights, and then including other innovation assets and challenges in GDD, including human capital, infra-

structure and business climate, networks, quality of life, and marketing Knowledge City. The analysis of existing conditions and innovation assets also draws on findings from a survey of high-technology firms in GDD conducted by GDD and RAND.

This research was sponsored by the Guangzhou Development District. This report should be of interest to GDD and Guangzhou officials responsible for the success of Knowledge City, researchers and government officials who focus on innovation-based economic development, and anyone studying or involved in the economic transformation of China.

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Contents

Preface	iii
Figures	ix
Tables	xi
Summary	xiii
Acknowledgments	xxxiii
Abbreviations	xxxv

Part I: Introduction to the Guangzhou Development District and Knowledge City

CHAPTER ONE

Introduction	3
---------------------------	---

CHAPTER TWO

Innovation Systems and Cluster Formation	5
What Is Innovation?	5
Innovation Systems and Innovation Policy	5
Innovation Systems and Innovation Policy in China	6
A Framework for the Knowledge City Innovation System	8
Innovation, Clusters, and Knowledge City	10
Why Clusters Form	10
How Clusters Form	11
Cluster Policies	12

CHAPTER THREE

GDD in Depth and in Comparative Perspective	15
A Portrait of High-Technology Firms in GDD	15
Guangzhou in Comparative Perspective	22

Part II: Three Case Studies of Innovative Clusters

CHAPTER FOUR

Case Study: Silicon Valley	27
Overview	27
History	31
Financing	32
Human Capital	34

Quality of Life	36
Other Factors	36
Government Policies	37
Intellectual Property Rights	37
Labor Mobility	37
State and Local Policies	38

CHAPTER FIVE

Case Study: Maryland's Life Sciences Cluster	41
Overview	42
History	42
Financing	44
Federal Financing	44
Tax Credits	45
Loans and Grants	46
Angel Investment	47
State Venture Capital	47
Human Capital	48
Quality of Life	49
Other Factors	50
Government Policies	51
Business Incubators	51
Education and Training	51
Technical Assistance	52
Ease of Doing Business	52
Marketing	52
Intellectual Property	52
Labor Mobility	52

CHAPTER SIX

Case Study: Israel's Information and Communication Technologies Firms	53
Overview	53
History	53
Financing	56
Research and Development Funding and Precommercialization Support	56
Venture Capital	58
Human Capital	60
Quality of Life and Other Factors	61
Government Policies	63
Taxes	63
Grants	63
Business Incubators	64
International Collaboration	64
Labor Mobility and Intellectual Property	65

Part III: Applying Global Practice to Knowledge City

CHAPTER SEVEN

Introduction	69
---------------------------	----

CHAPTER EIGHT

Lessons Learned from the Case Studies: Taxes, Nontax Incentives, and Intellectual

Property	71
Taxes	71
Lessons Learned from the Case Studies and the Literature	71
Conditions in GDD	72
Gap Analysis	77
Nontax Incentives	78
Lessons Learned from the Case Studies and the Literature	78
Conditions in GDD	80
How GDD Entrepreneurs View Nontax Incentive Policies	81
Gap Analysis	85
Intellectual Property Rights	87
Lessons Learned from the Case Studies and the Literature	87
Conditions in GDD	89
Gap Analysis	91

CHAPTER NINE

Lessons Learned from the Case Studies: Other Issues	93
Human Capital	93
Lessons Learned from the Case Studies and the Literature	93
Conditions in GDD	95
Gap Analysis	102
Infrastructure and Business Climate	103
Lessons Learned from the Case Studies and the Literature	103
Conditions in GDD	104
Gap Analysis	106
Networks	106
Lessons Learned from the Case Studies and the Literature	106
Conditions in GDD	107
Gap Analysis	110
Quality of Life	110
Lessons Learned from the Case Studies and the Literature	110
Conditions in GDD	110
Gap Analysis	112
Marketing Knowledge City	113
Lessons Learned from the Case Studies and the Literature	113
Conditions in GDD	115
Gap Analysis	116

CHAPTER TEN

Conclusions and Summary 119

APPENDIXES

A. Company Case Studies 121

B. Brief History of Small Business Investment Corporations 125

C. Excerpts from Speeches by Local Officials..... 127

D. GDD Project Survey Methodology and Results 131

E. Indicators of Innovation..... 149

Bibliography..... 161

Figures

S.1.	The Innovation System Framework	xv
S.2.	Map of Silicon Valley	xviii
S.3.	Map of the Maryland Life Sciences Cluster	xx
S.4.	Map of Israel's ICT Corridor	xxiii
S.5.	Top Two Reasons for Difficulty in Recruiting Staff	xxvii
2.1.	The Innovation System Framework.....	9
3.1.	Industry Distribution of High-Technology Firms in GDD	16
3.2.	Age Distribution of High-Technology Firms in GDD.....	16
3.3.	Employment Size Distribution of High-Technology Firms in GDD	17
3.4.	Revenue by Age	18
3.5.	Location of Firm Headquarters Among Subsidiaries.....	18
3.6.	Firm Origin.....	19
3.7.	Company Founders.....	20
3.8.	Employment Size Distribution of Computer Manufacturing Firms in Santa Clara County.....	21
3.9.	Employment Size Distribution of ICT-Related Firms in the United States	21
3.10.	Firms' Perceptions of Suitable Locations Other Than GDD.....	24
4.1.	Map of Silicon Valley.....	28
4.2.	Percentage Share of ICT-Related Industries in Overall Payroll, Employment, and Firms in Santa Clara County	29
4.3.	Annual Compensation per Employee in Santa Clara County.....	29
4.4.	Employment Size Distribution of Computer Manufacturing Firms in Santa Clara County.....	30
4.5.	Sources of Startups in Silicon Valley and Boston.....	30
4.6.	Top U.S. Metropolitan Areas in Terms of Number of Patent Grants from USPTO.....	31
4.7.	Worldwide Venture Capital Investments.....	33
4.8.	Share of Venture Capital Offices in Major Metropolitan Areas.....	34
4.9.	Education Levels in Santa Clara County	35
4.10.	Origins of Residents in Santa Clara County	35
5.1.	Map of the Maryland Life Sciences Cluster	41
5.2.	Percentage Share of Biotechnology-Related Industries in Overall Payroll, Employment, and Firms in Montgomery County.....	42
5.3.	Annual Compensation per Employee in Montgomery County.....	43
5.4.	Share of Venture Capital Investment in the United States by Development Stage	45
5.5.	Education Levels in Montgomery County	48
5.6.	Origins of Residents in Montgomery County.....	49
6.1.	Map of Israel's ICT Corridor.....	54
6.2.	Share of ICT in Israel's Exports and Employment	55

6.3.	Average Monthly Wage per Worker in Israel.....	55
6.4.	Utility Patents Granted by USPTO to Inventors in Israel.....	56
6.5.	Venture Capital Investments in Israel by Sector	59
6.6.	Share of Venture Capital Investment in Israel by Development Stage	59
6.7.	Education Levels in Israel.....	61
6.8.	Net Migration Rate as a Percentage of Population in Israel	62
8.1.	Firms' Perceptions of Services Provided by GDD Administration	76
8.2.	Firms' Perceptions of the Top Three Most Important New Policies GDD Administration Could Make	77
8.3.	Sources of Initial Funding	82
8.4.	Sources of Subsequent Funding	82
8.5.	Sources of First-Round Outside Funding	83
8.6.	High, Low, and Median Amounts of Initial Outside Funding by Source	83
8.7.	Timing of First-Round Outside Funding.....	84
8.8.	Structure of First-Round Outside Funding.....	85
8.9.	How GDD High-Technology Firms Protect IP	91
9.1.	Share of Employees with a Science or Engineering Bachelor's Degree or Above	97
9.2.	Share of Employees with a Management Degree	97
9.3.	Share of Employees with a Technical School or Junior College Degree	98
9.4.	Recruiting Venues	98
9.5.	Recruiting Locations	99
9.6.	Ability to Find Qualified Technical Staff.....	100
9.7.	Ability to Find Qualified Management Staff	100
9.8.	Top Two Destinations of Former Employees	101
9.9.	Ease of Doing Business	105
9.10.	Ease of Finding Local Suppliers, Buyers, and Services.....	108
9.11.	Marketing Channels.....	109
9.12.	Collaboration	109
9.13.	Top Two Reasons for Difficulty in Recruiting Staff.....	111
9.14.	Top Two Reasons for Difficulty in Retaining Staff.....	112
D.1.	GDD-RAND Knowledge City Innovation System Research Project Survey Process ..	132

Tables

S.1.	Rankings of Guangzhou and Major Peer Competitors	xvi
3.1.	Rankings of Guangzhou and Major Peer Competitors	23
8.1.	China's Enterprise Income Tax in Comparative Perspective	73
8.2.	Preferential Tax Policies in GDD by Type of Economic District or Zone.....	75
9.1.	Sino-Singapore Guangzhou Knowledge City Investment and Development Co., Ltd. Pillar Industries	116
D.1.	Time Line of the GDD Project Survey	135
E.1.	Indicators of Innovation.....	151

Summary

Guangzhou exemplifies the explosive economic growth that has taken place in China since the country's dramatic economic reforms started more than three decades ago. A major trading center even 2,000 years ago, Guangzhou was named one of China's 14 open coastal cities in 1984 and has become a global center of manufacturing. One of China's largest and richest cities, it is now focused on leading the way toward a high-technology and innovation-based future.

At the heart of this effort is a new project being carried out by the Guangzhou Development District (GDD) and Singbridge of Singapore, the creation of the Sino-Singapore Guangzhou Knowledge City. Knowledge City is to be a new environmentally and technologically advanced city that hosts innovative industries and their associated knowledge workers. To achieve this goal, GDD will need to create a system that supports research, innovation, and the commercialization of new and better products and services.

This report presents RAND's detailed analysis of innovation systems and the steps GDD will need to take to make Knowledge City a success. It is based on analysis of relevant data and documents, interviews with technology entrepreneurs in GDD and international business people and investors operating in China, three detailed case studies of innovative areas, and a formal survey of GDD technology firms.

The report consists of three sections. Part I discusses the concept of an innovation system and the formation of clusters and provides an overview of the innovation system in GDD. It then presents a portrait of high-technology firms in Guangzhou and compares Guangzhou with other Chinese cities—those likely to compete with it for innovative firms and talented workers. Part II describes the factors leading to success for three innovative clusters: Silicon Valley, the life sciences corridor in Maryland, and the information and communications technology corridor between Tel Aviv and Haifa in Israel.

Part III applies lessons learned from the three case studies, as well as from the broader literature on entrepreneurship, innovation, and cluster formation, to GDD and Knowledge City. It assesses existing conditions in GDD, first discussing taxes, nontax incentives, and intellectual property rights, and then considering other innovation assets. The lessons learned are then compared with existing conditions in GDD in a gap analysis.

Part I: Introduction to the Guangzhou Development District and Knowledge City

Innovation does not happen in a vacuum. Researchers who focus on innovation have identified the presence of an *innovation system* as being important for innovation and its role in economic development. Innovation systems consist of both *actors* and the *connections* among them. Innovation policy can be defined as “a set of policy actions to raise the quantity and efficiency of innovative activities” (European Commission, 2010). Although the discussion of innovation systems and innovation policies is often narrowly focused on science and technology policy, innovation systems and policies can include many types of social, political, and economic activities and institutions, particularly in the context of economic development (Lundvall et al., 2002; Liu et al., 2011).

Innovation Systems and Innovation Policy in China

China’s innovation system has undergone a major transformation over the past 30 years. It has moved from a system dominated by a few large, government-affiliated actors toward a more decentralized system and has made progress in developing many environmental factors that support innovation, including a venture capital market and an enhanced talent pool. China’s innovation policies have also shifted from being focused solely on science and technology to coordinating science and technology policy with industrial, financial, tax, and fiscal policies (Liu et al., 2011). The key components of the current medium- to long-term plan for science and technology are to increase research and development expenditure to 2.5 percent of gross domestic product (GDP) by 2020, to shift toward “indigenous innovation,” and to make the business sector the key force behind innovation (Schwaag Serger and Breidne, 2007).

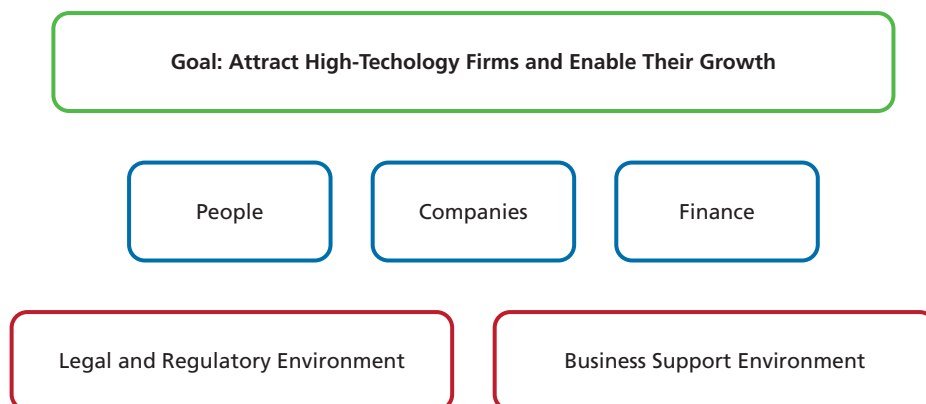
At a provincial level, Guangdong Province has a number of other innovation policies, focused on such areas as creating innovation networks, improving training and education, establishing research institutions, and implementing an intellectual property rights strategy (Kroll and Tagscherer, 2009). Although Guangdong Province is one of the top three regions in China in terms of total patent applications (Kroll, 2010), there are several challenges to its innovation system, including scarce venture capital, weak implementation of intellectual property rights, and a paucity of top universities and research centers. The extreme concentration of research and development in the field of electronic and telecommunications equipment, and in particular in one large telecommunications firm (Huawei), may also be a concern (Kroll and Tagscherer, 2009).

A Framework for the Knowledge City Innovation System

For purposes of the GDD-RAND Knowledge City Project, we consider the innovation system to have a base that includes the legal and regulatory environment and the business support environment, the latter of which can also be thought of as a set of specific GDD policies. We also include the companies themselves, the institutions that provide the physical and organizational space in which innovative activities occur; human talent, the people who carry out the innovative activities; and financing, the flow of money that enables companies and human talent to operate (Figure S.1). Ideally, these will combine into the creation and growth of firms that innovate.

The key reason to define and understand an innovation system is to find leverage points to spur innovation. These could involve government interventions regarding regulation, tax-

Figure S.1
The Innovation System Framework



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tion, or financing or they could involve interventions regarding how the different elements of the innovation system interact. These interventions collectively amount to innovation policy.

Clusters and Innovation

Industrial clusters are found throughout the world. Clusters may be described as geographic concentrations of interconnected companies and institutions in linked industries, including supplies and customers. A number of scholars have argued that when firms in the same industry are clustered together, the cluster contributes to innovation. In addition, the formation of clusters can be considered an outcome of successful innovation-based economic development policy and would be a sign of success in Knowledge City.

The formation of a cluster may be advantageous for individual firms by providing them with access to natural regional advantages, common infrastructure, lower transportation costs among customers and suppliers, access to a specialized labor pool, information, reputational effects, and the ability to coordinate marketing efforts. The formation of clusters, in turn, can be advantageous for the local area in terms of increasing output and incomes, providing better job opportunities, and expanding the local tax base.

To take advantage of such potential benefits, policymakers in a number of regions around the globe have attempted to foster the creation and growth of innovation-based clusters. Policy might help to form clusters in a number of ways, especially by providing local public goods that firms need but cannot provide for themselves and by creating conditions beneficial to specific, targeted industries. However, the literature suggests that policies to encourage clusters are neither necessary nor sufficient for cluster formation.

High-Technology Firms in GDD

RAND and GDD jointly developed a survey of high-technology firms in GDD, the GDD-RAND Knowledge City Innovation System Research Project Survey (“the GDD-RAND Knowledge City Project Survey”). GDD staff delivered approximately 1,500 surveys and 305 survey responses were received.

Most high-technology firms in GDD are concentrated in two industries: electronics and information technology, and biological and pharmaceutical technology. There are also smaller

groupings of firms in the manufacture of new materials and in the optical, mechanical, and electronic integration sector. The concentration of firms in these industries, especially the first two, raises the question of whether those sectors have an advantage in GDD and therefore whether GDD should concentrate on focusing on these sectors or diversify into other technology areas.

The majority of high-technology firms in GDD were originally founded in GDD or Guangzhou, although one-quarter of firms, accounting for approximately one-third of employment, are subsidiaries of firms located both in China and abroad. This suggests that GDD has gained much of its recent success from providing a fertile environment for domestic entrepreneurs. This does not rule out the importance of continuing to attract companies from outside, whether they are relocating companies or new subsidiaries of existing outside companies. However, it does highlight the importance of not ignoring the opportunities for local entrepreneurs.

Guangzhou in Comparative Perspective

Compared to its peer competitors in China, GDD does well in terms of the assets it has available for innovation. We compared Guangzhou (the jurisdiction in which GDD is located) with Beijing; Shanghai; Tianjin, site of Sino-Singapore Tianjin Eco-City; Suzhou, site of the China-Singapore Suzhou Industrial Park; Hangzhou, site of the Zhejiang California International NanoSystems Institute; and Shenzhen, one of China's first four Special Economic Zones and Guangzhou's neighbor (Table S.1).

Table S.1
Rankings of Guangzhou and Major Peer Competitors

	Guangzhou	Beijing	Shanghai	Tianjin	Suzhou	Hangzhou	Shenzhen
Population	4	2	1	3	5	7	6
GDP	3	2	1	6	5	7	4
Per capita GDP	3	5	4	7	2	6	1
Transportation infrastructure	2	5	1	4	7	6	3
College enrollment	1	3	4	5	6	2	7
Ranked universities	4	1	2	4	6	3	7
Science spending	6	2	1	4	5	7	3
Number of patents granted	7	3	1	7	2	4	5

SOURCES: *China City Statistical Yearbook*, 2009–2011; National Bureau of Statistics, 2011; Shanghai Ranking Consultancy, 2011; statistical yearbooks of individual cities.

NOTES: For the rankings, 1 signifies the highest, most, or best. Population and per capita GDP are from the 2010 census; GDP is calculated from the population and per capita GDP figures; transportation infrastructure includes airports, seaports, and inland waterway facilities; college enrollment includes enrollment in universities and junior colleges in 2008; and science spending reflects expenditures for any science and technology purpose. For ranked universities, we started with universities ranked 50 or higher in the 2011 Shanghai Rankings (Shanghai Ranking Consultancy, 2011) and in the Chinese Academy of Management Sciences rankings (2011). We computed our overall rankings by awarding five points for each university in the top five, two points for each university ranked six through 10, and one point for each university ranked 11 through 50. Under this system, Guangzhou was fifth in the Shanghai ranking and fourth in the Academy of Management Sciences ranking, and Tianjin was fourth and fifth in those same rankings. We therefore tied them at four. Results were similar for other scoring systems.

Guangzhou appears to have a younger population, better transportation infrastructure, and higher per capita GDP than its peer competitors in China, and many of its other assets are similar. However, the lack of top universities and lower ranks on selected science and innovation indicators are concerns. The similarities in assets suggest that Guangzhou can best differentiate itself through capitalizing on its location in southern China near Hong Kong and Southeast Asia and through its current industrial base and associated human capital, its transportation infrastructure, and better government policies and performance.

Part II: Three Case Studies of Innovative Clusters

Case Study: Silicon Valley

Silicon Valley is located in the San Francisco Bay Area in Northern California (Figure S.2). Santa Clara County, just south of San Francisco, can be considered the heart of Silicon Valley. Although Silicon Valley has a number of high-technology industries, it is best known for its success in information and communication technology (ICT). It is characterized by “creative destruction” (progress that occurs through the continuous birth and death of new ideas and new firms), by a high rate of spinoffs (new firms that started by former employees of major firms and universities in the area), and by its leading position in patenting.

The history of high-technology firms in Silicon Valley dates back to 1909, when Stanford graduate Cyril Elwell formed the Federal Telegraph Corporation. Stanford played an important role in Silicon Valley’s growth. One of its faculty members, Frederick Terman, encouraged his students, perhaps most famously William Hewlett and David Packard, to be entrepreneurial (Leslie, 2000; Saxenian, 1994; Sturgeon, 2000). During and after World War II, the key firm founded was Fairchild Semiconductor, which was itself founded by employees from another firm in Silicon Valley, and which spawned a large number of spinoffs.

Silicon Valley faced a crisis during the 1970s and 1980s when the semiconductor industry, in which it was a leader, became commoditized. Silicon Valley survived this crisis by moving into other areas and creating new firms. During this time, the “network” structure of Silicon Valley also developed. To survive, firms specialized in the design of high-value-added semiconductors while outsourcing manufacturing to other companies. This unbundling of production, along with an effort by new firms to avoid the previous models of large, “cumbersome organizations,” helped to create a network of interdependence among firms that persists to this day (Saxenian, 1994).

Financing. During its early years, individual angel investors financed a number of firms in Silicon Valley. Many other firms were supported by purchase orders from the government. During the 1950s, a small group of investors formed an investment group (called “The Group”) that collectively invested in startup firms. The first privately funded, limited capital partnership in California (Draper, Gaither and Anderson) was also established during this time (Kenney and Florida, 2000; Leslie, 2000). In the late 1970s, two federal policy reforms encouraged the growth of private venture capital. First, the U.S. Congress reduced the capital gains tax rate from between 40 and 50 percent (depending on specific situations) to 28 percent (Tax Policy Center, 2011). Second, the U.S. Department of Labor loosened its fiduciary responsibility guidelines for institutional investors, opening up venture capital funds as a suitable investment for pension managers. Today, Silicon Valley receives much more venture capital than other leading metropolitan areas in the United States and around the world.

Figure S.2
Map of Silicon Valley



SOURCE: Map generated by RAND using ArcView GIS, Version 10.0, Redlands, Calif.: Environmental Systems Research Institute, Inc., 2011.

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Human Capital. The population in Santa Clara County is relatively well educated, with 19 percent holding a graduate or professional degree, and nearly 45 percent holding at least a bachelor’s degree. These levels are much higher than levels in California or in the United States as a whole. Stanford University and the University of California, Berkeley, have provided skilled talent to the area for more than a century. Immigration is another important source of talent in Silicon Valley.

Quality of Life. Quality of life and the availability of amenities are thought to be potential ingredients in cluster formation, but there is limited empirical evidence. However, there is the “California puzzle.” California’s growth has been approximately on par with growth in the United States as a whole during the past 30 years, even though California ranks poorly in terms of taxes and costs. Kolko, Neumark, and Mejia (2011) show that in the case of California, mild climate, dry weather, the composition of existing industry, population density, and proximity to a coast have outweighed the potential negative effects from taxes and costs.

Other Factors. Silicon Valley has developed a support structure for startup firms. An entrepreneur can find a number of specialists to guide him or her through the process, including venture capital firms with significant experience working with startups, law firms well versed in relevant fields and willing to offer creative payment options to small firms, patent brokers, staff search companies, and other firms to which such functions as sales, marketing, and accounting can be outsourced. Social networks also play a crucial role in Silicon Valley. Saxenian (1994) points out that many entrepreneurs share ties from attending the same university or having worked for the same employer.

Government Policies. Intellectual property rights (IPR) are not generally discussed in case studies of Silicon Valley. However, the literature on university spinoffs and IPR suggests that allowing both universities and individual inventors to share some of the benefits from invention may be helpful in encouraging entrepreneurship. In Silicon Valley, Stanford University uses 15 percent of cash royalties to cover administrative overhead; patent filing fees are also deducted. The remaining royalty income is then evenly divided between the inventor, the inventor’s department, and the inventor’s school. Similarly, after deducting 15 percent of equity to cover overhead, equity is shared between the inventor and the university. The university’s share goes to a research and fellowship fund (Stanford University, 1999). At the University of California, Berkeley, the inventor retains 35 percent of net royalties and fees plus another 15 percent for use in the inventor’s campus or lab (University of California, Berkeley, 2011).

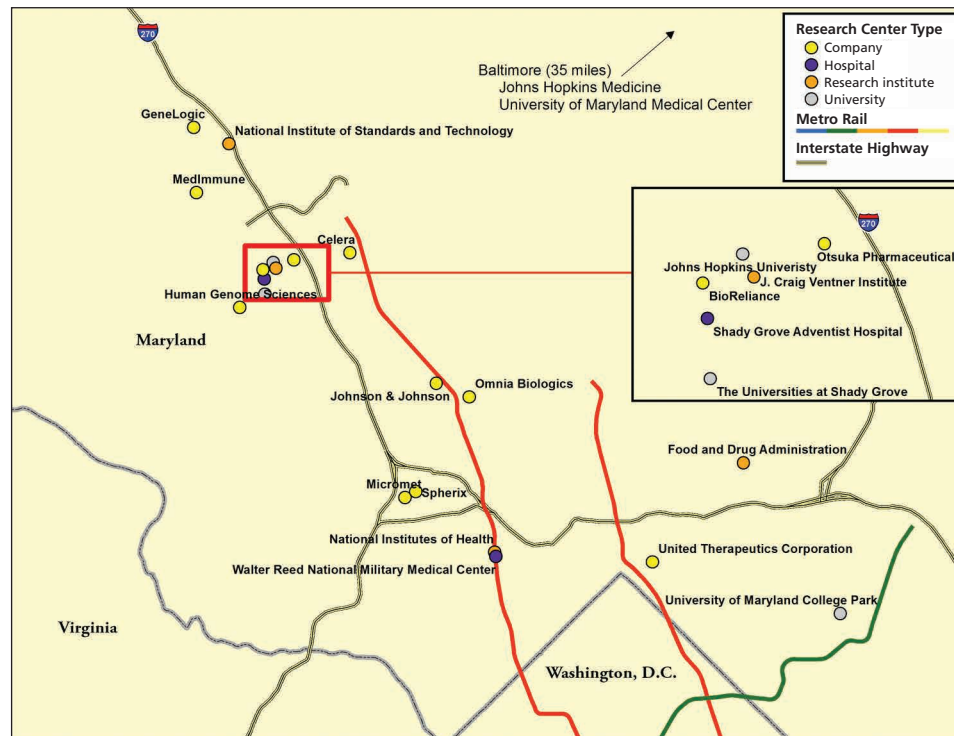
Another reason for Silicon Valley’s success is thought to be the fact that California does not allow the enforcement of noncompete clauses, thus allowing employees to move freely between firms. Even in California, however, trade secret law prohibits employees from disclosing an employer’s firm-specific trade secrets, although they can take their general and industry-specific human capital with them when they leave (Gilson, 1999). The empirical evidence suggests that labor mobility is much higher in California than in other parts of the United States.

Finally, the State of California and the cities of San Jose and San Francisco currently have a number of policies designed to encourage investment. Most of these policies were not in place during the formation of the Silicon Valley cluster, and none of the evidence or case studies we reviewed suggests that state or local government policies contributed significantly to the growth of the Silicon Valley cluster. The federal government can be seen as having played a larger role in cluster formation by acting as a major purchaser of technologies developed in Silicon Valley during its early years.

Case Study: Maryland’s Life Sciences Cluster

Maryland’s life sciences cluster is located just north of Washington, D.C., on the East Coast of the United States (Figure S.3). It is situated around a number of federal government laboratories and agencies, which provide the local area with a deep research base. Montgomery County, in the heart of the cluster, also specializes in other industries including information technology

Figure S.3
Map of the Maryland Life Sciences Cluster



SOURCE: Map generated by RAND using ArcView GIS, Version 10.0, Redlands, Calif.: Environmental Systems Research Institute, Inc., 2011.

RAND TR1293-5.3

and defense. In our case study, we focus on the life sciences cluster, which includes biotechnology, pharmaceuticals, and medical devices.

The share of biotechnology in Montgomery County's economy is approximately 10 times the share of biotechnology in the U.S. economy as a whole. Although this area does not record as many patents as Silicon Valley, it does rank fairly highly among other metropolitan areas in the United States. One key reason why the biotechnology industry is considered desirable by business development officials in Montgomery County is that the average compensation per employee is twice as high as overall average compensation and is also higher than the compensation among professional and scientific services industries as a whole.

Approximately 60 federal government agencies and laboratories are located near the Maryland life sciences cluster, including the National Institutes of Health (NIH), the National Institute of Standards and Technology, and the Food and Drug Administration. In addition, two major universities, the University of Maryland College Park (UMCP), and Johns Hopkins University, are located nearby. UMCP is located in the neighboring county, and Johns Hopkins University is located approximately 55 kilometers north of the cluster, in Baltimore, Maryland. The existing research base, in particular the federal laboratories, gave rise to a large, existing supply of private businesses in the life sciences fields.

The life sciences cluster began to take off during the late 1970s and early 1980s. Our interviews indicate that during this time, the Montgomery County government decided to

capitalize on the research taking place at the nearby federal laboratories by setting up a Life Sciences Center business park. The county government's vision for the business park was to have a hospital and direct medical services at the center, surrounded by firms performing related research.

At the beginning, the county offered only two financial incentives for firms moving into the business park: inexpensive land and a subsidized interest rate on bonds. The county also offered land to the University of Maryland in 1984 and to Johns Hopkins University in 1986.

Tax Incentives and Government Finance Programs. Firms in the cluster have access to a number of tax credits, although business development officials indicated that most of them are not used because many companies that could qualify do not have any profits and thus do not pay state taxes. Officials noted that "refundable tax credits," which allow firms without profits to carry over the tax credits until they do have profits, or to receive cash from the state, are more popular among firms but are more difficult to provide, since they require more state revenue. Other tax credits include property tax credits in certain areas and a Maryland investment tax credit for investment in an early-stage biotechnology firm. Firms also have access to loan and grant programs through the government and the University of Maryland.

Facilitating Private Financing. The Washington, D.C. – Maryland – Virginia metropolitan area, in which the cluster is located, receives a significant amount of venture capital, much of it from other states. A number of officials and entrepreneurs indicated that they feel there is a gap between research funding and late-stage funding. One solution has been the establishment of two angel investment networks, one through a state-funded agency and one through the University of Maryland. State agencies also operate or participate in several programs aimed at providing venture capital.

Human Capital. The population in Montgomery County is extremely well educated, with 30 percent holding a graduate or professional degree and nearly 60 percent holding at least a bachelor's degree. Montgomery County attracts an extremely educated population partly because of the proximity of the NIH and other federal research laboratories and agencies, which directly employ thousands of researchers and which attract private contractors to the area. Another reason cited by officials and entrepreneurs is the excellent quality of life in Montgomery County.

Quality of Life. Montgomery County has a good public school system, with two high schools in the top 100 and five in the top 250 nationally (Newsweek, 2011). Institutions of higher education, while perhaps not including many top research institutions in science and engineering, are plentiful. Besides the University of Maryland and Johns Hopkins University, regional universities include George Mason University, Georgetown University, and George Washington University, among many others. Urban and cultural amenities are also plentiful in the local metropolitan area.

Government and University Policies. Aside from financing, the local and state governments and the University of Maryland have a number of policy measures to encourage the life sciences cluster. These include business incubators and even a program that allows faculty members who start companies to keep their faculty jobs while working part-time on the start-ups; courses and workshops in entrepreneurship, as well as business plan competitions; and technical assistance programs. Montgomery County has taken steps to make it easier for firms to set up a new business by creating a Technical Advisory Board, a formalized group designed to coordinate county activities so that new buildings can be approved efficiently. The county is also making efforts to market its brand. Finally, although intellectual property rights are

designated somewhat differently at the University of Maryland than at Stanford and the University of California, Berkeley, they generally follow the principle of sharing between inventor and university.

Other Factors. Business development officials, as well as some entrepreneurs, expressed concern that the business culture in Montgomery County is risk-averse, particularly when compared with Silicon Valley. One potential reason is that government laboratories, while providing a rich pool of skilled researchers, also compete with private industry for talent. A researcher may prefer a stable job at NIH to an uncertain startup opportunity.

Another aspect of the culture concerns the local universities. Johns Hopkins University and University of Maryland representatives indicated that the university culture has not historically encouraged entrepreneurship; in the past, faculty members who started businesses were frowned upon. Today, university officials are making efforts to change the culture; more junior faculty members are interested in starting companies, and universities are trying to facilitate faculty participation in technology businesses.

Case Study: Israel's Information and Communication Technologies Firms

Beginning in the 1970s, the corridor from Tel Aviv to Haifa in Israel has become a center for ICT firms (Figure S.4). The main clusters of ICT firms are located in Herzliya and Ra'anana (just north of Tel Aviv), as well as in Haifa (about 100 kilometers to the north). In 2010, the ICT sector employed 7 percent of the Israel's workforce and accounted for 27 percent of the total value of Israel's exports (Israel Central Bureau of Statistics, 2011).

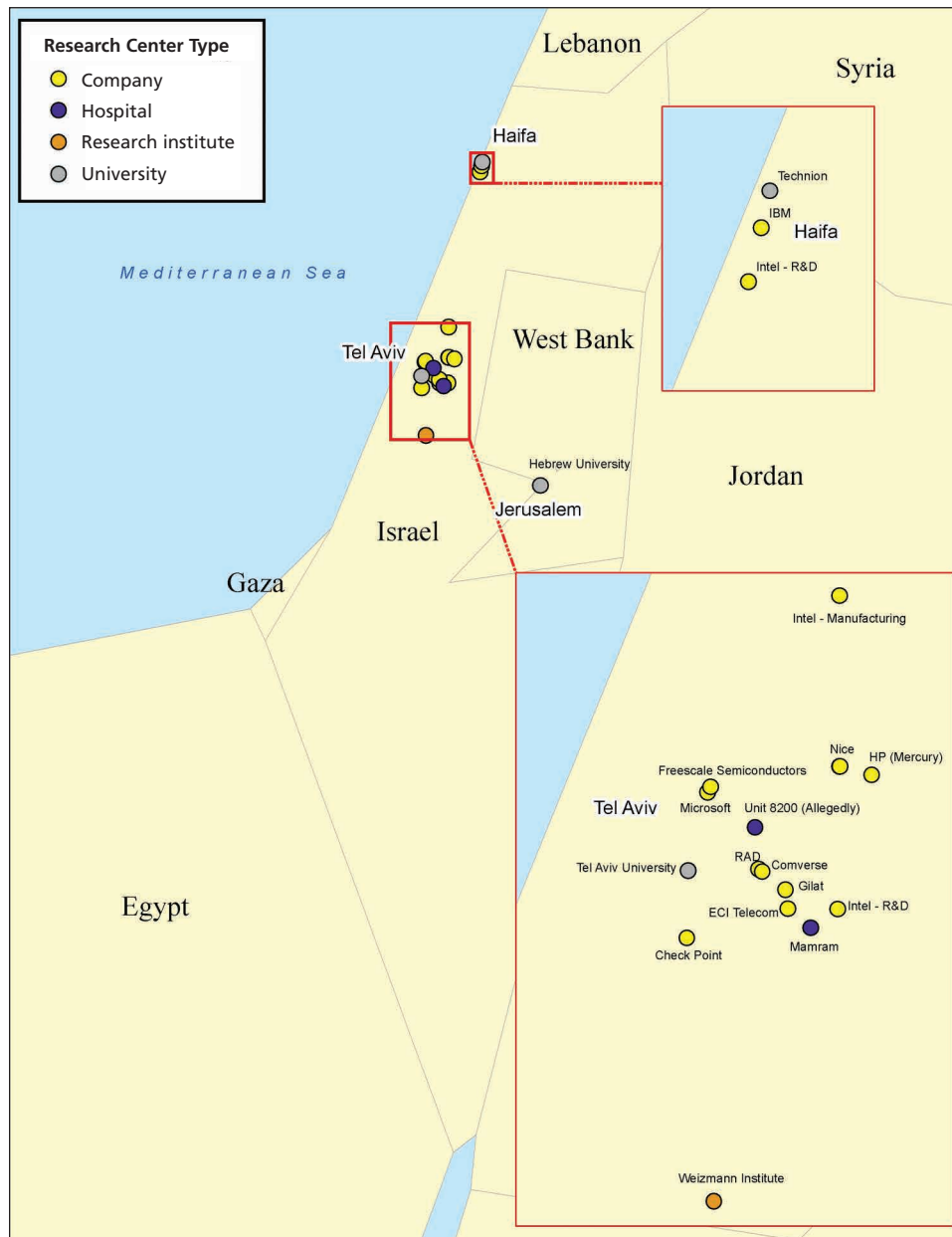
Multinational corporations (MNCs) played a large role in the development of Israel's ICT cluster and continue to be major employers and exporters. As in Silicon Valley, spinoffs have been important and there has been active patenting activity. The number of patents granted by the United States Patent and Trademark Office (USPTO) to inventors in Israel has risen sharply since the mid-1980s. In 2010, Israel accounted for approximately 1 percent of all patents granted by the USPTO.

Both home-grown and foreign firms were important in the development of the Israeli ICT cluster. During the 1960s, several Israeli high-technology firms were established; one of these firms, Elron Electronics, is sometimes considered similar to Fairchild Semiconductor in Silicon Valley in terms of its importance in generating future growth of the cluster. In 1964, Motorola set up a research and development (R&D) facility in Israel, followed by IBM and Intel in 1974.

The ICT boom accelerated in Israel during the late 1980s and 1990s. Our interviews suggest that many factors played a role in triggering this boom, including:

- Economic reforms of the 1980s and 1990s. During this period Israel made a number of structural changes to move toward a less regulated economy.
- Research taking place inside the Israel Defense Forces (IDF). The military does not have a noncompete policy for its former members and does not prevent former members from working in similar fields, with the exception of cryptography.
- The massive influx of Soviet immigrants who arrived in Israel during the early 1990s. Although they did not often become entrepreneurs themselves, they provided talented technical personnel.
- Multinational corporations such as Microsoft and Intel, which opened locations in Israel.

Figure S.4
Map of Israel's ICT Corridor



SOURCE: Map generated by RAND using ArcView GIS, Version 10.0, Redlands, Calif.: Environmental Systems Research Institute, Inc., 2011.

RAND TR1293-S.4

Financing. Three stages of financing have played a role in the ICT cluster: R&D funding, precommercialization funding, and venture capital.

Today, Israel has the highest gross domestic expenditure on R&D as a percentage of GDP among countries belonging to the Organisation for Economic Co-operation and Development (OECD). It also has the highest fraction of R&D expenditure by business enterprises (nearly 80 percent), and the share of R&D expenditures borne by the government (less than 5 percent)

is one of the lowest in the OECD (OECD, 2011). The Office of the Chief Scientist, a government body responsible for subsidizing commercial R&D projects, provides R&D support to firms that meet certain criteria. The R&D fund was originally designed to be industry-neutral but has shifted to providing higher subsidies to biotechnology and nanotechnology. Despite this, it is unclear whether Israel can be competitive in these fields.

In the realm of precommercialization support, the Office of the Chief Scientist also established a Magnet Program in 1993 to encourage joint industrial and academic partners to create “generic, pre-competitive technologies” (Trajtenberg, 2000).

The first venture capital fund in Israel was set up in 1985 by three private entrepreneurs (de Fontenay and Carmel, 2004). Between 1989 and 1992, several additional venture funds were established. In 1993, the government established its own venture program called *Yozma*. Government funds amounting to \$20 million were invested directly by a state-owned venture fund, later privatized in 1997 (Avnimelech and Teubal, 2004). The *Yozma* program also created 10 private funds, in which it invested \$8 million each on a matching basis. Each private fund had to combine a well-established Israeli financial institution with a foreign financial institution. In total, *Yozma* funds raised \$250 million and invested this money in more than 200 firms (Avnimelech, Schwartz, and Bar-El, 2007). Our interviews suggest that the *Yozma* program was considered important in spurring the growth of the Israeli venture capital industry for two reasons. First, it provided the first boost to the domestic venture capital industry. The firms that received *Yozma* funding had an easier time obtaining outside funding. Second, it provided a bridge to the venture capital industry in the United States, including expatriate Israelis and diaspora Jewish communities. Today, Israel is one of the top recipients of venture capital investment in the world.

Human Capital. Our interviews indicate that the IDF is perhaps the most important training ground for technical talent in Israel. The IDF not only has first choice of the recruits who present themselves for national service, but it also uses a battery of psychometric tests to evaluate and place candidates. The IDF has a number of technology-oriented units and programs, and recruits compete to be placed in many of these programs. Our interviews suggest that many former IDF members who go on to form companies were part of the technologically focused “Unit 8200,” which does work on signals, interception and interpretation, and more generally electronics and technology. A number of other programs result in the creation of a highly skilled technical workforce.

The IDF contributes to human capital development in other ways. Recruits are required to undertake a significant amount of responsibility at a young age, to work within and to manage teams, to think strategically, and to achieve goals rather than simply to carry out orders; this training provides them with important entrepreneurial skills. The military structure is fairly flat, and the culture encourages young recruits to communicate with, and even challenge, more senior members (de Fontenay and Carmel, 2004; Senor and Singer, 2009). Then, after serving in the military, many Israelis attend college. Our interviews suggest that technical education at the universities is considered to be excellent, but formal business and entrepreneurial education still leaves considerable room for improvement.

MNCs played, and continue to play, an important role in providing human capital for Israel’s ICT cluster. Our interviews indicate that Israelis working for foreign companies have been important in a number of firms’ decisions to locate in Israel. Historically, the MNCs also served as de facto educational facilities, providing training that would not otherwise be available without going abroad. The wave of approximately 800,000 Soviet immigrants to Israel in

the early 1990s also provided a large pool of technical talent (de Fontenay and Carmel, 2004; Senor and Singer, 2009).

Quality of Life and Networks. As in the Silicon Valley and Maryland clusters, quality of life appears to play a role in the specific locations of high-technology firms in Israel: The major high-technology clusters are generally considered the most desirable places to live in Israel. A variety of networks, including specialized supplier and support networks, have grown up in Israel during its high-technology boom of the 1990s. Some of these networks are oriented toward providing connections between Israel and its largest market, the United States, through the Israeli diaspora and through the operation of MNCs in Israel. As in Silicon Valley, social networks play a key role in Israel's high-technology cluster. However, unlike in Silicon Valley, the IDF plays a critical role in network formation. Startup teams are often identified with, and made up from, former colleagues in the army (de Fontenay and Carmel, 2004). Our interviews suggest that these networks are propagated by continued service in the reserve forces, which brings former IDF team members together periodically for training.

Government Policies. A number of government policies to encourage financing were discussed above. Here, we outline additional, nonfinancial policies that may be relevant to innovation-based cluster formation and growth.

Israel offers corporate and dividend tax reductions to both local and international companies that are considered "industrial" and "internationally competitive." However, our interviews indicate that tax concessions were not likely to have been the major driver in attracting MNCs to Israel. Rather, a combination of Israel's skilled workforce, along with encouragement from Israeli employees, was likely more important in attracting MNCs.

Israel also offers grants to investors, and these have been considered helpful in the development of the country's technology corridor. An incubator program started by the Office of the Chief Scientist between 1991 and 1993 also appears to have helped foster new firms. However, our interviews indicate that there is a concern that the incubators were not as effective as they could have been because they were run by bureaucrats rather than entrepreneurs, and they required too large a share of equity in the firms they helped establish. In addition, the incubators did not teach the skills required to become entrepreneurs.

The government has also tried to foster international cooperation. In 1977, the governments of Israel and the United States founded the Israel-U.S. Bi-national Industrial Research and Development Foundation. The program contributes up to 50 percent of the cost for joint U.S.-Israeli research efforts, up to \$1.5 million. Although many successful ventures grew out of this program, it is not clear how much of an impetus the foundation provided to the overall growth of the Israeli ICT cluster (de Fontenay and Carmel, 2004). Israel has also established relationships with other countries including Canada, Korea, and Singapore.

Part III: Applying Global Practice to Knowledge City

GDD can draw guidance from the three case studies as well as from the broader literature on entrepreneurship and cluster formation. We compare lessons learned with existing conditions in GDD that were identified throughout our research, supplemented by findings from the GDD-RAND Knowledge City Project Survey. We start by focusing on taxes, nontax incentives, and IPR policies and then move on to a number of broader issues, including human capi-

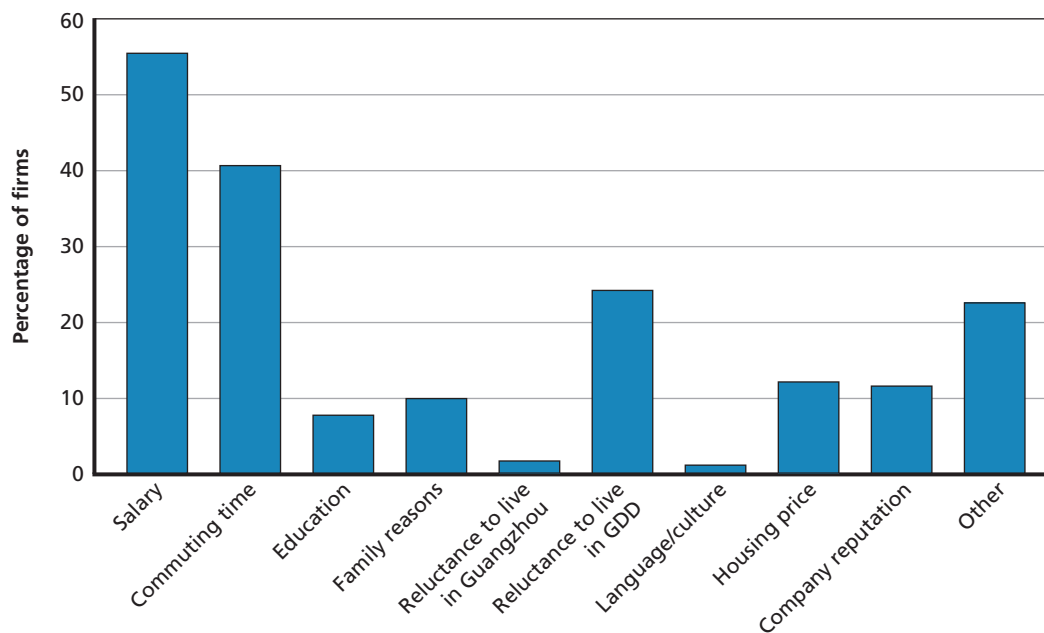
tal, infrastructure and business climate, networks, quality of life, and marketing Knowledge City.

Overview: Key Messages

Our findings lead us to a number of suggestions for the success of Knowledge City.

- There appears to be a gap in early-stage financing. In the GDD-RAND Knowledge City Project Survey, only 25 percent of firms reported receiving any outside funding. Bank loans appear to be the dominant source of outside funding, with very few firms reporting investment from angel investors or other types of private investment funds, even when additional funding rounds are considered. GDD may be able to help fill this gap by encouraging the formation of angel investor networks. Guangzhou has many successful, wealthy individuals who may be willing to invest in new firms but may not know how or where to find opportunities for investment. GDD may be able to draw on lessons from local development agencies and university organizations in Maryland, which have fostered such networks.
- We see a potential opportunity for GDD if it can become a zone of strict IPR enforcement, aggressively helping GDD companies protect their IPR throughout China and letting it be known that top innovators in China and abroad will have their rights protected if they locate in GDD. GDD may also wish to provide additional incentives to encourage companies to apply for international patents. Given the survey findings, which suggest that labor mobility is accepted in GDD, it is particularly important to ensure that IPR enforcement is strong so that firms' trade secrets are not divulged by former employees.
- To the extent possible, GDD should shift its emphasis more toward improving the living environment of Knowledge City and less toward business incentives. In the GDD-RAND Knowledge City Project Survey, firms most commonly listed salary, commuting time, and reluctance to live in GDD among the top difficulties in recruiting staff (Figure S.5). Improving the quality of life may be helpful in attracting the very top researchers, particularly expatriate Chinese.
- Attracting an anchor institution will be very important for the success of Knowledge City. By an anchor institution, we mean a major company or institution that is well regarded and can serve to attract suppliers, buyers, and other tenants to the area; provide a source of talent; or serve as a source of research that can be commercialized or of spinoffs. In marketing Knowledge City to potential tenants, it will be important to emphasize those factors that highlight GDD's strengths, particularly if they are relatively difficult for other areas to replicate. Two important assets that most other areas cannot replicate are Guangzhou's proximity to a major port and its historic role as a center of global commerce in China. In addition, GDD may find it valuable to focus on factors that take time to replicate, such as a good business climate, a reputation for IPR enforcement, strong angel investor networks, and excellent quality of life and local schools. Creating a reputation for having these factors could assist in attracting innovation-oriented firms to Knowledge City; the presence of these firms would reinforce Knowledge City's reputation for innovation, thus attracting more innovation-oriented firms to the area and creating a virtuous circle that would make it difficult for other regions to catch up.

Figure S.5
Top Two Reasons for Difficulty in Recruiting Staff



SOURCE: The GDD-RAND Knowledge City Project Survey.
 RAND TR1293-S.5

Selected Policies: Taxes, Incentives, and Intellectual Property Rights

Taxes. Overall, the tax situation in GDD does not appear to be a major constraint on innovation. The literature suggests that lower tax rates can be beneficial in promoting entrepreneurship and investment. However, all three of our case studies indicate that when selecting a location, innovative firms are more likely to consider such issues as availability of highly skilled labor, quality of life, and proximity to suppliers and buyers than tax issues. Tax concessions may add some additional inducement for firms already considering starting or locating in an area, but they are unlikely to be a major factor in driving the formation of an innovation-based cluster.

Although various national preferential tax policies applicable to firms in GDD may also encourage entrepreneurship, these preferential tax benefits also apply to other economic zones in China. The challenge for GDD, therefore, lies in attracting innovative firms specifically to locate in Knowledge City rather than in another economic zone in China. GDD could examine various options for providing concessions. However, the benefits of such policies may be less than expected, as they may be eroded by tax competition from other jurisdictions.

These concerns suggest that GDD may find it more beneficial to compete with other regions based on other factors, such as quality of life, strong enforcement of IPR, and the overall business climate, which take time to develop, and may be more difficult for other regions to imitate.

Nontax Incentives. Robust financing is an important component of a successful cluster. In GDD, the main gap in financing appears to be in the early stages of business growth. Most high-technology firms in GDD that reported outside financing received bank loans; very few firms were financed by angel investors, who often fill the gap between basic funding for

research and development, which is often provided by governments, and later-stage funding, which is often provided by venture capital firms.

GDD may be able to help fill this gap by encouraging the formation of angel investor networks. Guangzhou has many successful, wealthy individuals who may be willing to invest in new firms but may not know how or where to find opportunities for investment. Our case study of Maryland's life sciences firms offers some suggestions for how GDD might facilitate such investment. In Maryland, both a state development agency and a local university entrepreneurship center have established angel investor groups. These organizations invite investors in their networks to attend regular sessions, during which a selected number of companies pitch their ideas. The angels are typically successful local entrepreneurs but may also include wealthy individuals who do not have previous entrepreneurial experience.

Our review of the literature and case studies indicates that, as with taxes, although nontax incentives from local government may add some additional inducement in terms of attracting firms to GDD, they are unlikely to be a major factor in driving the formation of an innovation-based cluster. Even though nontax incentives may initially attract high-technology firms to an area, without other conditions, such as availability of skilled labor and protection of IPR, such firms are unlikely to survive and grow. To the extent that GDD has the resources to provide nontax incentives, it may be worthwhile to concentrate those benefits on a few anchor institutions.

Intellectual Property. Protecting IPR is a crucial component in attracting high-value-added activities, as well as investment and international collaboration in such activities. We see a potential opportunity for GDD if it can become a zone of strict IPR enforcement, aggressively helping GDD companies protect their IPR throughout China and letting it be known that top innovators in China and abroad will have their rights protected if they locate in GDD. GDD may also wish to provide additional incentives to encourage companies to apply for international patents. Nearly all patents to Chinese-origin inventors are issued in China, whereas a large minority of patents to U.S.-origin and Japanese-origin inventors is issued outside their home countries. Patenting in economically advanced countries may push inventors in GDD to higher standards.

Our research on university IPR practices indicates that allowing both universities and individual inventors to share the financial rewards from invention is likely to be helpful in promoting commercialization of technologies developed at universities. The exact division of royalties and equity rights differs between institutions and may influence whether inventors tend to start their own companies or to license their technology; there is probably no ideal division. In our case studies, we reviewed the distribution of IPR at several major universities and found that all of them make an effort to divide royalties or equity among the inventor, the inventor's laboratory or department, and the university. Many top research institutions make their policies public; we briefly summarized the key policies from Stanford University, the University of California, Berkeley, and the University of Maryland in our case study report. Such policies could serve as a guide for GDD.

Other Aspects of the Environment for Innovation

Human Capital. It appears that firms in GDD are able to find most of the talent they need within Guangzhou or Guangdong. There may be a gap for the very top research talent; our interviews suggest that firms may need to recruit talent from abroad to fill this gap.

Our review of the literature indicates that an influx of returnees from Silicon Valley to Taiwan played a critical role in the success of the Hsinchu cluster. Similarly, Guangdong's large, expatriate population should provide a way to help fill the gap for the very top research talent. The Hsinchu cluster experience and our interviews in GDD suggest that some expatriates prefer to leave their families in the United States because of differences in housing, lifestyles, and educational systems between the United States and China. To the extent that being separated from family poses a challenge in attracting foreign talent, GDD may be able to mitigate that challenge by seeking to provide amenities associated with a higher quality of life in Knowledge City, including more diverse, excellent educational opportunities.

The ability of workers to change jobs easily can also lead to human capital formation; the movement of employees between firms can help promote information spillovers. However, employers may be concerned that employees may take trade secrets as well as accumulated human capital to competitors. One way in which many firms attempt to protect their intellectual property is by requiring that employees sign nondisclosure and noncompete agreements. The literature and our case studies indicate that labor mobility helps to promote information spillovers and that these positive spillovers outweigh any losses to individual firms.

GDD does not appear to have any major challenges in this area. Most survey respondents indicated that it is easy for employees to move between firms; that it would be acceptable for an employee to leave and work for a competitor, supplier, or buyer; and that they would hire employees who had previously worked for competitors, suppliers, or customers.

Most of the literature on labor mobility is based on findings from the United States, where IPR protection is strong. Our case studies were conducted in the United States and Israel, which also has strong IPR enforcement. Firms' trade secrets are therefore protected even when employees leave and take their industry-specific human capital with them. Given the apparent acceptance of labor mobility in GDD, IPR enforcement needs to be strong so that firms' trade secrets are not divulged by former employees.

Infrastructure and Business Climate. Our preliminary analysis suggests that GDD has excellent infrastructure and that the overall business climate is fairly conducive to growth by innovative firms. Nonetheless, the case studies, interviews, and survey results suggest two areas where GDD may be able to improve its business climate.

First, 85 percent of firms indicated that it is not easy to lay off employees, and 40 percent indicated that it is not easy to shut down a firm. Given that creative destruction is an important component of innovation, GDD could improve its environment for innovation by addressing these two issues. Although GDD has no control over national regulations regarding layoffs and firm closures, it can seek to assist local firms to navigate the process of downsizing or closure more efficiently.

Second, although policymakers often focus on the supply side when encouraging firms to grow, our review of the literature and our case studies indicate that the demand for products created by innovative firms may play a key role in their success. Our interviews in GDD suggest that there may be a lack of demand for innovative products and services in the area. Support for initiatives by high-technology firms in Knowledge City to market their products in Hong Kong, Taiwan, Korea, and Japan, including actions to strengthen representative offices, encourage entrepreneurs to attend trade fairs in each location, and sponsor special events, may help companies find buyers of highly innovative products.

Networks. Networks are a key component of a cluster. They tend to be driven by social and business interactions among individuals rather than by alliances among firms or other insti-

tutions. Our case studies suggest that individuals often draw on their networks, which stretch across firm, industry, and regional boundaries for a variety of business purposes, including hiring talented employees, obtaining expert advice in a particular area, or starting a company.

The dominance of individual over institutional ties appears to be the case even when networks are based on relationships developed through shared formal institutions. One case in point is illustrated by the ICT cluster in Israel, in which one main source of network formation is common military service. After completing their military service, former members of the military appear to draw on their network through personal contacts rather than through formal channels.

Overall, our preliminary findings suggest that although networks initiated through official channels may be useful in certain contexts, it is more likely that the most important networks will be created by individuals as the cluster develops. It may be most valuable for GDD to focus its efforts on creating certain specific types of networks, such as angel investor networks, that may be less likely to form spontaneously.

Quality of Life. Our preliminary analysis suggests that GDD should shift its emphasis more toward improving the living environment of Knowledge City rather than just offering business incentives. As discussed above, some tax or nontax incentives may be useful, as would improving IPR enforcement as well as certain aspects of the business climate. However, innovators also want short commutes, good schools for their children, high-quality consumption opportunities, and entertainment opportunities. Our review of the literature and our case studies suggest that quality of life plays a role in determining where highly skilled people choose to live. Moreover, the survey of high-technology firms confirmed that such quality-of-life issues as commuting and, more broadly, a “reluctance to live in GDD” are potentially major impediments to attracting top talent. These issues are likely to be more pronounced for Knowledge City, since it is located farther from the center of Guangzhou than are other parts of GDD.

Although quality of life is important, the extent to which it precedes the creation of an innovation area versus the extent to which it is an outgrowth of an innovative area with highly educated workers is uncertain. Convenient commuting opportunities may precede the creation of an innovative area, whereas cultural opportunities, which need an audience to survive, may be an outgrowth. Nonetheless, GDD can take a number of steps to increase the quality of life as Knowledge City gets started. GDD should explore providing incentives to attract quality schools and quality shopping to induce technical talent to settle in Knowledge City along with their families. In addition, careful master planning of Knowledge City, including the provision of an attractive living environment, as well as human-scale designs for neighborhoods, will be an important element of success.

Marketing Knowledge City. Attracting an anchor institution will be very important for the success of Knowledge City. By an anchor institution, we mean a major company or institution that is well regarded and has top-quality innovation workers. The anchor institution may play a number of roles. First, suppliers, buyers, and other tenants may be attracted to Knowledge City because of the reputation of the anchor institution, or because other companies wish to collaborate with the anchor institution or to draw on its workforce. Second, the anchor institution may provide a source of talent, either by drawing skilled workers to the area or (in the case of a university) by producing skilled graduates. Third, the anchor may be the source of research that can lead to commercial products or spinoffs.

Our preliminary analysis suggests that GDD should shift its emphasis more toward the general innovation environment rather than only focusing on specific sectors. Our case study

of Maryland provides some evidence that sector-specific targeting may be able to attract the types of firms that policymakers want but only when the targeted sectors are in keeping with the local area's existing advantages. Attempting to target sectors in which the local area does not have an advantage may simply result in failure to attract firms to the area or a failure of any firms that start up or move into the area to thrive. In particular, we recommend that GDD draw on its existing strong base of tenants to see if one or more of them can be induced to set up research and development operations in Knowledge City.

GDD already has a number of policies in place that can assist in attracting anchor institutions and other innovative firms to Knowledge City and in encouraging entrepreneurs to start firms there. In the marketing plan, it will be important to emphasize those factors that highlight GDD's strengths, particularly those that are difficult for other areas to replicate. Two important assets that most other areas cannot replicate are Guangzhou's proximity to a major port and its historic role as a center of global commerce in China.

In contrast, there are factors that can be easily replicated elsewhere in China. As our case studies show, tax concessions and nontax incentives could be classified in this category, since many areas can match incentives offered by GDD. Although providing these incentives might assist in attracting a particular tenant who is already considering Knowledge City, the risk of entering into a competitive bidding contest is quite large, threatening to erode the value of attracting the firm because of the high cost of the subsidies offered to attract it.

GDD should also focus on factors that may eventually be replicated, but would likely take some time to do so: infrastructure, a good business climate, a reputation for IPR enforcement, strong angel investor networks, and excellent quality of life and local schools. Focusing on these factors during the creation of Knowledge City, and emphasizing them in GDD's marketing efforts, would create competitive advantages for GDD. First, it takes time to create these types of institutions, making it harder for other regions to compete with GDD, at least until they develop similar advantages. Second, clusters are often formed around areas that have a first-mover advantage—those that originally began creating a product or service, often through historical accident. If GDD creates a reputation for having these factors, this reputation could help to attract innovation-oriented firms to Knowledge City. The presence of these firms would reinforce Knowledge City's reputation for innovation, thus attracting more innovation-oriented firms to the area and creating a virtuous circle that would make it difficult for other regions to catch up.

Acknowledgments

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Abbreviations

BIRD	Israel-U.S. Bi-National Industrial Research and Development Foundation
EEED	Environment, Energy, and Economic Development Program
ETDZ	Economic and Technological Development Zone
FDA	Food and Drug Administration
FDI	foreign direct investment
GDD	Guangzhou Development District
GDP	gross domestic product
GETDD	Guangzhou Economic and Technological Development District
GHIDZ	Guangzhou High-Technology Industrial Development Zone
GEPZ	Guangzhou Export Processing Zone
GFTZ	Guangzhou Free Trade Zone
HIDZ	High-Technology Industrial Development Zone
ICT	information and communications technology
IDF	Israel Defense Forces
IP	intellectual property
IPO	initial public offering
IPR	intellectual property rights
IT	information technology
J&J	Johnson & Johnson
MIPS	Maryland Industrial Partnership
MNC	multinational corporation
MTTCF	Maryland Technology Transfer and Commercialization Fund
NIH	National Institutes of Health

OECD	Organisation for Economic Co-operation and Development
PwC	PricewaterhouseCoopers
R&D	research and development
RMB	renminbi
S&T	science and technology
SBIC	Small Business Investment Corporation
STEM	science, technology, engineering, and mathematics
TEDCO	Technology Development Corporation
UM	University of Maryland
UMCP	University of Maryland College Park
USPTO	United States Patent and Trademark Office
VAT	value-added tax

Part I:
**Introduction to the Guangzhou Development District and
Knowledge City**

Introduction

Innovation-based economic development involves fostering the creation and growth of innovative businesses. The success of innovative businesses in any location depends on the availability of the appropriate human, financial, and physical assets needed by these businesses. For these firms to flourish, innovative firms also need a supportive institutional and regulatory environment: the policies, institutions, laws, and regulations by which the government manages the economy.

Economic development based on innovation is of particular interest to the Guangzhou Development District (GDD), a specially designated economic district formed out of several other special economic districts and zones of different types. It is in the Luogang District of Guangzhou, which was formed in 2005.¹ Jointly with Singbridge, a Singapore-based state-owned company, GDD is developing Sino-Singapore Guangzhou Knowledge City in northern Luogang District with the intent of making it a site for innovative companies. The project is designed to provide an impetus to the transformation of Guangzhou from lower-wage manufacturing to higher-wage research- and innovation-based knowledge industries.

All levels of government influence the environment in which innovative firms operate. The central government, the Guangdong provincial government, the Guangzhou city government, and GDD all have separate, at times conflicting, roles to play in creating an environment in which innovative businesses can thrive.

This report is a companion volume to another RAND report, *An Outline of Strategies for Building an Innovation System for Knowledge City*, MG-1240-GDD. That report presents specific actions that GDD should undertake to promote the success of Knowledge City; its intended audiences include GDD, as well as others who are interested in creating innovative areas. This report, *Creating an Innovation System for Knowledge City*, is a compilation of interim analyses conducted during this project and provides supporting evidence for the companion volume. Its intended audiences include GDD, economic development practitioners, and scholars of innovation and regional development.

Part I provides an introduction to innovation systems and clusters, Knowledge City, GDD, and Guangzhou. Chapter Two outlines the basics of innovation systems and cluster formation. If Knowledge City is to be successful, GDD will need an effective innovation system. It will know it has achieved success when a cluster or clusters develop. Chapter Three gives a profile of high-technology companies currently in GDD. These provide a base of inno-

¹ GDD includes the Guangzhou Economic and Technological Development District (GETDD); the Guangzhou Free Trade Zone (GFTZ); Guangzhou Science City, also part of the Guangzhou High-Technology Industrial Development Zone (GHIDZ); the Guangzhou Export Processing Zone (GEPZ); and Guangzhou International Biological Island.

vative enterprises from which GDD can draw as it develops Knowledge City. The chapter also compares Guangzhou with other innovative regions of China. These will provide the most important competition for innovative firms and knowledge workers.

The report then continues in Part II, which provides in-depth case studies of three innovative areas—Silicon Valley, the Maryland life sciences corridor, and Israel’s information and communications technology cluster. The purpose is to draw lessons that may be relevant for the development of Knowledge City. In Part III, we summarize these lessons and the broader literature on innovation and cluster formation, compare the findings to existing conditions in GDD, and discuss where gaps exist and what the implications are regarding policies GDD should adopt to increase the chance of success in Knowledge City.

The report concludes with five appendices. Appendix A provides company case histories, building on the case studies of Part II. Appendix B briefly discusses Small Business Investment Corporations, which played a role in the development of Silicon Valley. Appendix C provides statements on innovation from two political figures from innovative areas. Appendix D gives a detailed report on a custom survey that GDD and RAND created for this project, described further below. Finally, as GDD develops Knowledge City, it will need to monitor its progress. The above-mentioned companion report, *An Outline of Strategies for Building an Innovation System for Knowledge City*, provides the most important indicators GDD will find useful to monitor. Appendix E of this report provides a more complete set of indicators that GDD officials may find useful.

Innovation Systems and Cluster Formation

What Is Innovation?

Although there is no single definition of innovation, one widely used definition was devised by economist Joseph A. Schumpeter (Schumpeter, 1934, as paraphrased or cited in Fagerberg, 2003; Lundvall, 2004; Organisation for Economic Co-operation and Development [OECD] and Eurostat, 2005). Schumpeter identified five types of innovation:

1. a new product or a qualitative change in an existing product
2. a new method of production, also known as a process innovation
3. a new market
4. a new source of supply or raw materials or other inputs
5. a new way to organize a business.

These innovations could be radical, disrupting the economy or industries in some way, or incremental, continuously improving the operation of the economy or an industry.

OECD and Eurostat (2005, p. 46) summarized the various definitions into one statement:

An innovation is the implementation of a new or significantly improved product (good or service) or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations.

These definitions of innovation highlight that innovation is an economic activity; innovation is related to creating something that consumers or businesses will demand or that will help a firm better compete. Innovation does not include such elements of learning, knowledge, and discovery as invention or research and development, although innovations are likely to be based on these elements.

Innovation does not happen in a vacuum. Researchers who focus on innovation have identified the presence of an *innovation system* as being important for innovation and its role in economic development.

Innovation Systems and Innovation Policy

Innovation systems consist of both *actors* and the *connections* among them. The concept of an innovation system is relatively new, but the building blocks of innovation systems—including

systems of production, education, and infrastructure—were identified nearly 200 years ago (Lundvall et al., 2002).

In some definitions, the actors in an innovation system may include entrepreneurs, private companies, universities, and public research institutions (OECD, 1997, 2010a). In other definitions, the actors may include the companies that carry out innovations, universities and other educational institutions, government policies, enabling elements such as finance and standards, and even the receptivity of the market (Andersson et al., 2004, Figure 10, p. 69).

The components of an innovation system are only one aspect of such a system. The other is the *connections* among the components. These include the types of interactions among actors as well as the incentives actors face to cooperate and interact. Interactions may also be facilitated by institutions such as universities (OECD, 2010a).

Innovation systems may be international, national, or subnational. In the first case, the different components are in different countries but support each other in fostering innovation; in a national system, the different components are all in one nation; whereas in a subnational system, the different components are all in one region within a nation.

The European Commission (2000) defines innovation policy as “a set of policy actions to raise the quantity and efficiency of innovative activities.” Although the discussion of innovation systems and innovation policies is often narrowly focused on science and technology policy, innovation systems and policies can include many types of social, political, and economic activities and institutions, particularly in the context of economic development (Lundvall et al., 2002; Liu et al., 2011). Some analysts have identified informal institutions and even culture as being part of innovation systems and suggest that these informal institutions are likely to be regionally distinctive (Gertler et al., 2004). For example, Freeman (1995) conducts a comparative analysis of national innovation systems and notes that quantitative measures such as research and development (R&D) expenditures cannot by themselves explain the divergence between different economies; rather, qualitative measures, such as networks and incentives to innovate, are also important. Fagerberg and Srholec (2008) use factor analysis to show that a country’s per-capita gross domestic product (GDP) is strongly correlated with its innovation system, as measured by a broad set of indicators reflecting both “technological capability” (for example, patents and publications) and “social capability” (for example, education).

Innovation Systems and Innovation Policy in China

China’s innovation system has undergone a major transformation over the past 30 years. Before these changes, there were five major actors in science and technology: the Chinese Academy of Sciences, public research institutes affiliated with ministries, public research institutes affiliated with provincial governments, universities, and national defense research institutes. Science and technology policy was focused on national defense issues; the connections between research and commercialization, and between research and education, were lacking (Benner, Liu, and Schwaag Serger, 2012). Innovation occurred within government agencies, and there were no incentives for other actors, such as enterprises or research institutes, to innovate (White, Gao, and Zhang, 2005).

Beginning in the late 1970s, and concurrent with its economic development reforms, China initiated policies to increase its science and technology output (White, Gao, and Zhang, 2005). Liu et al. (2011) divide the past 30 years into four distinct periods, noting that although science and technology policy was the “starting point,” China’s government has created a broad range of policies, including industrial, financial, tax, and fiscal policies, aimed at fostering

innovation. The first period (1980–1984) was characterized by the creation of a small number of science and technology programs that sought to revitalize China’s capabilities. During the second period (1985–1994), there were several policies aimed at reforming the science and technology system, which led to the spinoff of high-technology startups from research institutions and universities and to the creation of high-technology parks. In addition, policies for improving the overall business environment were put forward, as were guidelines emphasizing the importation and assimilation of foreign technology in certain sectors. During the third period (1995–2005), the concept of “innovation” was introduced, and in addition to science and technology and industrial policies, a number of financial, tax, and fiscal policies were introduced. Government research institutions were reformed, and more emphasis was placed on innovation in private enterprises. The fourth period, from 2006 to the present, began when the State Council adopted The Medium- and Long-Term Plan for Science and Technology Development (2006–2020) (Liu et al., 2011). Liu et al. (2011) argue that one goal of this plan was to move toward a more coordinated innovation policy that combined science and technology, industrial, financial, tax, and fiscal policies, and that the plan represents a step forward in terms of coordinating policy across government agencies.

The first major component of the plan is to increase R&D expenditure to 2.5 percent of GDP by 2020. This component, combined with the goal of quadrupling GDP between 2000 and 2020, suggests a dramatic increase in projected R&D expenditure through 2020. The second major component of the plan is a shift toward “indigenous innovation,” moving China away from its reliance on foreign technology and foreign-invested firms. The third major component is to make the business sector the key force behind innovation. This shift had already begun, with a reduction in employment at government research institutes and a growing share of business sector R&D (Schwaag Serger and Breidne, 2007). Many detailed policies, covering topics such as recruiting overseas talent, reforming education, and providing preferential tax treatment in high-technology industrial zones, have been created by various agencies under the umbrella of this medium- and long-term plan (Liu et al., 2011).

The plan also identifies a number of priority areas for research, as well as specific projects (Schwaag Serger and Breidne, 2007). This type of specificity is also reflected in many of China’s other science and technology policies; Benner, Liu, and Schwaag Serger (2012) argue that much of China’s science and technology funding is “mission-oriented” (specifying targets or areas in which innovation is to be achieved) and “excellence-oriented” (focused on research quality and concentrated in a few areas of excellence). In contrast, they document few programs that seek to promote diffusion or capacity-building.

Priorities for China’s innovation policy are set at a variety of levels, including “overarching national strategy,” medium- and long-term plans (such as the plan discussed above), and priorities set in national science and technology programs and research institutes and funding agencies (Benner, Liu, and Schwaag Serger, 2012). Various institutions, including the Chinese Communist Party Central Committee, the National People’s Congress, and the State Council, are responsible for the broad design of innovation policies, and ministries are responsible for more detailed policy design (Liu et al., 2011).

At a provincial level, Guangdong Province has created a regional version of the medium- and long-term science and technology plan discussed above. The province also has a number of other innovation policies, focused on such areas as creating innovation networks, improving training and education, establishing research institutions, and implementing an intellectual property rights (IPR) strategy (Kroll and Tagscherer, 2009).

As China's innovation policies have evolved, so have many elements of its innovation system. One key change has been the creation and growth of China's venture capital industry. The first venture firms of the early 1990s were local government-financed; corporate-backed firms were allowed starting in 1998, signaling an ideological shift toward considering venture capital a commercial rather than a government activity. Nonetheless, governments continue to play a large role in the venture capital market, through such activities as identifying priority sectors, maintaining government-backed venture funds, and providing loan guarantees. Although venture firms tend to target relatively late-stage investments, the institutional environment for investment in new firms has been improved (White, Gao, and Zhang, 2005). Other changes to the innovation environment include the development of an IPR system and the enhancement of human capital through educational reforms and the recruitment of overseas talent (Yang, 2003; Liu, 2011). However, some authors have noted that China still faces many challenges in creating the broader elements of an innovation system, including appropriate legal and regulatory frameworks for venture capital, a match between education and required skills, and strong IPR (White, Gao, and Zhang, 2005; Schwaag Serger and Breinde, 2007).

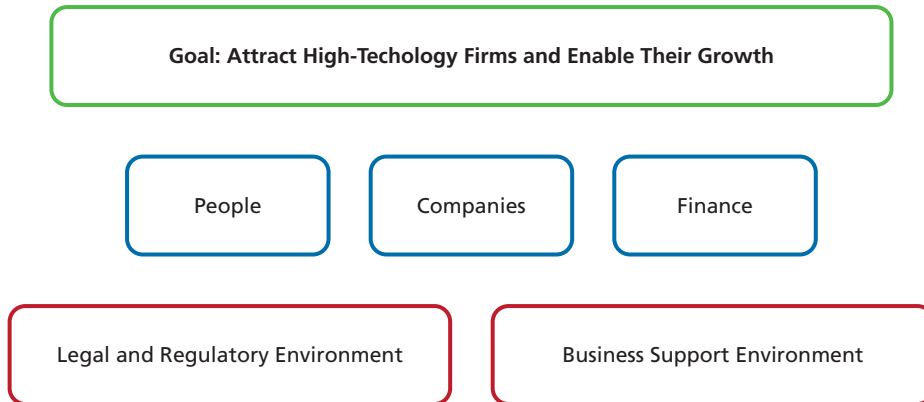
As with national policy, Guangdong Province's innovation policy has become broader, with attempts to integrate educational policies with science and technology policies (Kroll and Tagscherer, 2009). In recent years, Guangdong Province has been one of the top three regions in China in terms of total patent applications (Kroll, 2010). The business sector in Guangdong Province plays a large role in this province: the share of R&D expenditures from large and medium enterprises was 83 percent in 2007, compared to 57 percent in China as a whole; and scientific publications from Guangdong Province, compared to China as a whole, are more likely to involve industry participation (Kroll and Tagscherer, 2009). Nonetheless, Kroll and Tagscherer (2009) note several challenges to Guangdong Province's innovation system. First, venture capital remains scarce, and government policies are designed to focus on special banks rather than on enhancing venture capital. Second, implementation of IPR is still weak. Third, Guangdong Province has a paucity of top universities and research centers and a lower share of R&D personnel than Beijing and Shanghai.

Another potential challenge deals with the concentration of R&D in Guangdong. More than 80 percent of R&D expenditures in Guangdong Province in 2007 were in the field of electronic and telecommunications equipment, with one large telecommunications firm (Huawei) accounting for more than one-third of all industrial R&D expenditure in Guangdong Province in 2006. Transnational patenting from 2003 to 2005 was highly concentrated in electrical engineering, with Huawei accounting for more than 60 percent of transnational patent applications during this time (Kroll and Tagscherer, 2009).

A Framework for the Knowledge City Innovation System

For purposes of the GDD-RAND Knowledge City Project, RAND has developed a basic innovation system framework (Figure 2.1). Specifically, we consider a base that includes the legal and regulatory environment and the business support environment, the latter of which can also be thought of as a set of specific GDD policies. We also include the companies themselves, the institutions that provide the physical and organizational space in which innovative activities occur; human talent, the people who carry out the innovative activities; and finance, the flow of money that enables companies and human talent to operate. Ideally, these will combine into the creation and growth of firms that innovate.

Figure 2.1
The Innovation System Framework



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From the standpoint of RAND and GDD, the key reason to define and understand an innovation system is to find leverage points to spur innovation. These could involve government interventions regarding regulation, taxation, or finance, for example, or they could involve interventions regarding how the different elements of the innovation system interact (OECD, 1997). The need to intervene could stem from a failure of the market, but intervention could also involve changing or removing a government policy, in effect, correcting a government failure. These interventions collectively amount to innovation policy.

GDD staff members have conducted their own investigation of innovation policy systems, including visiting high-technology parks in China and science parks elsewhere in the world. GDD considers an innovation policy system as comprising five components: (1) providing direct support, (2) providing indirect support, (3) incentivizing demand, (4) enhancing services that support innovation, and (5) promoting technological innovation and cooperation (Shen, 2011). In general terms, direct support includes grants for specific purposes and special funds to award innovation activity. Indirect support includes financing guarantees and preferential tax rates. Incentivizing demand for innovations includes any method of increasing sales of innovative products. Enhancing innovation services includes guidance by the government and ensuring that financial institutions, research institutes, and intermediaries are present. Finally, promoting technological innovation and cooperation includes encouraging a variety of collaborations that enhance companies' competitiveness in innovation (Shen, 2011).

GDD has provided a considerable amount of *direct support* for innovation, including a science and technology (S&T) development fund; special S&T grants; project matching funds for S&T projects that have already been recognized at the national, provincial, and municipal levels; and S&T R&D expense subsidies (Shen, 2011).

GDD *indirectly supports* innovation activities through support for initial public offerings, subsidized interest payments for projects recognized as a key S&T project at the municipal level or above, equity investments for talented entrepreneurs, and Guangzhou GET Co. Ltd., GDD's venture capital firm. We discuss human capital and financial incentives further below.

To *incentivize demand*, GDD prioritizes purchasing products listed in the national, provincial, and city catalogues of indigenous innovation products (Shen, 2011).¹

In terms of *innovation services*, GDD sets innovation policy, talent policy, R&D support policy, and intellectual property protection policy; it runs incubators and technology accelerators; and it provides help with finance, technology transfer, consulting, mentorship, and facilities, among other assistance. To *promote technological innovation and collaboration*, GDD has collaborated with 75 universities, colleges, and research institutes and established resource-sharing mechanisms with 32 key national and provincial laboratories. Key participating institutions include South China University of Technology, which conducts R&D, incubation, commercialization, and talent training; and Sun Yat-Sen (Zhongshan) University, which established the GDD-Zhongshan Biotech Industrial Research Institute to support Sun Yat-Sen University professors who are commercializing their research (Shen, 2011).

Innovation, Clusters, and Knowledge City

A number of scholars have argued that when firms in the same industry are clustered together, the cluster contributes to innovation. The formation of clusters can lead to higher productivity, increased output and incomes, better job opportunities, and a higher local tax base. For this reason, we discuss clusters and how they might be induced to form in Knowledge City.

Industrial clusters are found throughout the world. Clusters may be described in a number of ways; one of the most commonly used definitions is from Michael Porter (1998), who defines them as “geographic concentrations of interconnected companies and institutions in a particular field.” He notes that clusters may include not simply one industry but “an array of linked industries” including suppliers and customers.

Although some of the most famous clusters are oriented toward high-technology, clusters may encompass any type of industry, such as fashion in Milan, automobile manufacturing in Detroit, or button production in Qiaotou. In our case studies, we focused on three clusters formed around industries with relatively high wages. Guangdong itself has been highly successful at creating industrial clusters; although they are not all high-wage industries, they nonetheless help to create jobs. Porter (1998) argues that “there is no such thing as a low-tech industry. There are only low-tech companies.” In other words, companies in any industry can use cutting-edge practices to increase productivity and thus ultimately to increase wages and improve their competitive position.

Why Clusters Form

Why is industrial production concentrated geographically? The theoretical and empirical literature has identified a number of potential reasons for this phenomenon. First, an area may host a cluster because it has natural advantages, such as a pleasant climate, low costs (for example, low shipping costs because of a nearby port), a local workforce with particular skills, or the historical presence of an industry. Ellison and Glaeser (1999) show that in the United States,

¹ We note that these catalogues have been viewed as discriminatory by foreign businesses and have been cause for contention (The U.S.-China Business Council, 2011).

approximately 20 percent of the geographic concentration of manufacturing industries can be explained by local conditions that include input costs, labor market conditions, and transportation costs. Similarly, Kolko, Neumark, and Mejia (2011) find that California has higher growth than would be predicted by its business climate, largely because of its mild climate and the existing composition of industry.

Second, clusters may form because localized “spillovers” within and across industries raise the productivity of firms in the cluster. A spillover occurs when an activity affects parties that are not directly involved in the activity. For example, if a large company hires talented individuals from around the world and brings them to a particular city, then other companies located in that city may benefit from a larger local talent pool. Marshall (1890) argues that firms located near one another have lower shipping costs to consumers and from suppliers, can draw on a common labor market, and benefit from knowledge spillovers. Ellison, Glaeser, and Kerr (2010) use data on co-agglomeration—the co-location of two industries—in the United States to show that all three of these factors are important and are jointly more important than natural advantages in explaining geographic clustering.

A number of other reasons have been posited for cluster formation, including fostering a reputation for a particular industry, allowing joint marketing efforts, providing access to common institutions and public goods (provided by both the public and private sectors), and making it easier to gauge performance against rivals (Porter, 1998).

How Clusters Form

Although there are a number of reasons why clusters form, the specific reasons that particular industries aggregate in particular places is less well understood. Natural advantages offer one explanation: Holland’s central location in Europe, for example, is cited as a reason for its current position as a transportation hub (Porter, 1998).

Other clusters have formed around unusual local conditions or local demand. For instance, Porter (1998) points out that Israel’s success in agricultural technology arose because of its critical need to grow crops in a desert; similarly, Finland’s environmental technology cluster arose because of the environmental damage caused by the clustering of other local industries such as forestry and chemicals. In the same vein, cluster formation is often *path-dependent*: Hospers, Sautet, and Desrochers (2008) review a number of successful European clusters and conclude that most of them are based on knowledge developed in pre-existing, successful local industries.

Blum (2008) distinguishes between *horizontal* clusters, in which many small firms group together to take advantage of a local resource such as a skilled labor force, and *vertical* clusters, which are dominated by one or more anchor firms, and associated suppliers. More broadly, suppliers and buyers can gather around anchor firms, and those anchors can also create spinoffs and increase specialized skills among the local workforce. Horizontal and vertical clustering are not mutually exclusive. Examples of anchor firms include Fairchild Semiconductor (semiconductor industry in Silicon Valley), Medtronic (medical device industry in Minneapolis), and MCI and America Online (telecommunications industry in Washington, D.C.) (Porter, 1998; Saxenian, 1994).

Other clusters may spring up for less well-defined reasons, including historical accident, culture, or local amenities and infrastructure. Krugman (2011) points out that, according to

anecdotal evidence, the reason that 60 percent of the world's buttons are made in the city of Qiaotou, China, is that three brothers saw buttons lying in a gutter 30 years ago and recognized an opportunity for profit. Porter (1998) notes that the reason the city of Omaha in the United States is a modern hub for telemarketing operations is that the U.S. military placed the first installation of fiber optic cable on its base there. Saxenian (1994) argues that Silicon Valley's culture of risk-taking and experimentation encouraged the formation and long-run survival of its high-technology cluster.

Cluster Policies

The literature on cluster formation is divided as to whether policies, particularly policies aimed directly at fostering clusters, can drive cluster formation. Martin and Sunley (2003) summarize a variety of ways in which policies directed at creating clusters might help to address market failure by providing local public goods:

- helping to establish cooperative networks that allow firms to share information, pool resources, or work collectively
- providing collective marketing services for the cluster
- providing services (for example, financial or marketing) for local firms
- filling gaps in the production chain by targeting marketing strategies toward certain firms

However, the literature suggests that policies to encourage clusters are neither necessary nor sufficient for cluster formation. For example, Hospers, Sautet, and Desrochers (2008) review a number of successful clusters in Europe and conclude that government played very little role in their formation, whereas in other cases, government policies to promote or sustain certain clusters failed.

Policies to encourage the formation of clusters are often targeted toward specific industries or types of firms. However, a number of authors suggest that a more appropriate role for policy may be to focus on broader issues such as improving the business climate, building infrastructure, or providing assistance with marketing (see, among others, Hospers, Sautet, and Desrochers, 2008; Porter 1996). Bresnahan and Gambardella (2004) note that long-term investments, including investment by private entities in firm-building and market-building, as well as investment by government in such factors as a skilled labor force, are necessary to create the "preconditions for an innovation cluster's takeoff."

There is a growing body of empirical evidence examining the impacts of broader policies, such as regulatory burden and taxes, on entrepreneurship. However, other than case studies of clusters, there is much less empirical evidence on whether policies targeted specifically at cluster formation and sustenance are effective or desirable for local regions to pursue. For example, Wallsten (2004) matches U.S. counties that started a science park with other, similar counties that did not, and finds no significant differences between them in terms of high-technology employment, venture capital, or numbers of small firms. In contrast, some recent evidence from Greenstone, Hornbeck, and Moretti (2010) and Greenstone and Moretti (2004) suggests that it may be worthwhile for local areas to bid to attract anchor firms.

Overall, the literature on cluster policy has not reached a consensus as to whether government-led policies for cluster formation are effective. Nonetheless, many authors cite

common elements that are important for cluster formation, including a talented workforce, availability of finance, and an attractive business climate (see, among others, Bresnahan and Gambardella, 2004; Lee et al., 2000).

GDD in Depth and in Comparative Perspective

A Portrait of High-Technology Firms in GDD

RAND and GDD jointly developed a survey of high-technology firms in GDD, the GDD-RAND Knowledge City Innovation System Research Project Survey (“the GDD-RAND Knowledge City Project Survey”). This chapter provides a brief portrait of high-technology firms in GDD, based on the sample of survey respondents. The approach and composition of the survey are described in detail in Appendix D. Basic information concerning the survey is given below.

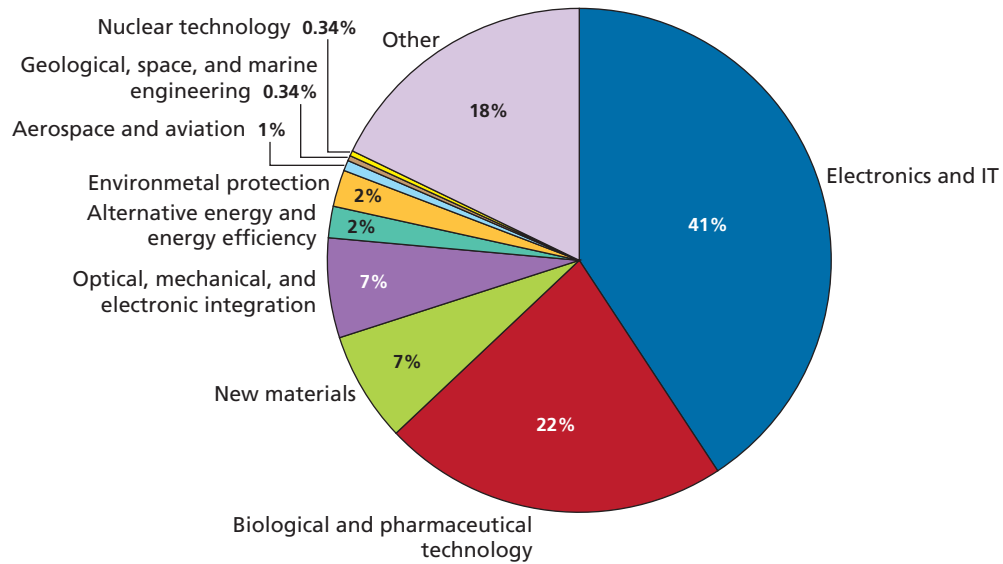
GDD staff estimated that, according to existing databases, as of mid-September 2011 there was a population of approximately 786 high-technology firms in GDD. GDD staff followed up with firms to address such issues as incorrect contact information and nonresponse and expanded their database of firms. Ultimately, they delivered a total of approximately 1,500 surveys, identifying more than 1,000 additional firms that could be classified as engaged in high technology. A total of 305 survey responses were received.

Among the 305 responses, there was some variation in response rates for individual survey questions. In referring to the survey results below, the numbers we provide are based on surveys with responses. For example, approximately 95 percent of firms (289 out of 305) answered a question about the founder’s previous experience. Among these firms, approximately 26 percent (76 out of 289) indicated that the founder had previously started companies in Guangzhou. We report the 26 percent figure. If there is a particularly low response rate that warrants further discussion, we include specific information when discussing the results. We report survey results as if they were representative of high-technology firms in GDD; however, we note two caveats about interpretation of the results. First, given the response rate for each question and our best knowledge about the population size, the margin of error for the survey responses is between 5 and 7 percentage points at a confidence level of 95 percent. Second, we may have sampling bias: It is possible that nonresponse was higher among certain types of firms than others. The footnotes for each table indicate the number of responses on which the results are based, and Appendix D provides more information about the statistical properties of the survey.

The two high-technology industries that dominate in GDD are electronics and information technology (IT) and biological and pharmaceutical technology (Figure 3.1). Together, these two industries account for nearly two-thirds of high-technology firms in GDD. Two other industries with a greater than 5 percent presence are optical, mechanical, and electronic integration, and new materials.

Despite the fact that technology changes rapidly and that technology industries depend on innovation and invention, most firms are between 6 and 20 years old (Figure 3.2). Firms

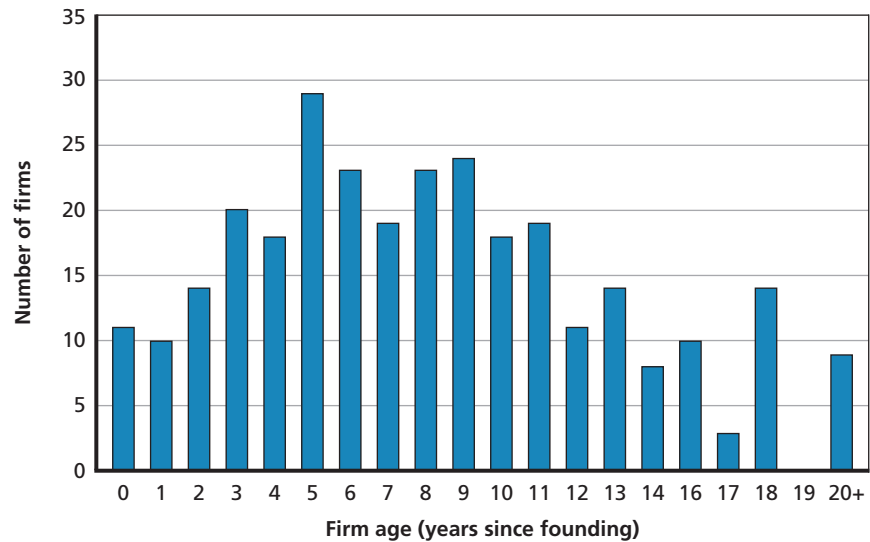
Figure 3.1
Industry Distribution of High-Technology Firms in GDD



SOURCE: The GDD-RAND Knowledge City Project Survey.
 NOTES: Results are based on responses from 297 firms (out of 305 surveys received). Percentages do not sum to 100 due to rounding.

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Figure 3.2
Age Distribution of High-Technology Firms in GDD



SOURCE: The GDD-RAND Knowledge City Project Survey.
 NOTE: Results are based on responses from 297 firms (out of 305 surveys received).

RAND TR1293-3.2

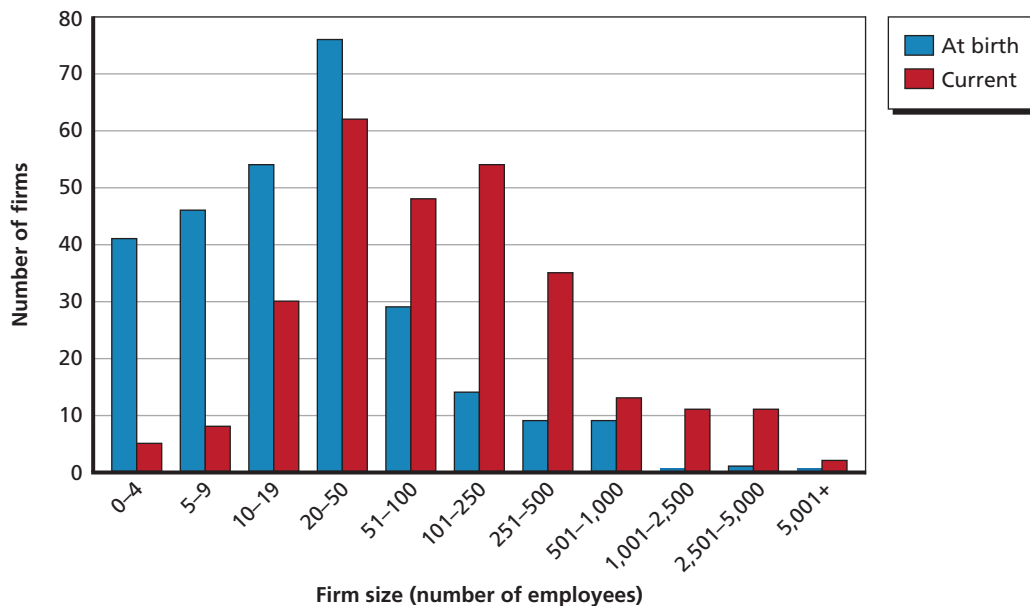
between 1 and 5 years old accounted for about 34 percent of respondents. Fewer than 3 percent of firms are more than 20 years old.¹

Figure 3.3 shows the distribution of high-technology firms in GDD by number of employees; these data come from survey respondents who provided information on both on their firms' size at birth and on current size. As we would expect, nearly 95 percent of firms reported having fewer employees at birth than currently, which is reflected in the fact that the current distribution of firms by number of employees has shifted to the right relative to the distribution of firms by number of employees at the firms' birth. Some firms have been extraordinarily successful in adding employees, as reflected by the flatter and wider current employment distribution.

Firm revenue tends to rise with firm age for firms from 0 to 20 years old (Figure 3.4). This pattern does not appear to hold for firms more than 20 years old, but this is likely due to the very few firms in that age range.

Approximately one-quarter of respondents indicated that their firm is a subsidiary of another company. Among these subsidiaries, nearly half are subsidiaries of companies headquartered outside China (Figure 3.5). Most of the remaining subsidiaries have their parents in Guangdong Province, either in GDD (a plurality of Guangdong-domiciled parents), in Guangzhou outside GDD, or in the rest of Guangdong Province. About one-fifth of all subsidiaries have parent companies located in China outside Guangdong, suggesting that about 5 percent of all GDD high-technology firms were started by Chinese companies with headquarters outside Guangdong Province.

Figure 3.3
Employment Size Distribution of High-Technology Firms in GDD



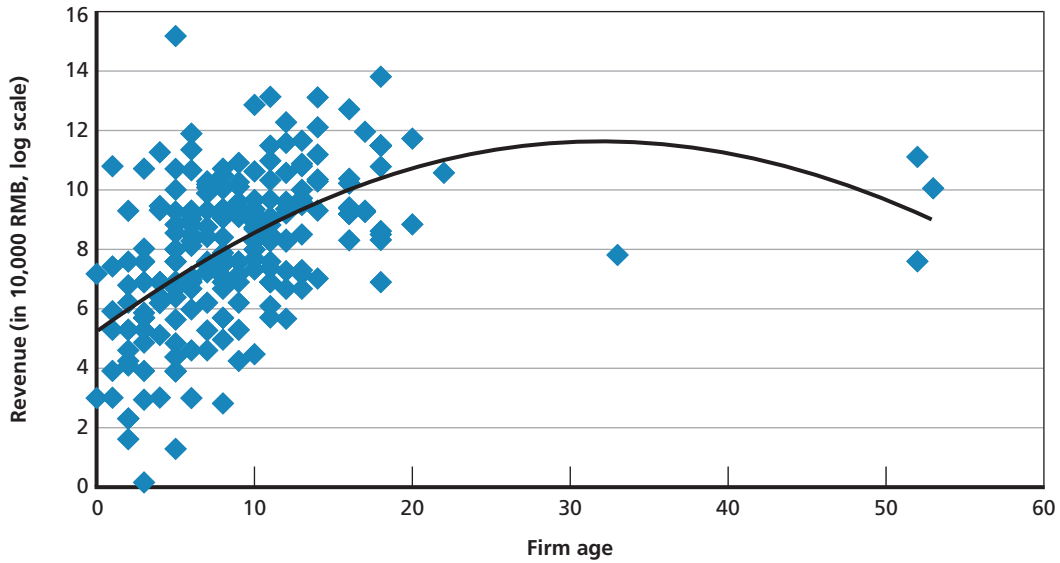
SOURCE: The GDD-RAND Knowledge City Project Survey.

NOTE: Results are based on responses from 279 firms (out of 305 surveys received).

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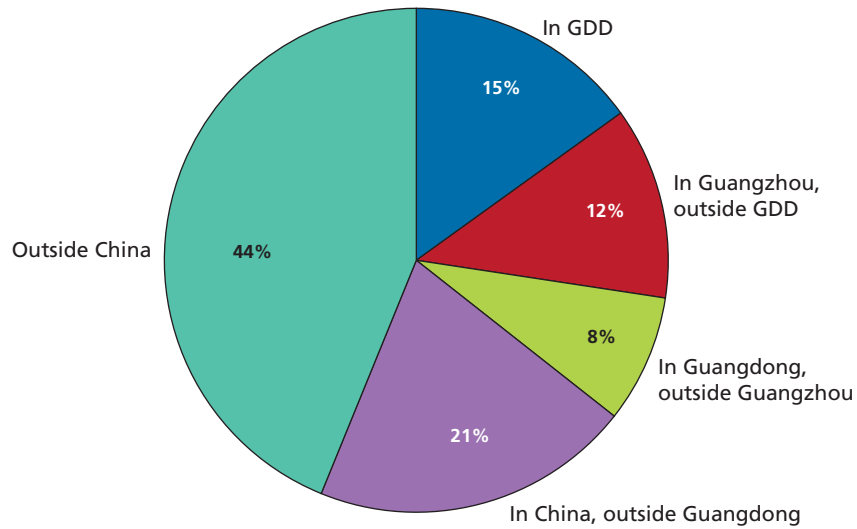
¹ Age is calculated by subtracting the year in which the company was founded from the year in which the survey was conducted (2011).

Figure 3.4
Revenue by Age



SOURCE: The GDD-RAND Knowledge City Project Survey.
NOTE: Results are based on responses from 230 firms (out of 305 surveys received).
RAND TR1293-3.4

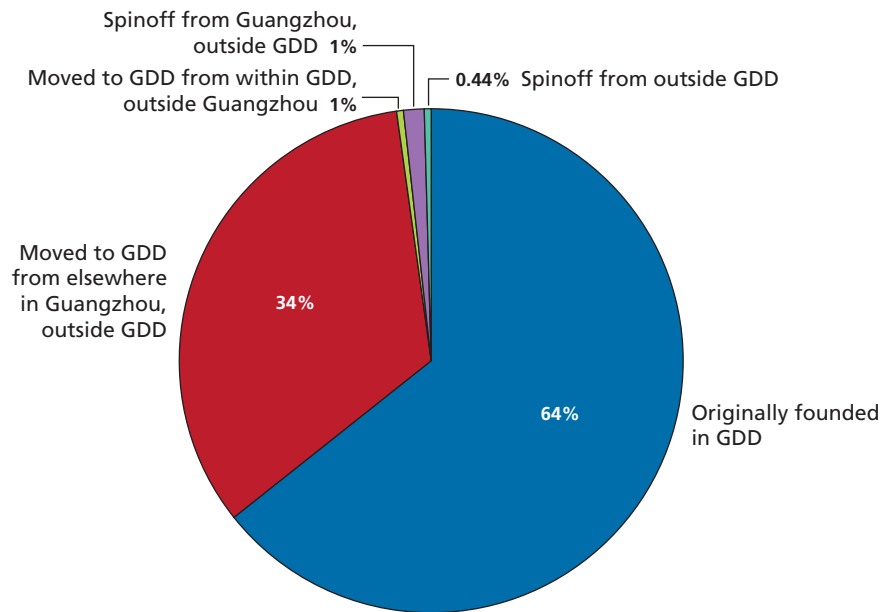
Figure 3.5
Location of Firm Headquarters Among Subsidiaries



SOURCE: The GDD-RAND Knowledge City Project Survey.
NOTE: Results are based on responses from 73 firms (out of 73 that reported being subsidiaries, among a total of 305 surveys received).
RAND TR1293-3.5

Most high-technology companies that are not subsidiaries were founded locally. Approximately two-thirds of these firms were originally founded in GDD, whereas nearly all of the remaining firms moved to GDD from elsewhere in Guangzhou (Figure 3.6). This means that

Figure 3.6
Firm Origin



SOURCE: The GDD-RAND Knowledge City Project Survey.
 NOTES: Results are based on responses from 227 firms (of 229 firms that reported not being subsidiaries, among a total of 305 surveys received). Percentages do not sum to 100 due to rounding.

RAND TR1293-3.6

other than subsidiaries of other companies, GDD has attracted very few high-technology firms from outside Guangzhou. Only 1 percent of nonsubsidiary firms moved to GDD from elsewhere in Guangdong Province. Fewer than 2 percent of nonsubsidiary firms are spinoffs.²

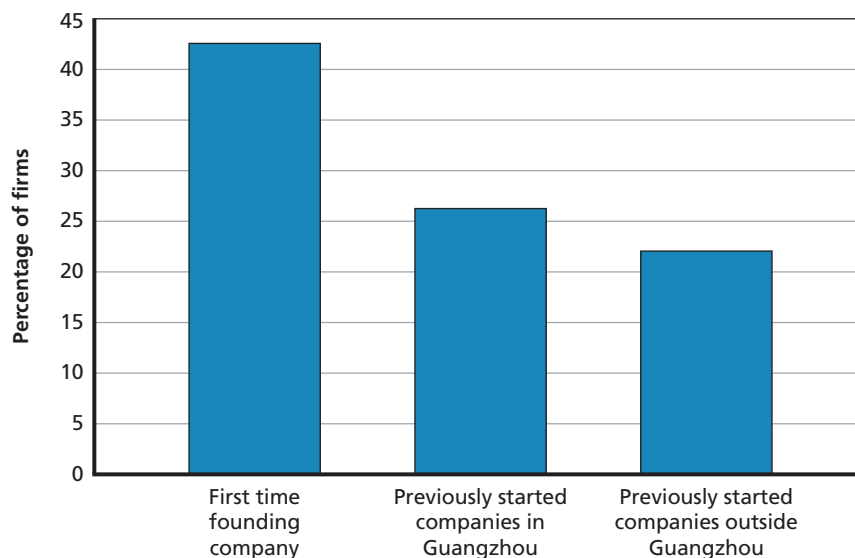
The 73 firms in GDD that reported being subsidiaries employed a total of approximately 46,000 workers, and the 229 firms that did not report being subsidiaries employed a total of nearly 82,000 workers. These data on firm origins and employment are in accordance with other findings on employment generation through firm births, expansion, and movement. Despite an emphasis by many economic development agencies on attracting existing firms, relatively little employment is generated by existing firms that move to a new location (Neumark, Zhang, and Wall, 2006; Kolko and Neumark, 2007). Most employment is generated by new firms that originate in a locality rather than by firms that have been attracted to a locality.

GDD appears to have a group of serial entrepreneurs—those people who have started more than one company (Figure 3.7). Although more than 40 percent of company founders are first-time entrepreneurs, almost half of all company founders said that they had previously founded at least one company.³ Given the presence of a cohort of serial entrepreneurs, this past

² A spinoff can be based on an innovation of, or founded by, researchers or former employees from a variety of sources, including a university, a government, or another company. This survey question asked specifically about spinoffs from other companies.

³ This survey question also asked about previous work experience and asked respondents to select all answers that applied. However, only 26 percent of respondents indicated that the company founder had previously worked for another firm. This

Figure 3.7
Company Founders



SOURCE: The GDD-RAND Knowledge City Project Survey.
NOTES: Firms could give more than one answer to this question. Results are based on responses from 289 firms (out of 305 surveys received).

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history suggests that some of the new entrepreneurs are likely to become serial entrepreneurs themselves.

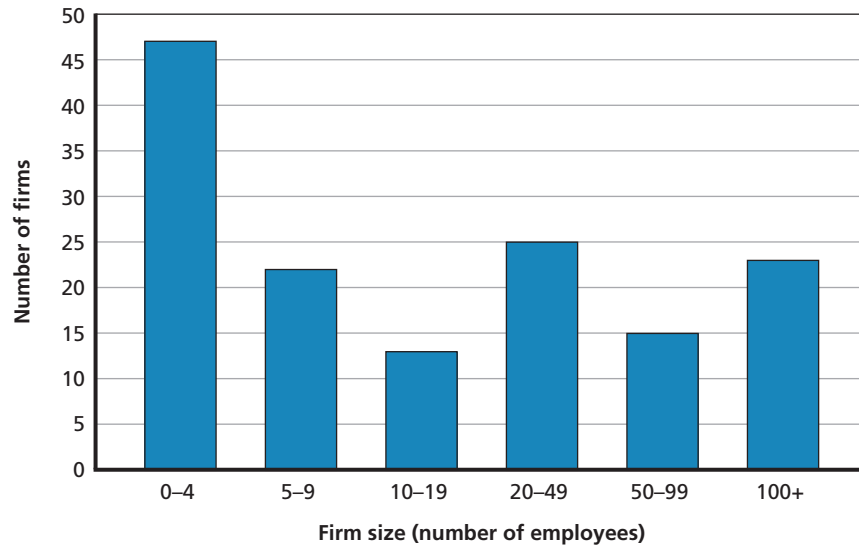
These basic data show that most high-technology firms in GDD are concentrated in just a few industries and tend to grow. The majority of these firms were originally founded in GDD or Guangzhou, although one-quarter of firms, accounting for approximately one-third of employment, are subsidiaries of firms located both in the rest of China and abroad. This suggests that in addition to benefitting from subsidiaries of foreign firms or firms headquartered elsewhere in China, GDD has gained a substantial share of its recent success from providing a fertile environment for domestic entrepreneurs.

The concentration of firms in two industries, and a visible presence in two others, raises the question of whether those sectors have an advantage in GDD and therefore whether GDD should concentrate on boosting them or whether GDD should diversify into other technology areas.

Finally, the data on firm size raise one concern. In GDD, there are relatively few small firms. In contrast, in Santa Clara County, the heart of Silicon Valley, small computer manufacturing firms are dominant (Figure 3.8). A similar pattern is observed for a variety of information and communications technology (ICT) sectors (computer manufacturing, software, and computer services) in the United States as a whole (Figure 3.9). Since GDD places considerable emphasis on attracting entrepreneurs and encouraging startups, the relative lack of small firms in GDD is surprising.

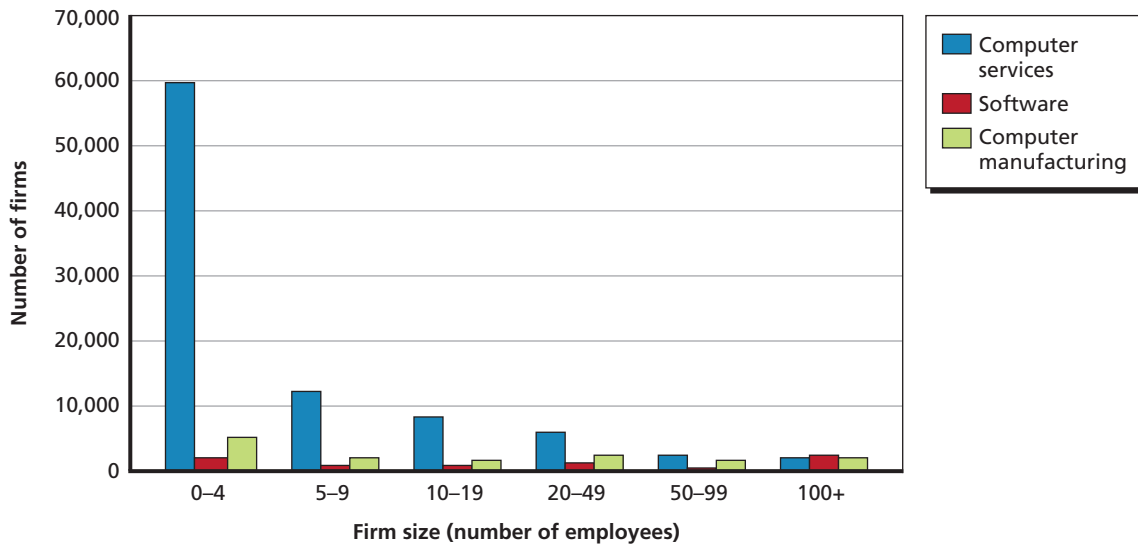
low response could indicate that most respondents have never been employees (rather than founders) or have never held another job, but it is more likely that respondents simply did not select all relevant responses.

Figure 3.8
Employment Size Distribution of Computer Manufacturing Firms in Santa Clara County



SOURCE: Authors' calculations based on the United States Census Bureau, 2007.
 RAND TR1293-3.8

Figure 3.9
Employment Size Distribution of ICT-Related Firms in the United States



SOURCE: Authors' calculations based on the United States Census Bureau, 2007.
 RAND TR1293-3.9

Data from GDD's Bureau of Statistics, covering all industrial enterprises above a designated size in GDD in 2009, indicate that the mean number of employees in these firms was 316. The mean number of employees in our survey data is 452. We cannot draw any firm conclusions from these figures, since the data from the GDD Bureau of Statistics are for industrial enterprises above a certain size, whereas the survey was sent only to firms in designated high-technology sectors. Nonetheless, there are several potential explanations for the employment size distribution observed in the survey. First, there may be factors in GDD's environment that attract relatively large high-technology firms. For example, wages in GDD are relatively low compared to wages the United States, so firms in GDD may be more labor-intensive than similar firms in Silicon Valley. Second, the relatively large mean size observed in the survey, particularly when compared to the mean size from the GDD Bureau of Statistics data, suggests that small firms may have had a lower survey response rate than large firms.

Guangzhou in Comparative Perspective

To better assess GDD's (and Guangzhou's) prospects for succeeding with Knowledge City, we compared the key innovation assets of Guangzhou (the jurisdiction in which GDD is sited) with those of six major competitor cities: Beijing; Shanghai; Tianjin, site of Sino-Singapore Tianjin Eco-City; Suzhou, site of the China-Singapore Suzhou Industrial Park; Hangzhou, site of the Zhejiang California International NanoSystems Institute; and Shenzhen, one of China's first four Special Economic Zones (SEZ) and Guangzhou's neighbor. Table 3.1 shows comparisons of these cities across a number of different dimensions.

In terms of population, Guangzhou is the sixth-largest city in China, with almost 13 million residents, according to the 2010 census. Among the comparison cities, this is well below the population of Shanghai (23 million) and Beijing (almost 20 million) but just below that of Tianjin (13 million) and above that of Suzhou (10 million), Shenzhen (10 million), and Hangzhou (8.7 million). Individuals with residency permits or the *hukou* population in each is smaller: In 2009 the *hukou* population in Guangzhou was almost 7.9 million according to the *China City Statistical Yearbook 2009–2010*. Counting just the *hukou* population, Guangzhou was the fourth-largest of these seven cities, smaller than Shanghai and Beijing, about equal to Tianjin, and larger than Suzhou, Hangzhou, and Shenzhen.

In contrast, Guangzhou is third among these seven cities in terms of total as well as per capita GDP. Guangzhou's total GDP of nearly 1.1 trillion renminbi (RMB) in 2010 was approximately 63 percent that of Shanghai, which had the highest total GDP, and 75 percent that of Beijing, but it was nearly 80 percent higher than that of Hangzhou, which had the lowest total GDP. Guangzhou's per capita GDP of 83,500 RMB in 2010 was 91 percent that of Shenzhen, the highest of the seven, and 95 percent that of Suzhou, but between 13 percent and 23 percent higher than the per capita GDPs of the other four cities.

Guangzhou also has the highest proportion of its population enrolled in school. Comparing 2008 enrollments in all schools from elementary to university to the 2010 census population figure, 18.5 percent of Guangzhou's population was enrolled, compared to 16.5 percent for Hangzhou; between 10 and 14 percent for Tianjin, Suzhou, Shenzhen, and Beijing; and 9.2 percent for Shanghai. The share of students in Guangzhou's population is higher at all levels of education except high school.

Table 3.1
Rankings of Guangzhou and Major Peer Competitors

	Guangzhou	Beijing	Shanghai	Tianjin	Suzhou	Hangzhou	Shenzhen
Population	4	2	1	3	5	7	6
GDP	3	2	1	6	5	7	4
Per capita GDP	3	5	4	7	2	6	1
Transportation infrastructure	2	5	1	4	7	6	3
College enrollment	1	3	4	5	6	2	7
Ranked universities	4	1	2	4	6	3	7
Science spending	6	2	1	4	5	7	3
Number of patents granted	7	3	1	7	2	4	5

SOURCES: *China City Statistical Yearbook*, 2009–2011; National Bureau of Statistics, 2011; Shanghai Ranking Consultancy, 2011; statistical yearbooks of individual cities.

NOTES: For the rankings, 1 signifies the highest, most, or best. Population and per capita GDP are from the 2010 census; GDP is calculated from the population and per capita GDP figures; transportation infrastructure includes airports, seaports, and inland waterway facilities; college enrollment includes enrollment in universities and junior colleges in 2008; and science spending reflects expenditures for any science and technology purpose. For ranked universities, we started with universities ranked 50 or higher in the 2011 Shanghai Rankings (Shanghai Ranking Consultancy, 2011) and in the Chinese Academy of Management Sciences rankings (2011). We computed our overall rankings by awarding five points for each university in the top five, two points for each university ranked six through 10, and one point for each university ranked 11 through 50. Under this system, Guangzhou was fifth in the Shanghai ranking and fourth in the Academy of Management Sciences ranking, and Tianjin was fourth and fifth in those same rankings. We therefore tied them at four. Results were similar for other scoring systems.

According to the Shanghai university rankings in 2011 (Shanghai Ranking Consultancy, 2011), Beijing has the top two Chinese universities, Hangzhou has the fourth-ranked university, Shanghai has the fifth and sixth, and Tianjin has the eighth. Guangzhou's top university, Sun Yat-Sen University, is ranked 16. Despite Shenzhen's economic success, it has no university in the top 50. Of the top 50 universities, Beijing has 12, Shanghai has six, Tianjin has three, Guangzhou has two (South China University of Technology is ranked 29), Hangzhou and Suzhou have one each, and Shenzhen has none.

An alternative university ranking system implemented by a team at the Chinese Academy of Management Sciences (2011) ranks Sun Yat-Sen 7 and South China University of Technology 24. The team at the Chinese Academy of Management Sciences also ranks Sun Yat-Sen as 8 in science and South China University of Technology as 9 in engineering. Of the top 50 universities in this ranking system, Beijing has eight, Shanghai has seven, Tianjin and Guangzhou each have two, Hangzhou has one (although it is ranked number one), and Suzhou has one.

Guangzhou fares less well in certain science indicators. Guangzhou ranks sixth in terms of total science spending and seventh in terms of total number of patents granted.

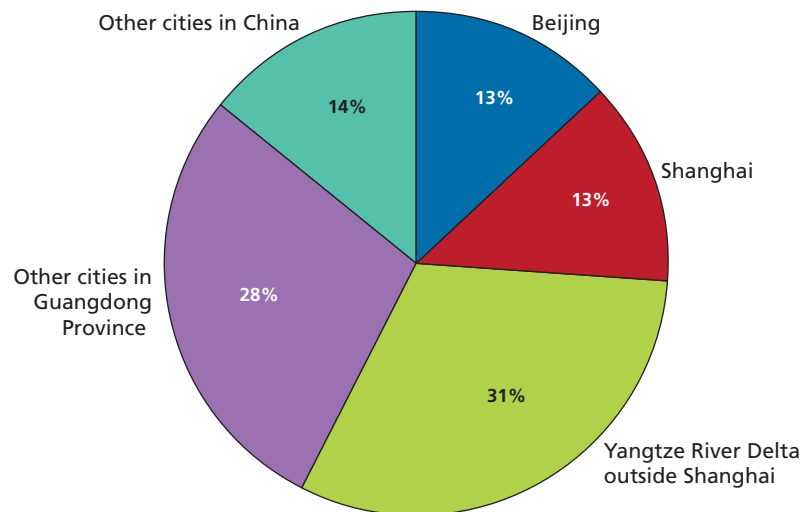
Shanghai, Guangzhou, Shenzhen, and Tianjin appear to have more diversified infrastructure for international connectivity than Beijing, Suzhou, and Hangzhou, as the first four have both major airports and seaports. Beijing has the busiest airport in China but no seaport. Hangzhou and Suzhou have water connectivity through inland waterways, and Suzhou has no civil airport.

All seven cities have economic zones. As of December 2011, Shanghai had four national Economic and Technological Development Zones (ETDZs) and two national High-Technology Industrial Development Zones (HIDZs). Guangzhou had three national ETDZs and one national HIDZ; Shenzhen itself is a Special Economic Zone and had one national HIDZ; Hangzhou had two national ETDZs and one national HIDZ; the other three cities all had one national ETDZ and one national HIDZ.⁴

Guangzhou has similar assets compared to those of its peer competitors in China, although it appears to have a younger population, based on school enrollment data; it has better international transportation connectivity, and its per capita GDP is higher. The lack of a concentration of top universities is of some concern, but the cases of Shenzhen and Suzhou suggest that other assets can make up for this. Performance on certain science indicators are also of some concern. The similarities in basic assets suggest that Guangzhou can best differentiate itself through capitalizing on its location in southern China near Hong Kong and Southeast Asia, through its current industrial base and associated human capital, and through better government policies and performance.

As GDD tries to build its innovation-based cluster, it will face competition from other locations in China. Figure 3.10 illustrates the perceptions of firms in GDD about suitable locations in China to operate other than GDD. Approximately one-third of survey respondents indicated that, considering areas outside GDD, cities in Guangdong Province would also be suitable for them, and another 44 percent mentioned the Yangtze River Delta, including Shanghai. The area of the Yangtze River Delta outside Shanghai was viewed as the most suitable area in China, even more than other cities in Guangdong Province.

Figure 3.10
Firms' Perceptions of Suitable Locations Other Than GDD



SOURCE: The GDD-RAND Knowledge City Project Survey.

NOTES: Results are based on responses from 267 firms (out of 305 surveys received). Percentages do not sum to 100 due to rounding.

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⁴ Information on zones is from the websites of the Ministry of Commerce and the Ministry of Science & Technology.

Part II:
Three Case Studies of Innovative Clusters

Case Study: Silicon Valley

Silicon Valley is the best-known high-technology cluster in the world. It is known for having a dynamic economy characterized by creative destruction as well as a number of networks and support systems for entrepreneurs.

Overview

Silicon Valley is located in the San Francisco Bay Area in Northern California (Figure 4.1). Santa Clara County, just south of San Francisco, can be considered the heart of Silicon Valley, although firms in an area approximately 80 kilometers long and 30 kilometers wide may be considered part of the broader Silicon Valley region.

Although Silicon Valley has a number of high-technology industries, it is best known for its success in information and communication technologies. In Santa Clara County, ICT-related industries (computer and electronic product manufacturing, computer systems design, software publication, and telecommunications) account for 8 percent, 15 percent, and 23 percent of firms, employment, and payroll, respectively—much greater shares than are found in the United States as a whole (Figure 4.2). Average compensation in these industries is approximately 1.5 times as high as compensation in Santa Clara County as a whole (Figure 4.3).

Silicon Valley is an excellent example of what Schumpeter (1942) calls “creative destruction”—that is, progress that occurs through the continuous birth and death of new ideas and new firms. For example, the size distribution of computer manufacturing firms in Santa Clara County is dominated by firms with fewer than five employees (Figure 4.4). Zhang (2003) follows a cohort of high-technology firms in Silicon Valley from 1990 to 2000 and finds that during this period, between 30 and 50 percent of the firms in every size category, including the largest, died.

Silicon Valley is also characterized by the number of spinoffs it generates. Figure 4.5 compares the estimated number of former employees of major firms and universities who started companies (“employee founders”) and the resulting number of startups (“spinoff startups”) from local firms in Silicon Valley, to similar figures from Boston’s Route 128, which is also a high-technology cluster. The estimates are limited to startups whose founders were funded by venture capital between 1992 and 2001. Local universities in Silicon Valley (Stanford University and the University of California, Berkeley) and Boston (Massachusetts Institute of Technology [MIT] and Harvard University) produce similar numbers of startups. However, the number of startups produced by firm employees, and of firm spinoffs, in Silicon Valley dwarfs

Figure 4.1
Map of Silicon Valley



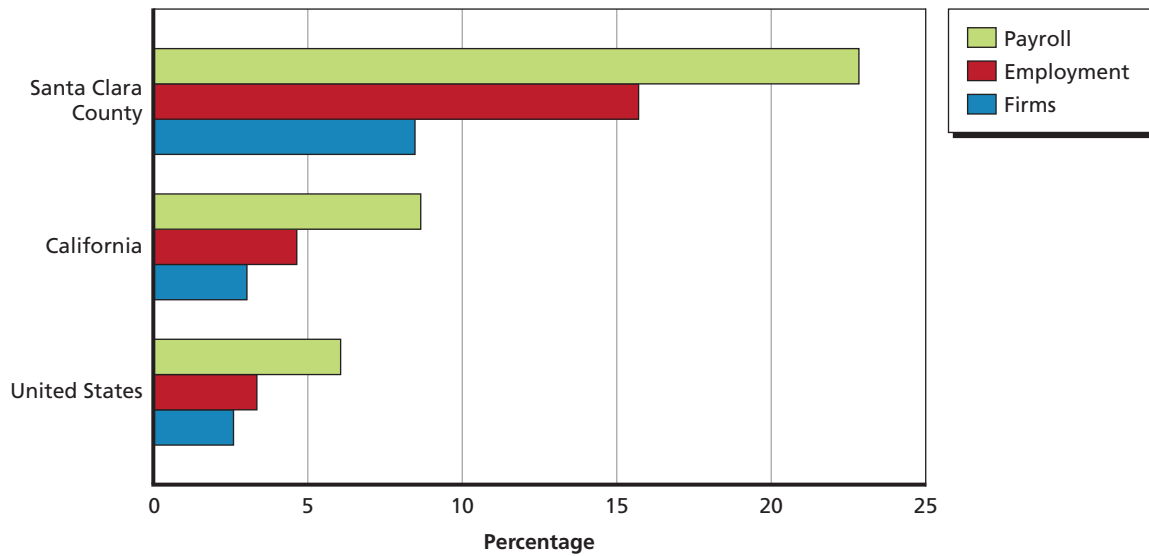
SOURCE: Map generated by RAND using ArcView GIS, Version 10.0, Redlands, Calif.: Environmental Systems Research Institute, Inc., 2011.

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the number in Boston. This culture of spinoffs has been present since the formation of the Silicon Valley cluster, as we discuss below.

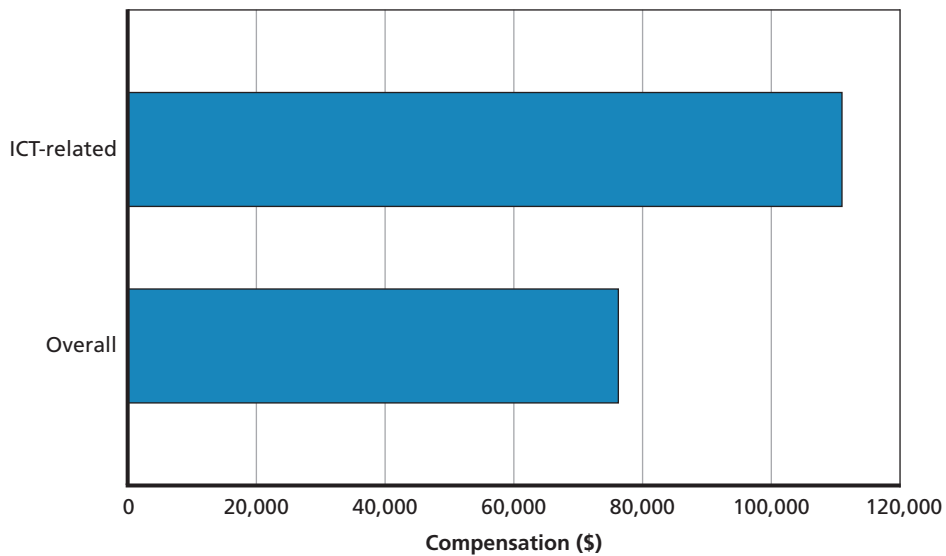
Another measure of Silicon Valley's success is its leading position in patenting. Inventors in the San Jose-Sunnyvale-Santa Clara metropolitan area, the heart of Silicon Valley, were responsible for approximately 40,000 utility patent grants from the United States Patent and Trademark Office (USPTO) between 2006 and 2010 (Figure 4.6). In 2010, this area

Figure 4.2
Percentage Share of ICT-Related Industries in Overall Payroll, Employment, and Firms in Santa Clara County



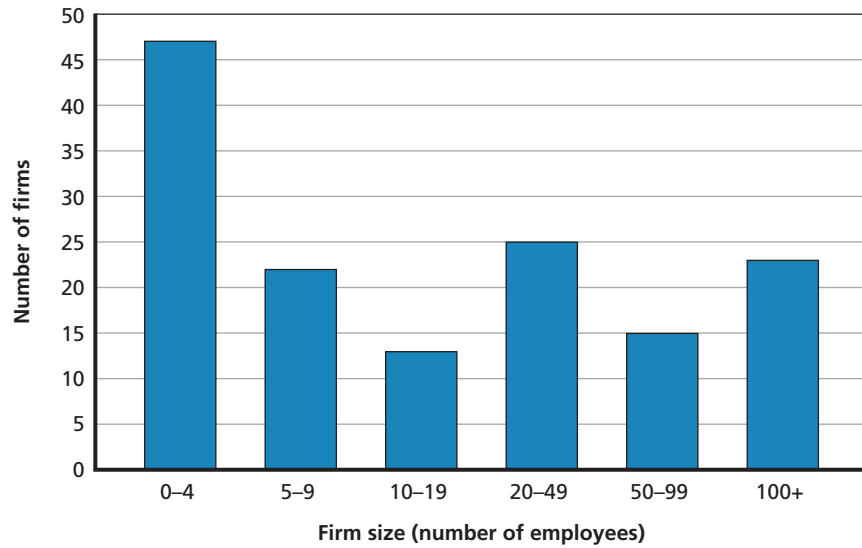
SOURCE: United States Census Bureau, 2009.
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Figure 4.3
Annual Compensation per Employee in Santa Clara County



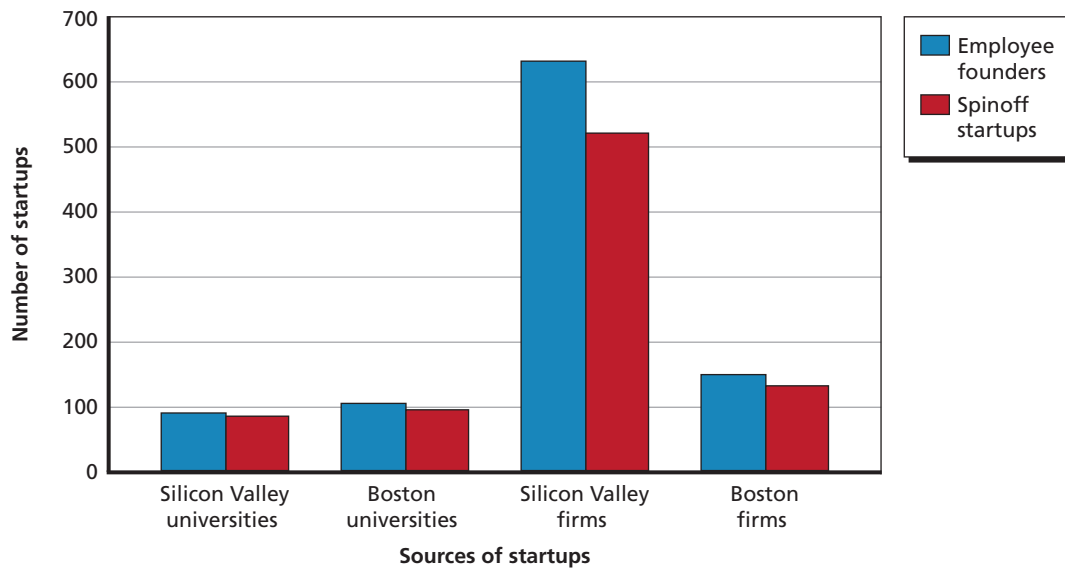
SOURCE: Authors' calculations based on United States Census Bureau, 2009.
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Figure 4.4
Employment Size Distribution of Computer Manufacturing Firms in Santa Clara County



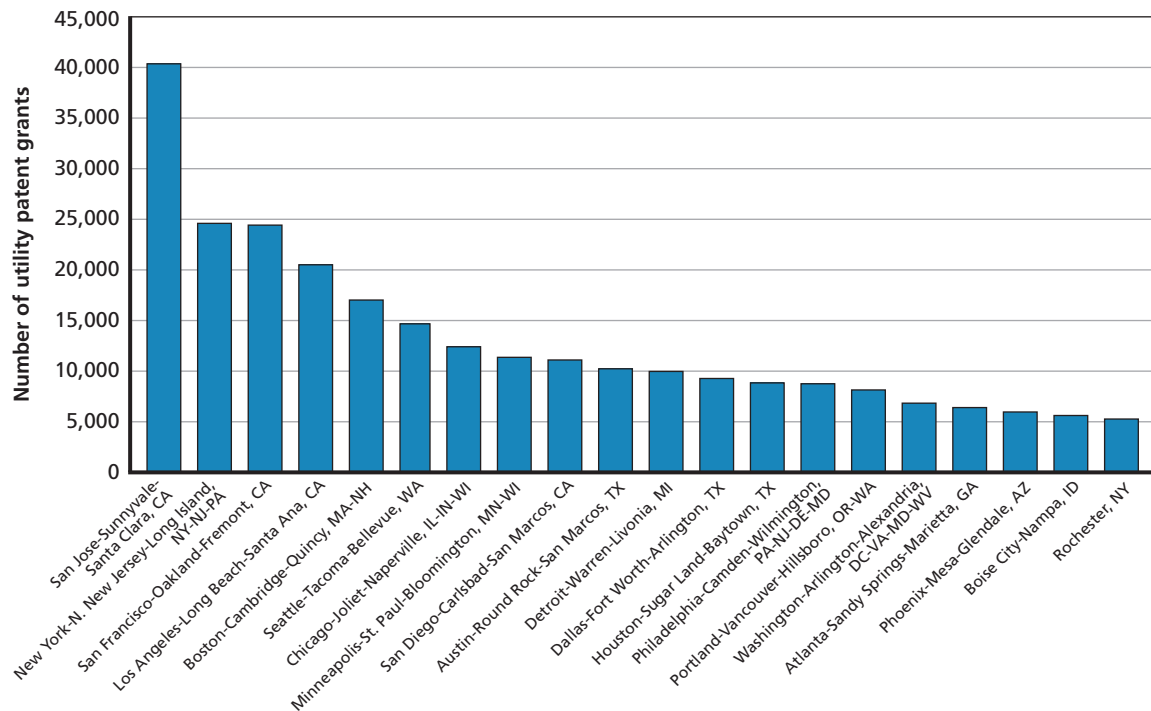
SOURCE: Authors' calculations based on the United States Census Bureau, 2007.
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Figure 4.5
Sources of Startups in Silicon Valley and Boston



SOURCE: Zhang, 2003.
 RAND TR1293-4.5

Figure 4.6
Top U.S. Metropolitan Areas in Terms of Number of Patent Grants from USPTO



SOURCE: United States Patent and Trademark Office, undated.

RAND TR1293-4.6

accounted for nearly 5 percent of all utility patent grants by the USPTO to both U.S. and foreign inventors.

History

The history of high-technology firms in Silicon Valley dates back to 1909, when Stanford graduate Cyril Elwell procured the rights to use the “Poulsen arc” technology for radio communications and formed the Federal Telegraph Corporation (FTC). FTC won several contracts from the U.S. Navy for long-range radio communication and eventually produced a number of spinoffs, including Magnavox, Litton Industries, and Fisher Research Laboratories (Sturgeon, 2000).

Stanford played an important role in Silicon Valley’s growth. In 1925, Professor Frederick Terman became a faculty member at Stanford and encouraged his students to be entrepreneurial. Perhaps his most famous deed was encouraging students William Hewitt and David Packard to found a company based on an audio oscillator developed by Hewlett (Leslie, 2000; Saxenian, 1994; Sturgeon, 2000).

During Silicon Valley’s early years, the communications industry was dominated by major firms on the East Coast of the United States. However, during World War II and the Korean War, Silicon Valley firms won a number of contracts to provide equipment to the mili-

tary. When the war orders ceased, firms found new commercial applications for technologies developed during these wars (Leslie, 2000).

After spending World War II at Harvard's Radio Research Laboratory near Boston, Terman returned to Stanford and established closer links between Stanford and the surrounding community. First, he established Stanford Industrial Park, where a number of firms set up their facilities. Second, he established the Honors Cooperative Program and the Stanford Research Institute, to provide ongoing training for employees of local firms and to assist local businesses. During the period after World War II, a number of new companies were founded in Silicon Valley, and several large firms from outside the area established facilities there (Leslie, 2000; Saxenian, 1994; Sturgeon, 2000).

Perhaps the key firm founded during this time was Fairchild Semiconductor, which spawned a large number of spinoffs. Fairchild Semiconductor was itself founded by employees from another firm in Silicon Valley. Appendix A provides a short history of the role that Fairchild Semiconductor played in Silicon Valley during this time.

Silicon Valley faced a crisis during the 1970s and 1980s. Japanese firms captured a large share of the market for semiconductors—an industry in which it had been a leader. Although some firms established the Semiconductor Industry Association to attempt to lobby the government to prevent what they termed “dumping,” a report by Hewlett-Packard confirmed that Japanese manufacturers did, in fact, have superior manufacturing processes. Silicon Valley survived this crisis by moving into other areas and creating new firms. Many engineers left existing firms to start their own companies, not only in the semiconductor industry but also in computers, disk drives, software, and networking (Saxenian, 1994).

During this time, the “network” structure of Silicon Valley emerged. To survive, firms specialized in the design of high-value-added semiconductors, while outsourcing manufacturing to other companies. This unbundling of production, along with an effort by new firms to avoid the previous models of large, cumbersome organizations, helped to create a network of interdependence among firms that persists to this day (Saxenian 1994).

Financing

During its early years, individual angel investors financed a number of firms in Silicon Valley. Many other firms were supported by purchase orders from the government. During the 1950s, a small group of investors formed an investment group (called “The Group”) that collectively invested in startup firms. The first privately funded, limited capital partnership in California (Draper, Gaither and Anderson) was also established during this time (Kenney and Florida, 2000; Leslie, 2000).

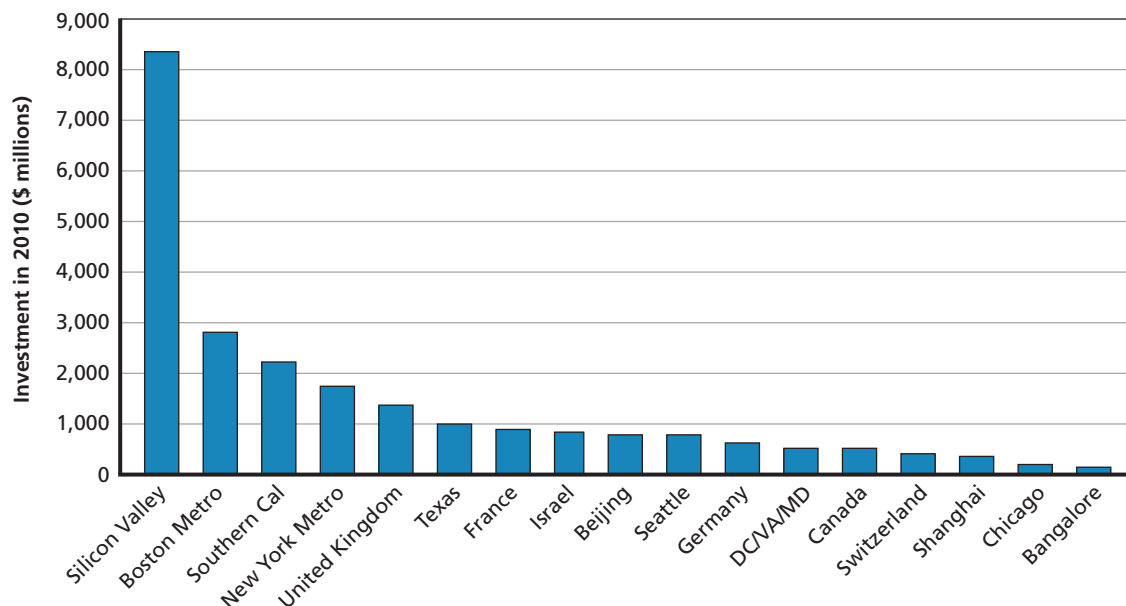
In 1958, the U.S. government passed the Small Business Act, which spurred the creation of Small Business Investment Corporations (SBIC). SBICs offered tax advantages, as well as up to \$300,000 in matching funds for private investments of \$150,000 (Kenney and Florida, 2000). Although a number of SBICs were founded in the 1960s, the program did not last long. Kenney and Florida (2000) note that SBICs imposed regulatory burdens on investors and could not use capital from institutional investors or offer as great an upside potential as limited partnerships. Moreover, Lerner (2002) notes that many SBICs made poor investments and that SBIC managers were not given proper incentives to monitor portfolio firms because of the government guarantee. Appendix B lists some major SBICs that were established in Silicon Valley.

In the late 1970s, two federal policy reforms encouraged the growth of private venture capital. First, the U.S. Congress reduced the capital gains tax rate from between 40 and 50 percent (depending on specific situations) to 28 percent (Tax Policy Center, Urban Institute, and Brookings Institution, 2011). Second, the U.S. Department of Labor loosened its fiduciary responsibility guidelines for institutional investors. Until then, its rule requiring that pension managers invest like a “prudent man” made many fund managers avoid venture funds. In 1979, the Department of Labor indicated that prudent investments would include portfolio diversification, so small investments in venture capital were seen as being acceptable (Gompers and Lerner, 1999). Gompers and Lerner (1999) show that lower capital gains tax rates are associated with higher venture funding (most likely by increasing the demand for such funding from entrepreneurs) and that allowing pension funds to invest in venture funds increased the amount of commitments to venture capital.

Silicon Valley receives much more venture capital than other leading metropolitan areas in the United States or elsewhere in the world (Figure 4.7). In the third quarter of 2011, PricewaterhouseCoopers (PwC) reported a total of 155 venture capital firms in the Silicon Valley area, with portfolios focused largely on software, information technology services, biotechnology, and medical devices and equipment. There were approximately 273 deals and \$2.7 billion in investment during that quarter, for an average deal size of \$9.8 million. The average deal size for Silicon Valley is slightly higher than for the United States as a whole, which was \$7.9 million in the third quarter of 2011 (PwC MoneyTree database, 2011).

Zhang (2003) documents that although the average size of investments received by firms in Silicon Valley is approximately the same as in other locations, Silicon Valley firms receive investments earlier. The early timing of venture investment in Silicon Valley may be due to several reasons. First, it is possible that firms in Silicon Valley are concentrated in industries

Figure 4.7
Worldwide Venture Capital Investments



SOURCE: Ernst and Young, 2010.

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with products that are commercialized more quickly (for example, software instead of pharmaceutical products). Second, the concentration of venture capital firms in Silicon Valley may be responsible. Nearly 25 percent of venture capital offices in the United States are located in Silicon Valley (Figure 4.8).

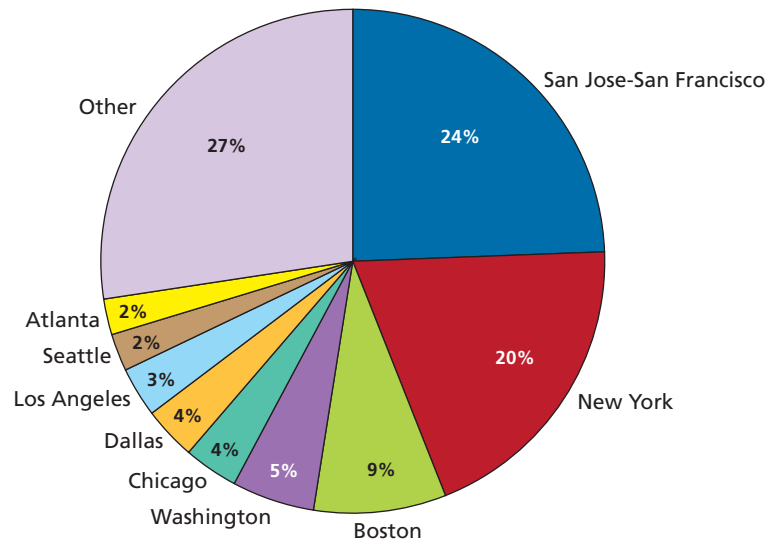
Human Capital

The population in Santa Clara County is well educated: 19 percent of the population holds a graduate or professional degree, and nearly 45 percent holds at least a bachelor's degree. These levels are much higher than levels in California or in the United States as a whole (Figure 4.9).

Stanford and University of California, Berkeley, have provided skilled talent to the area since 1900. Stanford, in particular, has a long history of collaboration with local firms; Stanford encourages graduates and faculty to become entrepreneurs (Sturgeon, 2000; Saxenian, 1994).

Immigrants are another important source of talent in Silicon Valley (Figure 4.10). More than one-third of the population working in Silicon Valley was born outside the United States, and another 20 percent was born outside California. Saxenian (1999) documents that immigrants made up nearly one-third of the science and engineering workforce in 1990 and that Indian and Chinese immigrants made up a growing share of entrepreneurs during the following decade, rising to nearly 30 percent by 1998. Similarly, Wadhwa et al. (2007) estimate that 25 percent of engineering and technology companies founded in the United States between 1995 and 2005, and more than 50 percent of such companies founded in Silicon Valley, had at least one immigrant founder.

Figure 4.8
Share of Venture Capital Offices in Major Metropolitan Areas

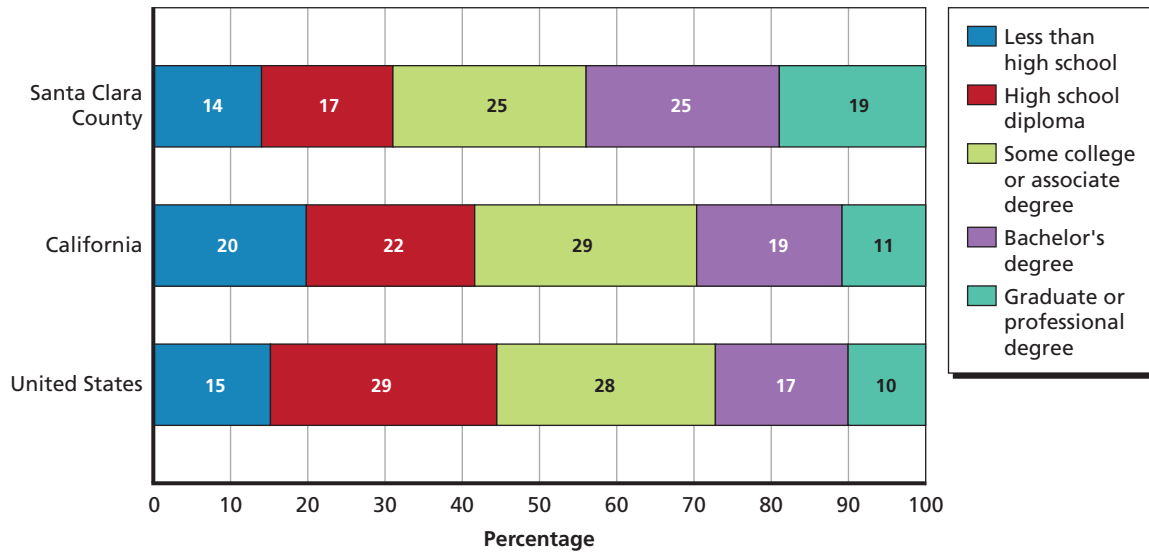


SOURCE: Chen et al., 2010.

NOTE: Percentages do not sum to 100 due to rounding.

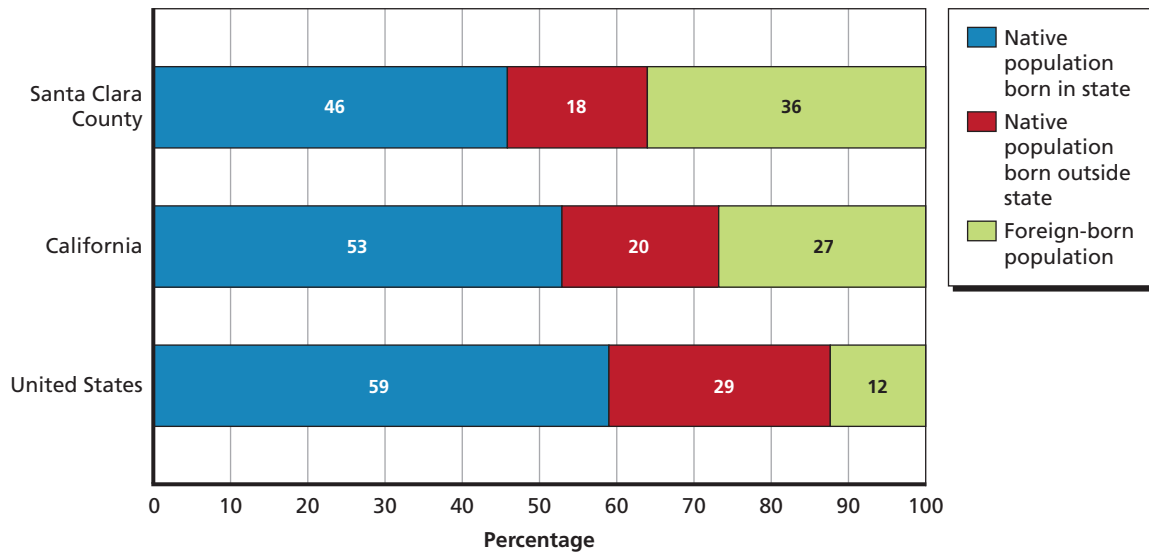
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Figure 4.9
Education Levels in Santa Clara County



SOURCE: United States Census Bureau, 2005–2009.
RAND TR1293-4.9

Figure 4.10
Origins of Residents in Santa Clara County



SOURCE: United States Census Bureau, 2005–2009.
RAND TR1293-4.10

Quality of Life

As discussed above, quality of life and the availability of amenities are thought to be potential ingredients in cluster formation. However, there is little empirical evidence concerning this hypothesis. Kolko, Neumark, and Mejia (2011) examine correlations between state-level growth in the United States and business climate rankings. Business climate rankings are notoriously imprecise: For example, the study documents that nearly all states rank in the top 20 in at least one index but also in the bottom half in at least one index. California also has diverse rankings, although it generally measures well in terms of productivity and quality of life but poorly in terms of taxes and costs.

These authors discuss the “California puzzle”: the fact that California’s growth has been approximately on par with growth in the United States as a whole during the past 30 years, even though California ranks poorly in terms of taxes and costs. The authors show that although taxes and costs do help to predict growth, other factors—namely, mild climate, dry weather, the composition of existing industry, population density, and proximity to a coast—outweigh the effect of the business climate. In the case of California, these natural advantages counterbalance any potential negative effects from taxes and costs.

Other Factors

Silicon Valley is often called an *ecosystem*. Saxenian (1994) documents that during the 1980s, firms began to specialize in parts of the production chain. They purchased inputs from local, specialized suppliers; few companies were vertically integrated. She argues that an industry characterized by independent, specialized companies that serve a cluster necessitates close collaboration, communication, and long-term relationships. For these types of relationships to develop, partners have to be local. The close collaboration between suppliers and original equipment manufacturers also aids in knowledge spillovers.

Silicon Valley has also developed a support structure for startup firms. An entrepreneur can find a number of specialists to guide him or her through the process, including venture capital firms with significant experience working with startups, law firms well versed in relevant fields and willing to offer creative payment options to small firms, patent brokers, staff search companies, and other firms to which such functions as sales, marketing, and accounting can be outsourced (see, among others, Lee et al., 2000; Monk, 2009; Suchman, 2000). Suchman (2000) highlights the fact that in addition to providing legal services, lawyers in Silicon Valley also act as business advisers and dealmakers who can provide introductions to financiers and others.

Social networks play a crucial role in Silicon Valley. Saxenian (1994) points out that many entrepreneurs share ties because they attended the same university or worked for the same employer. The case study of Fairchild Semiconductor (Appendix A) highlights the importance of knowledge flows generated by former Fairchild employees. Social networks are also propagated by other players in the support structure, including venture capitalists and lawyers (Kenney and Florida, 2000; Suchman, 2000). The high rate of spinoffs in Silicon Valley and the high rate of labor mobility contribute to the sense of a collective identity. Saxenian (1994) documents this sentiment by an engineer in Silicon Valley: “Here in Silicon Valley there’s far greater loyalty to one’s craft than to one’s company. A company is just a vehicle which allows

you to work. If you're a circuit designer, it's most important for you to do excellent work. If you can't succeed in one firm, you'll move on to another one."

Government Policies

Intellectual Property Rights

Although IP rights are not generally discussed in case studies of Silicon Valley, patent issues did play some role in Silicon Valley's early days. During the 1920s, local firms fought many legal battles over patent rights with more established, East Coast firms, most notably Radio Corporation of America (RCA). Sturgeon (2000) suggests that in part, Silicon Valley firms focused on military and specialized products rather than on consumer products to avoid RCA's control of many patents on radio technologies.

The dissemination of IP developed at Bell Telephone Laboratories may also have played a role in the takeoff of Silicon Valley's semiconductor industry. In 1947, Bell invented the first transistor (Wessner, 2003). Bell was part of AT&T, which, in 1956, was required through an antitrust settlement to license its technologies. In advance of the settlement, however, the president of Bell decided to sell licenses to the transistor to other companies (Public Broadcasting Service, 1999). In 1951 and 1952, Bell also held two conferences in which it demonstrated the capabilities and applications of the transistor. The conference proceedings volume became known as "Mother Bell's Cookbook" (Wessner, 2003). Moore and Davis (2004) argue that the "true birth of the [semiconductor]" industry occurred at the 1951 conference.

University patenting also contributed to the development of Silicon Valley. Reasons for increases in university patenting include the Patent and Trademark Amendments of 1980, known as the Bayh-Dole Act; increased industry funding of university research; and an increase in university technology transfer offices. Furthermore, universities have shared the benefits of invention between the university and the inventor. In Silicon Valley, Stanford University uses 15 percent of cash royalties to cover administrative overhead; patent filing fees are also deducted. The remaining royalty income is then evenly divided between the inventor, the inventor's department, and the inventor's school. Similarly, after deducting 15 percent of equity to cover overhead, equity is shared between the inventor and the university. The university's share goes to a research and fellowship fund (Stanford University, 2011). At the University of California, Berkeley, the inventor retains 35 percent of net royalties and fees, plus another 15 percent for use in the inventor's campus or lab (University of California, Berkeley, 2011).

Labor Mobility

Gilson (1999) attributes part of Silicon Valley's success to the fact that California does not allow the enforcement of noncompete clauses, thus allowing employees to move freely between firms. He cites California's Business and Professions Code, which states that "every contract by which anyone is restrained from engaging in a lawful profession, trade, or business of any kind is to that extent void." Saxenian (1994) argued that the high rate of labor mobility in Silicon Valley played an important role in encouraging knowledge spillovers.

Noncompete clauses in employment agreements are common, particularly in high-technology industries. They are generally written so as to prevent employees from working for a competitor before a specified period of time has elapsed (Stuart and Sorenson, 2003). Even in California, trade-secrets law prohibits employees from disclosing an employer's firm-specific

trade secrets, although employees can take their “general and industry-specific human capital” with them when they leave (Gilson, 1999). Gilson (1999) notes that it is difficult to find a case in which a California court has enforced a noncompete clause, except when necessary to protect trade secrets.

The empirical evidence suggests that labor mobility is much higher in California than in other parts of the United States. Fallick, Fleischman, and Rebitzer (2006) show that labor mobility is much higher in the computer industry in California than in other states. Almeida and Kogut (1999) document that patent-holders change firms much more often in Silicon Valley than in other major metropolitan areas in the United States.

State and Local Policies

The State of California and the cities of San Jose and San Francisco currently have several policies designed to encourage investment. Most of these policies were not in place during the formation of the Silicon Valley cluster; none of the evidence or case studies we reviewed suggests that state or local government policies contributed significantly to the growth of the Silicon Valley cluster. However, the federal government does appear to have played a large role in cluster formation by acting as a major purchaser of technologies developed in Silicon Valley during its early years. Below, we briefly describe some current policies in state and local governments.

State of California Policies (Based on Information from the Governor's Office of Economic Development)

- Enterprise zones: Originally established in the mid-1980s, the purpose of these zones was to encourage investment and job creation in economically disadvantaged areas by offering tax credits and other incentives. Parts of San Jose and San Francisco are enterprise zones. However, recent research indicates that the enterprise zones are not particularly effective (Kolko and Neumark, 2009).
- Empowerment zones: San Francisco is part of a national program that offers wage and tax credits, as well as low interest rate bonds, for businesses locating or expanding in the city.
- Local Agency Military Base Recovery Areas, Manufacturing Enhancement Areas, and Targeted Tax Areas: These areas, along with enterprise zones, are considered “economic development areas” and are eligible for a variety of tax credits and other benefits.
- Research and development tax credit: Firms receive a 15 percent credit against their bank and corporation tax liability for qualified in-house research expenses and a 24 percent credit for research outsourced to other organizations.
- New hire tax credit: Small businesses that hire new employees receive a temporary credit.
- Employment training panel: Certain types of companies in particular industries receive training funds.
- Sales and use tax credits: These are available for clean technology manufacturing.
- Small business loan guarantees for up to seven years: These generally require collateral.
- Industrial development bond program: Small manufacturing and processing businesses may qualify to issue tax-exempt bonds of up to \$10 million.

City of San Jose Policies

- **Incubators:** The City of San Jose, through the San Jose Redevelopment Agency, has partnered with the San Jose State University Research Foundation (SJSURF) to fund four business incubators. The incubators are managed by SJSURF. Three of the incubators are oriented toward providing services for early-stage firms, and a fourth aims to assist international companies that want to establish business operations in the United States (San Jose BioCenter, 2012).
- **Small business loans:** Small loans of up to \$25,000 are available to retail businesses in redevelopment areas (San Jose Redevelopment Agency, 2012).
- **Foreign trade zone:** San Jose is part of the national foreign trade zone program, which reduces duties paid on imports of foreign merchandise (City of San Jose, 2012).

City of San Francisco Policies (Based on Information from the San Francisco Center for Economic Development)

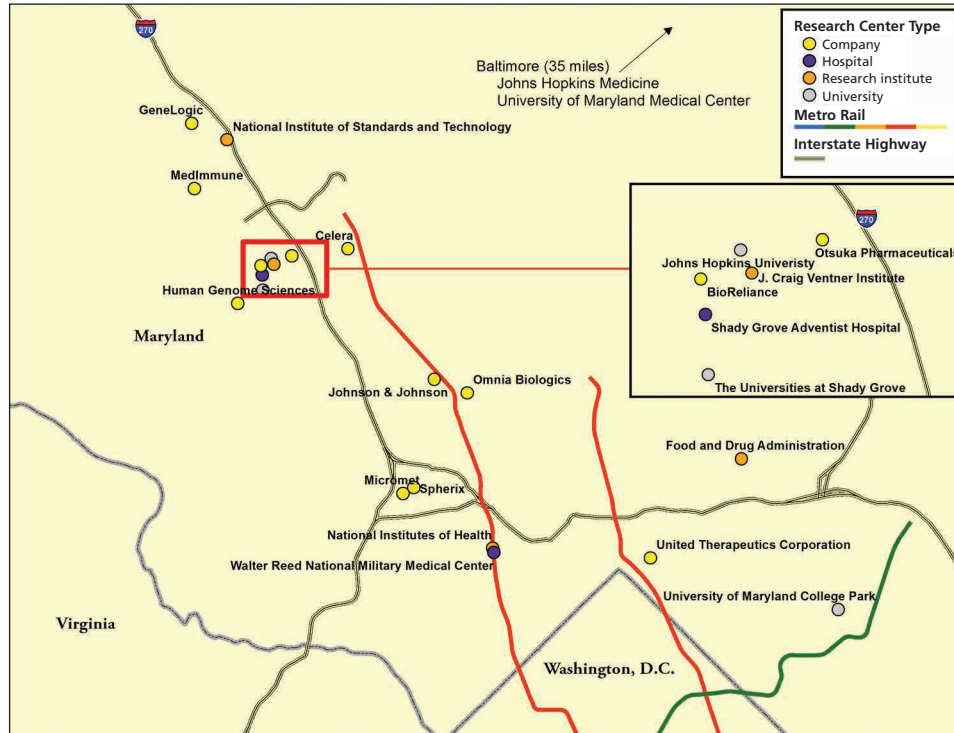
- **Biotechnology payroll tax exemption:** Qualified businesses engaged in biotechnology research and development are exempt from the current 1.5 percent local payroll tax for up to 7.5 years.
- **Clean technology payroll tax exemption:** Qualified businesses with more than 10 employees and fewer than 100, and that are engaged in production, installation, and related clean energy development, are exempt from the local payroll tax for up to 10 years.

Appendix C includes some excerpts from the Mayor of San Francisco's 2010 State of the City address that are relevant to tax incentives and industry growth.

Case Study: Maryland's Life Sciences Cluster

Maryland's life sciences cluster is located just north of Washington, D.C. (Figure 5.1). It is centered on a number of federal government laboratories and agencies, which provide the local area with a deep research base. Montgomery County, in the heart of the cluster, also specializes in other industries, including information technology and defense. In our case study, we focus on the life sciences cluster, which includes biotechnology, pharmaceuticals, and medical devices. The life sciences industry is also active in a number of areas in the state, including Frederick County, Baltimore County, and Baltimore City. In this chapter, we focus on Montgomery County, since it is the dominant area of the cluster.

Figure 5.1
Map of the Maryland Life Sciences Cluster



SOURCE: Map generated by RAND using ArcView GIS, Version 10.0, Redlands, Calif.: Environmental Systems Research Institute, Inc., 2011.

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Overview

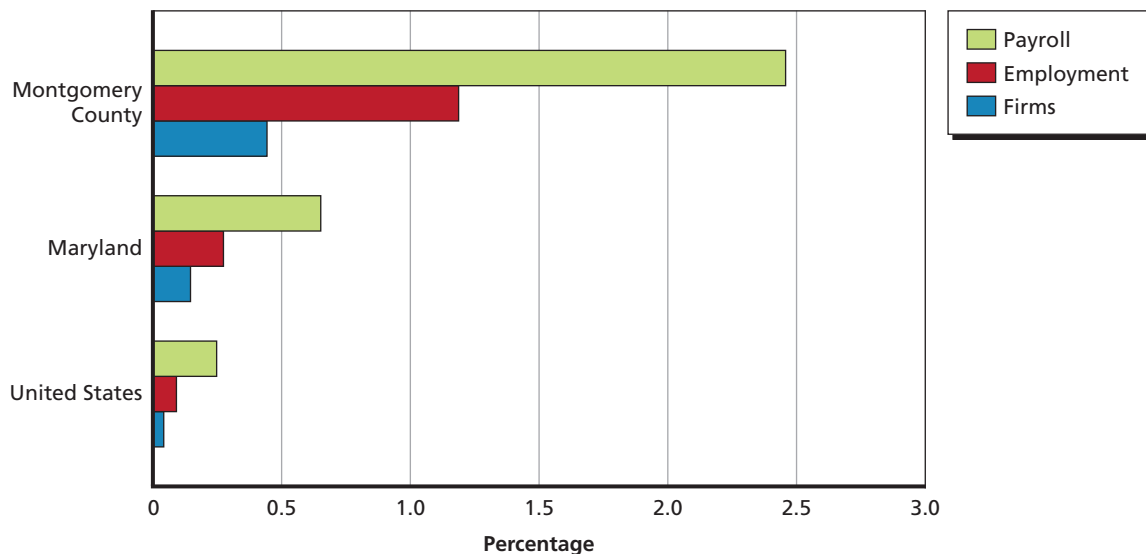
The share of biotechnology in Montgomery County's economy is approximately 10 times the share of biotechnology in the U.S. economy as a whole (Figure 5.2). (Although not shown in Figure 5.2, the share of biotechnology in Montgomery County is approximately two to three times the share of biotechnology in Santa Clara, the heart of Silicon Valley. In Frederick County, adjacent to Montgomery County, the share of biotechnology firms in overall industry is approximately eight times the share in the U.S. economy as a whole.) The strength of Montgomery County is partially reflected by patenting activity among inventors in the Washington, D.C. – Maryland – Virginia metropolitan area (Figure 4.6, above). Although this area does not record as many patents as Silicon Valley, it does rank fairly highly among other metropolitan areas in the United States.

One reason the biotechnology industry is considered desirable by business development officials in Montgomery County is that the average compensation per employee (calculated by dividing total payroll by total number of employees) in the biotechnology industry is twice as high as overall average compensation and is also higher than the compensation among professional and scientific services industries as a whole (Figure 5.3).

History

Approximately 60 scientifically oriented federal government agencies and laboratories are located near the Maryland life sciences cluster, including the many institutes in the National Institutes of Health (NIH), the National Institute of Standards and Technology, and the Food and Drug Administration (FDA); 19 of these federal agencies are located in Montgom-

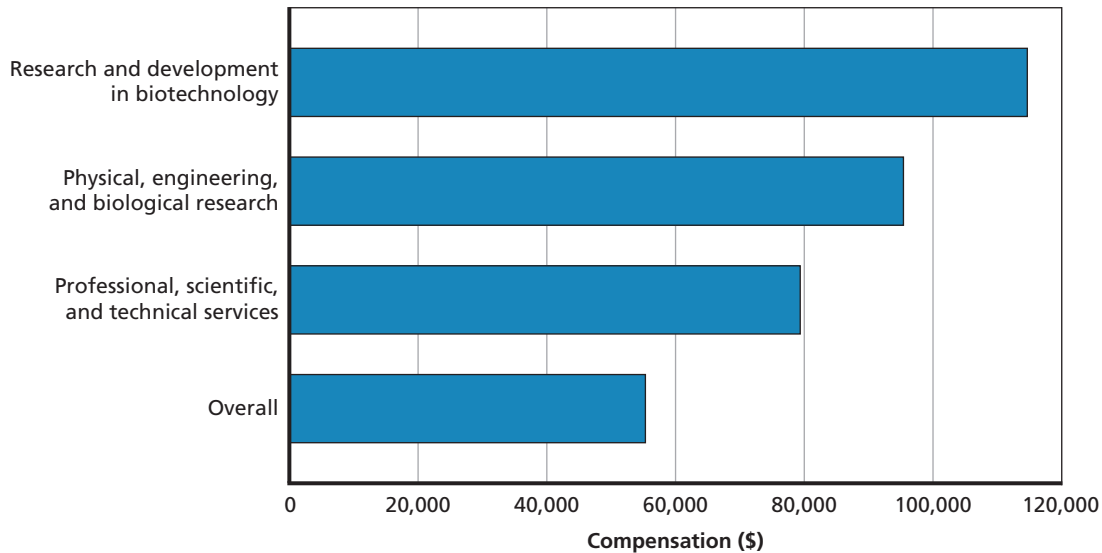
Figure 5.2
Percentage Share of Biotechnology-Related Industries in Overall Payroll, Employment, and Firms in Montgomery County



SOURCE: United States Census Bureau, 2009.

RAND TR1293-5.2

Figure 5.3
Annual Compensation per Employee in Montgomery County



SOURCE: Authors' calculations based on United States Census Bureau, 2009.

RAND TR1293-5.3

ery County. In addition, two major universities, the University of Maryland-College Park (UMCP) and Johns Hopkins University, are located nearby. UMCP is located in a neighboring county, and Johns Hopkins University is located approximately 55 kilometers north of the cluster, in Baltimore, Maryland. The existing research base, in particular the federal laboratories, has given rise to a large, existing supply of private companies in the life sciences fields.

The life sciences cluster began to take off during the late 1970s and early 1980s. Our interviews indicate that during this time, the Montgomery County government decided to capitalize on the research taking place at the nearby federal laboratories by setting up a Life Sciences Center business park. The county government's vision for the business park was to have a hospital and direct medical services at the center, surrounded by firms performing related research. The cluster is shown in the inset in Figure 5.1.

At the beginning, the county offered only two incentives for firms moving into the business park: inexpensive land and a subsidized interest rate on bonds. The county sold the land to a private developer, who was required to bring in an anchor institution and other life sciences companies. The developer already owned a nearby building housing private firms doing contract work for NIH. The county offered to help the developer relocate these firms to the business park if he was unable to fill the park with new firms. The developer was willing to offer flexible arrangements and small office spaces for startups. The fact that the developer had existing tenants helped lower his risk of failure. During our interviews, an entrepreneur whose firms expanded into the business park indicated that firms seeking to expand were willing to move into the park because of the inexpensive land and the high quality of life in the area.

Montgomery County also offered land to the University of Maryland (UM) in 1984 and to Johns Hopkins University in 1986. UM opened an undergraduate campus in the cluster. Now, nine institutions from the UM system are in the cluster. Johns Hopkins University conducted a market assessment and concluded that the large, high-income population and the

proximity to Washington, D.C., would provide a good location for a professional campus. It subsequently opened a graduate campus for professional students. Since then, Johns Hopkins University has leased space on its land to approximately 10 to 15 firms.

Financing

Federal Financing

In addition, such federal institutes and agencies as the NIH and the Department of Defense have played an important role in early-stage funding for life science companies in Maryland. For example, many federal agencies participate in the Small Business Innovation Research program, which provides R&D funding for small firms. Our interviews suggest that many companies are founded upon receiving an initial government grant and that the geographic proximity of federal agencies to Maryland's life sciences cluster also facilitates communication and mobility of researchers between the agencies and companies.

Financing for several of the firms in the Life Sciences Center business park was provided by a venture fund from another state. The Washington, D.C. – Maryland – Virginia metropolitan area, in which the cluster is located, receives a significant amount of venture capital (Figure 4.7). In the third quarter of 2011, PwC reported a total of 27 investment firms in this metropolitan area, with portfolios focused mainly on medical devices and equipment, software, information technology services, and telecommunications. There were approximately 32 deals and \$237 million in investments that quarter, for an average deal size of \$7.4 million, slightly lower than the national average (PwC MoneyTree database, 2011).

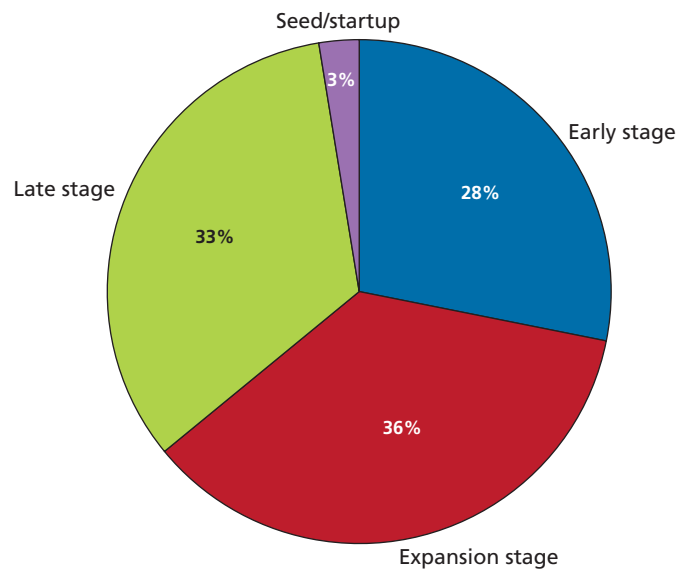
In general, county and state business development officials, as well as entrepreneurs, indicated that venture funding was available for relatively late-stage companies in the cluster. Regardless of the location of the venture funds, these officials indicated that the funds are attracted to the Maryland cluster by the existing human capital in life sciences. In addition, many local life science firms perform contract work for NIH, providing them with a revenue stream while they undertake R&D activities.

County officials suggested that venture capital funds wish to make relatively large investments (at least \$10 million) in late-stage companies. A number of officials and entrepreneurs indicated that they feel there is a gap between research funding and late-stage funding.

It is difficult to verify whether a lack of funding for early-stage companies constitutes a market failure. Nonetheless, PwC confirms that in the United States, approximately 70 percent of venture funding (in 446 deals) in the third quarter of 2011 went to expansion and late-stage companies, whereas startup companies received only 3 percent of venture funding (in 89 deals), and early-stage companies received 28 percent (in 341 deals) (Figure 5.4). The average size of deals for startup companies was \$2 million, the average size for early-stage companies was \$5.7 million, and the average size for late-stage companies was \$12.5 million (PwC MoneyTree database, 2011).

A number of government policies and university programs have been started in an attempt to address this perceived gap. Some of the main programs are outlined below. Several of them are part of Maryland's Bio 2020 Strategic Plan. Appendix C includes an excerpt from a speech by the Governor of Maryland, announcing the launch of this plan. Most programs are run by the Department of Business and Economic Development, the main state agency for business development, and by the Maryland Technology Development Corporation (TEDCO), an

Figure 5.4
Share of Venture Capital Investment in the United States by
Development Stage



SOURCE: PwC MoneyTree database, 2011.

RAND TR1293-5.4

agency primarily funded by the state. TEDCO is governed by a board of leaders in technology from the private sector, universities, nonprofit entities, and the public sector, who are appointed by the Governor of Maryland with the consent of the state legislature. TEDCO was set up to address the gap between research and innovation, mainly through funding.

Tax Credits

The Department of Business and Economic Development offers a number of tax credits, although business development officials indicated that most of them are not used because many companies that could qualify do not have any profits and thus do not pay state taxes. Officials noted that “refundable tax credits,” which allow firms without profits to carry over the tax credits until they do have profits or to receive cash from the state, are more popular among firms but are more difficult to provide, since they require more state revenue. The state also offers property tax credits to firms that locate in certain areas. However, one official with whom we talked did not feel that these tax credits were large enough to change firms’ location decisions, although they might be helpful if a firm were already interested in coming to the state. In 2010, the state offered a \$5,000 tax credit for hiring unemployed workers, although officials reported that very few firms used it, as they did not find the incentive worthwhile.

One popular state tax program is an investment tax credit for 50 percent of an eligible investment in an early-stage biotechnology firm, up to \$250,000. Firms can apply for this credit at the beginning of the fiscal year. Applicants must meet certain minimum criteria, and then credits are given on a first-come, first-served basis until funds are exhausted. The program is always fully subscribed, although there are some bureaucratic challenges for firms, as firms are required to secure all of the targeted investment within 30 days of applying for the credit. Montgomery County also provides investor tax credits on top of the state’s program.

Maryland competes with other states for investment, and Department of Business and Economic Development representatives indicated that companies interested in moving to Maryland have usually discussed the issue with site location consultants and have narrowed down their choices to a few locations. Department of Business and Economic Development officials argued that location decisions are largely driven by the business case (for example, proximity to customers, workforce quality, existing local industries). In the opinion of the officials we interviewed, the tax rate is not particularly important to knowledge-based companies. For example, they cited an example of one large firm in a knowledge-based industry that was considering locating in Maryland or a neighboring state, Virginia. This company indicated that because its employees are “cosmopolitan” and travel globally, proximity to an airport and a cosmopolitan, urban area was critical.

Loans and Grants

The Department of Business and Economic Development has discretionary funds that can be used to attract very large projects to the state. The program can be used to structure debt and loans at favorable terms; in addition, the loans can be converted into grants if the firm meets specific targets such as reaching a specified amount of capital investment and creating a specified number of jobs. Officials noted that demand for these programs tends to come from established companies, as young companies are unlikely to make large investments in fixed capital. Although the program has a provision that allows the state to recover funds if certain conditions are not met, the state has no way to recover such funds if the company goes out of business. The Maryland Biotechnology Center, an organization within the Department of Business and Economic Development, also offers funding of up to \$200,000 to assist in commercialization of biotechnology research.

TEDCO has its own set of financing programs. The Maryland Tech Transfer and Commercialization Fund offers small loans (up to \$75,000) to firms working with universities or federal laboratories or located in a business incubator. Firms must match 50 percent of TEDCO’s contribution but may do so in-kind (for example, by paying less than market salaries). In the past, firms were required to pay back the loans through some percentage of revenue; however, the loans are now considered to be convertible debt, with 8 percent interest accrued until the loan is paid back. If the firm receives outside investment, TEDCO may opt to convert its loan to equity; the entrepreneur bears no personal responsibility for the debt if the firm fails. TEDCO offers small grants (up to \$15,000) with no payback requirement to a team (usually a technology transfer officer at a university, an entrepreneur, and an inventor) to help assess the commercial potential of an invention created at a federal laboratory or university. TEDCO also offers \$50,000 loans to universities to help them develop proof-of-principle studies for new technologies; the loans must be paid back through royalties if the technology is successful. TEDCO also provides grants to support incubators, which in turn help businesses.

UM’s Maryland Industrial Partnerships (MIPS) program offers small research grants to firms that collaborate with UM faculty. The program was started in 1987 and holds two funding rounds every year. Funding is allocated on a competitive basis; approximately one-half of the applicants are funded. MIPS can help match interested firms with research groups at UM, or pre-formed alliances between firms and UM researchers may approach Maryland Industrial Partnerships for funding. Maryland Industrial Partnerships offers approximately \$100,000 per year for up to two years; firms have to pay some share of the costs, ranging from 10 percent for startups to 50 percent for firms with more than 100 employees. Most of the money is used to

pay graduate students, who often go to work for the firms afterward. Approximately 80 percent of participants are startups. Any IP created by the university researchers as part of the program is owned by the university, but the firm has an exclusive license to the IP. Faculty members generally receive what UM considers to be a standard IP deal of 50 percent of royalties from any patents.

Despite the value of loans and grants, evidence from the early years of the cluster suggests that such financial incentives by themselves may not be what firms most value. During our interviews, we discussed a specific incentive of \$1.5 million offered by Montgomery County to Human Genome Sciences, a firm that was considering locating in the area. As we discuss in more detail in Appendix A, Human Genome Sciences representatives did not simply want the \$1.5 million grant that was originally offered by the county; rather, the county worked with firm representatives to create a package of incentives including a synthetic lease agreement, loans and loan guarantees, and a streamlined permitting process.

Angel Investment

TEDCO has established an angel investment network. Approximately two to three times a year, TEDCO invites approximately 20 companies from its portfolio of firms and from incubators to pitch their ideas and selects the top 10 to pitch to the angel group. Approximately 25 angel investors attend each meeting; companies have 10 minutes to explain their ideas, followed by a networking event. The specific angel investors differ; there is a stable group and others who attend sporadically. Most angel investors are successful entrepreneurs, although others are successful professionals such as lawyers from the local area. Approximately 20 percent of the companies are funded, although TEDCO does not yet formally track outcomes.

The Dingman Center for Entrepreneurship at the Robert H. Smith School of Business at UM also runs an angel investor network. Once a month, approximately 20 to 50 angel investors come to Dingman to hear three to five entrepreneurs present investment opportunities. Dingman officials indicated that the angel investors pay approximately \$1,250 per year and in return receive a constant flow of high-quality opportunities. The remaining cost for the program is subsidized by UMCP and Dingman.

State Venture Capital

The Department of Business and Economic Development operates several programs aimed at providing venture capital. The Maryland Venture Fund, a state-run venture fund, was established in the 1990s and had some successful investments during the Internet boom but subsequently had much of its funding taken away. The fund has since made small investments in relatively late-stage companies, on the order of \$100,000, although not as the lead investor. The fund is somewhat different from a private venture capital fund: It has a goal of driving job creation and is strictly for Maryland firms.

To revitalize its venture fund, the state developed a plan to raise at least \$70 million in funding that will be invested in several private venture funds and in the Maryland Venture Fund. The state raises this funding by allowing insurance companies to pay taxes on their premiums early, at 70 cents on the dollar, until 2015, thus providing an immediate source of revenue that the state can invest. As of August 2012, the state had raised \$84 million under this program. Approximately \$45 million will be invested with two private venture funds that include Maryland investments in their portfolios. The state will set up a fund authority to select the two venture funds rather than selecting them directly. Approximately \$6 million to

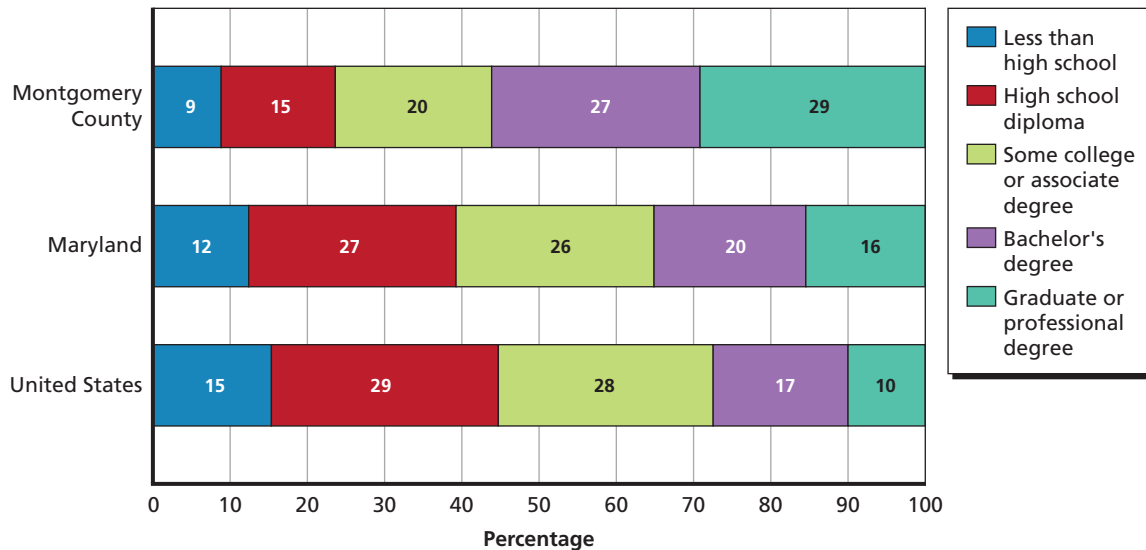
\$7 million will be used to fund minority-owned venture funds. Another \$17 million to \$18 million will go to the Maryland Venture Fund. State officials indicated that they hope that the additional funding for the Maryland Venture Fund will allow them to make larger and earlier-stage investments than has been their practice.

TEDCO has also developed a joint public-private partnership with Johnson & Johnson (J&J), called the J&J Investment Fund. J&J committed an initial investment of \$250,000 to the fund, which operates jointly with the Maryland Technology Transfer and Commercialization Fund (MTTCF), described above. J&J reviews companies that have applied to the MTTCF, can choose companies in which to invest, and then co-invests with the MTTCF; as part of this, J&J must sign nondisclosure agreements to protect the firms' IP. Firms are eligible for a second phase of funding through the MTTCF, although J&J may decide to fund them directly in the second phase. J&J benefits from seeing promising technologies being developed that it can then license. The companies benefit from J&J's commercial advice and from having an outlet to which they can license their products or technologies.

Human Capital

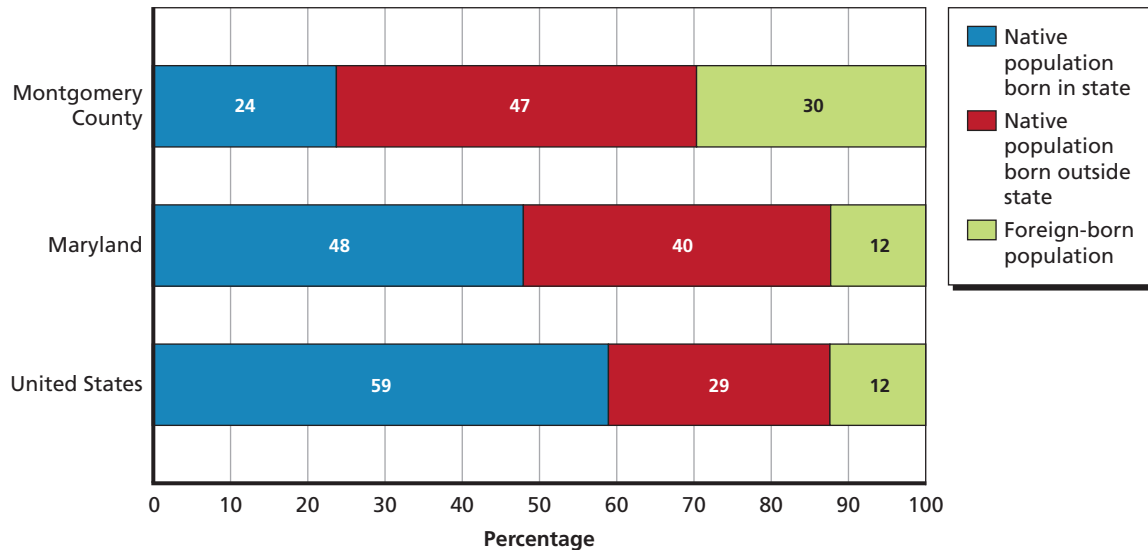
The population in Montgomery County is extremely well educated, with 30 percent of the population holding a graduate or professional degree and nearly 60 percent holding at least a bachelor's degree. These levels are much higher than the levels in Maryland or in the United States as a whole (Figure 5.5); education levels in Montgomery County are also higher than levels in Santa Clara County (Figure 4.9). As with Santa Clara County, Montgomery County is also home to many immigrants. Thirty percent of the population was born outside the United States, and 27 percent was born outside Maryland (Figure 5.6).

Figure 5.5
Education Levels in Montgomery County



SOURCE: United States Census Bureau, 2005–2009.
RAND TR1293-5.5

Figure 5.6
Origins of Residents in Montgomery County



SOURCE: United States Census Bureau, 2005–2009.

RAND TR1293-5.6

Unlike Santa Clara County, which depends in part on Stanford and UC-Berkeley to provide top scientists, engineers, and entrepreneurs, Montgomery County does not have a top research institution within its boundaries. UMCP is located in a neighboring county, and Johns Hopkins Medical is located 55 kilometers north in Baltimore, Maryland. Some officials expressed concern that other than Johns Hopkins Medical, none of the local campuses are considered among the top research institutions in the country.

Nonetheless, Montgomery County attracts an extremely educated population. One reason is the proximity of the NIH and other federal research laboratories and agencies, which directly employ thousands of researchers and which attract private contractors to the area. Another reason cited by officials and entrepreneurs is the excellent quality of life in Montgomery County.

Quality of Life

Quality of life in Montgomery County was frequently cited as one reason for the cluster's success. Montgomery County has an excellent public school system, with two high schools in the top 100, and five in the top 250 nationally (Newsweek, 2011). In comparison, the Silicon Valley area has three high schools in the top 100 and four in the top 250 nationally. Institutions of higher education, although perhaps not including many top research institutions in science and engineering, are plentiful. Aside from UM and Johns Hopkins University, regional universities in nearby Washington, D.C., include Georgetown University, George Washington University, American University, and Catholic University, among others.

Urban and cultural amenities are excellent in the local metropolitan area. Baltimore offers excellent art museums and an outstanding symphony orchestra, and Washington, D.C., offers

the Smithsonian Institution and the Kennedy Center for the Performing Arts. Within Montgomery County, Strathmore Hall hosts performances by all major local symphony orchestras and visiting artists.

Quality-of-life issues play a critical role in the county's current efforts to expand the cluster to the county's east, near the FDA (see Figure 5.1). One local official indicated that its plans to expand the cluster have not been successful. Firms are not as interested in locating near the FDA as they are in locating near the NIH. This may be because the FDA's main role is regulatory, whereas the NIH's main role is to provide research funding. Primary and secondary schools in the area near the FDA are of lower quality than those near the current cluster. The area near FDA lacks mass transit and has congested roads. Urban amenities in the eastern part of the county are not considered to be as good as in the western part. A local official indicated that one major firm that did open an office in the city of Silver Spring, in the eastern area, chose its location because of the local subway service to Silver Spring and the city's urban amenities.

Other Factors

During our interviews, business development officials, as well as some entrepreneurs, expressed concern that the business culture in Montgomery County is risk-averse, particularly when compared with Silicon Valley. One potential reason for this reported risk-aversion is that government laboratories, while providing a rich pool of skilled researchers, also compete with private industry for talent. A researcher may prefer a stable job at NIH to an uncertain opportunity in a startup.

Another aspect of the culture concerns the local universities. Johns Hopkins University and UM representatives indicated that the culture in their universities has not historically encouraged entrepreneurship; in the past, faculty members' attempts to start businesses were frowned upon. On a related note, county and state officials expressed concern that local universities received a significant amount of research funding but could not always turn that funding into commercial products.

University officials are making efforts to change this culture: Faculty members are encouraged to become chief scientific officers in firms, although not chief executive officers (CEOs). UM and Johns Hopkins University, as well as TEDCO, are striving to create some of the networks that Silicon Valley already has. For example, Johns Hopkins University hosts events to connect researchers with entrepreneurs and provides researchers with mentoring from investors, lawyers, and research and development managers. Two centers at UM also run programs that connect startups with successful entrepreneurs. TEDCO runs networking events for its portfolio of companies, introduces them to venture capitalists, and provides workshops that bring in outside speakers on a number of topics such as how to obtain funding, pitch business ideas, and write grant applications. Perhaps, not surprisingly, more junior faculty members are interested in starting companies.

Government Policies

In this section, we provide an overview of some of the main, nonfinancial government programs, as government policies pertaining to financing were discussed above. This section also includes a number of policies that are run by UM, a public university.

Business Incubators

The county and state governments sponsor a number of business incubators, including several through UM. One of UM's incubators, the Technology Advancement Program, houses about 12 companies. Firms outside the incubator can have affiliate status. The incubator is headed by successful local entrepreneurs, who know the venture capital community; these entrepreneurs provide the firms with help in a number of areas, including developing business plans and filling management teams. The incubator does not focus on a particular industry but rather selects firms that have some type of technology venture. Their successes include Martek Biosciences Corporation, a nutritional product firm acquired by DSM Nutritional Products in 2011 (Martek Biosciences Corporation, 2011); and Digene Corporation, a medical diagnostics firm acquired by Dutch biotechnology company QIAGEN in 2007 for \$1.6 billion (*The Wall Street Journal*, 2007).

UM offers other services that are similar to the Technology Advancement Program. For example, one incubator is aimed at university affiliates; it provides office space and advice, although significantly less than in the Technology Advancement Program incubator. The UM-China Research Park incubator enables companies run by Chinese nationals in the United States to collaborate with UM and do business locally and has recently been expanded to include other international entrepreneurs. Another UM program helps faculty members (and, to some extent, students) start companies. The program is headed by someone who knows the venture capital community and acts as an interim CEO for about two to three startups at a time. This program allows faculty members who start companies to keep their faculty jobs while working part-time on the startups; if they join the Technology Advancement Program, they are expected to be fully committed to the firm. The standard IP deal at UM allows faculty members to keep 50 percent of any patent revenue.

Education and Training

UM offers a number of courses and workshops in entrepreneurship, as well as business plan competitions that provide awards of up to \$75,000 to winning student teams. The Dingman Center provides advice to students with business ideas and has invested in some student startups. Their most successful firm, Under Armour, is a clothing company started by a student. In addition, the university provides workshops to keep employees up-to-date on cutting-edge biotechnology research, including courses for specific local firms.

TEDCO has developed two training courses for potential entrepreneurs. The first program trains mid-career women to start businesses; women with both technical and business backgrounds are recruited and participate in a one-year class in which they learn the steps to commercialize a technology. The classes are taught by faculty members with business experience and by entrepreneurs-in-residence. Every year, 17 to 20 students are enrolled, and approximately four companies are started. TEDCO has recently started a similar program to train graduate students and postdoctoral researchers to found companies.

Technical Assistance

UM runs a number of technical assistance programs. The Manufacturing Assistance Program provides manufacturing companies with temporary help in process improvement from experienced engineers. The bioprocess scaleup facility houses large-scale equipment that firms can use for pilot tests. The facility has a fee-for-service structure; priority is given to Maryland companies, but out-of-state companies are also allowed to use equipment, although the fees are higher. The majority of clients are young firms that lack the capital to purchase their own equipment, although some established firms have used the facility to avoid contaminating their sterile areas. The Dingman Center runs a program in which students working on their master of business administration (MBA) degree evaluate the commercialization potential of technologies developed by faculty members at UM as well as at Technion University in Israel.

Ease of Doing Business

Montgomery County has taken steps to make it easier for firms to set up a new business by creating a Technical Advisory Board, a formal group consisting of all agencies concerned with the building process. The goal is to coordinate county activities so that new buildings can be approved efficiently. The case study on Human Genome Sciences discusses a particular example of this effort (Appendix A).

Marketing

Montgomery County is making efforts to market its brand; a group of employees recruit firms and entrepreneurs from the surrounding communities. In the past, the county has also talked with researchers at NIH about various aspects of starting a business and is currently in talks with the technology transfer office at NIH regarding the commercialization of research from NIH. The county has held a fair for postdoctoral researchers, but one official indicated that it was not considered a success.

Intellectual Property

IP rights are divided somewhat differently at UM than at Stanford and UC-Berkeley, but they generally follow the principle of sharing between inventor and university. At UM, after deducting expenses, the first \$5,000 goes to the inventor, as does 50 percent of subsequent revenues. UM makes an effort to dedicate 85 percent of the University System Administration's share of revenue to research in the inventor's department, up to \$100,000 per fiscal year. Remaining revenues are dedicated to research and patent promotion (University System of Maryland, 2012).

Labor Mobility

Maryland's enforcement of noncompete clauses was not brought up by any interviewees. Maryland is ranked approximately in the middle of states in terms of enforcing noncompete clauses; Garmaise (2009) assigns Maryland a score of 5 out of 12, where higher scores indicate greater enforcement of noncompetition law. In contrast, California scores zero out of 12, and the highest score is 9 out of 12, for Florida. We specifically asked a former entrepreneur and current development official about the potential impact of noncompete clauses in Maryland. The entrepreneur indicated that although noncompete clauses were technically enforceable, they did not in practice appear to limit labor mobility.

Case Study: Israel's Information and Communication Technologies Firms

Overview

Beginning in the 1970s, the corridor from Tel Aviv to Haifa in Israel has emerged as a center for ICT firms (Figure 6.1). Other, peripheral industries have also taken off in this corridor, including firms engaged in the fields of medicine and biotechnology, agricultural technology, and materials (de Fontenay and Carmel, 2004). The main clusters of ICT firms are located in Herzliya and Ra'anana (just north of Tel Aviv), as well as in Haifa (about 100 kilometers to the north) (Figure 6.1). In 2010, the ICT sector employed 7 percent of the Israel's workforce and accounted for 27 percent of the total value of Israel's exports (Israel Central Bureau of Statistics, 2011).

Multinational corporations (MNCs) played a large role in the development of Israel's ICT cluster and continue to be major employers and exporters. As in Silicon Valley, spinoffs are also important. Avnimelech and Feldman (2010) reviewed the evidence from selected local firms in spawning spinoffs in a number of clusters, including three in Israel—RAD Data Communications, Fibronics, and Comverse—that were founded during the late 1970s and early 1980s, before the ICT boom, and found that former employees of these firms had created a number of new companies.

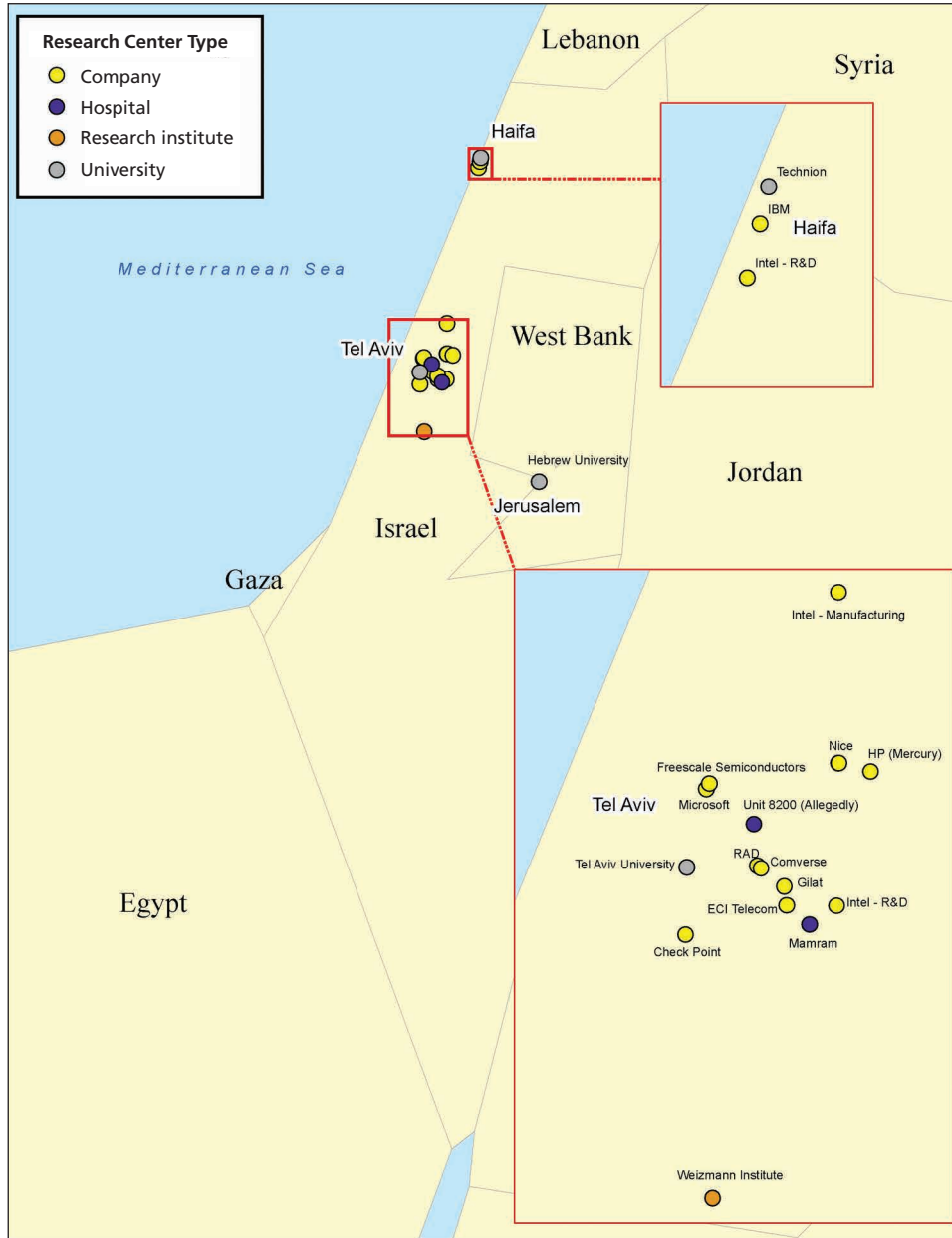
The share of the ICT sector in the Israeli economy grew during the 1990s but has leveled off since approximately 2000 (Figure 6.2). However, the ICT cluster continues to generate relatively high-wage jobs (Figure 6.3).

The number of patents granted by the USPTO to inventors in Israel has risen sharply since the mid-1980s (Figure 6.4). In 2010, Israel accounted for approximately 1 percent of all patents granted by the USPTO to both U.S. and foreign inventors.

History

From the 1950s to the 1970s, Israel's per capita income, relative to that of the United States, more than doubled. During that time, there was little scope for private entrepreneurship; large, state-led investment projects were more important for growth (Senor and Singer, 2009). The defense industry was a major source of R&D during this time; some authors have traced the start of high-technology industries to military R&D projects (Dvir and Tishler, 2000). Israel's development strategy based on state-owned companies failed following the Yom Kippur War of 1973. Israel faced a "lost decade" in terms of economic growth, and the 1980s brought hyperinflation (Senor and Singer, 2009). A change in economic policy in response to the

Figure 6.1
Map of Israel's ICT Corridor



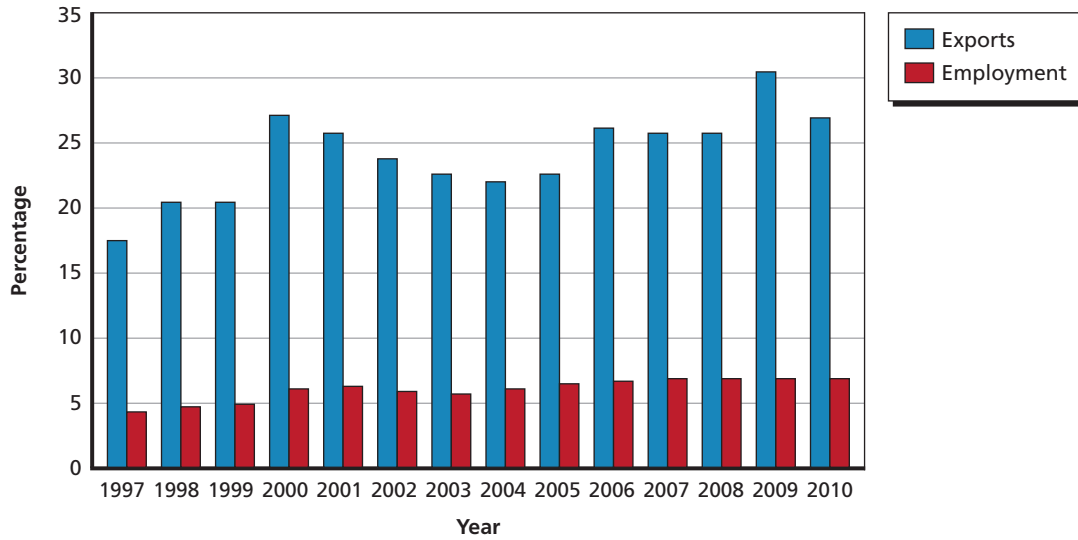
SOURCE: Map generated by RAND using ArcView GIS, Version 10.0, Redlands, Calif: Environmental Systems Research Institute, Inc., 2011.

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problems of that decade played a major role in the development of high-technology industries in Israel.

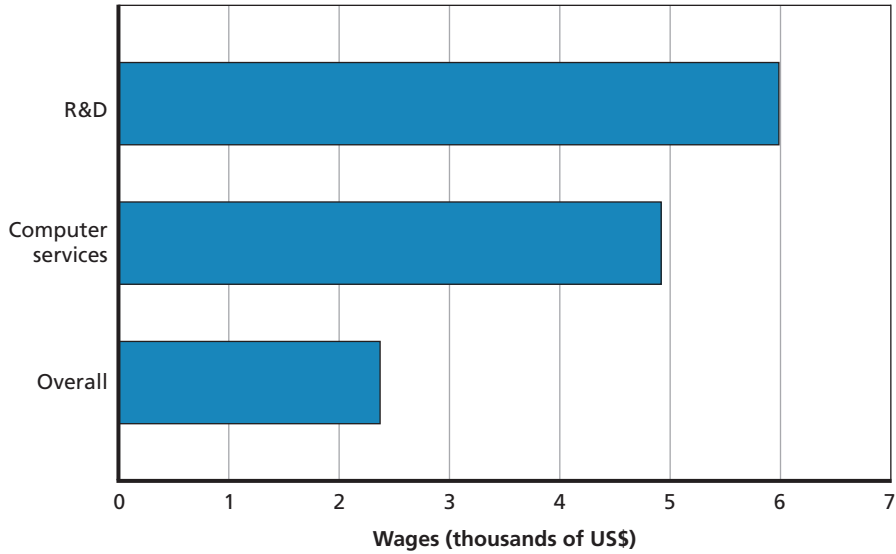
Both home-grown and foreign firms have been important in the development of the Israeli ICT cluster. During the 1960s, several Israeli high-technology firms were established; one of these firms, Elron Electronics, is sometimes considered similar to Fairchild Semiconductor in Silicon Valley in terms of its importance in generating future growth of the cluster.

Figure 6.2
Share of ICT in Israel's Exports and Employment



SOURCE: Israel Central Bureau of Statistics, 2011.
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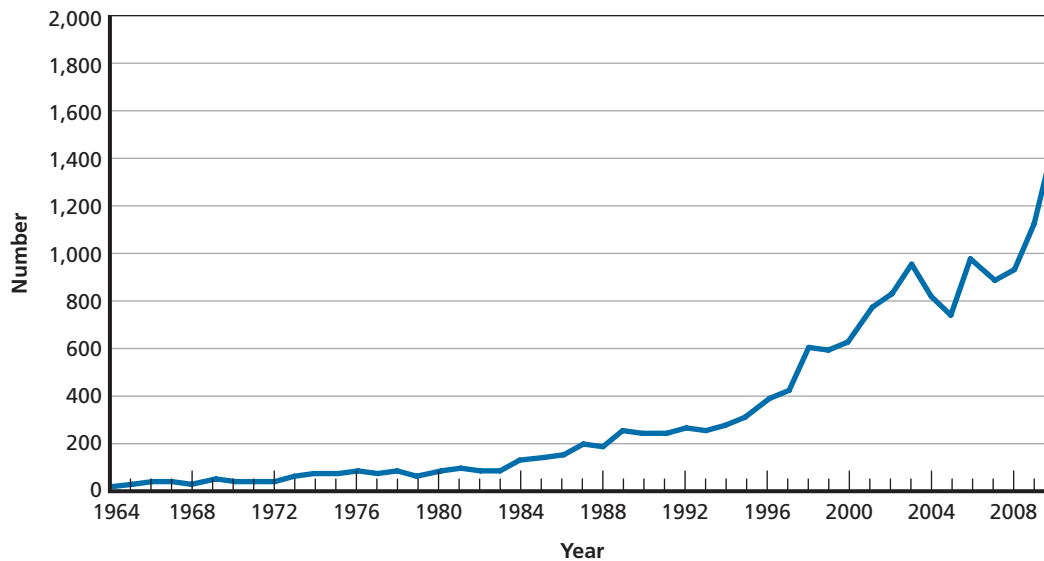
Figure 6.3
Average Monthly Wage per Worker in Israel



SOURCE: Israel Central Bureau of Statistics, 2011.
NOTE: Data were converted from Israeli shekels to U.S. dollars using exchange rates for 2010 from the International Monetary Fund's International Financial Statistics Database.
RAND TR1293-6.3

In 1964, Motorola set up an R&D facility in Israel. The facility was originally focused on wireless products and later went on to work on microchips (de Fontenay and Carmel, 2004). In 1974, IBM and Intel also set up facilities in Israel (Kaplan, 1998).

Figure 6.4
Utility Patents Granted by USPTO to Inventors in Israel



SOURCE: U.S. Patent and Trademark Office, undated.

RAND TR1293-6.4

The ICT boom accelerated in Israel during the late 1980s and 1990s. Our interviews suggest that many factors played a role in triggering this boom, including the following:

- The economic reforms of the 1980s and 1990s. During this period Israel made a number of structural changes to move toward a less regulated economy. These reforms contributed to creating a business climate in which entrepreneurs could flourish.
- Research taking place inside the Israel Defense Force (IDF). The IDF is a key source of technical and entrepreneurial training in Israel.
- Immigration. The massive influx of Soviet immigrants who arrived in Israel during the early 1990s did not often become entrepreneurs themselves, but they provided talented technical personnel who could work for young companies started by native-born Israelis.
- Multinational corporations. As with Microsoft and Intel, a number of MNCs opened branches in Israel during the 1980s and 1990s for chip design and manufacture, as well as for software development.

Financing

Research and Development Funding and Precommercialization Support

Today, Israel has the highest gross domestic expenditure on R&D, as a percentage of GDP, among countries belonging to the OECD. It also has the highest fraction of R&D expenditure by business enterprises (nearly 80 percent), whereas the share of R&D expenditures borne by the government (less than 5 percent) is one of the lowest in the OECD (OECD, 2011). Below, we outline two major government programs that provide R&D funding at various stages of commercialization.

R&D Funding

The Office of the Chief Scientist (OCS), a government body responsible for subsidizing commercial R&D projects, provides R&D support to firms that meet certain criteria.¹ The OCS was founded in 1969. In 1985, the Law for Encouragement of Industrial R&D charged the Office of the Chief Scientist with promoting “science-based, export-oriented industries” (Trajtenberg, 2000). The central program is a fund that provides up to a 50 percent match (66 percent for startups) for the development of “innovative, export-targeted products” for firms that meet certain criteria (Trajtenberg, 2000). The projects are screened by a Research Committee, which includes government officials, but outside, professional advisers review the applications. The applicant firm must agree to carry out the project itself, to manufacture resultant products in Israel, and not to transfer the knowledge acquired during the project to third parties (Trajtenberg, 2000). Foreign companies that establish R&D centers in Israel are also eligible for OCS funding, if they establish the center as a subsidiary to an Israeli company, with the IP registered as property of the Israeli company (Invest in Israel Investment Promotion Center, 2011). Successful firms are required to pay back their grants through royalty payments. Trajtenberg (2000) notes that in 2000, paybacks were substantial, accounting for nearly one-third of the OCS budget.

The OCS's R&D fund was originally designed to be officially neutral (not favoring certain sectors and not subjecting projects to a competitive review). However, as Trajtenberg (2000) notes, since the OCS budget has not kept up with growing demand, continuing the neutral position for grants while continuing to fund all qualified applicants has become infeasible. In recent years, the OCS has shifted to a less neutral policy, under which biotechnology and nanotechnology efforts are eligible for higher subsidies than other sectors (Invest in Israel Investment Promotion Center, 2011). Our interviews suggest that there is an unofficial target for providing approximately 30 percent of funding to biotechnology and related fields.

Despite the OCS's current focus on biotechnology, it is unclear whether Israel is likely to be competitive in this field. One observer whom we interviewed noted that the vast bulk of R&D support from the OCS has been for individual projects rather than for infrastructure. This has been a potential drag on development of sectors other than ICT, for which there may be a substantial threshold in the form of basic equipment needed for startups. There is a dearth of common infrastructure, such as clean rooms, that may be needed to support industries such as biotechnology.

Trajtenberg (2000) reviews the literature on OCS programs and R&D in Israel and concludes that there is some evidence suggesting that OCS grants may have increased productivity among R&D-intensive sectors. However, our interviews indicate that many successful ICT companies try to avoid using OCS funding because of the concern that potential investors may have with respect to IP restrictions. The main concern is not royalty payments per se but rather potential acquirers' concern that the firm might not be able to offer them a clear title to the technology and that they would have to negotiate with the government as well as the firm concerning ownership and future sales of the technology.

¹ Most ministries in Israel have chief scientists. The chief scientist for what is now called the Ministry for Industry, Trade and Labor plays the role of government chief scientist for civilian purposes.

Precommercialization Support

The OCS also established a Magnet Program in 1993 to encourage joint industrial and academic partnerships to work on “generic, pre-competitive technologies” (Trajtenberg, 2000). R&D grants of up to 66 percent of costs are provided for three to five years; there is no repayment requirement. The applicants are required to make their results available at “prices that do not reflect the exercise of monopoly power” to interested local parties (Trajtenberg, 2000). The Magnet Program targets technologies at a precommercialization stage and selects projects on a competitive basis (Trajtenberg, 2000).

Venture Capital

The first venture capital fund in Israel was set up in 1985 by three private entrepreneurs (de Fontenay and Carmel, 2004). Between 1989 and 1992, several additional capital venture funds were established. In 1993, the government established its own venture capital program called *Yozma* (“Initiative”). Government funds amounting to \$20 million were invested directly by a state-owned venture fund. The *Yozma* program also created 10 private funds, in which it invested \$8 million each on a matching basis. Each private fund had to combine funds from a well-established Israeli financial institution with funds from a foreign financial institution. In total, *Yozma* funds raised \$250 million and invested this money in more than 200 firms (Avnimelech, Schwartz, and Bar-El, 2007). After four years of operation, the state venture capital fund was privatized in 1997 (Avnimelech and Teubal, 2004).

A related program was implemented by the Government Insurance Company (Inbal) in the early 1990s that guaranteed up to 70 percent of the value of venture funds traded in the stock market. Four funds were established under this program and had to adhere to certain restrictions. This program was not considered particularly successful; all four funds eventually left the program as a result of bureaucratic requirements and low valuations (Avnimelech and Teubal, 2001).

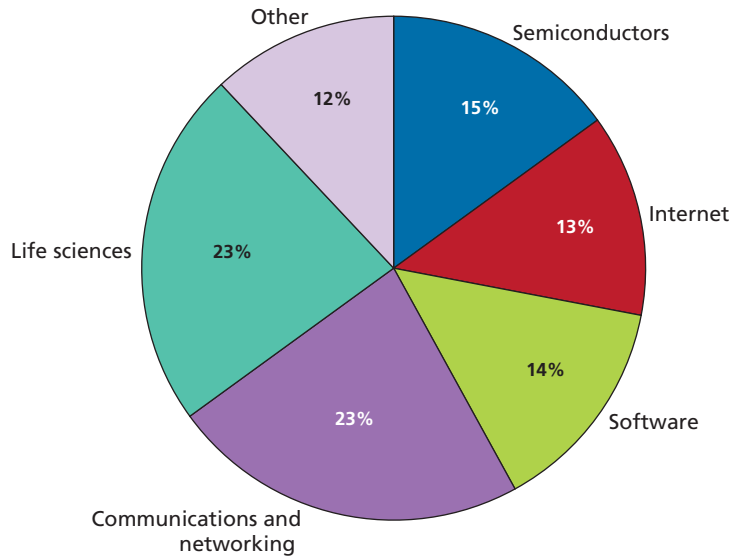
Avnimelech, Schwartz, and Bar-El (2007) document that the number of venture funds rose from one in 1989 to 93 in 2004 and that concurrently, the number of startups rose from approximately 300 during the 1980s to nearly 4,000 between 1991 and 2004. Our interviews suggest that the *Yozma* program was considered important in spurring the growth of the Israeli venture capital industry for two reasons:

1. It provided the first boost to the domestic venture capital industry. Since the government provided some of the money for the private venture capital funds, there was built-in leverage; the firms that received *Yozma* funding had an easier time obtaining outside funding.
2. It provided a bridge to the venture capital industry in the United States, including expatriate Israelis and diaspora Jewish communities.

Today, Israel is one of the top recipients of venture capital investment in the world (Figure 4.7). Most venture financing still goes toward ICT-related industries, although nearly a quarter went to the life sciences industry in 2010 (Figure 6.5). In the third quarter of 2011, PwC reported that Israel received a relatively higher share of early-stage funding than did the United States (Figures 6.4 and 6.6).

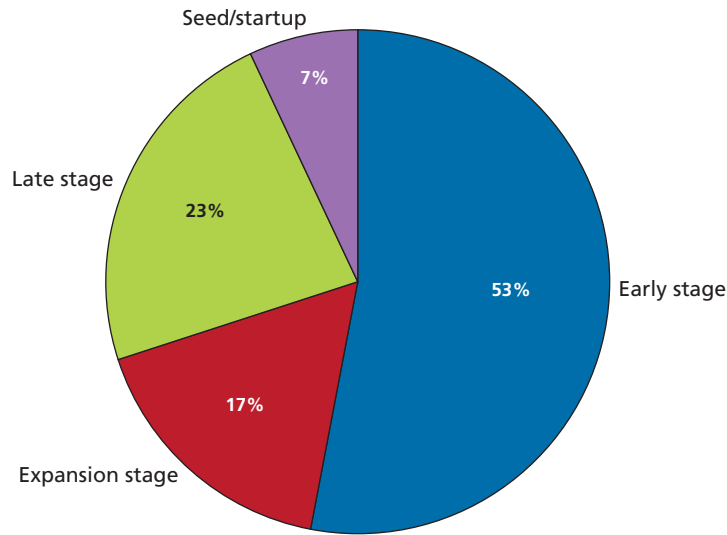
Since the onset of the global financial crisis, the Israeli government has initiated a few steps to support the venture capital industry. In 2009, the government established public-

Figure 6.5
Venture Capital Investments in Israel by Sector



SOURCE: PwC Israel, 2010.
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Figure 6.6
Share of Venture Capital Investment in Israel by Development Stage



SOURCE: PwC Israel, *Money Tree Report*, Q3 2011.
 RAND TR1293-6.6

private biotechnology venture capital funds (Israel Ministry of Industry, Trade and Labor, 2011). In 2010, the government adopted additional steps to encourage investment, including taking on some of the risk associated with venture capital investments of Israeli institutional investors and offering tax breaks to investors in early-stage companies (Israel Gateway, 2011).

Human Capital

Our interviews indicate that the IDF is perhaps the most important training ground for technical talent in Israel. Military service (three years for men, two for women) is compulsory, but exemptions exist for various reasons. Although not everyone actually serves, observers note that the participation rate in compulsory service is skewed toward the best-educated and most skilled part of the potential population of young people. The IDF not only has first choice of the recruits who present themselves for national service, but it also uses a battery of psychometric tests to evaluate and place candidates.

IDF has a number of technology-oriented units and programs; recruits compete to be placed in many of these programs. Our interviews suggest that many former IDF members who go on to form companies were part of the technologically focused “Unit 8200,” which does work on signals, interception, and interpretation, and, more generally, electronics and technology. Another important program is the *Talpiot* program, which selects the “best-of-the-best” and provides them with advanced technical training in exchange for a commitment to an additional four years of service. The IDF’s Center of Computing and Information Systems (*Mamram*) is considered one of the best sources of high-quality software professionals in Israel. In general, former IDF members are allowed to create civilian versions of technologies originally developed inside the army. Such elite, technology-oriented units provide not only military training but also technical training equivalent in some aspects to an undergraduate engineering degree.

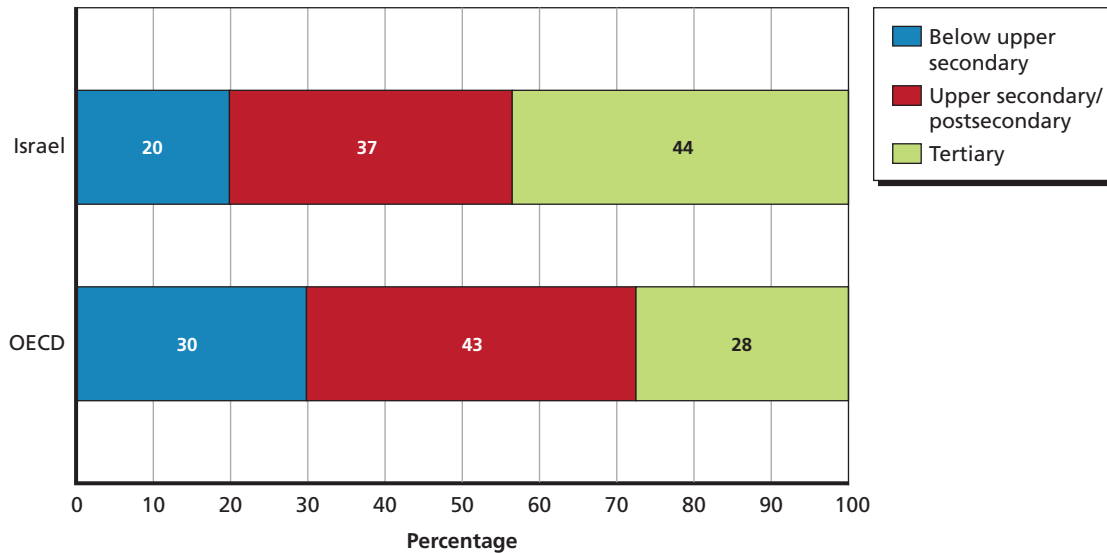
IDF recruits are required to undertake a significant amount of responsibility at a young age, to work within and to manage teams, to think strategically, and to achieve goals rather than simply to carry out orders; this training provides them with important entrepreneurial skills. The military structure is fairly flat, and the culture encourages young recruits to communicate with, and even challenge, more senior members (de Fontenay and Carmel, 2004; Senor and Singer, 2009).

After serving in the military, many former military personnel attend college. Nearly 45 percent of the adult Israeli population has some tertiary (university) education (Figure 6.7). The share of Israelis with tertiary education is extremely high by international standards; only two other OECD countries (Canada and Russia) have higher shares (OECD, 2010b). Two of the premier technical universities in Israel are the Israel Institute of Technology (Technion, in Haifa) and the Weizmann Institute (in Rehovot, near Tel Aviv).

Our interviews suggest that technical education is considered to be excellent, but formal business and entrepreneurial education still leaves considerable room for improvement. There is mixed evidence on the importance of universities in creating innovations. For example, de Fontenay and Carmel (2004) argue that universities played a key role in developing technology for the data security and life science industries. In contrast, our interviews suggest that the ties between universities and private sector firms are not particularly close and that university inventions have only recently begun to be viewed as potential vehicles for commercialization. Nearly all universities in Israel are public. As public employees, faculty members are somewhat limited in the types of private sector work they can take on. However, one interviewee noted that because faculty salaries in Israel are low (relative to those in the United States, for example), faculty members have an incentive to be somewhat strategic in reporting such activities.

MNCs played, and continue to play, an important role in providing human capital for Israel’s ICT cluster. Our interviews indicate that Israelis working for foreign companies have

Figure 6.7
Education Levels in Israel



SOURCE: OECD, 2010b.

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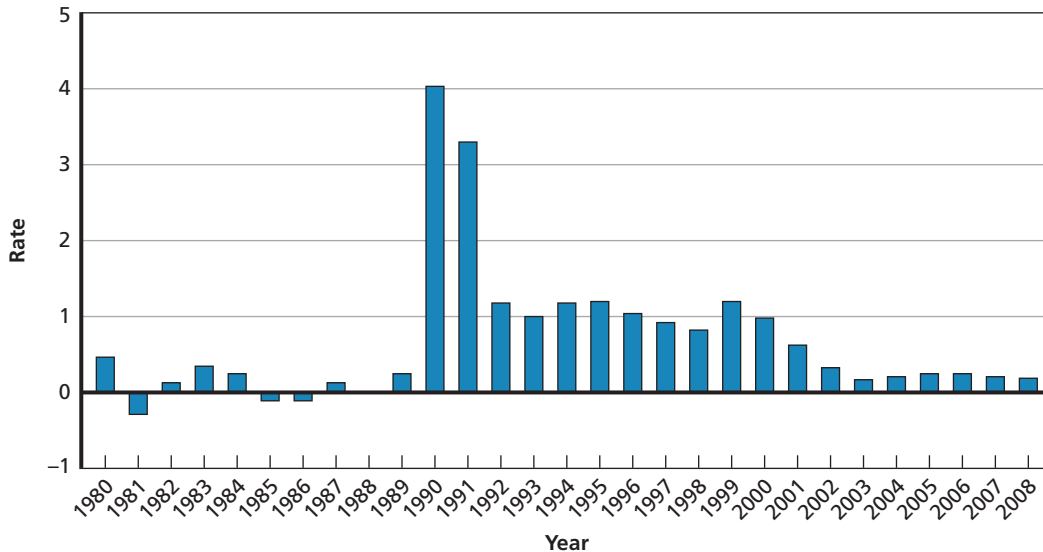
been important in a number of firms' decisions to locate in Israel. Historically, MNCs have also served as de facto educational facilities, providing training that would not otherwise be available without going abroad. Working for an MNC exposes locals to world standards in production and technology and helps them understand market needs as well as how to engage customers.

The wave of approximately 800,000 Soviet immigrants to Israel in the early 1990s provided a large pool of technical talent (de Fontenay and Carmel, 2004; Senor and Singer, 2009). During 1990 and 1991, net migration into Israel was equal to 3 to 4 percent of the population per year; migration rates stayed relatively high throughout the 1990s (Figure 6.8). Our interviews indicate that the Soviet immigrants added to the domestic workforce, which already had high levels of educational attainment. Although the Israeli government started an incubator program in part to find employment for the Soviet immigrants, these immigrants tended to provide skilled labor for local firms, rather than start their own companies. Lerner and Hen-deles (1996) conducted a survey of recent immigrants and found that in 1991 only 7 percent of recent immigrants were self-employed, compared with 15 percent of the overall population. However, over 30 percent of recent immigrants reported that they would prefer an entrepreneurial career. These authors argue that a variety of factors could explain this gap, including lack of language skills, business connections, and overall experience with Israeli conditions.

Quality of Life and Other Factors

As in the Silicon Valley and Maryland clusters, quality of life appears to play a role in the specific locations of high-technology firms in Israel: The major high-technology clusters (Her-

Figure 6.8
Net Migration Rate as a Percentage of Population in Israel



SOURCE: OECD, 2010b.

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zliya, Tel Aviv, Ra'anana, and Haifa) are generally considered the most desirable places to live in Israel.

A variety of networks, including specialized supplier and support networks, have matured in Israel during its high-technology boom of the 1990s. Some of these networks are oriented toward providing connections between Israel and its largest market, the United States, through the Israeli diaspora and through the operations of MNCs in Israel. As in Silicon Valley, social networks play a key role in Israel's high-technology cluster. However, unlike in Silicon Valley, the IDF plays a critical role in network formation. Startup teams are often identified with, and made up from, former colleagues in the army (de Fontenay and Carmel, 2004). Our interviews suggest that these networks are propagated by continued service in the reserve forces, which brings former IDF team members together periodically for training.

Networks with the Israeli and Jewish diaspora abroad, particularly in the United States, are also critical to Israel's high-technology cluster. Many Israelis study or work in the United States (de Fontenay and Carmel, 2004). This diaspora can impose costs in terms of losing high-technology talent; however, these citizens can also serve as links between U.S. and Israeli firms. For example, one of the reasons Intel invested in an Israeli facility is because Israeli engineer Dov Frohman, an early employee of Intel in the United States, helped to convince Intel to open an R&D center in Haifa to take advantage of Israel's highly skilled workforce (Senor and Singer, 2009).

As discussed above, one key factor in the Israeli high-technology cluster is the IDF. In addition to providing training and a fertile ground for network formation, the military provides a large initial market for certain firms as a buyer and targets specific types of technologies (for example, ICT) because of its needs. Dvir and Tishler (2000) note that although the military conducts a significant amount of R&D in technology, most successful commercialization efforts of military technology have occurred because former military members move to the

private sector; they argue that most direct efforts by the military to commercialize technology have failed.

Israel's culture has also been credited for playing a role in its success. Senor and Singer (2009) argue that the Israeli notion of "chutzpah" leads to a culture in which "assertiveness is the norm" and that subordinates (including students, junior military officers, and employees) are encouraged to challenge their bosses. As discussed in Appendix A, they point out that Intel's success in launching its Centrino chips in 2003 was due largely to the long campaign by Israeli engineers at Intel to convince the parent organization in Silicon Valley that Intel should pursue a new design strategy. At the same time, as de Fontenay and Carmel (2004) point out, Israel has a strong collectivist nature, which encourages teamwork and loyalty. They note that this attitude generally leads to relatively low turnover among firms, which can provide benefits when a firm is engaged in long-term design activities.

One main challenge that has historically been faced by Israeli firms is the small local market, which likely held back Israeli ICT firms during the early years of cluster formation. As a result of the long distance between Israeli ICT firms and their main market, the United States, as well as cultural differences, working in consumer-oriented fields has proven challenging. Instead, Israeli ICT firms often focus on products that are sold to business clients rather than to the final consumer (de Fontenay and Carmel, 2004).

Government Policies

A number of government policies to encourage financing were discussed above. Here, we present additional, nonfinancial policies that may have contributed to cluster formation and growth.

Taxes

Israel offers corporate and dividend tax reductions to both local and international companies that are considered "industrial" and "internationally competitive" (meaning capable of exporting). An exception to the exporting requirement is made for biotechnology and nanotechnology companies. Companies that meet these requirements are offered a 15 percent corporate tax rate (falling to 12 percent by 2015), rather than the 25 percent standard rate. Investments in "priority areas" are offered further tax concessions. The tax benefits continue as long as the company maintains its status as "internationally competitive" (Invest in Israel Investment Promotion Center, 2011).

Our interviews indicate that tax concessions were not likely to have been the major driver in attracting MNCs to Israel. Rather, a combination of Israel's skilled workforce, along with encouragement from Israeli employees, was likely more important in attracting MNCs.

Grants

Although Israel's tax breaks are not considered to have played a major role in attracting MNCs, the government has supported MNCs and local firms in other ways. Intel Israel, for example, reports that its fabrication plant in Qiryat Gat was started in 1996 with \$1 billion in investment from Intel and \$0.6 billion from the Israeli government (Intel, 2011).

Investments in "priority areas" are eligible for grants equal to 20 percent of "approved investment." In addition, in a targeted effort to support the financial IT sector, starting in

2010, the government has offered foreign companies that do not currently conduct R&D in Israel, that operate in the financial sector, and that have turnover in excess of \$10 billion, five-year grants for establishing R&D centers in Israel. In exchange for funding ranging from 25 to 50 percent (depending on location and year of the grant), the company must commit to employ a certain number of R&D workers (with at least 80 workers by the third year of the grant) (Invest in Israel Investment Promotion Center, 2011).

A number of grant programs are targeted at businesses that employ new immigrants. The Ministry of Industry offers financial assistance to support worker training programs (Invest in Israel Investment Promotion Center, 2011).

Business Incubators

Between 1991 and 1993, the OCS established 28 incubators. These incubators were run by boards made up of businesspeople, government officials, and scientists (Avnimelech, Schwartz, and Bar-El, 2007). The incubators also provided assistance in a variety of areas such as determining a product's technological and market potential, obtaining financial resources, finding staff, and obtaining support services (Trajtenberg, 2000).

This program was started partly to provide opportunities for the large influx of Soviet immigrants. Each incubator generally housed 10 to 15 projects and was targeted toward innovative, export-oriented R&D. Projects could stay in the incubator for up to two years and could receive a maximum of \$150,000 per year. Entrepreneurs were required to repay the loans through royalty payments (Trajtenberg, 2000) and to provide 15 percent of financing themselves, in exchange for equity (Shefer and Frenkel, 2002).

In 2001, two faculty members at Technion conducted an evaluation of the incubator program by interviewing the managers of 21 incubators and representatives of 109 projects. They concluded that the incubators did fulfill their purpose, in that 86 percent of projects "graduated" and 78 percent of those secured other financing after graduation. Other key conclusions included: (1) the leadership and skills of the incubator's manager were important in determining success; (2) there were significant differences between project selection criteria and future funding rates for projects in incubators in the central region versus the periphery; (3) over 60 percent of the incubators' funding came from private sources, including royalties and strategic partnerships; (4) funding outcomes were no different for incubators that specialized in certain areas than for nonspecialized incubators; and (5) financial support, marketing, international collaboration, and networking with strategic partners were identified by project initiators as the key factors affecting a project's success.

However, our interviews indicate that there is a concern that the incubators were run by bureaucrats rather than entrepreneurs and that the incubators required too large a share of equity in the firms they helped establish. In addition, the incubators did not teach the skills required to become entrepreneurs (which was particularly important given that the Soviet immigrants were generally highly skilled engineers with no entrepreneurial skills). The findings of the Lerner and Hendeles (1996) study discussed above corroborate this concern.

International Collaboration

In 1977, the governments of Israel and the United States founded the Israel-U.S. Bi-national Industrial Research and Development Foundation (BIRD). The program contributes up to 50 percent of the cost of joint U.S.-Israeli research efforts, up to \$1.5 million. The usual structure

of a project relies on products manufactured in Israel and marketed by the U.S. firm. Successful projects are required to pay the program back through royalties of up to a total of 150 percent of the loan amount (de Fontenay and Carmel, 2004; Trajtenberg, 2000). Although many successful ventures grew out of this program, it is not clear how much of an impetus the BIRD program provided to the overall growth of the Israeli ICT cluster (de Fontenay and Carmel, 2004).

Since the initial BIRD program, Israel has established relationships with other countries, including Canada, Korea, and Singapore. The goal of each program is similar to that of the BIRD program; each seeks to support collaborative R&D (Israel Office of the Chief Scientist, 2011).

Labor Mobility and Intellectual Property

As discussed above, de Fontenay and Carmel (2004) note that labor mobility has historically been low in Israel. Interestingly, although noncompete clauses are common among Israeli firms, these authors note that the military does not have a similar noncompete policy for its former members and, with the exception of cryptography, does not prevent former members from working in similar fields. These practices, combined with the fact that the military itself does not often spin off commercial applications of its technology, may have helped to spur the creation of a number of technology firms by former service members (de Fontenay and Carmel, 2004).

Part III:
Applying Global Practice to Knowledge City

Introduction

This section summarizes lessons learned from the case studies of the three successful clusters—the high-technology agglomeration in Silicon Valley, the life sciences corridor in Maryland, and the ICT industry in Israel—as well as from the broader literature on innovation and cluster formation. The lessons learned are compared to existing conditions in GDD and supplemented by findings from the GDD-RAND Knowledge City Project Survey.

The second chapter of this section discusses three key aspects of the innovation environment in GDD—taxation, nontax incentives, and intellectual property rights. The third chapter focuses on lessons learned with respect to other aspects of the environment for innovation, including human capital, infrastructure and business climate, networks, quality of life, and marketing. Chapter Ten, the final chapter of this section, presents a brief summary and conclusions.

Lessons Learned from the Case Studies: Taxes, Nontax Incentives, and Intellectual Property Rights

In this chapter, we concentrate on three selected aspects of the innovation environment—tax policy, nontax incentives, and intellectual property rights—and their implications for attracting companies, encouraging innovation, and fostering company growth. In our innovation system framework, these constitute parts of the legal and regulatory environment, the business support environment, and finance (Figure 2.1). For each aspect, we first present lessons learned from the case studies of three successful clusters as well as from the broader literature on entrepreneurship and cluster formation. Next, we summarize conditions in GDD based on a review of documents, the survey of high-technology firms in GDD, interviews with firms and officials in GDD, and interviews with businesses and investors outside GDD. Finally, we conduct a gap analysis by comparing conditions in GDD with lessons learned.

Taxes

Lessons Learned from the Case Studies and the Literature

Our review of the literature on taxes and entrepreneurship generally suggests that lower taxes can increase entrepreneurial effort. Theoretically, higher tax rates can either increase or decrease entrepreneurial activity, because they reduce both the return and the risk of such activity (Cullen and Gordon, 2007; Bruce and Mohsin, 2006).¹ Several early empirical studies found a positive link between tax rates and self-employment (see Bruce and Mohsin, 2006, for a review). However, more recently, a number of studies have documented a negative relationship between various measures of entrepreneurship and a variety of tax rates, including personal, corporate, and capital gains (see, for example, Bruce and Mohsin, 2006; Cullen and Gordon, 2007; Da Rin, Di Giacomo, and Sembenelli, 2011; Gentry and Hubbard, 2000). Similarly, Carroll et al. (2000) documented that entrepreneurs facing lower marginal personal income tax rates were more likely to hire workers. In related work, Gompers and Lerner (1999) found a negative relationship between national capital gains tax rates and venture capital flows, which they attributed to reduced demand for venture capital by entrepreneurs.

However, it is doubtful whether tax rates themselves can be considered a major incentive for high-technology firms to locate in a cluster, nor can low tax rates be considered a necessary

¹ Domar and Musgrave (1944) originally noted that tax payments can create risk-sharing between the entrepreneur and the government. The government shares the entrepreneur's yields; in addition, if the entrepreneur's losses may be used to offset other income, the government also assumes some of the risk. Cullen and Gordon (2007) illustrate additional mechanisms through which differential tax rates for self-employment and wage income, and for personal and corporate income, could encourage risk-taking.

condition for successful cluster formation. In the case of Silicon Valley, some observers have suggested that lowering the *national* capital gains tax rates in 1978 increased venture funding, which contributed to growth of high-technology clusters (for example, Kenney and Florida, 2000). However, state tax rates in California are high; Kolko, Neumark, and Mejia (2011) argue that California as a whole has enjoyed solid growth in spite of its tax rate, not because of it. During our interviews in Maryland, state economic development officials expressed their doubts as to the impact of tax rates on high-technology firms; they indicated that in their experience, such firms tend to focus on such issues as the quality of the labor pool and access to urban amenities. Similarly, in the case of Israel, our interviews suggest that Israel's highly skilled, relatively low-wage labor pool, rather than its tax breaks, was responsible for attracting MNCs to the country. More broadly, Chen et al. (2010) did not find a relationship between the location of venture capital firms and *state* tax rates in the United States.

Conditions in GDD

Enterprise Income Tax

Effective January 1, 2008, under the Enterprise Income Tax law approved in 2007, companies in China pay a national corporate income tax rate of 25 percent. Under previous laws, the standard rate for foreign-invested enterprises and domestic companies was 33 percent, which included a 3 percent local tax (Herbert Smith, 2010). However, qualified foreign enterprises enjoyed lower tax rates of 15 percent or 24 percent and several years of full and half tax exemptions. The new law removed this preferential policy, depending on various conditions. After the 2007 law was passed, domestic and foreign enterprises now face the same tax rate. Aside from some sector preferences (discussed below) a 15 percent tax rate is applicable for some economic zones and western development areas for encouraged industries. Under the new law, China's nonpreferential rate is now 25 percent, which places it in the middle (a rank of 49) among 114 tax jurisdictions reported on by KPMG in 2010 and almost exactly at the average rate (KPMG, 2010). Table 8.1 shows China's tax rate in comparative perspective.

Other Taxes²

China does not have a capital gains tax for most forms of investment. It levies a value added tax (VAT)—an indirect tax—which has two rates: 13 percent or 17 percent. The 17 percent rate is slightly higher than the average indirect tax rate among the group of 114 tax jurisdictions cited above, at least as of 2010, which was 15.61 percent; China was tied with three other jurisdictions with a rank of 66 (KPMG, 2010). The personal income tax rates start at 5 percent, rising to 45 percent.

China levies a variety of other taxes, such as a business revenue tax, generally 3 percent to 5 percent for certain services, with higher rates for entertainment services; a land-use fee, which may be imposed by local governments; and a combination land appreciation tax and fee.

National law also offers a number of reductions and incentives related to innovation in regards to personal income tax.

Some of the taxes levied in China go entirely to the national government, including a consumption tax and tariffs; others go to local governments, such as an urban maintenance and construction tax and an urban land-use tax; and others are shared, including VAT, a sales

² When a citation is not listed, information on taxes comes from a communication from the GDD Policy Research Office, April 2011.

Table 8.1
China's Enterprise Income Tax in Comparative Perspective

Country or Entity	Tax Rate (%)	Rank Out of 114 Jurisdictions
China	25	49 (tie among 16 jurisdictions)
Other BRIC countries		
Brazil	34	100 (tie among 2 jurisdictions)
India	33.99	98 (tie among 2 jurisdictions)
Russia	20	34 (tie among 9 jurisdictions)
Other Asian jurisdictions		
Bangladesh	27.5	70 (tie among 2 jurisdictions)
Cambodia	20	34 (tie among 9 jurisdictions)
Indonesia	25	49 (tie among 16 jurisdictions)
Republic of Korea	24.2	48
Malaysia	25	49 (tie among 16 jurisdictions)
Pakistan	35	104 (tie among 7 jurisdictions)
Philippines	30	79 (tie among 12 jurisdictions)
Taiwan, China	17	26 (tie among 3 jurisdictions)
Thailand	30	79 (tie among 12 jurisdictions)
Vietnam	25	49 (tie among 16 jurisdictions)
Average	24.99	

SOURCE: KPMG, 2010.

NOTES: The BRIC countries include Brazil, Russia, India, and China. A low rank signifies a low tax rate and a high rank signifies a high tax rate.

tax, the enterprise income tax, and the personal income tax. In the past, some local governments have been permitted to return a part of their portion of the shared taxes to the taxpayer as a tax incentive.

Special Sector Taxation

The decision to change corporate income tax rates in the 2007 law was part of a shift in the policy of the Chinese government from trying to attract foreign investment to trying to provide a more favorable environment for specific types of industries. A variety of industries and other types of entities receive preferential treatment under the 2007 law:

- companies involved in scientific and technological progress, technological innovation, and research and development
- companies involved in energy saving, environmental protection, and comprehensive utilization of resources
- companies in the software, integrated circuits, and animation industries
- venture capital firms
- small, low-profit businesses and nonprofit organizations

- exporting enterprises
- nonresident (foreign) enterprises
- special groups
- cultural institutions and cultural enterprises
- income from qualified insurance policies, interest, dividends, bonuses, and capital markets.

Of these, the sectors and entities most relevant to the formation of innovation clusters include industries involved in *scientific and technological progress*, *technological innovation*, and *research and development*; *energy saving*, *environmental protection*, and *comprehensive utilization of resources*; and *software*, *integrated circuits*, and the *animation industry*. Benefits for these industries generally include corporate income tax exemptions or reductions, VAT exemptions or reductions, greater ability to deduct certain expenses, and accelerated depreciation.

A fourth sector relevant to innovation that receives benefits is *venture capital*. Venture capital firms that invest in small- and medium-sized high-technology firms for two years can deduct some part of their investment against their taxable income, as long as the firms in which the investments are made do not become publicly listed. National tax laws also include rebates and exemptions related to *exports*. Although not all exports relate to innovation and high technology, exporting can provide a powerful incentive to innovate by providing larger markets and by causing firms to strive to reach world-class standards. Finally, *income from qualified insurance policies*, *interest*, *dividends*, *bonuses*, and *capital markets* are exempt from corporate income tax.

National Tax Laws As Applied to GDD

National tax preferences translate into benefits for companies in GDD depending on the type of economic district or zone in which they are located (Table 8.2).

How GDD Entrepreneurs View Tax Policies

As noted above, most tax policies in China are set at the national or provincial level, thus allowing little scope for GDD to affect taxes on firms operating within its jurisdiction. In general, entrepreneurs with whom we met who have operations in GDD did not see the current tax system as having major effects on the innovation environment. They did not find tax rates or the tax administration to be barriers to innovation. Entrepreneurs valued tax exemptions for high-technology firms. In fact, our interviews suggest that the most important benefit provided by GDD appears to be assistance with certifying that a resident company is eligible for national tax preferences and working with the tax administration to ensure that the company receives those benefits. As important, they praised GDD's help in certifying them as high-technology firms to enable them to get the exemptions. An entrepreneur from an investment firm specifically cited GDD's proposed policy to try to rebate some portion of corporate income tax paid to Guangdong as advantageous. However, another investor noted that GDD increasingly faces competition from central China provinces, which may provide subsidies to partially compensate for tariff or corporate income tax payments, along with other nontax incentives, such as low electricity prices, for firms.

In the GDD-RAND Knowledge City Project Survey, nearly 70 percent of firms indicated that GDD provides preferential tax policies (Figure 8.1). The firms indicating that GDD provides preferential tax policies appear to operate in a fairly similar set of industries and to have

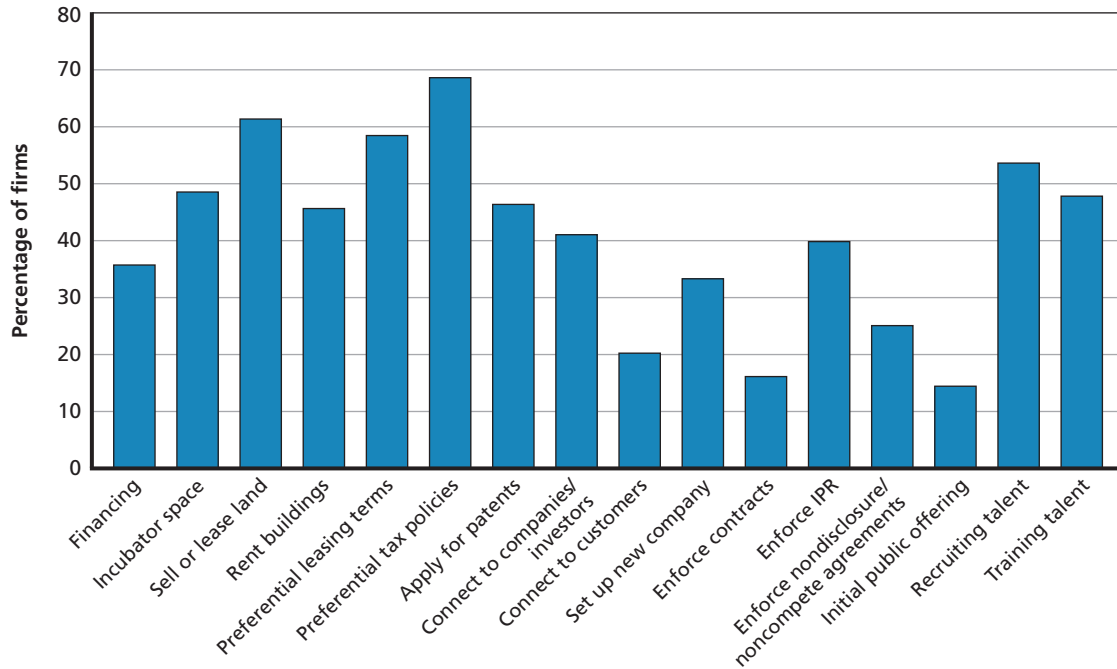
Table 8.2
Preferential Tax Policies in GDD by Type of Economic District or Zone

	GETDD	GHIDZ	GEPZ	GFTZ
Status	State-level development zone	State-level development zone	State-level development zone	State-level development zone
Duty and VAT for self-use equipment and spare parts	Exemption for those that belong to “encouraged industries,” which is determined by the central government of China		Exemption	
Duty and VAT on office appliances	No exemption		Exemption	
Duty and VAT on raw materials and parts	Exemption for processing trade enterprises only		Exemption	
Import licenses for equipment, raw materials, and office appliances of processing trade	Free of license only for processing trade of “encouraged industries”		Free of license for all processing trade products	
Domestic sales of finished products with duty-free raw materials	Levy on finished products		Levy on finished products	Levy only on imported raw materials and parts
VAT refund for finished products made with domestic raw materials	VAT is refunded after exports of finished products leave the country		Immediate VAT refund for domestic raw materials upon entering the area	VAT is refunded after exports of finished products leave the country
Ratio between export and domestic sale	Decided by investors as long as their projects are in compliance with national industry guideline and are excluded from export license and quota management		More than 70 percent export required	No restriction
	High flexibility for the ratio between export and domestic sale			
Standing book deposit system	Conduct the system by categorizing enterprises into type: A, B, C, D		Not available	
Rate of VAT	13 percent (agriculture-related projects), 17 percent			
Real estate tax	Exemption for 3 years		Exemption for 3 years	
	Exemption for 5 years for high-technology companies, 1.2 percent afterward		Exemption for 5 years for high-technology companies	

SOURCE: Guangzhou Development District, undated.

NOTES: The four zones constitute GDD. “Standing book deposit system” is a way to ensure payment of customs duties and prevent smuggling, tax evasion, or other forms of illegal trade by export-processing companies. Under the guarantee deposit system, companies in the system must put a deposit into designated banks until their goods using the imported commodities are exported. The system is also for evaluation. Companies are categorized into A, B, C, or D based on their historical records. Companies in each category face different requirements set by the central government, with A companies having the fewest requirements. The VAT rate is the same for zones as for the economy outside zones. The regular real estate tax rate is 1.2 percent for nonrental property and 12 percent for rental property.

Figure 8.1
Firms' Perceptions of Services Provided by GDD Administration



SOURCE: The GDD-RAND Knowledge City Project Survey.

NOTES: Each category represents a separate question. Results are based on responses from a range of 241 to 263 firms (out of 305 surveys received), depending on the specific question.

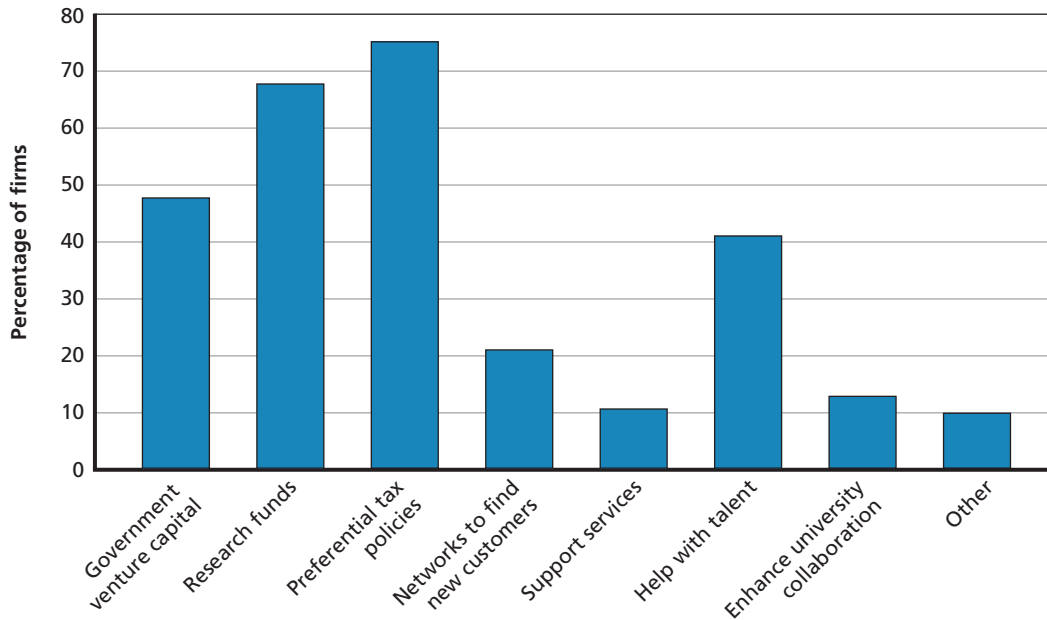
RAND TR1293-8.1

similar revenues as those that did not indicate that GDD provides preferential tax policies, although the firms indicating the presence of a preference appear to be somewhat older. This difference may reflect the fact that older firms are more aware of the existence of such policies, or it may reflect the fact that these older firms received preferences under the previous tax law, which ended in 2008.

Approximately one-third of firms selected “Provide preferential tax policies” as the most important new policy that the GDD administration could adopt to improve the climate for innovation, and nearly three-quarters ranked it among the top three most important new policies (Figure 8.2). Interestingly, the request for new preferential tax policies is not simply a reflection of firms that do not currently see GDD as providing preferential tax policies. Rather, the fraction of firms that selected “Provide preferential tax policies” as the most important new policy that GDD could provide was approximately 30 percent among firms that indicated that GDD currently provides preferential tax policies.

The desire for additional tax preferences was confirmed by our interviews: The entrepreneurs with whom we spoke indicated that they valued tax exemptions for high-technology firms and that a policy to refund provincial taxes would be helpful. In general, however, the entrepreneurs with whom we met who have operations in GDD did not see the current tax system as having a major effect on the environment for innovation.

Figure 8.2
Firms’ Perceptions of the Top Three Most Important New Policies GDD Administration Could Make



SOURCE: The GDD-RAND Knowledge City Project Survey.
 NOTES: Firms could give up to three choices for this question, so the total sums to more than 100 percent. Results are based on responses from 275 firms (out of 305 surveys received).
 RAND TR1293-8.2

Gap Analysis

Overall, the tax situation in GDD does not appear to place a major constraint on innovation. Companies in China generally face a tax rate of 25 percent on all corporate income, including capital gains, although there are lower rates for certain types of companies.

The literature does suggest that, in many cases, lowering tax rates can help to promote entrepreneurship and investment. Various national preferential tax policies applicable to firms in GDD may encourage entrepreneurship, but these preferential tax benefits also apply to other economic zones in China. The challenge for GDD, therefore, lies in attracting innovative firms to locate in Knowledge City rather than another economic zone in China. Companies that invest in China put tax concessions as one of their major concerns. In particular, larger companies prefer lower tax rates and low-cost land, whereas smaller companies look for lower rents. That is to say, although tax concessions could be decisive in competition among economic zones in China. GDD could examine various options for providing concessions. However, the benefits of such policies may be less than expected, as they may be eroded by tax competition from other jurisdictions.

In addition, all three of our case studies indicate that when selecting a location, innovative firms are more likely to consider such issues as the availability of highly skilled labor, quality of life, and proximity to suppliers and buyers than tax issues. Tax concessions may add some additional inducement for firms but are unlikely to be a major factor in driving the formation of an innovation-based cluster.

These concerns suggest that the most important tax benefit that GDD can provide is assistance with certifying that a resident company is eligible for national tax preferences and working with the tax administration to ensure that the company receives those benefits. Beyond taxes, GDD may find it more beneficial to compete with other regions based on other factors, such as quality of life, strong IPR enforcement, and overall business climate, which take time to develop and may be more difficult for other regions to imitate.

Nontax Incentives

GDD staff described GDD's innovation policy system as consisting of five components—direct support, indirect support, incentives to stimulate demand, services that support innovation, and promotion of technological innovation and cooperation (Shen, 2011).³ These involve nontax incentives, and our interviews indicate that entrepreneurs in GDD have found a number of these nontax incentives helpful.

One major set of nontax incentives provided by GDD pertains to financing. In this section, we focus specifically on these incentives. We also briefly discuss other nontax incentives such as provision of land, incubators, and preferential leasing terms. Another key area of nontax incentives involves GDD's policies to attract human capital, which we discuss in Chapter Nine.

Lessons Learned from the Case Studies and the Literature

Firm financing can be divided conceptually into several broad stages. During the basic research or technology-creation phase, most funding tends to come from government agencies, universities, or similar funding sources. Next, as the firm begins to develop the technology before commercialization, it faces a “valley of death,” as it usually relies on the entrepreneur's personal funds, or funding from friends, family, or angel investors, to survive. Once the technology is ready for commercialization, venture capital firms may step in to fund some fraction of firms. Finally, a few firms progress to the point where they can receive funding from public markets through an initial public offering (IPO) or can support themselves through sales (based on Murphy and Edwards, 2003).

A number of studies suggest that the growth of young, small firms may be limited by capital constraints; for example, Evans and Jovanovic (1989) use data from the United States to show that wealthier people are more likely to become entrepreneurs, and Angelini and Generale (2008) show that firms that report being financially constrained tend to be smaller than other firms, particularly in countries that are not members of the OECD.

Many studies on financing pertain to the venture capital stage. There is an extensive literature showing that venture capital-backed firms perform better than other firms along a variety of dimensions (see Chen et al., 2010, for a brief summary). However, these findings likely reflect a selection effect as well as an effect of venture capital backing: The evidence suggests that venture capital firms target innovative firms and that they assist those firms through the process of commercialization (Da Rin, Hellman, and Puri, 2011).

³ Guangdong Province also uses a number of policy instruments to promote innovation, discussed in Section I.2 of this report.

Our case studies suggest that financing is an important component of a successful cluster. In Silicon Valley, for example, early inventors were financed in part by government purchases of their products and in part by individual angel investors. However, more organized financing (including an organized angel investor group, as well as Small Business Investment Corporations, the predecessors of venture funds) became available during the start of the transistor era in the 1950s and 1960s. In Israel, the government's *Yozma* program to facilitate local venture capital funding coincided with the rapid growth of the ICT sector.

It is not clear that a cluster needs its own, local venture capital industry at the start. In the Israeli case, the *Yozma* program leveraged foreign funding by creating 10 private venture funds, which were required to combine money from well-established Israeli institutions with that from foreign financial institutions. The program aimed to create numerous funds rather than just one large fund that would have possibly required more government involvement, been the subject of more influence, and run the risk of investing in only a limited set of companies. These funds needed to compete with each other and could be judged (and could judge themselves) by the performance of the others. The government formally withdrew the program after only a few years, leaving the funds in private hands. In Maryland, many of the venture firms that invested in local companies during the 1980s and 1990s were not located in the same state. During our interviews, development officials indicated that the venture capital funds were willing to invest in Maryland companies because of the reputation of the local life sciences industry. However, some of these development officials believe that the predominance of funding from venture capital firms creates a gap between funding for basic research, provided by other sources, and late-stage funding, provided by the venture capital funds.

Evidence on the role of government in promoting firm financing is mixed. Lerner (1999) showed that small companies in the United States that received government research grants grew faster and were more likely to receive venture capital funding, although the effect was confined to regions with strong venture capital industries and was particularly pronounced in high-technology industries. In contrast, Da Rin, Nicodano, and Sembenelli (2006), using data from 14 European countries, found no links between increased public funding for R&D and the share of high-technology and early-stage venture capital investments.

Da Rin, Hellman, and Puri (2011) reviewed the evidence on venture capital funds that receive some backing from government and found mixed evidence on their performance. Companies backed only by government venture funds had relatively poor performance. This effect disappeared for companies supported by both government venture funds and private venture funds. Similarly, the authors found that venture capital funds controlled completely by government exhibited poorer performance than venture capital funds controlled partially by government. Finally, they found that the evidence on whether government venture funding complements or crowds out private venture funding was inconclusive.

Evidence on the role of government financial incentives from our case studies is also mixed. In the United States, a number of federal agencies participate in the Small Business Innovation Research program, which provides R&D funding for small firms; our interviews suggest that this program may have been helpful in Maryland because of the proximity of the cluster to many agencies. However, the major case histories of Silicon Valley do not identify government financial incentives as having played a role in the formation of the ICT cluster. In Maryland, government and university officials are attempting to fill the perceived gap between research and venture capital funding through a variety of grant and loan programs, the cre-

ation of a state venture fund, and development of angel investor networks; to our knowledge, no rigorous evaluations of the effects of these programs have been conducted.

In Israel, a number of observers have attributed part of the credit for jump-starting the private venture capital industry to the *Yozma* program by providing leverage and by signaling the strength of companies that were funded. In contrast, Avnimelech and Teubal (2001) argued that the *Inbal* program, a separate program that established four traded venture funds and guaranteed 70 percent of the value of their public issue, was not a success. These authors noted that the fund valuations were low, the funds encountered challenges in reporting requirements, and all four funds eventually left the program. Similarly, Lerner (1999) and Kenney and Florida (2000) argued that the Small Business Investment Corporations established in the United States in the 1950s, which provided matching funds and tax advantages for investors, made poor investments, had poor incentives to monitor portfolio firms because of government guarantees, and suffered from regulatory burdens. Reviews of an Israeli government program to provide loans for early-stage commercialization are mixed; given the potential IP restrictions on any technology developed using such loans, some observers noted that entrepreneurs do not necessarily want to apply for them.

Other case studies offer similar, mixed messages. Saxenian (2004) concluded that Taiwan's grants, loans, and subsidies for foreign and domestic electronics firms did play a role in the development of its ICT industry, as did the research and technical services provided by the publicly funded Industrial Technology Research Institute. However, she noted that for a decade after the Hsinchu Science Park was established in 1980 (along with a number of financial incentives to locate there), Taiwan was a low-value producer, and did not start moving up the value chain until thousands of Taiwanese expatriates began returning from the United States in the 1990s. Similarly, Arora, Gambardella, and Torrisi (2004) surveyed a long-standing debate between observers who argued that the Irish government's deliberate policy of attracting foreign investment and encouraging global linkages (through tax breaks, grants, and investment in skills and infrastructure) was responsible for cluster growth and others who argued that Ireland's success was due to the luck of having a skilled labor force at a time when there was an international skills shortage. These authors did not resolve the debate, although they did note that leaders of the two main development agencies in Ireland include former business executives who have maintained their connections with the private sector and that these agencies operate relatively independently from the central bureaucracy. This suggests that to the extent that industrial policy played a role in encouraging cluster growth, that policy was designed by former business leaders rather than government officials.

Conditions in GDD⁴

GDD has set up several financing mechanisms to promote innovation. GDD owns and manages Guangzhou GET Co. Ltd., a venture capital firm. In 2008, the Luogang District Financing Bureau of GDD invested 1 billion RMB in Guangzhou GET to establish two types of venture capital funds, both designed to attract private investment. The first type is a Seed Fund allocated to startups. Under the terms under which the fund was started, the government contribution may constitute the largest share, but GET would own less than 49 percent of the venture, with the rest coming from private investors. After the project has been designated as

⁴ Information from *Luogang Yearbook*, 2010.

completed, the private investors have first priority to purchase the government's shares. The second type is a Fund of Funds, used to support funds of private investors, such as angel investors and venture capital firms.

The district has also set aside 300 million RMB to provide guarantee funds, a form of government-provided collateral, for high-technology companies. In 2009, GDD and three other entities introduced the Zhongke Baiyun Fund.⁵ With a starting capital value of 5 billion RMB, the fund has mainly been used to invest in government science and technology development funds, seed funds, and other types of funds in support of innovative companies.

How GDD Entrepreneurs View Nontax Incentive Policies

GDD entrepreneurs with whom we met mentioned a number of GDD's nontax incentives that have proven helpful. Chief among these have been R&D grants; other incentives mentioned include rewards for top talent, land, and rent subsidies, and loan guarantees. GDD's policies were sometimes described as better than those in comparable districts and were cited by some entrepreneurs as a reason for choosing to locate in GDD.

Several entrepreneurs mentioned government programs to provide R&D grants as advantageous. However, other entrepreneurs claimed that the size of the R&D grants available, particularly for early-stage companies, was too small; some entrepreneurs reported difficulty in obtaining funds.

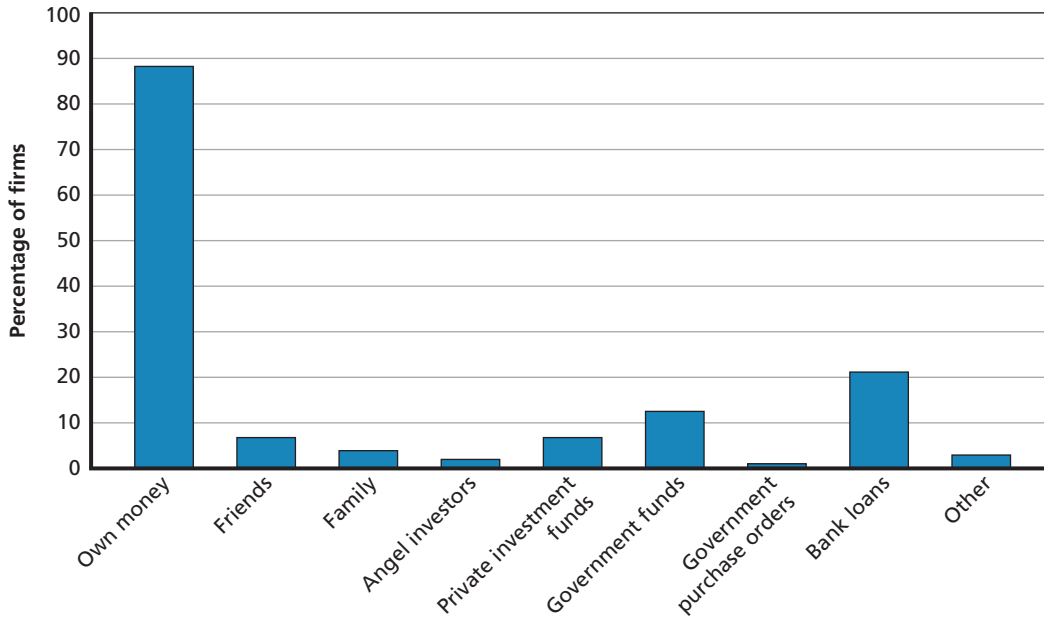
The GDD-RAND Knowledge City Project Survey found that nearly 90 percent of high-technology firms surveyed indicated that they used their own money for at least part of their initial investment (Figure 8.3). The next most common sources of initial funding were bank loans (21 percent) and government funding (13 percent). Very few firms received money from angel investors, even during subsequent funding rounds (Figure 8.4). Rather, the most common sources of funding for subsequent funding rounds included the entrepreneur's own money (56 percent), bank loans (45 percent), retained earnings (22 percent), government funds (21 percent), and initial public offerings (18 percent).

Approximately 25 percent of survey respondents indicated that they had received some outside funding. These firms do not appear to be concentrated in particular industries. Among these firms, the most common sources of the initial round of outside funding were banks and bank loans (49 percent); investment funds including venture capital, private equity, other investment funds, and sale of minority shares (15 percent); government, including the Development and Reform Commission and GET (7 percent); angel investors (5 percent); and parent companies (5 percent) (Figure 8.5).

The median amount of the first round of outside funding provided by banks was approximately twice as large as the median amount provided by government or investors, and three times as large as the median amount provided by angel investors. The maximum amount provided by government and banks was nearly three times as large as the maximum amount provided by angel investors and investment funds. The median and maximum amounts received by the three firms that had an IPO were two to three orders of magnitude larger than the amounts received from other sources, presumably largely because of a large amount of financing was raised from the offering (Figure 8.6).

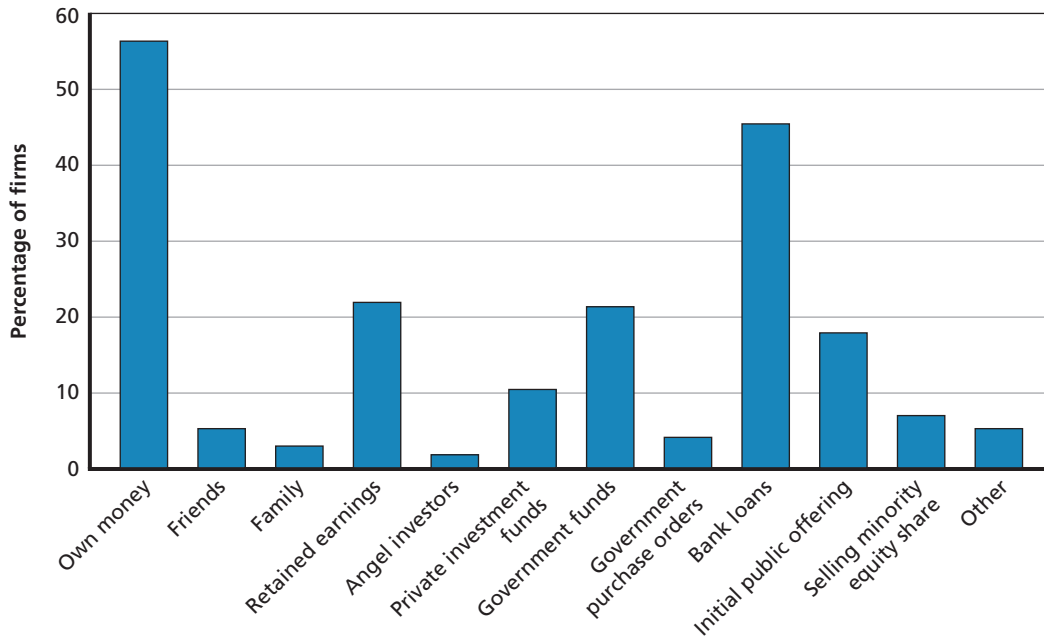
⁵ The three entities are China Science & Merchants Investment Management Co., Ltd, a nationwide capital management company headquartered in Beijing; Guangdong Airport Management Group; and GET.

Figure 8.3
Sources of Initial Funding



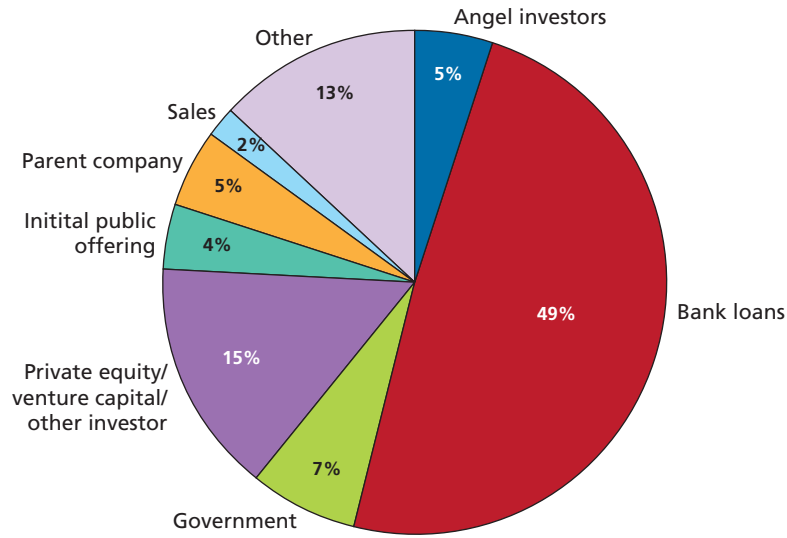
SOURCE: The GDD-RAND Knowledge City Project Survey.
 NOTES: Firms could give more than one answer to this question, so the total sums to more than 100 percent. Results are based on responses from 293 firms (out of 305 surveys received).
 RAND TR1293-8.3

Figure 8.4
Sources of Subsequent Funding



SOURCE: The GDD-RAND Knowledge City Project Survey.
 NOTES: Firms could give more than one answer to this question, so the total sums to more than 100 percent. Results are based on responses from 290 firms (out of 305 surveys received).
 RAND TR1293-8.4

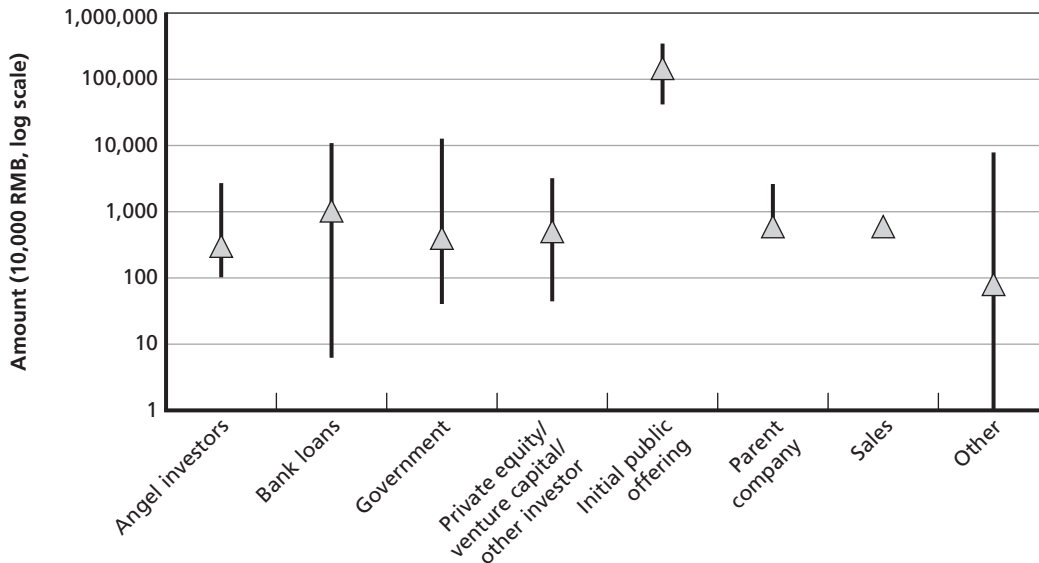
Figure 8.5
Sources of First-Round Outside Funding



SOURCE: The GDD-RAND Knowledge City Project Survey.
 NOTES: Results are based on responses from 75 firms (out of 82 that reported receiving outside funding, among a total of 305 surveys received). The “Other” category includes the following reported sources: “Britain,” “legal entity,” “loan guarantee,” “self,” and “friends.”

RAND TR1293-8.5

Figure 8.6
High, Low, and Median Amounts of Initial Outside Funding by Source



SOURCE: The GDD-RAND Knowledge City Project Survey.
 NOTES: High and low values are shown by the top of the lines, respectively. Median values are shown by triangles. Results are based on responses from 66 firms (out of 82 that reported receiving outside funding, among a total of 305 surveys received).

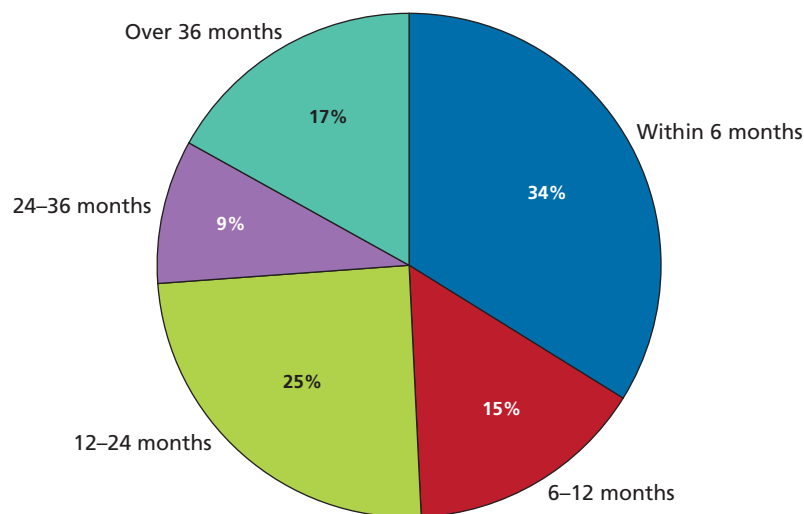
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Among firms that received outside funding, approximately one-third managed to secure outside funding within 6 months of founding; another 15 percent of firms received outside funding within one year; and nearly 20 percent secured outside funding more than three years after founding (Figure 8.7). Most of this funding was structured as collateralized loans or as equity participation by the investor (Figure 8.8).

Overall, our survey and interviews indicate that early-stage financing from outside the firm, particularly the lack of angel investors, may be a major challenge in GDD. Only 25 percent of firms received any outside funding at all. Among these firms, only 5 percent reported that their first round of outside funding came from angel investors, and fewer than 15 percent reported that their first round of outside funding came from venture capital funds, private equity funds, or similar types of investors. Bank loans appear to be the dominant source of outside funding.

Furthermore, the survey found that approximately 20 percent of firms received government funds in funding rounds after their first round (Figure 8.4). Approximately 35 percent of firms confirmed that GDD provides some sort of financial support (Figure 8.1).⁶ In Part I of this report, we noted GDD efforts to provide funding through GET Co. Ltd. and R&D grants. Nonetheless, it appears that obtaining additional funding is a key issue for the majority of firms. Nearly 50 percent of firms ranked increased government venture capital among the top three most important new policies GDD could provide, and 67 percent did the same for increased research funds (Figure 8.2).

Figure 8.7
Timing of First-Round Outside Funding

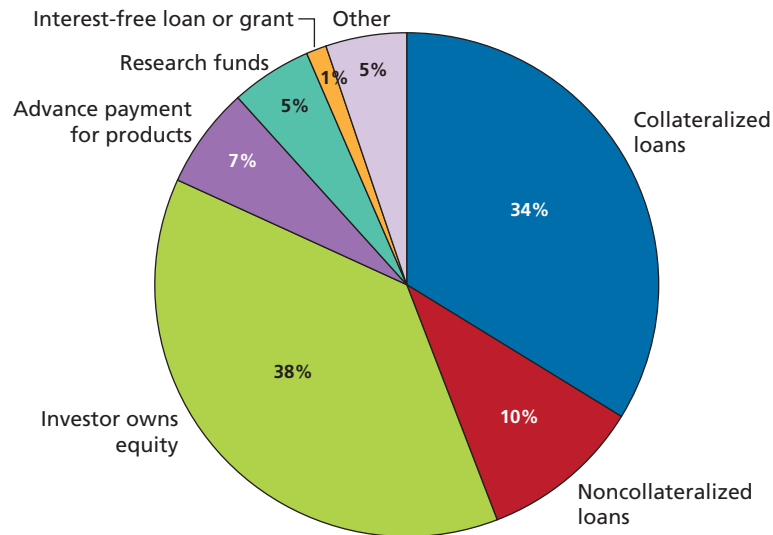


SOURCE: The GDD-RAND Knowledge City Project Survey.
NOTE: Results are based on responses from 65 firms (out of 82 that reported receiving outside funding, among a total of 305 surveys received).

RAND TR1293-8.7

⁶ The question about financing after the first round of funding asked whether the firm had received “government funds” in subsequent funding rounds, whereas the question about financing from GDD asked whether GDD “provide[d] financing”; these questions did not distinguish between specific types of financial support.

Figure 8.8
Structure of First-Round Outside Funding



SOURCE: The GDD-RAND Knowledge City Project Survey.
 NOTE: Results are based on responses from 77 firms (out of 82 that reported receiving outside funding, among a total of 305 surveys received).

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Our interviews suggest that, in contrast to these challenges, GDD's ability to supply cost-competitive land, office, and production facilities appears to be quite favorable for innovation. Similarly, in the survey, approximately 50 to 60 percent of firms in the survey indicated that GDD provides assistance with renting incubator space and buildings, leasing land, and providing preferential lease terms (Figure 8.1). Other economic zones in China may be able to provide similarly cost-competitive land and facilities. This type of asset is fairly easy to replicate, as we discuss at the end of Chapter Nine.

Gap Analysis

As with taxes, our review of the literature and the case studies indicate that although nontax incentives from local government may add some additional inducement in terms of attracting firms to GDD, they are unlikely to be a major factor in driving the formation of an innovation-based cluster. Even though nontax incentives may initially attract high-technology firms to an area, without other conditions, such as the availability of skilled labor and protection of IP, such firms are unlikely to survive and grow. The importance of anchor institutions (discussed in detail in Chapter Nine) suggests that to the extent that GDD has the resources to provide nontax incentives, it may be worthwhile to concentrate those benefits on a few key firms or organizations that could, in turn, attract other firms to Knowledge City.

Robust financing is an important component of a successful cluster. In GDD, the main gap appears to be in early-stage financing. Funding for research and commercialization can be conceptually divided into three stages: basic R&D funding, which generally covers technology creation; early-stage funding, during which a product is developed and in which angel investors often play a role; and later-stage funding, which may take a product through its early stages of commercialization, often with the help of a venture capital firm.

During the first stage, basic R&D funding is often provided by governments, although this often takes place at a national rather than a subnational level and is directed at research institutions rather than firms. In the United States, for example, the NIH and the National Science Foundation are two major sources of basic R&D funding. This funding is granted on a competitive basis and usually goes to major research universities or institutions, although there are programs to which small businesses can apply directly. Given the relatively large investment generally needed to fund this type of basic research, this stage of funding may not be appropriate for GDD.

The second stage, early-stage financing, is where the main gap in GDD appears to be located. This gap is not unique to GDD. For example, White, Gao, and Zhang (2005) argue that China's venture capital firms tend to fund late-stage, rather than early-stage, companies, and Benner, Liu, and Schwaag Serger (2012) argue that China has a "severe shortage of innovation funding, particularly for private firms and for SMEs [small and medium enterprises]."

Most high-technology firms in GDD that reported outside financing received bank loans; very few firms were financed by angel investors, who often fill the "valley of death" between R&D support and later-stage, venture financing. In the Guangzhou area, there appear to be few angel investors who are willing to invest in risky, early-stage companies in Guangzhou. GDD does provide some early-stage funding for companies, particularly R&D grants. However, our interviews suggest that although such funding is viewed as helpful, there are concerns among both entrepreneurs and individuals engaged in disbursing the grants. On the one hand, some entrepreneurs indicated that the amounts provided are insufficient to take an innovation to market, particularly for high-technology companies. Some entrepreneurs reported difficulty in obtaining funds, particularly when the funds are targeted at specific types of projects. On the other hand, individuals engaged in disbursing grants have commented on the lack of evaluation of this program. It was not clear from either entrepreneurs or grant-makers whether an innovation would have been developed even if the grant had not been made. It is also not clear whether the innovations that were developed generated sales commensurate with the grant support received by the company. In other words, we cannot confirm that the current policy generates a satisfactory rate of return in terms of sales of innovations.⁷

GDD may be able to help fill this gap by encouraging the formation of angel investor networks. Guangzhou has many successful, wealthy individuals who may be willing to invest in new firms but may not know how or where to find opportunities for investment.

The Maryland case study offers some suggestions for how GDD might facilitate such investment. In Maryland, both a state development agency (TEDCO) and a local university entrepreneurship center (the Dingman Center) have established angel investor groups. Once every few months, these organizations invite investors in their networks to attend a session, during which a selected number of companies pitch their ideas. The angels are typically successful local entrepreneurs but may also include wealthy individuals who do not have previous entrepreneurial experience.

Companies invited to pitch their ideas to the angel investors could be selected from among the high-technology firms in GDD. For example, TEDCO invites approximately 20 companies from its portfolio firms and from incubators to pitch their ideas to TEDCO officials and

⁷ A number of studies investigate more broadly whether the benefits of specific government policies exceed their costs (see, for example, Harrison and Rodriguez-Clare, 2009, for a review of studies that examine the costs and benefits of infant-industry protection policies).

selects the top 10 to address the angel group. Approximately 25 angel investors attend each meeting; companies have 10 minutes to explain their ideas, followed by a networking event. Our interviews with representatives of the Dingman Center indicate that angel investors in their network pay a small sum to be part of the group, since this allows them access to a constant flow of high-quality opportunities. GDD could set up such forums to provide a platform for angel investors and entrepreneurs to meet regularly. GDD could also hire advisors to educate entrepreneurs how to prepare presentations. Leaders in GDD would need to attend these meetings to underline their importance to potential investors. To draw on existing investment efforts, GDD could coordinate with GET to identify individual investors, arrange meetings, and select potential firms to present.

With respect to later-stage, venture financing, the evidence suggests that government-run venture funds have a relatively poor performance record. One exception may be the *Yozma* program initiated by Israel's government to jump-start its venture capital industry. However, it is important to note that 80 percent of the funds dedicated to that program were used to provide leverage for private venture capital firms, and that the program was privatized according to schedule within five years after its inception.

Overall, GDD's ability to supply cost-competitive land, office, and production facilities appears to be quite favorable for innovation, although other economic zones in China may also have this ability. However, GDD does not appear to have the full range of financing techniques available to it. Although it can make loan guarantees, it does not have the ability to make loans. Other financing avenues may be lacking as well. We find that the most important role for GDD may be in encouraging early-stage financing by helping to develop angel investor networks. In addition, nontax incentives geared toward attracting a few anchor institutions to GDD could help to attract other firms to the area.

Intellectual Property Rights

Lessons Learned from the Case Studies and the Literature

IPR and Innovation

In the literature on IPR, the most common view has generally been that protecting IPR facilitates innovation and investment in commercialization. However, a more recent strand of literature has found some evidence to support the "anti-commons" hypothesis, which suggests that IPR may inhibit the flow of information, and, by extension, future innovation (Murray and Stern, 2007, offer a summary of studies supporting these two opposing points of view).

More broadly, research has shown that weak IPR can have pernicious effects beyond directly harming innovators and innovation. First, weak IPR can affect the composition of foreign direct investment (FDI). Lee and Mansfield (1996) found that countries with weak IPR received lower levels of FDI from U.S. firms and that the FDI they did receive tended toward sales, distribution, and basic production and assembly facilities rather than more advanced processes. Smarzynska Javorcik (2004) found in an analysis of FDI into Eastern Europe and the former Soviet republics that weak IPR is associated with lower levels of investment in technology sectors that depend on IPR and more investment in distribution rather than local production. Second, weak IPR can affect the quality of international research alliances. Comune, Naghavi, and Prarolo (2011), who surveyed firms in nine countries, found that stronger IPR

are associated with a higher likelihood of involvement in a global innovation network involving the development of the innovations that are most important to the corporate network.

Some recent studies have examined the impact of IPR on investment in China in particular. Du, Lu, and Tao (2008) found that U.S. multinationals preferred to invest in Chinese regions with better IPR. There is also evidence that some foreign firms and venture funds operating in China change their patterns of behavior because of the threat of IP theft. For example, Keupp, Beckenbauer, and Grossman (2009) interviewed several wholly owned subsidiaries of foreign firms operating in China and documented several methods used by these firms to avoid IP theft, including increasing complexity to make imitation difficult, ensuring “de facto secrecy” by limiting access to information, building relationships with employees and officials, and educating consumers about imitators. Similarly, Quan and Chesbrough (2010) conducted a survey and case studies of multinational corporations in China and found that these firms tend to segment their R&D process to avoid IP theft; the authors pointed out that such segmentation can limit the amount of information and high-value-added processes that firms are willing to locate in regions with weak IPR.

In a related vein, Fuller (2010) studied venture investment in China and found that foreign venture funds were less likely to invest in technology-intensive firms than were foreign venture funds run by ethnic Chinese or “embedded in ethnic Chinese communities.” He argued that the reason for this discrepancy is the fact that most foreign venture funds are not used to operating in markets with weak IPR, whereas ethnic Chinese entrepreneurs have been exposed to such markets, particularly in Taiwan.

In our three case studies, the issue of IPR came up only tangentially. This is likely because the United States and Israel have relatively good IP protection. A 2011 report on IP, which considers protection of IPR, patent protection, and copyright piracy, ranks the United States third, and Israel twenty-third, out of 129 countries. China ranks sixtieth on this list (Jackson, 2011).

In summary, our findings suggest that poor enforcement of IPR can hurt innovation and efforts to move up the value-chain. This raises a particular concern for a region seeking to attract innovation-oriented foreign firms and venture capital funds. Such firms and funds may seek to limit the amount of information they share with local firms or employees, thus reducing informational spillovers; to invest in less technologically intensive firms; or to locate lower-value-added processes in a region with weak IPR.

Licensing from Universities

A related strand of the literature addresses the issue of how patent rights are distributed when research is funded by the government. One law that is often cited as having increased university patenting in the United States is the Patent and Trademark Amendments of 1980, otherwise known as the Bayh-Dole Act. In enacting this law, the federal government gave up its right to claim income from patents developed under federally funded grants. The empirical evidence on the effects of this law suggests that it was only one of several factors that may have increased university patenting. For example, Henderson, Jaffe, and Trajtenberg (1998) documented a sharp increase in university patenting after the passage of the law. However, they note that university patenting had already started to increase before the act’s passage but argued that the increase most likely could not have been sustained without this policy change. These authors also found that the quality of patents (measured by citations) declined after the act’s passage, although this finding was challenged by Sampat, Mowery, and Ziedonis (2003). Mowery et al. (2001) studied the patenting and licensing behavior of three universities before

and after the passage of the law and concluded that the Bayh-Doyle Act was only one of many factors related to the increase in university patenting and licensing. Other factors cited by Henderson, Jaffe, and Trajtenberg (1998) and by Mowery et al. (2001) include increased federal funding of biomedical research, increased industry funding of university research, an increase in university technology transfer offices, and court rulings and policy changes that made it easier to patent biomedical results.

More broadly, the literature on university spinoffs and IP rights suggests that allowing both universities and individual inventors to share some of the benefits from invention may be helpful in encouraging entrepreneurship. For example, Lockett, Wright, and Franklin (2003) surveyed technology transfer officers in 57 universities in the United Kingdom. They found that universities that had been most active in spinning out companies were less likely to create agreements in which either the university or the investor had no equity stake. In our case studies, we reviewed the distribution of IP rights at several major universities and found that all of them make an effort to divide royalties or equity among the inventor, the inventor's laboratory or department, and the university.

The specific division of equity and royalties differs among universities; there is probably no ideal division. With respect to royalties, for example, Di Gregorio and Shane (2003) point out that inventors can earn money either through licensing a product to an existing firm or through starting their own firms. Higher royalty payments to inventors may create an incentive for them to license their technology rather than start their own firms. These authors used a sample of 101 universities in the United States and confirmed that a higher minimum share of royalties received by the investor was associated with a lower startup rate.

Conditions in GDD

IPR in GDD is governed by the national IPR legal framework; there are no statutory differences between regions. The national framework includes the copyright law, the trademark law, the patent law, the unfair competition law, the copyright law implementing regulations, the trademark law implementing regulations, and the patent law implementing regulations.

Nationally, China's intellectual property registration rules are reported to be consistent with international rules (Herbert Smith, 2010). However, despite gains, enforcement remains a serious problem (Canadian Embassy in Beijing, 2010; McGregor, 2010; Suttmeier and Yao, 2011; Yang, 2003). In general, administrative enforcement action is preferred to litigation, although going to court is sometimes useful (Herbert Smith, 2010), suggesting that GDD can play an important role in enforcing IPR.

China has been remarkably successful at increasing patenting. In 2009, 68,307 China-origin patents were granted, the third-highest level in the world among countries, up from only 1,679 in 1995. However, these patents may not be up to international standards. Whereas in 2009, 39 percent of U.S.-origin patents were granted outside the United States, and 28 percent of Japan-origin patents were granted outside Japan, only 4.3 percent of China-origin patents were granted outside China (World Intellectual Property Organization, 2011). In addition, China has only two companies among the top 50 patenting through the Patent Cooperation Treaty (Japan has 15 and the United States has 13) and no universities among the top 50 universities using the Patent Cooperation Treaty (the United States has 31 and Japan has seven) (World Intellectual Property Organization, 2011).

The use of patented information is covered by the patent law, and non-patented technologies are protected from disclosure if they meet the criteria of trade secrets. Preventing employ-

ees from disclosing technology and business information is usually done through having them sign a confidentiality agreement or a noncompetition agreement.⁸

Discussions with GDD staff members indicate that GDD views intellectual property rights as important to innovation and the future success of Knowledge City. GDD officials have gone so far as to say that without protection, there will be no innovation. As a result, GDD and the Guangdong Intellectual Property Bureau set up a high-level IPR service center in Science City, an area that is jointly part of the Guangzhou High-Technology Industrial Development Zone and GDD, and will set one up in Knowledge City as well. The service center not only helps with patenting but can provide legal consulting should IPR be violated. However, the decision to go to court will rest with the company. Currently, going to court is rare; negotiation is the preferred method of settling IP disputes, although GDD staff members have said they would like to set up a specialized institute for mediation and arbitration.

GDD supports IP development through a variety of mechanisms, such as by subsidizing patent applications, providing grants to help with registering trademarks and brands, and offering grants to people participating in standards organizations.

Importantly, it also subsidizes intellectual property protection fees for patent infringement—30 percent of the total cost, up to 30,000 RMB (Shen, 2011). We do not have enough information to judge whether this amount is enough to effectively help combat patent infringement.

GDD entrepreneurs generally echoed GDD staff members in their views of IPR. Those with whom we discussed the issue said that they were active in patenting and that patents were important, but that punishments for violators were generally weak and pursuing cases of intellectual property theft or other violations through courts was expensive and time-consuming. As a result, companies take preventive steps, such as limiting access to intellectual property or monitoring employees. These steps may be more costly than would be necessary under a stronger IPR protection system.

Several entrepreneurs discussed their individual experiences with IPR. One entrepreneur in the biotechnology industry reported that although he was not particularly concerned about IPR given the difficulty in replicating his firm's technology, his colleagues at software and information technology firms do complain about the difficulty of enforcing patents and protecting their intellectual property. An entrepreneur in the software industry said that employees are required to sign nondisclosure and security agreements and that Internet access, email attachments, and the use of laptops and universal serial bus (USB) devices are controlled.

From the point of view of foreign businesses, IPR protection in China is getting better. The laws on IPR in China are viewed as sufficient, but companies still need to find ways to protect themselves. One of the biggest problems is employees leaving with company secrets; noncircumvention, noncompete clauses are also hard to enforce, and penalties are low.

Results of the GDD-RAND Knowledge City Project Survey support the statements of GDD officials and entrepreneurs. The patenting process in China appears to be relatively simple and efficient; 83 percent of survey respondents indicate that they patent their innovations to protect them (Figure 8.9). However, our interviews suggested that enforcing patents and otherwise protecting IPR remains a challenge, particularly for firms in industries such as software.

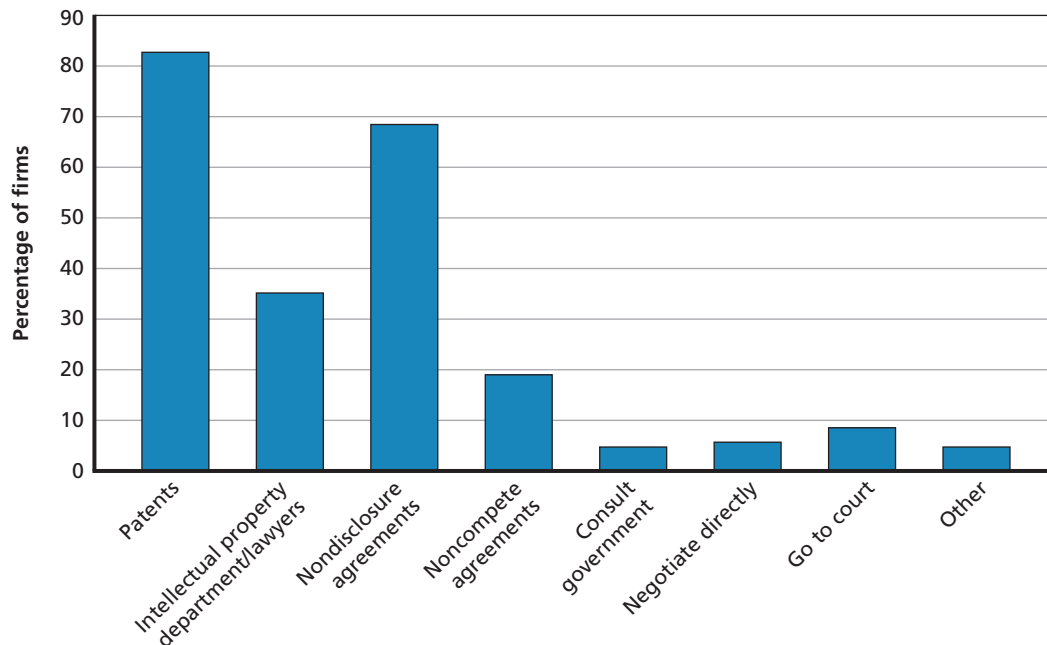
⁸ Communication from GDD Policy Research Office, April 2011.

Several studies have documented that although China has improved its legal IPR framework, many firms find it difficult to enforce their IPR in China (see, among others, Keupp, Beckenbauer, and Grossman, 2009; Quan and Chesbrough, 2010). However, GDD has already taken steps to help with patenting and enforcing patents, including setting up the high-level IPR service center in Science City, mentioned above. Currently, only 4 percent of firms in the survey reported that they consult government if their patents are infringed on (Figure 8.9), although 40 percent indicated that GDD administration does help to enforce IPR or patent rights (Figure 8.1), and 80 percent indicated that it was easy to obtain services related to IPR (Figure 9.10, below). Nine percent of firms indicated that they would resolve such issues in court, and 6 percent indicated that they would negotiate directly with the entity that used their innovation.

Gap Analysis

Our research suggests that protecting IPR is a crucial component in attracting high-value-added activities, as well as investment and international collaboration in such activities, particularly in industries such as software development in which IP theft is relatively easy. The patenting process in China is fairly simple and efficient, but enforcing patents and otherwise protecting IPR remains a challenge, particularly for firms in industries like software. While intellectual property law is set at the national level, GDD has already taken steps to help with patenting and enforcing patents. For example, we were told that entrepreneurs found seminars arranged by GDD on how to apply for patents helpful. There may be room to enhance some

Figure 8.9
How GDD High-Technology Firms Protect IP



SOURCE: The GDD-RAND Knowledge City Project Survey.

NOTES: Firms could give more than one answer to this question, so the total sums to more than 100 percent. Results are based on responses from 301 firms (out of 305 surveys received).

RAND TR1293-8.9

of GDD's assistance programs in this area, particularly to assist firms facing potential patent infringement.

We see a potential opportunity for GDD if it can become a zone of strict IPR enforcement, aggressively helping GDD companies protect their IPR throughout China and letting it be known that top innovators in China and abroad will have their rights protected if they locate in GDD and, more specifically, Knowledge City. GDD may also wish to provide additional incentives to encourage companies to apply for international patents.

Our research on university IP practices indicates that allowing both universities and individual inventors to share the financial rewards from invention is likely to be helpful in promoting commercialization of technologies developed at universities. The exact division of royalties and equity rights may influence whether inventors tend to start their own companies or to license their technology. Many top research institutions make their policies public; in Part II, we briefly summarize the key policies from Stanford University, the University of California, Berkeley, and the University of Maryland. Such policies could serve as a guide for GDD.

Lessons Learned from the Case Studies: Other Issues

In this chapter, we address a number of other issues that are important in cluster formation: human capital, infrastructure and business climate, networks, quality of life, and marketing. As in the previous chapter, we present lessons learned from other clusters, summarize conditions in GDD, and conduct a gap analysis for each issue.

Human Capital

Lessons Learned from the Case Studies and the Literature

Concentration of labor with particular skills has been shown to be an important factor in explaining agglomeration in the United States (Ellison, Glaeser, and Kerr, 2010). Other studies in the United States support the link between the labor pool and entrepreneurship more broadly. For example, Doms, Lewis, and Robb (2010) show that regions with higher levels of education have higher entrepreneurship rates. Kerr and Lincoln (2010) demonstrate the importance of immigrants by showing that less restricted admittance to the United States under a visa program targeted at scientists and engineers was linked to increased immigrant science and engineering employment as well as to inventions by scientists with Indian and Chinese surnames in the United States.

Sources of Skilled Labor

One key source of skilled workers—universities—may also play a role in cluster formation and entrepreneurship. Local universities are seen as important for the formation of a number of clusters including Silicon Valley, Boston's Route 128, and the United Kingdom's Cambridge high-technology cluster (Athreye, 2004; Porter, 1998; Saxenian, 1994). Although it is difficult to quantify the effect of universities in cluster formation or development, several studies have attempted to gauge the effect of university R&D on the local or regional economy. Results generally suggest a positive, although potentially small, effect. For example, Gompers and Lerner (1999) found that both industrial spending and academic R&D spending were correlated with higher venture capital. Jaffe (1989) and Anselin, Varga, and Acs (1997) show that university research increased local innovative activity. Although Woodward, Figueiredo, and Guimaraes (2006) show that university R&D funding was associated with new high-technology plant births, they noted that the effects were small. Lester (2005) found that often, the most important contribution a university can make to an area is through its core function of education. Universities can also contribute by transferring their discoveries to local firms, by adapting knowledge created elsewhere to local conditions, and by attracting new human, knowledge, and financial resources. However, the nature of their contribution depends heavily on the type

of innovation occurring in an area—new industry formation, industry transplantation, industry diversification, or industry upgrading.

In each of our three case studies, one common factor that helped to start and foster the development of the cluster was an existing pool of high-skilled labor. Many other case studies of high-technology clusters have also documented the importance of highly skilled labor, improvements in education, and investment in public research (see, among others, Arora, Gambardella, and Torrasi, 2004; Athreye, 2004; Saxenian, 2004; Yamamura, Sonobe and Otsuka, 2003).

However, the main source of highly skilled labor was different in each of our case studies. In the case of Silicon Valley, Stanford University and the University of California, Berkeley, provided a steady stream of skilled engineers and managers. The Maryland case study illustrated that a top national research university in the immediate area is not necessary for high-technology cluster formation. Highly skilled workers came from the NIH and other federal laboratories and agencies, as well as from associated private contractors. In the case of Israel, the country has relatively high levels of education. Building on this base, the IDF places emphasis upon knowledge, learning, and initiative. Many of the top inductees receive training in the intelligence- and technology-oriented units, resulting in cohorts of highly skilled workers. Later in the evolution of the cluster, multinational corporations, such as Intel and Microsoft, provided a pool of skilled workers.

In each of our case studies, immigration as well as home-grown institutions played an important role in providing skilled labor. In Silicon Valley, immigrants constitute a large share of the science and engineering workforce and a growing proportion of entrepreneurs (Saxenian, 1999). In Maryland, nearly 80 percent of the local population was born outside the state (United States Census Bureau, 2005–2009), and our interviews indicate that immigration to the local area is a major source of skilled labor. In Israel, the nearly one million former Soviet immigrants who arrived during the 1990s provided a large pool of highly skilled labor that helped to fuel the growing ICT boom (de Fontenay and Carmel, 2004).

Diaspora communities can also help in cluster formation. Interviews for our case study of Israel indicated that Israeli national connections in Silicon Valley and other parts of the United States were important in attracting multinational corporations to Israel. Saxenian and Hsu (2001) argued that the Taiwanese-born, U.S.-educated engineers who form a link between Silicon Valley and Taiwan were to a large extent responsible for the success of Taiwan's Hsinchu cluster.

Overall, our research suggests that a pool of high-skilled labor is critical to the formation of high-technology clusters. Excellent local universities are one source, but not the only potential source, of such labor.

Labor Mobility

Labor mobility is one way that skills can spread and the level of human capital can be increased. Job changes by talented individuals who see a better opportunity can result in information spillovers—the sharing of specialized knowledge learned at one company with another. Labor mobility does bring challenges regarding IPR, however. On the one hand, the movement of employees between firms can help promote information spillovers; on the other hand, employers may be concerned that employees may take trade secrets as well as accumulated human capital to competitors. One way in which many firms attempt to protect their IP is by requiring that employees sign nondisclosure and noncompete agreements.

As noted in the case studies, Silicon Valley in particular is known for its high rates of labor mobility (see, among others, Almeida and Kogut, 1999; Fallick, Fleischman, and Rebitzer, 2006). This high rate of labor mobility played an important role in encouraging knowledge spillovers in Silicon Valley, and one reason for the high rate of labor mobility is that California does not allow the enforcement of noncompete clauses (Saxenian, 1994; Gilson, 1999). However, trade secret law in California prohibits employees from disclosing an employer's firm-specific trade secrets, although employees can still take their "general and industry-specific human capital" (Gilson 1999). In Israel, although labor mobility among firms has been low, the lack of noncompete clauses between the military and its former members may have contributed to the formation of the technology cluster there. Individuals in the IDF were free to re-form working groups once they returned to civilian life and to work on problems similar to those they pursued in the IDF (de Fontenay and Carmel, 2004).

The broader empirical evidence generally confirms the view that areas that restrict the enforcement of noncompete clauses have higher labor mobility and higher rates of entrepreneurship. For example, beyond our three case studies, Marx, Strumsky, and Fleming (2009) used a change in Michigan's policy on enforcing noncompete clauses to show that enforcing such contracts did limit labor mobility, particularly for inventors with specific technical or firm-related skills.

With respect to broader issues of entrepreneurship and firm performance, the results are mixed. Stuart and Sorenson (2003) document that regions that do not enforce noncompete clauses had more biotech entrepreneurship after an acquisition or IPO in the industry. Similarly, Samila and Sorenson (2011) showed that in regions that did not enforce noncompete clauses, venture capital investments were associated with larger increases in the number of patents, firm starts, and employment. Garmaise (2009) showed that states that did not enforce noncompete agreements had more mobility among executives, higher executive compensation, and higher capital expenditures per employee. However, he did not find any relationship between enforcement and two key measures of firm performance: market-to-book ratios and profitability. In addition, he reported mixed results with respect to the effects of enforcement on R&D investment.

Conditions in GDD

Sources of Skilled Labor

GDD has a number of policies aimed at attracting talented workers. One program aims to attract selected overseas returnees, who receive a number of incentives from GDD, including money for starting a company; free or subsidized rent for the company; access to facilities such as conference rooms, faxes, and printers; and even subsidized housing and school fees.

GDD has also established a "100 leading talents" policy to attract 100 highly skilled workers from across the globe. GDD aims to provide up to 15 million RMB in grants, subsidies, and funds to each selected individual. Special benefits include free rent or a purchase subsidy for a residence, help in finding jobs for relatives, and overseas travel subsidies. The national government has a "1,000 talents plan" to attract 1,000 highly skilled workers from around the globe. As of February 2012, 15 people in GDD are listed in the central government's "1,000 talents plan." GDD provides extra benefits for these people (Shen, 2011).

Apart from these highly skilled workers, GDD aims to recruit technical talent more broadly. GDD now has attracted a number of talented workers, including two academicians in the Chinese Academy of Science, nine experts who enjoy special allowances from the State

Council, 15 national “1,000 talents plan” winners, eight Guangzhou excellent experts, and 20 GDD S&T leading experts. GDD also has 2,000 returnees who have founded 700 companies. More broadly, the average educational level in Guangzhou has been steadily rising (Shen, 2011).

GDD entrepreneurs with whom we met noted that GDD rewards for top talent have proven helpful, particularly in attracting returnees. Although interviewees noted that Guangdong Province has a number of colleges and universities, they also indicated that Guangdong would benefit from more top-tier educational institutions and high-technology talent, including qualified postdoctoral students. Several entrepreneurs mentioned various programs and policies to attract leading talent, particularly returnees, from other parts of the world. GDD’s policies of providing free incubator space and subsidized housing for leading talent were cited as advantageous. One entrepreneur commented that GDD’s fund for employee training is more targeted than the national Ministry of Commerce’s fund, so that GDD funds can be used only for specific types of training efforts or projects.

Beyond specific GDD policies, Knowledge City may have a number of other advantages regarding human capital and talent. Guangzhou has a very high level of school enrollment. Our interviews and surveys suggest that employers find it easy to recruit and train technical workers. In many cases, these come from local universities, including Sun Yat-Sen University and South China University of Technology. In addition, Guangzhou and Guangdong Province are the origin of a large number of Chinese expatriates. As discussed above, expatriate entrepreneurs have proven valuable for igniting domestic innovation in other regions.

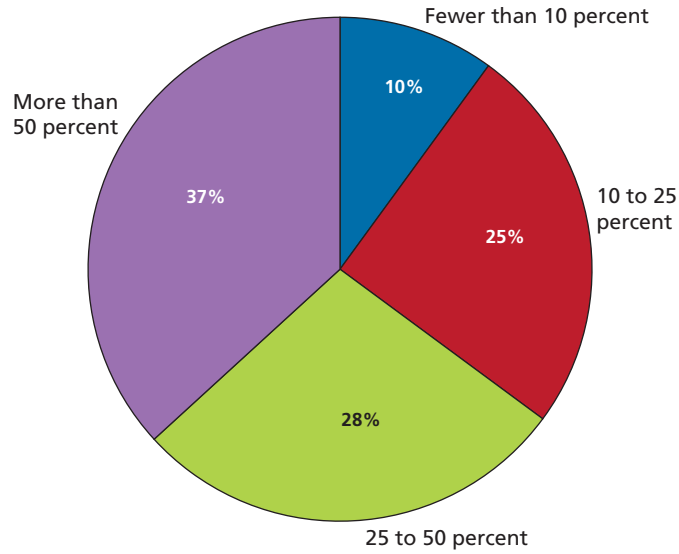
The GDD-RAND Knowledge City Project Survey results indicated that in approximately one-third of firms, the majority of the workforce has a science or engineering bachelor’s degree or above (Figure 9.1). Fewer employees have management degrees (Figure 9.2); in nearly 90 percent of firms, less than a quarter of the workforce has a college-level management degree or MBA. Over 80 percent of firms have at least one worker with a master’s degree, and 50 percent of firms have at least one worker with a Ph.D. The survey also indicated that in approximately one-quarter of firms, the majority of employees have a degree from a technical secondary school or junior college (Figure 9.3).

Recruiting seems to be tilted more toward universities than technical schools. Nearly 60 percent of firms surveyed recruit on university campuses, and 25 percent recruit at technical schools, suggesting that employers are likely able to find qualified graduates for most jobs (Figure 9.4). However, on-campus recruiting is not the most common method of recruiting: Rather, 65 percent of firms recruit at job fairs, and 73 percent of firms use advertisements.

Most employers recruit within Guangzhou (80 percent), elsewhere in Guangdong Province (74 percent), and in southern or central China (58 percent) (Figure 9.5). Fewer employers recruit from other major urban areas such as Beijing or Shanghai (16 percent) or Hong Kong, Taiwan, or Macao (9 percent). Some firms also make an effort to recruit Chinese expatriates (15 percent) and foreigners (4 percent). These findings are consistent with our interviews, during which some firms indicated that their top recruits from other cities in China were less likely to remain in Guangzhou than were local recruits.

During our interviews, some people expressed a concern that Guangzhou does not have the best universities in China. This may indeed be a problem for jobs that require the most advanced skills, but most firms in GDD report that they are able to find qualified staff. Eleven percent of survey respondents indicated that they could find technical staff in Guangzhou (including GDD) qualified to work immediately, and another 73 percent indicated that they

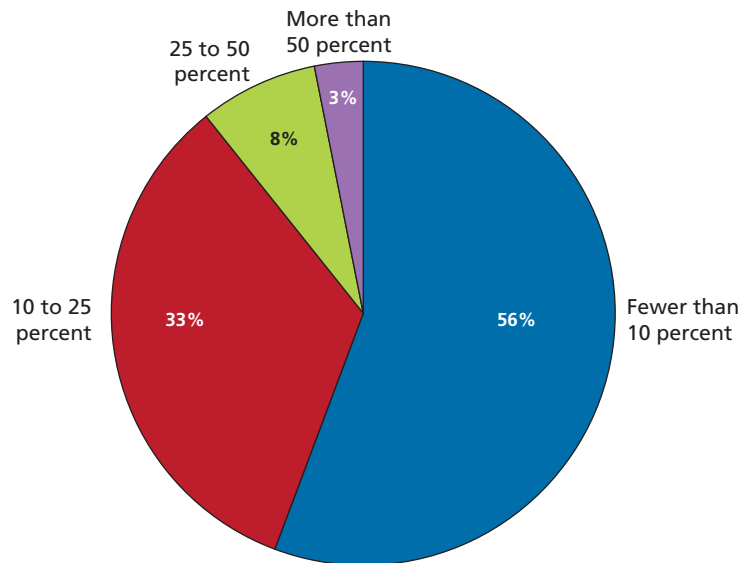
Figure 9.1
Share of Employees with a Science or Engineering Bachelor's Degree or Above



SOURCE: The GDD-RAND Knowledge City Project Survey.
 NOTE: Results are based on responses from 299 firms (out of 305 surveys received).

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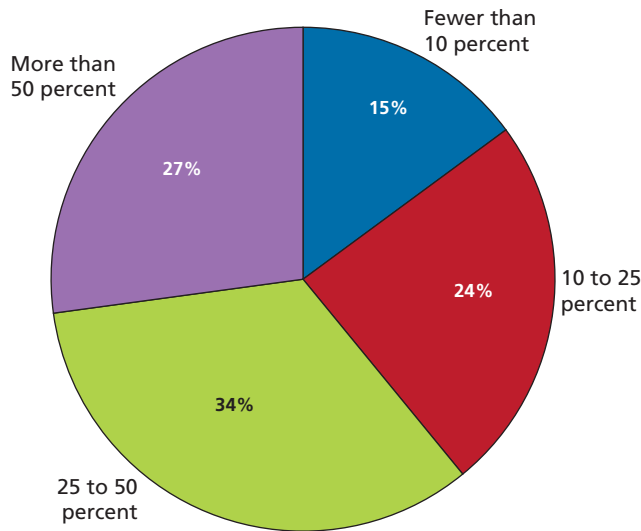
Figure 9.2
Share of Employees with a Management Degree



SOURCE: The GDD-RAND Knowledge City Project Survey.
 NOTE: Results are based on responses from 289 firms (out of 305 surveys received).

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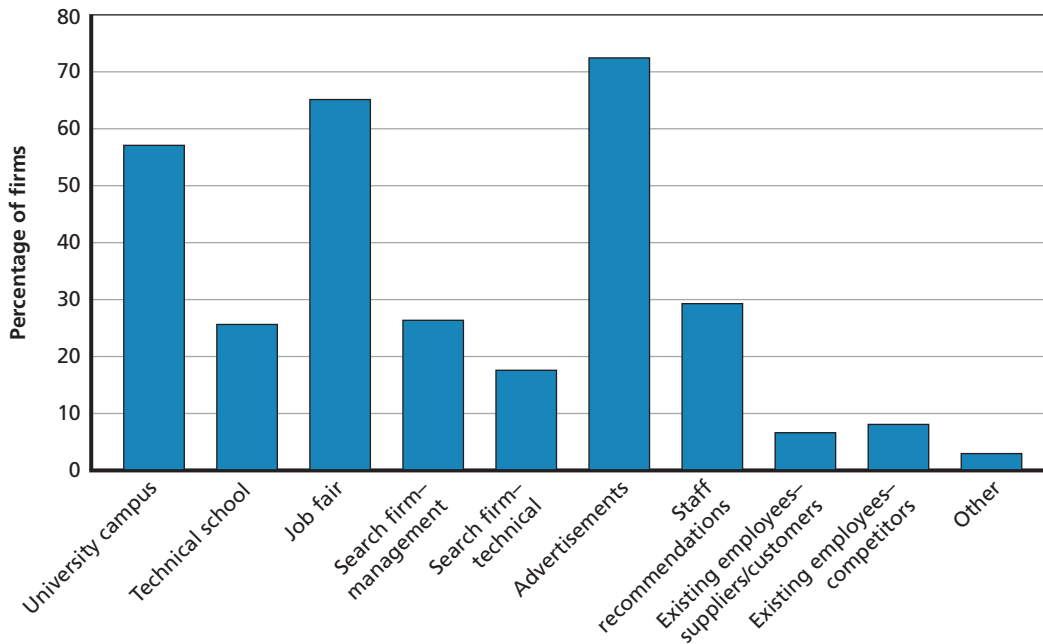
Figure 9.3
Share of Employees with a Technical School or Junior College Degree



SOURCE: The GDD-RAND Knowledge City Project Survey.
NOTE: Results are based on responses from 302 firms (out of 305 surveys received).

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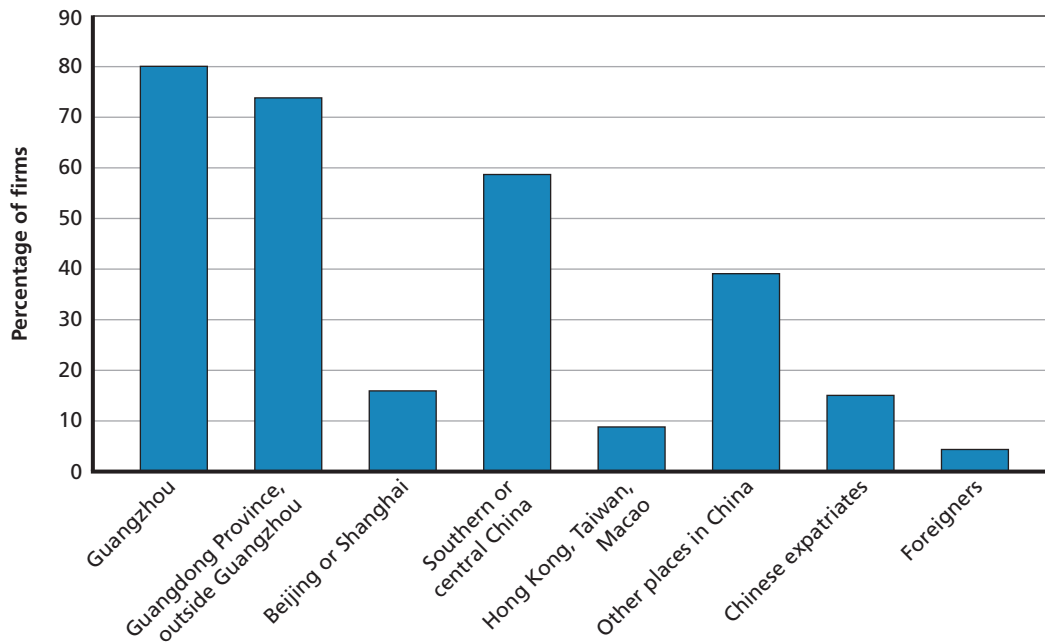
Figure 9.4
Recruiting Venues



SOURCE: The GDD-RAND Knowledge City Project Survey.
NOTES: Firms could give more than one answer to this question, so the total sums to more than 100 percent. Results are based on responses from 300 firms (out of 305 surveys received).

RAND TR1293-9.4

Figure 9.5
Recruiting Locations



SOURCE: The GDD-RAND Knowledge City Project Survey.

NOTES: Firms could give more than one answer to this question, so the total sums to more than 100 percent. Results are based on responses from 303 firms (out of 305 surveys received).

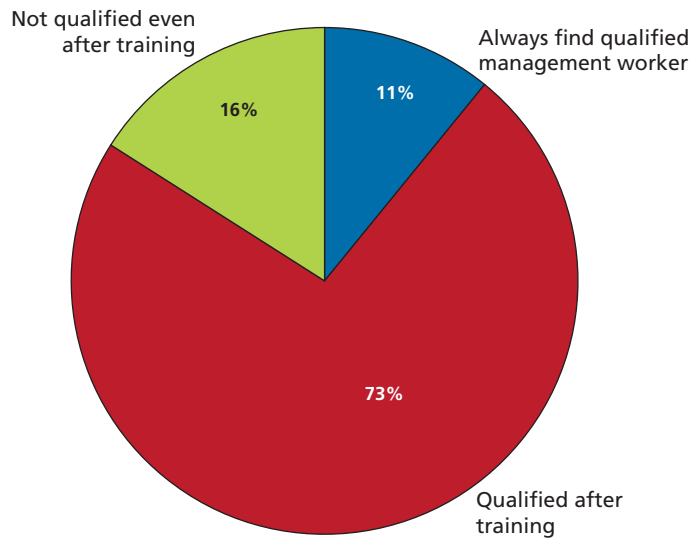
RAND TR1293-9.5

could find technical staff qualified to work after training. However, the remaining 16 percent indicated that they were not able to find local technical staff who were qualified to work even after training (Figure 9.6). The inability to find qualified staff did not seem to be concentrated in one particular industry. Similar numbers were reported for finding qualified management staff (Figure 9.7). One possibility is that these firms are seeking staff with very specific qualifications. For example, one interviewee told us that his firm could not find qualified postdoctoral fellows in Guangzhou—or in China for that matter—who were capable of conducting advanced research. The firm relied on their U.S. affiliate to conduct this research as they found it easy to recruit postdoctoral researchers in the United States, whereas postdoctoral students are relatively rare in China, are expensive to hire, and are of lower quality. Similarly, another interviewee mentioned that the company for which she worked, even though headquartered in GDD, set up its research laboratory in Shanghai because the head researcher that they had recruited preferred to live there. The interviewee also argued that it was easier to recruit high-quality, scientific research staff in Shanghai than in Guangzhou.

The three most common reasons cited for difficulty in recruiting staff were salary, commuting time, and reluctance to live in GDD. The most common difficulties cited for retaining staff were salary, commuting time, and housing prices. We discuss these issues in more detail below.

GDD's policies to subsidize incubator space and housing for leading talent were mentioned as advantageous during our interviews but have not been sufficient to overcome the challenge in recruiting or retaining a highly skilled workforce. In the survey, 40 percent of

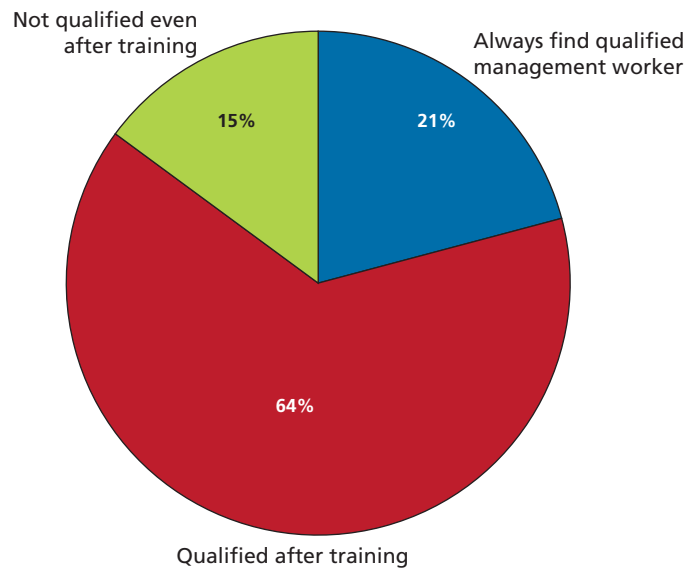
Figure 9.6
Ability to Find Qualified Technical Staff



SOURCE: The GDD-RAND Knowledge City Project Survey.
NOTE: Results are based on responses from 294 firms (out of 305 surveys received).

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Figure 9.7
Ability to Find Qualified Management Staff



SOURCE: The GDD-RAND Knowledge City Project Survey.
NOTE: Results are based on responses from 302 firms (out of 305 surveys received).

RAND TR1293-9.7

firms listed help with recruiting and training talent among the top three most important policies GDD could institute (Figure 8.2).

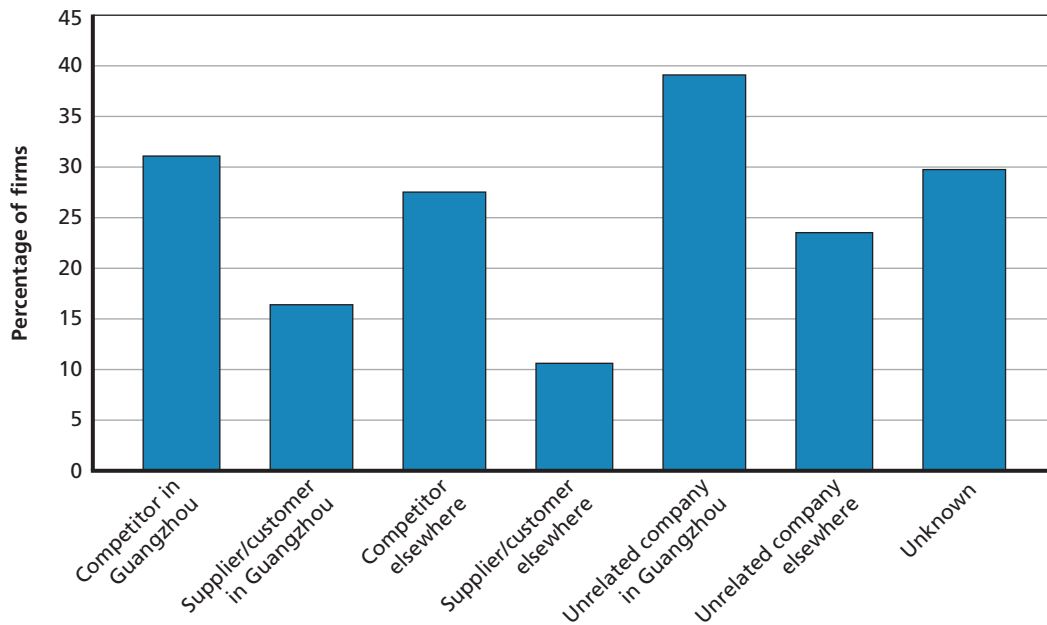
Labor Mobility

Survey evidence indicates that there is labor mobility between high-technology firms in GDD. Figure 9.8 shows that the most frequently mentioned of the top destinations for employees who leave a high-technology firm in GDD are unrelated companies in Guangzhou (39 percent), competitors in Guangzhou (32 percent), and competitors in another part of China or abroad (28 percent). The fact that such a large fraction of employers report competitors among the top two destinations of former employees suggests that there are likely to be information spillovers from employee movements, although only some of those spillovers are confined to the local area. Horizontal spillovers—movement of employees to competing companies—appear to be more common than vertical spillovers—movement of employees to suppliers or customers—although 16 percent of employers report that suppliers or customers in Guangzhou are among the top two destinations for employees.

Labor mobility does not appear to be a concern for most employers in the survey. More than 70 percent indicated that it would be acceptable for an employee to leave and work for a competitor, and more than 85 percent reported the same for a supplier or customer. Similarly, more than 80 percent of employers reported that they would hire employees who had previously worked for competitors, suppliers, or customers.

However, GDD employers do make an effort to protect their IP when employees change jobs. Nonpatent information in GDD companies is often protected through the use of non-

Figure 9.8
Top Two Destinations of Former Employees



SOURCE: The GDD-RAND Knowledge City Project Survey.
 NOTES: Firms could give up to two answers to this question, so the total sums to more than 100 percent. Results are based on responses from 284 firms (out of 305 surveys received).

disclosure or noncompete clauses in employment contracts, although our interviews suggest that these may also be difficult to enforce. Nearly 70 percent of survey respondents indicated that their employees have to sign nondisclosure agreements, and 20 percent reported that their employees have to sign noncompete agreements (Figure 8.9).

Gap Analysis

Our analysis of the literature and our case studies indicate that a pool of highly skilled labor is critical to the success of an innovation-based cluster. Overall, it appears that firms in GDD are able to find most of the talent they need within Guangzhou or Guangdong. Employers have reported that it is easy to recruit and train technical workers. In many cases, these come from local universities, including Sun Yat-Sen University and South China University of Technology. However, our interviews suggest that the lack of postdoctoral candidates from top universities and of research leaders with experience in leading teams doing cutting-edge innovation remains a serious challenge for GDD. This challenge is not unique to GDD: Our interviews with government officials indicate that although the Guangzhou government had a number of applicants for its grants for leading talent, few applicants met the award criteria. GDD's policies to subsidize incubator space and housing for leading talent were mentioned as advantageous but have not been sufficient to overcome the challenge of recruiting or retaining a highly skilled workforce.

Guangdong's large, expatriate population should provide a way to help fill that gap. GDD has already had some success in recruiting Chinese expatriates who have developed their research skills abroad through its "100 leading talents" program. Our review of the literature on the success of the Hsinchu cluster in Taiwan indicates that an influx of returnees who had been educated abroad and trained in Silicon Valley played a critical role in the cluster's success. In addition, many of the knowledge spillovers between Hsinchu and Silicon Valley occurred because these returnees frequently traveled between the two regions, helping to promote collaboration between the two clusters (Saxenian and Hsu, 2001).

Saxenian and Hsu (2001) also pointed out that many of the expatriate engineers who traveled between Silicon Valley and Hsinchu left their families in California, given its "lifestyle advantages." During our interviews in GDD, we heard that some expatriates prefer to leave their families in the United States because of the differences in housing, lifestyles, and educational systems between the United States and China. To the extent that being separated from one's family poses a challenge in attracting foreign talent, GDD may be able to mitigate that challenge by seeking to provide amenities associated with a higher quality of life, including more diverse, excellent educational opportunities, in Knowledge City.

GDD does not appear to have any major challenges in the area of labor mobility: Most survey respondents indicated that it is easy for employees to move between firms; that it would be acceptable for an employee to leave and work for a competitor, supplier, or buyer; and that they would hire employees who had previously worked for competitors, suppliers, or customers.

However, this high level of labor mobility suggests another reason for GDD to strengthen IPR. Most of the literature on labor mobility is based on findings from the United States, where IPR protection is strong. Our case studies were conducted in the United States and Israel, which also has strong IPR enforcement. Firms' trade secrets are therefore protected even when employees leave and take their industry-specific human capital with them. Given the apparent acceptance of labor mobility in GDD, it is even more important to ensure that IPR enforcement is strong so that firms' trade secrets are not divulged by former employees.

Infrastructure and Business Climate

Lessons Learned from the Case Studies and the Literature

A number of commentators have argued that one of the most important initiatives governments can take to promote cluster formation and growth is to improve the overall business conditions for all firms, for example, by protecting IPR, developing infrastructure, investing in a skilled labor force, or lowering the cost of starting a firm (see, among others, Hospers, Sautet and Desrochers, 2008; Porter, 1998). Our case studies provide some support for this hypothesis. Silicon Valley provides somewhat mixed evidence: Although California's business climate is generally ranked poorly in terms of taxes, it scores highly on other measures such as productivity and quality of life (Kolko, Neumark, and Mejia, 2011). In Maryland, the decision of Human Genome Sciences to locate in Montgomery County (see Appendix A) was facilitated, in part, by county officials' willingness to make the permitting process easier. Our interviews suggest that in Israel, reforms of the 1980s and 1990s, which liberalized the economy and shifted it toward a more private sector focus, were important prerequisites for the subsequent ICT boom.

The evidence from other clusters around the world, as well as from the general literature on business climate and entrepreneurship, supports these findings. For example, Arora, Gambardella, and Torrisi (2004) argue that in the case of India, public policy did not play a critical role in actively promoting ICT cluster development. However, these authors pointed out that the government did assist in creating an overall business climate conducive to cluster formation through measures such as infrastructure creation, economic liberalization, looser listing requirements, and favorable tax treatment of exports and options. More broadly, Da Rin, Nicodano, and Sembenelli (2006) used data from 14 European countries to show that a number of government policies aimed at improving the business climate—the opening of stock markets targeted at entrepreneurial companies, reductions in capital gains taxes, and reductions in labor regulations—were linked with an increased share of high-technology and early-stage venture investments. Their work on labor regulations was corroborated by other studies illustrating that labor market rigidities were associated with less venture capital or private equity investment in certain circumstances (Bozkaya and Kerr, 2009; Jeng and Wells, 2000).

Beyond the improvement in business conditions, demand has been important in cluster formation. Bresnahan and Gambardella (2004) reviewed evidence on clusters in Israel, India, Ireland, and Taiwan and noted that all of them had access to a large market (the United States and the European Union in these cases). Moreover, each of these clusters took advantage of a new market opportunity that had not previously been addressed by existing, large producers. Their focus on new markets and technologies allowed them to offer complementary, rather than competing, products and services and to take advantage of growing demand.

Although the government did not play a significant role on the supply side of the development of the cluster in Silicon Valley, it did assist on the demand side, particularly during the early years of cluster formation. The federal government was one of the largest, often the largest, purchaser of much of the equipment developed by Silicon Valley firms before, and during, World War II. After the war, purchases by the government decreased. Many of the firms then created or discovered commercial applications for technology that had been developed for military use (Leslie, 2000).

In Maryland, the local government played a more active role in the formation of the cluster than governments did in Silicon Valley. It provided inexpensive land for the Life Sci-

ences Center business park during the 1980s, and it offered the opportunity to issue bonds at subsidized interest rates. However, during the formation of the cluster, it did not offer many of the other incentives, such as financing and training, that it now provides. As in the case of Silicon Valley, the federal government (through the NIH) played a critical role as a purchaser of services from life science firms in the area.

Israel's government played a more active role in the formation of its cluster through developing the *Yozma* venture capital funds, offering tax incentives, and creating incubators. Our interviews indicate that the Israel Defense Force was not only a source of technological innovation but also a purchaser of technology developed in the private sector.

Conditions in GDD

GDD has a number of important assets related to infrastructure and the business climate. Guangzhou has historically been a center of global commerce for China and, as such, has been open to new ideas and foreign investment. GDD's reputation for fast growth was mentioned by entrepreneurs as a major asset. Hand-in-hand with its global position, GDD has access to excellent transportation infrastructure (including both airports and seaports) both in Guangzhou and nearby in the inner Pearl River Delta region, allowing quick connectivity to Southeast Asia and good connections with all major markets in the world. Guangzhou and GDD also have excellent infrastructure for intra-regional transportation.

Not only does GDD have access to global markets, but the nearby domestic market, including Hong Kong, is large. GDD was praised for having an extensive supplier base, as well as inexpensive support services such as lawyers and accountants. More broadly, at least one experienced China investor praised Guangzhou as one of the few places in China with a strong cohort of career managers—people who do not necessarily aspire to own their own businesses but are expert at managing businesses. Although some entrepreneurs mentioned that it was difficult to find local suppliers and that marketing channels were complicated, several interviewees mentioned GDD policies that have helped them to build their supplier, buyer, and support networks. Specific advantageous policies that were mentioned include arranging seminars by outside experts on such issues as patents and funding applications, providing information about other companies in the area, and offering help in finding local suppliers.

This global market orientation has been accompanied by local governments (GDD, Guangzhou, Guangdong Province) that are reported to be flexible and responsive in dealing with businesses, especially in comparison with other local governments in China. GDD government's services include providing "one-stop" services, "green channel," and "entrepreneur assistant" services for startup companies for one to two years. We were told that GDD's process for registering a firm was simple and efficient.

These assets have helped GDD develop a strong manufacturing base that has mastered the art of exporting and is now engaged aggressively in serving the domestic market and practicing incremental innovation—continuous improvement in the operation of the economy or an industry—a fact that policymakers will need to take into account when planning innovation policy. For example, representatives in one industry group indicated in our interviews that they had recently collaborated with a university to increase the productivity of one part of its manufacturing process. Another interviewee noted that companies in Guangzhou and South China have become adept at tailoring their products for different local market niches in China.

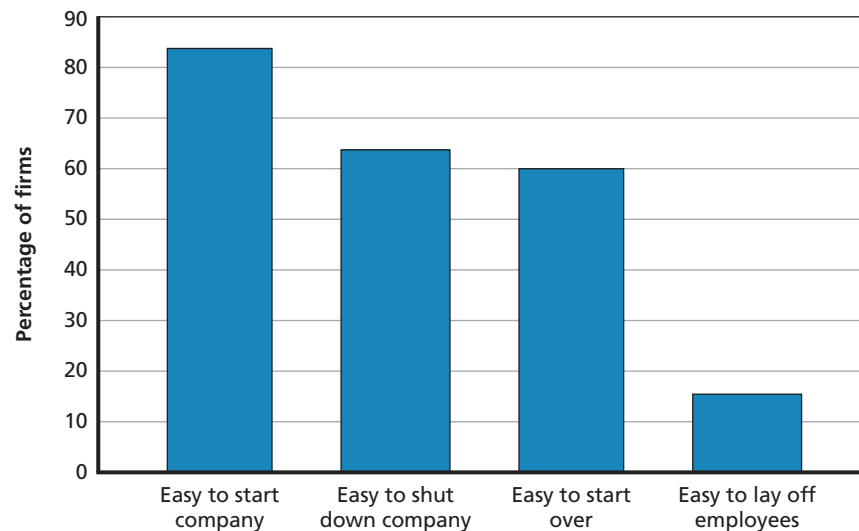
Despite those assets, GDD faces a number of challenges with respect to its overall business climate. Oddly, one of its advantages—its strong manufacturing base—appears to be

a disadvantage. GDD's reliance on assembly operations and product improvement for the Chinese market has created some degree of skepticism among some investors that Guangzhou can be a site of new product and technology innovation. Despite Guangzhou's excellent business culture, several interviewees noted that the entrepreneurial culture in developing new product innovations is lacking.

Despite the size of the Pearl River Delta economy, we have also been told that consumers there lack the high levels of sophistication that would provide demand for products and services produced by truly innovative companies and that necessary suppliers are sometimes lacking in the region. On a related note, although Guangzhou is a center for global commerce, one entrepreneur indicated that he had experienced challenges in importing essential supplies through customs.

According to the GDD-RAND Knowledge City Project Survey, managers and entrepreneurs operating in Guangzhou report some frictions in terms of running their businesses. The main challenge appears to be laying off employees: Only 15 percent of survey respondents reported that it was easy to lay off employees (Figure 9.9), although 62 percent reported that it was easy for employees to move between companies in GDD. The ease of starting and shutting down a company is higher: Nearly 85 percent of firms reported that it would be easy to start a company in GDD, although only 65 percent of firms indicated that it would be easy to shut one down. Approximately 60 percent of survey respondents indicated that if they tried to start a company and it failed, it would not be difficult to start a new company. These figures suggest that although starting and expanding a firm may be easy, shutting down a firm and starting over are perceived as somewhat more difficult, whereas downsizing the workforce is perceived as particularly hard. Since creative destruction is an important part of the innovative process, particularly for young firms, these frictions may impede innovation in GDD.

Figure 9.9
Ease of Doing Business



SOURCE: The GDD-RAND Knowledge City Project Survey.

NOTE: Results are based on responses from a range of 217 to 280 firms (out of 305 surveys received), depending on the specific question.

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Gap Analysis

GDD has excellent infrastructure, and the overall business climate is fairly conducive to firm growth. However, the case studies, interviews, and survey results suggest two areas in which GDD may be able to improve its business climate.

First, 85 percent of firms indicated that it is not easy to lay off employees, and 40 percent indicated that it is not easy to shut down a firm. Given that creative destruction is an important component of innovation, GDD could improve its environment for innovation by addressing these two issues. Although GDD has no control over national regulations regarding layoffs and firm closures, it can seek to assist local firms to navigate the process of downsizing or closure more efficiently.

Second, assistance in marketing to nearby, wealthy markets may help enlarge the market for the innovative products and services that are meant to be produced in Knowledge City. Although policymakers often focus on the supply side when encouraging firms to grow, our review of the literature and our case studies indicate that the demand for products created by innovative firms may play a key role in their success. Our interviews in GDD suggest that there may be a lack of demand for innovative products and services in the area. Support for initiatives by high-technology firms in Knowledge City to market their products in Hong Kong, Taiwan, Korea, and Japan, including actions to strengthen representative offices, encourage entrepreneurs to attend trade fairs in each location, and sponsor special events, may help companies find buyers of highly innovative products.

Networks

Lessons Learned from the Case Studies and the Literature

Networks have often been highlighted as a distinguishing feature of a cluster. Such networks can be supply chains, links between buyers and suppliers, links between startups and support services, links between spinoffs and former parent companies, industry associations, or social networks.

The origins of such networks and the relative importance of each type of network differ by cluster. In Silicon Valley, nearly all of these types of networks have become important and have been propagated through a variety of means, including shared university connections, former employers, and connections with such supporting actors as law firms and venture capitalists (see, for example, Kenney and Florida, 2000; Saxenian, 1994; Suchman, 2000). Our interviews in Israel suggest that social networks have generally been formed through shared experiences in the IDF, often based on prior service in teams that had served together on technological tasks. Athreye (2004) noted that, in the ICT cluster in Cambridge, United Kingdom, nearly half of all firms were linked to other firms because of the movement of employees between them and that many spinoffs maintained informal or formal links with parent companies. Saxenian and Hsu (2001) highlighted the role of various associations of Taiwanese engineers in Silicon Valley, and their subsequent interactions with the business community in Taiwan, in the success of the Hsinchu cluster.

One important lesson from these case studies is that before cluster formation some of the social networks—such as Silicon Valley’s university ties and Israel’s IDF—already existed,

but many did not—such as support from specialized support firms or complete supply chains. These formed as the cluster grew (Bresnahan and Gambardella, 2004). In that sense, networks do not need to be considered a prerequisite for cluster formation but rather may be a byproduct.

Conditions in GDD

Networks among entrepreneurs, as well as among suppliers, buyers, and supporting actors, can play an important role in innovation clusters. As of spring 2011, there were nine social groups in GDD, such as trade unions, the Chamber of Commerce, and charitable organizations.¹ According to GDD's Bureau of Civil Affairs, GDD also had 27 associations and 161 intermediary institutions. We interviewed two industry alliances that consisted of several firms in a supply chain. The goals of the alliances include facilitating technical cooperation, coordinating research and development activities, organizing conferences, and providing a platform for networking. One alliance noted that such groups are generally formed based on encouragement from the government, and government may play a role in the alliance or provide funds. In addition, 10 firms in GDD reported the participation of university professors, suggesting that there are some ties between firms and universities. In addition, five GDD firms reported collaborations with international institutes.

GDD entrepreneurs with whom we met noted that money from GDD to support inter-institutional collaborations, such as with universities and within industries, and softer aid for innovation, such as help with marketing and networking, have proven helpful. However, international collaborations appear to be relatively few, although we may lack complete data about these.

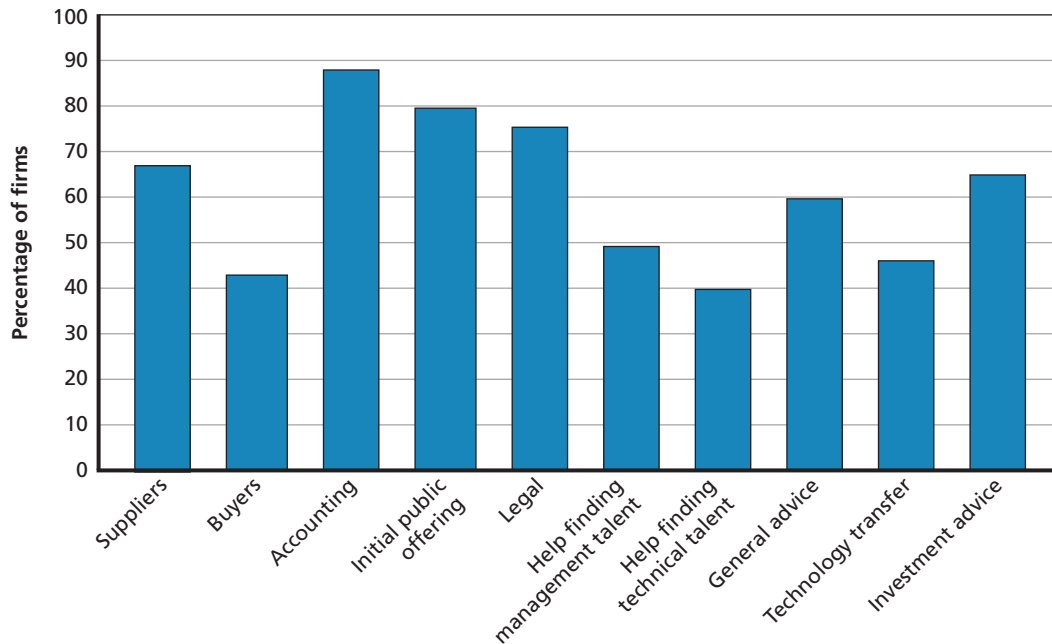
Beyond its assistance, GDD was praised in our interviews for having an extensive supplier base, as well as inexpensive support services such as lawyers and accountants. Among survey respondents, approximately two-thirds indicated that they could find local suppliers, and 45 percent indicated that their buyers are located nearby. Approximately 80 to 90 percent of firms indicated that it was easy to obtain services related to accounting, IPR, and legal issues (Figure 9.10). Fewer firms, however, found it easy to obtain help in finding management and technical talent.

Although some entrepreneurs mentioned that it was difficult to find local suppliers and that marketing channels were complicated, several interviewees mentioned GDD policies that have helped them to build their supplier, buyer, and support networks. Approximately 20 percent of survey respondents indicated that GDD provides help in connecting to customers, and 40 percent indicated that GDD provides help in connecting to companies and investors (Figure 8.1). Specific advantageous policies that were mentioned during our interviews included arranging seminars by outside experts on such issues as patents and funding applications, providing information about other companies in the area, and offering help in finding local suppliers. There is some desire among employers for additional help in networking; approximately 20 percent of survey respondents ranked help in creating networks to find new customers among the top three new policies GDD could adopt (Figure 8.2).

Sixty percent of survey respondents chiefly market their new innovations by directly contacting consumers or by providing samples or trials; another 24 percent chiefly market their

¹ Communication from GDD Policy Research Office, April 2011.

Figure 9.10
Ease of Finding Local Suppliers, Buyers, and Services



SOURCE: The GDD-RAND Knowledge City Project Survey.

NOTE: Results are based on responses from a range of 243 to 284 firms (out of 305 surveys received), depending on the specific question.

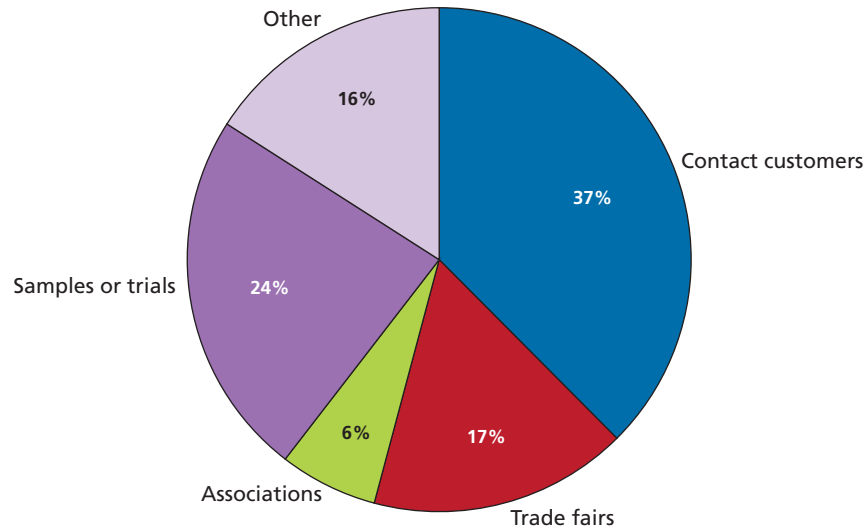
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innovations through trade fairs or associations (Figure 9.11). In addition, 22 percent of firms reported collaborating with industry associations in innovation (Figure 9.12).

Our interviews and the survey indicate that firms collaborate with universities and research institutes. During our interviews, ten firms in GDD reported collaborating with university professors, and five GDD firms reported collaborating with international institutes. Among survey respondents, many firms reported collaborating with Chinese universities (64 percent), overseas universities (11 percent), Chinese research institutions (55 percent), and overseas research institutions (17 percent) (Figure 9.12). Twelve percent of respondents indicated that the most important source of their innovations was universities or other research organizations. Firms seem to find existing avenues for collaborating with universities adequate: Only 13 percent of firms ranked enhanced collaboration with Guangzhou universities, in order to provide a source of qualified talent, as one of the top three policies the GDD administration could implement. From our interviews, we learned that several universities and research institutes have played major roles in technical alliances in GDD. These institutes will contribute to innovation and cluster formation.

We found that GDD has a number of organizations approved by the government, which facilitates business activities. Members of these organizations are Chinese nationals. Foreign companies tend to be members of organizations, such as the American Chamber of Commerce in South China, that represent the interests of foreign investors. In addition, company manag-

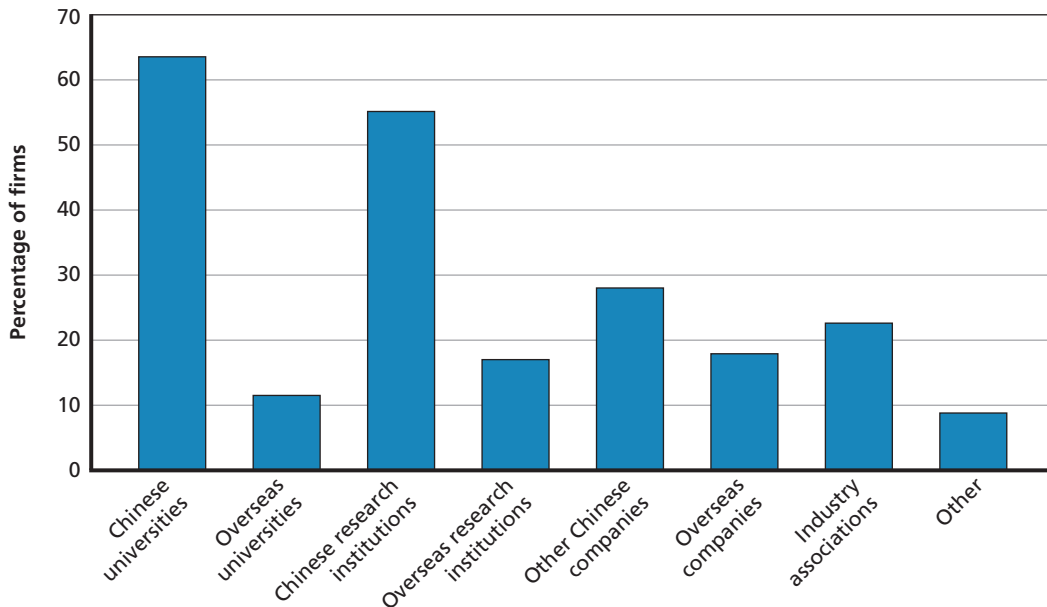
Figure 9.11
Marketing Channels



SOURCE: The GDD-RAND Knowledge City Project Survey.
 NOTES: Results are based on responses from 301 firms (out of 305 surveys received). Six firms selected more than one response, although the survey requested a single choice; these firms' responses have been categorized under "Other."

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Figure 9.12
Collaboration



SOURCE: The GDD-RAND Knowledge City Project Survey.
 NOTES: Firms could give more than one answer to this question, so the total sums to more than 100 percent. Results are based on responses from 296 firms (out of 305 surveys received).

RAND TR1293-9.12

ers, venture capitalists, government officials, and financiers appear to have created a number of strong informal networks based on personal and business ties.

Gap Analysis

Our review of the literature, as well as the case studies, suggest that networks are a fundamental condition of a cluster. Most of the networks in the case studies we reviewed are informal and are driven by social and business interactions among individuals rather than by alliances among firms or other institutions. Personal ties as well as shared business interests are important in network formation (Kenney and Florida, 2000; Suchman, 2000; Hsu and Saxenian, 2000). Our case studies suggest that individuals often draw on their networks, which stretch across firm, industry, and regional boundaries, for a variety of business purposes, including hiring talented employees, obtaining expert advice in a particular area, or starting a company.

The dominance of individual over institutional ties appears to be the case even when networks are based on relationships developed through shared formal institutions. One case in point is illustrated by the ICT cluster in Israel, in which one main source of network formation is common service in the military. After completing their military service, former members of the military appear to draw on their network through personal contacts rather than through formal channels.

Although networks initiated through official channels may be useful in certain contexts, it is more likely that the most important networks will be generated by individuals as the cluster develops. It may be most valuable for GDD to focus its efforts on creating certain specific types of networks, such as the angel investor networks, that may be less likely to form spontaneously.

Quality of Life

Lessons Learned from the Case Studies and the Literature

In all three of our case studies, quality of life was an important factor. Kolko, Neumark, and Mejia (2011) argued that in Silicon Valley, California's mild climate and dry weather could explain much of its growth. A number of observers indicated that in Maryland, quality-of-life issues, such as excellent public schools, urban amenities, and good transportation, were key criteria that attracted them or their firms to the area. For example, one official recounted that a major firm that recently relocated to the cluster chose its location because of good public transit and urban amenities. In Israel, the main hubs of the ICT cluster—Herzliya, Tel Aviv, Ra'anana, and Haifa—are considered the most desirable places to live in the country.

Quality-of-life issues are often rated highly in other clusters as well. For instance, Athreye (2004) documented results of a firm survey in the ICT cluster in Cambridge, United Kingdom, in which the factor most often ranked as important for the firm's development was "Attractive local living environment for staff/directors." Dahl and Sorenson (2010) highlighted a related issue by documenting that proximity to friends and family plays a large role in the location decisions of Danish scientists and engineers.

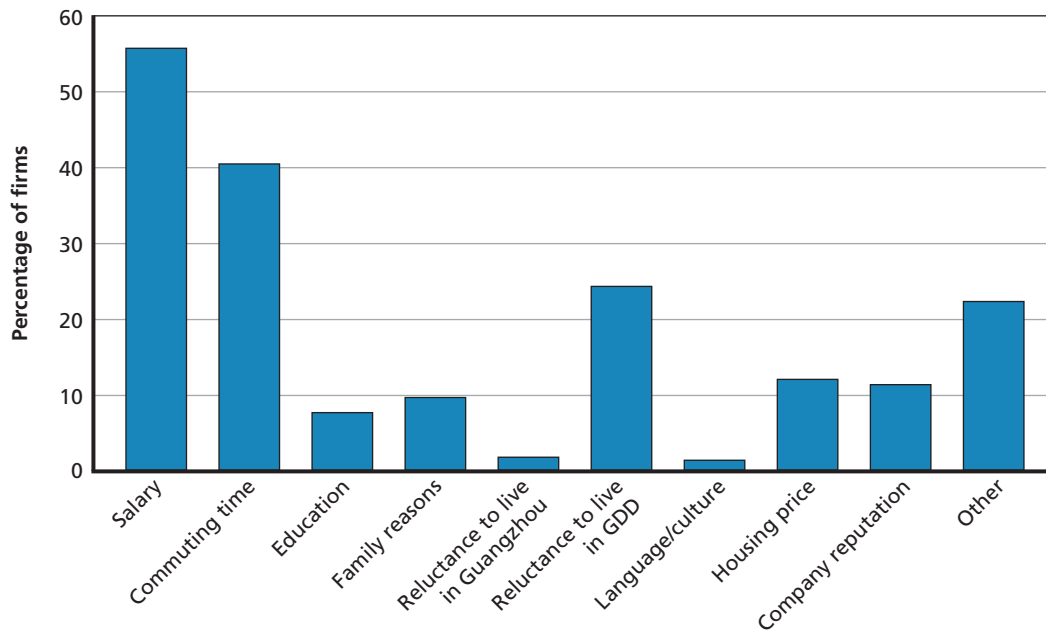
Conditions in GDD

During our interviews, entrepreneurs and investors mentioned a shortage of low-cost housing; lack of local amenities such as schools, hospitals, and shopping centers; and a long commute

from Guangzhou City, where many people prefer to live or where one spouse often works. Among survey respondents, the issue most frequently ranked among the top two challenges in recruiting and retaining staff was reported to be salary. However, quality-of-life issues were also critical. After salary, the most frequently cited difficulties in recruiting staff were commuting time (40 percent), reluctance to live in GDD (24 percent), housing prices (12 percent), company reputation (11 percent), family reasons (10 percent), and educational opportunities for children (8 percent) (Figure 9.13). Similar difficulties were cited for retaining employees (Figure 9.14). These challenges, particularly the commuting issue, will be exacerbated in the case of Knowledge City, which is located farther from the center of Guangzhou than Science City.

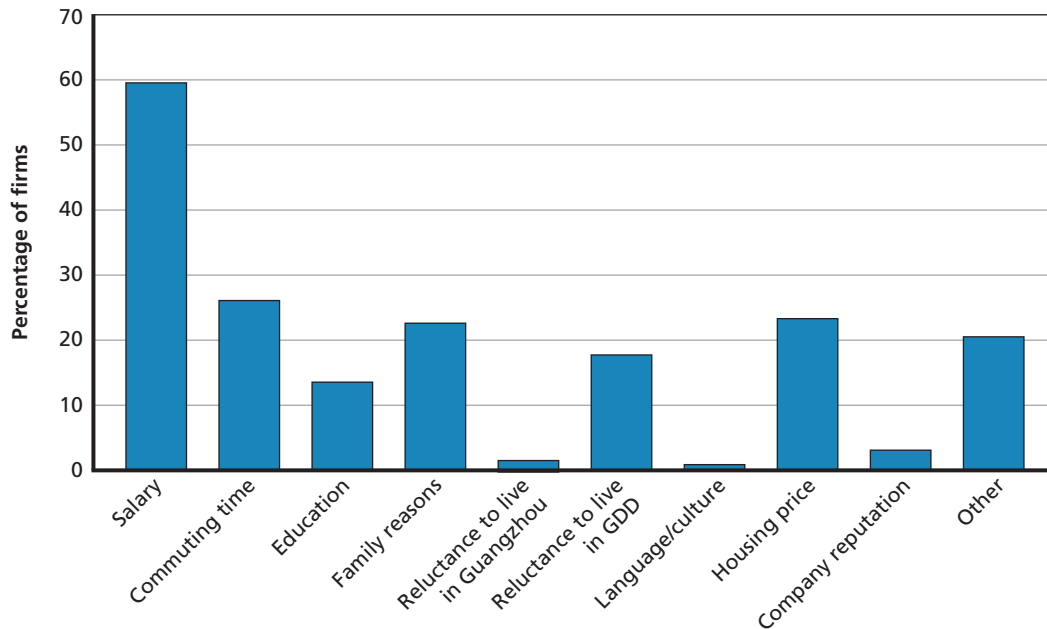
During our interviews, several entrepreneurs mentioned GDD policies that have helped to mitigate the land and housing challenges, including GDD’s programs to build dormitories in the area and to attract a real estate developer to build apartments. As noted above, GDD has policies to improve the quality of life of returnees and extremely talented individuals, including subsidized housing and school fees for returnees, free rent or a purchase subsidy for a residence, help finding jobs for relatives, and overseas travel subsidies for people who are in one of the talents plans. Entrepreneurs cited the subsidized housing for leading talent as advantageous. However, one entrepreneur noted that despite such efforts, the rent for apartments suitable for “S&T talent” remains unaffordable.

Figure 9.13
Top Two Reasons for Difficulty in Recruiting Staff



SOURCE: The GDD-RAND Knowledge City Project Survey.
 NOTES: Firms could give up to two answers to this question, so the total sums to more than 100 percent. Results are based on responses from 301 firms (out of 305 surveys received).

Figure 9.14
Top Two Reasons for Difficulty in Retaining Staff



SOURCE: The GDD-RAND Knowledge City Project Survey.

NOTES: Firms could give up to two answers to this question, so the total sums to more than 100 percent. Results are based on responses from 300 firms (out of 305 surveys received).

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Gap Analysis

We suggest that GDD shift its emphasis more toward improving the living environment of Knowledge City and less toward business incentives. As discussed above, some tax or nontax incentives may be useful, as would improving IPR enforcement and certain aspects of the business climate. However, innovators also want short commutes, good schools for their children, and high-quality shopping and entertainment opportunities. Our review of the literature and our case studies suggests that quality of life plays a role in determining where highly skilled people choose to live. The survey of high-technology firms confirms that such quality-of-life issues as commuting and, more broadly, a “reluctance to live in GDD” are potentially major impediments to finding top talent. These issues are likely to be more pronounced for Knowledge City, since it is located farther from Guangzhou city than other parts of GDD, like Science City.

Although quality of life is important, the extent to which it precedes the creation of an innovation area versus the extent to which it is an outgrowth of an innovative area with highly educated workers is uncertain. Convenient commuting opportunities may precede the creation of an innovative area, whereas cultural opportunities, which need an audience to survive, may be an outgrowth. Nonetheless, GDD can take a number of steps to increase the quality of life as Knowledge City gets started.

GDD should explore providing incentives to attract quality schools and quality shopping, to induce technical talent and their families to settle in Knowledge City. In addition, a thoughtful master plan for Knowledge City, including the provision of an attractive living environment, as well as human-scale designs for neighborhoods, will be an important element

of success. We are aware that Guangzhou No. 2 Middle School, a top local middle school, has moved its high school campus to Science City. Knowledge City would benefit from similar efforts to attract high-quality schools, especially elementary schools. Better transportation could also draw more students from all over Guangzhou to attend these schools. We learned that GDD has been trying to attract a shopping mall to Science City, but there were not enough people to encourage its establishment. Zoning that would place the center away from transportation hubs is also a problem. Knowledge City should ensure that zoning places shopping centers next to major transportation hubs, such as subway stops.

Although housing costs can be a burden on workers and business owners, most attractive locations, particularly in coastal areas, have high housing costs. The ability to work at an innovative company and live in a desirable area is in some ways compensation for paying high housing costs. The best solution to high costs for nearby housing is to ensure that transportation links are speedy and reliable so that employees will have a broader range of housing on which to draw.

Marketing Knowledge City

Lessons Learned from the Case Studies and the Literature

Anchor Institutions

One critical lesson learned from our case studies is that anchor institutions play an important role in cluster formation. Having an anchor institution can be an important marketing tool, since these institutions can attract talented workers, suppliers, and customers to the area and can enhance the area's reputation.

Each cluster we studied was formed around the presence of one or more anchor institutions. In the case of Silicon Valley, several local institutions could be considered anchors. Stanford University established close ties with the surrounding business community through its industrial park and through exchange programs and provided a substantial flow of technical and business talent (Saxenian, 1994; Sturgeon, 2000). Fairchild Semiconductor was linked to dozens of spinoffs and employee-founded firms and helped to propagate Silicon Valley's social network (Laws, 2010; Saxenian, 1994). In Maryland, the NIH and other federal laboratories and agencies filled the role of anchor institutions, providing a large pool of highly skilled workers as well as demand for services from the growing life sciences firms. In the case of Israel, our interviews suggest that universal conscription and the emphasis placed by the military on technological development made the IDF the original anchor institution. Subsequently, such multinational corporations as Intel and Microsoft also played important roles as anchors, by training thousands of ICT workers in how the international marketplace functions and what it demands. This enabled technical personnel to become entrepreneurs with a particular set of skills that could be focused on potentially fruitful business ventures.

Such anchor institutions can serve a number of functions. In many of the cases we examined, including Stanford University, Fairchild Semiconductor, the NIH, the IDF, and multinationals in Israel, the anchors served as sources of employees and entrepreneurs with a particular set of skills. Another role is to serve as a source of demand for a growing cluster's services, as in the case of the NIH for Maryland. Anchor institutions also often provide a source of spinoffs. Fairchild Semiconductor proved important to the development of Silicon Valley through its dozens or perhaps hundreds of "Fairchildren" spinoffs (Laws, 2010). Although spinoffs may be

particularly important in Silicon Valley, they have played a role in other clusters as well, including the ICT clusters in Ireland and India, the automobile cluster in Detroit, and the tire cluster in Ohio (Arora, Gambardella, and Torrissi, 2004; Buenstorf and Klepper, 2010; Klepper, 2010).

One critical question is how these anchor institutions were created or attracted to the area. In several cases—for example, Stanford University and the NIH—the institutions were historically located in the area. In certain cases, unique local characteristics were responsible for the creation of the anchor institutions. For example, our interviews suggest that Israel's reliance on a combination of conscription and the need for superior military technology helped to create the IDF's orientation toward technology and ability to recruit Israel's top talent. In other cases, both existing local strengths as well as luck were responsible. In short, our case studies suggest that anchor institutions can be private or public entities that are already in the local area or that are attracted to the local area through a variety of channels.

The role that government policy can play in attracting anchor institutions is a subject of extensive debate. Our case study of Israel suggests that government incentives specifically aimed at attracting foreign investment, such as tax incentives, were not primarily responsible for multinational corporations' decisions to open plants there. The evidence from other clusters is mixed. As discussed in Chapter Eight, Arora, Gambardella, and Torrissi (2004) survey an ongoing, unresolved debate between observers who argue that multinational corporations were attracted to Ireland because of government incentives and those who argue that Ireland's luck in having a skilled English-speaking labor force in a country that is part of the European Union at a time when there was an international skills shortage was more important.

One concern with attempts to attract such institutions is that local governments often compete with one another, thus increasing the size of incentives offered to the institution until the costs outweigh any potential benefits (see, for example, Porter, 1996). It is extremely difficult to provide empirical evidence for this hypothesis, but two recent papers by Greenstone, Hornbeck and Moretti (2010) suggest that despite the risk of sparking a zero-sum contest, there may be benefits to attracting large anchor firms to a local area. Greenstone, Hornbeck, and Moretti (2010) compared various outcomes in counties in the United States that succeeded in attracting million-dollar plants to counties that were short-listed by the plant owners but were not chosen.² They found that the productivity of incumbent firms in winning counties, as well as county-level wages, increased in the years following the openings of million-dollar plants relative to losing counties. However, the authors cautioned that there was a substantial amount of variation in the results, with some winning counties experiencing large productivity gains but some experiencing productivity losses.

Similarly, Greenstone and Moretti (2004) argue that if property prices appropriately reflect both the benefits of attracting the plant (for example, though increased wages) and the costs (for example, through higher local taxes or reduced public services, which may be required to pay for the incentives offered to attract million-dollar plants), then measuring changes in property prices should reflect whether the local area gained or lost from attracting the plant. They found that the growth in property prices was higher in winning counties compared to losing ones, suggesting that whatever the county paid to attract the million-dollar plants was, in fact, worthwhile. However, they noted that there were a number of limitations to this interpretation, including the possibility that property prices may not accurately reflect

² The term "million-dollar plant" is used by the authors to refer to plants listed in a regular feature in the corporate real estate journal *Site Selection* (Greenstone and Moretti, 2004; Greenstone, Hornbeck, and Moretti, 2010).

welfare. This study provides some evidence that the benefits of attracting an anchor institution may outweigh the costs.

In summary, anchor institutions played important roles in the formation of each cluster we studied. There remains a concern that attempting to attract anchor institutions through incentives may simply result in a zero-sum game among local governments, but recent empirical evidence indicates that on average, regions that manage to “win” such institutions may reap spillover benefits in terms of higher productivity and wages.

Sector-Specific Targeting

There is an ongoing debate about whether government policy should selectively promote certain sectors. Historically, this type of policy has often taken the form of infant industry protection and is usually referred to as “industrial policy” when it consists of tariffs, subsidies, or tax breaks that go above and beyond what could be considered “optimal” from an economic point of view (Harrison and Rodriguez-Clare, 2009). The conventional wisdom has been that “governments are not particularly good at picking winners” and that industrial policy may create industry lobbies; however, some authors have argued that industrial policy can be designed effectively to promote high-growth sectors (Aghion et al., 2011). In a recent series of papers, Lin (2011) and Lin and Monga (2011) have argued that countries can succeed at targeting industries using certain policies if they follow specific criteria (outlined in Lin and Monga, 2011) and if those industries match the countries’ comparative advantage.

In the case of Maryland, the local government did specifically target the life sciences sector, initially building a business park because of the life sciences research taking place in the area. In Israel, the government’s policy for R&D funding was originally neutral with respect to sectors (Trajtenberg, 2000), although it has recently favored biotechnology firms. The effectiveness of this sector-specific targeting is not yet clear. Officials at the Maryland Department of Business and Economic Development indicated that they currently are trying to grow the local cyber security industry. This industry is once again based on the area’s existing strengths, mainly its proximity to the federal government, a major potential customer of cyber security products and services. The effectiveness of this effort is difficult to gauge, particularly since Maryland Department of Business and Economic Development officials indicated that they believe the industry will grow regardless of their activities and that they are simply seeking to fill gaps in private funding.

Conditions in GDD

Anchor Institutions

During our interviews, Singbridge officials indicated that they are attempting to attract industry leaders from designated sectors to Knowledge City, so that other firms in the supply chain may follow. Singbridge is also trying to attract a university or a top research facility to Knowledge City. We were told by interviewees in the Investment Promotion Office of GDD that it is pursuing a number of high-profile companies.

Sector-Specific Targeting

Both GDD and Singbridge are targeting a large number of sectors for Knowledge City (Table 9.1). Experienced international investors noted to us that it is difficult for economic development authorities to tailor their policies to a large number of sectors. This suggests that if GDD chooses to target sectors, it might increase its chances of success by narrowing the range of

Table 9.1
Sino-Singapore Guangzhou Knowledge City Investment and Development Co., Ltd Pillar Industries

GDD Investment Promotion Office September 21, 2011	Singbridge Presentation April 11, 2011
New generation of IT	IT convergence
Biotech & Health	Biotech and pharmaceutical
New energy, energy saving, and environmental protection	Energy and clean technology
New materials	Advanced manufacturing
S&T services	R&D services
Culture and creative industries	Creative industries
Headquarters	Education and training
	Health and wellness

sectors it hopes to attract to Knowledge City. Our research suggests that it might also achieve success by focusing on improving underlying conditions that are attractive to all sectors.

Gap Analysis

Attracting an anchor institution will be very important for the success of Knowledge City. The anchor institution may play a number of roles. First, suppliers, buyers, and other tenants may be attracted to Knowledge City because of the reputation of the anchor institution or because other companies wish to collaborate with it or to draw on its workforce. Second, the anchor institution may provide a source of talent, either by drawing skilled workers to the area or (in the case of a university) by producing skilled graduates. Third, the anchor may be the source of research that can be commercialized or of spinoffs.

If the anchor institution is a business, it should be more than just a sparsely populated headquarters; it should include real operations, such as research and development, marketing, logistics, or production. The better the facility, the more likely top-quality supplier networks will also set up operations in Knowledge City and the more likely there will be innovative spinoffs. If such an anchor institution is a research institution or a university, then it will be valuable if it has programs that can link it to businesses and that can help spin off research into commercial applications.

We recommend that GDD shift its emphasis more toward improving the general innovation environment rather than just targeting specific sectors. Although we do not rule out targeting sectors, truly innovative companies could come from any sector and merit support given the goals of Knowledge City. Our case study of Maryland provides some evidence that sector-specific targeting may be able to attract the types of firms that policymakers want but only when the targeted sectors are in keeping with the local area's existing advantages. For example, GDD could sponsor an international conference in a technological area in which GDD already has a foothold. Attempting to target sectors in which the local area does not have an advantage may simply result in a failure to attract firms to the area or a failure to thrive of any firms that start up or move into Knowledge City. The usefulness of an anchor institution

along with the need to match existing advantages suggests that GDD should draw on its existing strong base of companies to see if one or more of them can be induced to set up research and development operations in Knowledge City.

GDD already has a number of policies in place to attract high-technology firms and encourage their growth. In the marketing plan, it will be important to emphasize those factors that highlight GDD's strengths, particularly if these strengths are relatively difficult for other areas to replicate.

Our analysis to date suggests that it may be possible to categorize the factors that drive the success of an innovative-based cluster into three broad areas. First, there are factors that may be considered natural advantages and cannot be replicated unless other areas happen to have the same advantages. These advantages include, for example, mild weather in Silicon Valley and the location of the NIH in Maryland. Guangzhou's proximity to a major port and its historic role as a center of global commerce in China are such assets. No other area without a port is likely to be able to compete with GDD on such measures, so these advantages should be emphasized when marketing Knowledge City.

Second, some factors can be easily replicated. As our case studies show, tax concessions and nontax incentives can be classified in this category, since many areas can replicate these incentives, matching or increasing incentives offered by GDD. Although providing these incentives might assist in attracting a particular company or organization that is already considering an area, there is a great risk in entering into a competitive bidding contest, which might threaten to erode the value of attracting any firm because of the high cost of the subsidies offered to attract it.

Third, some factors can be replicated eventually, but doing so would likely take some time. These factors include infrastructure, a good business climate, a reputation for IPR enforcement, strong angel investor networks, and excellent quality of life and local schools. Focusing on these factors during the creation of Knowledge City could create a competitive advantage for GDD in two ways. First, it takes time to create these types of institutions, making it harder for other regions to compete with GDD, at least until they develop similar advantages. Second, clusters are often formed around areas that have a first-mover advantage—those that originally began creating a product or service, often through historical accident. Even if other areas tried to follow GDD by creating those assets, GDD would have the first-mover advantage. Therefore, if GDD creates a reputation for having these factors, this reputation could help to attract innovation-oriented firms to Knowledge City. The presence of these firms would reinforce Knowledge City's reputation for innovation, thus attracting more innovation-oriented firms to the area and creating a virtuous circle that would make it difficult for other regions to catch up.

Conclusions and Summary

Our investigation indicates that GDD has a number of assets that have contributed to its success so far. Tax policy in GDD does not appear to be a constraint on innovation, and the overall infrastructure and business climate appear to be advantageous in terms of fostering growth. In addition, firms in GDD appear to have access to the talent they need, except perhaps for the very top researchers.

In this section, we have suggested other aspects of the innovation environment that GDD could address to increase the chances of success for Knowledge City. Below, we summarize some of our key suggestions.

First, there appears to be a gap in early-stage financing. GDD may be able to help fill this gap by encouraging the formation of angel investor networks. Guangzhou has many successful, wealthy individuals who may be willing to invest in new firms but may not know how or where to find opportunities for investment. GDD may be able to draw on lessons from local development agencies and university organizations in Maryland, which have fostered such networks.

Second, we see a potential opportunity for GDD if it can become a zone of strict IPR enforcement, aggressively helping GDD companies protect their IPR throughout China and letting it be known that top innovators in China and abroad will have their rights protected if they locate in Knowledge City. GDD may also wish to provide additional incentives to encourage companies to apply for international patents. Given the survey findings, which suggest that labor mobility is accepted in GDD, it is particularly important to ensure that IPR enforcement is strong so that firms' trade secrets are not divulged by former employees.

Third, GDD should shift its emphasis more toward improving the living environment of Knowledge City and less toward business incentives. We do not rule out business incentives; in fact, we find that they can be valuable. However, in addition to a good business climate, innovators also want short commutes, good schools for their children, high-quality consumption opportunities, and entertainment opportunities. As it evaluates its incentive policies, GDD should explore providing incentives to attract quality schools and quality shopping. Human-scale designs for neighborhoods may be an important element of success. Improving the quality of life may be especially helpful in attracting the very top researchers, particularly expatriate Chinese.

Finally, attracting an anchor institution will be very important for the success of Knowledge City. In marketing Knowledge City to potential tenants, it will be important to emphasize those factors that highlight GDD's strengths, particularly if they are relatively difficult for other areas to replicate. Two important assets that most other areas cannot replicate are Guangzhou's proximity to a major port and its historic role as a center of global commerce in

China. In addition, GDD may find it valuable to focus on factors that take time to replicate, such as its good business climate, a reputation for IPR enforcement, strong angel investor networks, and excellent quality of life and local schools. Creating a reputation for having these factors could assist in attracting innovation-oriented firms to Knowledge City; the presence of these firms would reinforce Knowledge City's reputation for innovation, thus attracting more innovation-oriented firms to the area and creating a virtuous circle that would make it difficult for other regions to catch up.

Company Case Studies

Fairchild Semiconductor (Silicon Valley)

Fairchild Semiconductor (Fairchild) can be considered the grandfather of dozens, if not hundreds, of firms in Silicon Valley. Fairchild was founded in 1957 by eight engineers and scientists who left Shockley Semiconductor Laboratories, another Silicon Valley firm. During its first decade, the company developed a number of breakthrough products and processes; former Fairchild R&D Director Gordon Moore is famous for coining “Moore’s Law,” a prediction of the rate of technological progress in chip capacity (Laws, 2010).

Fairchild has a mixed ownership history and went through periods of growth and decline during its existence. Moore reports that he and the other founders each contributed \$500 (one month’s salary at the time) to its initial financing (Moore, 1994). Arthur Rock, an investment banker in New York, approached a number of potential corporate funders and eventually secured \$1.5 million in financing from a company located on the East Coast of the United States, Fairchild Camera and Instrument. In exchange, Fairchild Camera was granted the right to purchase the founders’ shares for \$300,000 apiece (Kenney and Florida, 2000; Laws, 2010). The founders advertised for a general manager and hired the engineering manager from Hughes Semiconductor (Moore, 1994).

Within three years of its founding, Fairchild Camera exercised its option to purchase the founders’ shares. Moore (1994) reports that “things began to deteriorate,” in part because the company was run by an East Coast firm. Engineers began leaving the company and creating their own firms; perhaps most famously, two of the founders, Gordon Moore and Robert Noyce, left to launch Intel. Arthur Rock, who had by then set up an investment bank in Silicon Valley, assisted Moore and Noyce with their first round of financing for Intel. By 1968, only one of the original founders remained (Moore, 1994; Laws, 2010).

In 1968, Fairchild Camera relocated its headquarters to Silicon Valley. Fairchild Semiconductor was later bought by a French conglomerate; its assets were subsequently sold to National Semiconductor; and it was later “reborn” as a public company (Laws, 2010).

Spinoffs from Fairchild, as well as other companies founded by former employees, abound. The exact number of spinoffs is debated but acknowledged to be large. Laws (2010) reports that the number of “Fairchildren” was reported to be 15 in 1971, 66 in 1977, and 125 in 1985, and that the numbers are likely much higher if nonlocal firms and firms outside the immediate industry are included. Klepper (2010) documents a total of 24 local semiconductor spinoffs for Fairchild, including seven spinoffs that were among the top-20 producers in terms of sales as recorded by the Integrated Circuit Engineering group. He also notes that the three

next most important semiconductor firms in terms of spinoffs in Silicon Valley are themselves Fairchild spinoffs.

Even when Fairchild employees did not directly found companies, they contributed to local knowledge spillovers. For example, former Fairchild employee Federico Faggin was instrumental in creating two technologies at Fairchild that were later important to microprocessor development at Intel, which he eventually joined (Laws, 2010). Saxenian (1994) writes that “fewer than two dozen of the four hundred men present at a 1969 semiconductor industry conference held in Sunnyvale had never worked for Fairchild.”

Although Fairchild is best known for its technological advances, it also pioneered a number of marketing techniques, including a television infomercial on integrated circuits, mass marketing of technology products, and new organizational structures for the sales force. Early marketers at Fairchild also contributed to knowledge spillovers, joining firms such as Advanced Micro Devices and Apple (Laws, 2010).

Human Genome Sciences (Maryland)

In many ways, Human Genome Sciences epitomizes the strong research culture in Maryland’s life sciences cluster as well as the links with government. Human Genome Sciences was founded jointly with the Institute for Genomic Research in 1992. Wallace H. Steinberg, chairman of a venture capital fund, Investment Capital Corp., approached Craig J. Venter, a former NIH scientist, in hopes of setting up a company using Venter’s techniques for rapid DNA sequencing. Venter did not want to run a business, so Steinberg arranged to make Venter the head of the Institute for Genomic Research, a nonprofit research institute, and to jointly found Human Genome Sciences, a for-profit firm. Steinberg then recruited Dr. William Haseltine, a well-known AIDS researcher at Harvard University, to run Human Genome Sciences (Ahkin et al., 1997; Cook-Deegan, 1994). The original agreement between Human Genome Sciences and the Institute for Genomic Research indicated that Human Genome Sciences would pay the Institute for Genomic Research \$85 million over 10 years and in exchange would retain rights to the Institute for Genomic Research’s intellectual property, except for the Institute for Genomic Research’s work that was funded by government or nonprofit grants or contracts. The Institute for Genomic Research also owned stock in Human Genome Sciences (Cook-Deegan, 1994).

From 1992 to 2006, Human Genome Sciences developed its product pipeline. During this time, it received funding from a variety of sources. Its initial funding, secured in 1992, was structured as a loan, and then a stock purchase agreement, from two venture funds. Human Genome Sciences also entered into a strategic agreement with SmithKlineBeecham, a pharmaceutical company, which provided payments and agreed to purchase stock when Human Genome Sciences met specific milestones (Cook-Deegan, 1994). Although SmithKlineBeecham (now part of GlaxoSmithKline) was the main partner, Human Genome Sciences’ annual reports indicate that it entered into a number of collaborative agreements. The firm also sold shares publicly in 1993, 1995, and 1997 (Ahkin et al., 1997).

According to our interviews, in 1997, Human Genome Sciences decided to locate a new production facility in Montgomery County. It first conducted an international search with the assistance of a site-selection firm. The site-selection firm originally suggested locating in Frederick County, to the north, where it was considered easier to get building permits from local

government agencies. However, Human Genome Sciences representatives felt that employees would not want to commute to Frederick County and instead approached Montgomery County officials. Montgomery County officials originally offered Human Genome Sciences a \$1.5 million grant. However, Human Genome Sciences requested a “full package” instead. Human Genome Sciences had already been offered a \$15 million package from a county in Virginia, a neighboring state. Montgomery County then worked with Human Genome Sciences to make arrangements that included a pseudo-state agency to underwrite bonds and act as a developer; a synthetic lease agreement, in which the county constructed the building and leased it back to Human Genome Sciences; and loans as well as loan guarantees. In addition, the county coordinated all of its permitting agencies to ensure that the permitting process was simplified.

In 2009, Human Genome Sciences received its first revenue from product sales by selling ABthrax, used to treat cases of anthrax inhalation, to the federal government. The FDA has not yet licensed ABthrax, although Human Genome Sciences is to receive additional payment when such approval is received. In 2010, Human Genome Sciences and GlaxoSmithKline jointly submitted an application to FDA for BENLYSTA, a drug to treat lupus. The FDA approved the drug in 2011, allowing Human Genome Sciences to pursue commercial sales (Human Genome Sciences, various years).

Intel Israel

Intel Israel highlights a number of key factors about Israel’s ICT cluster, including the role of the Israeli diaspora and of MNCs in cluster development, and the importance of Israel’s culture of assertiveness.

Intel founded its first major international R&D center in Haifa, Israel, in 1974. One of its early employees, Dov Frohman, grew up in Israel and later moved to the United States to attend graduate school at the University of California, Berkeley. He worked at Fairchild Semiconductor and was later recruited to Intel. After rising to a position in management, he left Intel to teach electrical engineering in Ghana (Senor and Singer, 2009).

During the early 1970s, Intel faced a critical shortage of engineers. Frohman persuaded his former colleagues at Intel to consider setting up a center in Israel to take advantage of the highly skilled labor there. The R&D center was started with only five full-time employees but grew to become the largest private employer in the country (Senor and Singer, 2009).

The role that Intel Israel played in Intel’s successful development of its Centrino chip is cited as an example of Israel’s culture of assertiveness. During the 1990s, companies competed to make computer chips with ever-faster “clock speed,” which increased their power but also made them more likely to overheat. The Intel Israel team developed a chip that had a lower clock speed but used a different process that allowed it to run software faster than chips with higher clock speeds. Intel’s leadership in Silicon Valley originally disliked the idea of launching a chip with a slower clock speed but was eventually persuaded by the persistence of Intel Israel team members, who often traveled to Intel headquarters in Silicon Valley to make their case. In 2003, Intel launched its Centrino chip, based on the Israeli innovation, and the chip became an integral part of Intel’s sales growth. The incident highlights the willingness of the Israeli team to assert their opinions to management; Frohman said, “The goal of a leader should be to maximize resistance—in the sense of encouraging disagreement and dissent. . . . If you aren’t

even aware that the people in the organization disagree with you, then you are in trouble” (Senor and Singer, 2009).

Today, Intel continues to maintain, and even to expand, its operations in Israel. It has five sites in Israel, including R&D centers, fabricating plants, and sales and marketing support offices. One of the sites is in Haifa, where Intel originally opened a plant in 1974; the other four near Tel Aviv, at the southern end of the ICT cluster (Intel, undated).

Brief History of Small Business Investment Corporations

In this appendix, we provide some details on major SBICs that were established in Silicon Valley during the 1960s, based on Kenney and Florida (2000).

- 1959: Continental Capital Corp. SBIC established
- 1959: Small Business Enterprise Corporation SBIC established by Bank of America
- 1962: SBICs on the West Coast form Western Association of Small Business Investment Corporations
- 1962: Sutter Hill (already operating as a venture capital firm) receives SBIC license
- 1962: SBIC established by Bill Draper (son of one of the founders of Silicon Valley's first limited partnership venture firm, Draper, Gaither & Anderson) and Franklin Johnson; the SBIC's assets were later acquired by Sutter Hill
- 1962: Family-funded SBIC started by several members of "The Group" (early group of investors in Silicon Valley)
- 1969: Western Association of Small Business Investment Corporations reorganized into Western Association of Venture Capitalists.

Excerpts from Speeches by Local Officials

This appendix contains (1) excerpts from the State of the City 2010 address by San Francisco Mayor Gavin Newsom, and (2) excerpts from the speech by Maryland Governor Martin O’Malley launching the Bio 2020 Initiative. Note that certain programs discussed, such as the Jobs Now program, are no longer active, while others have not yet been enacted.

Excerpts from San Francisco Mayor Newsom’s State of the City 2010 Address

“I always joke that in politics, unlike baseball, you don’t get credit for saves. We were very fortunate we were able to keep Levis from leaving the San Francisco area, but we had to do things differently. It’s in that spirit that we need to focus on stimulating job growth in the city and county of San Francisco. Now, we didn’t wait for our State of the City to do that. Over a year ago, we introduced a local stimulus plan. I don’t know many cities that actually introduced local stimulus plans, and I want to just quickly update you on some of those initiatives and the status of those initiatives. Remember the liquidity and credit crisis? We wanted to get money out there that couldn’t otherwise be distributed in our communities, so we created a revolving loan fund of microloans. We’re out there in Noe Valley, in Bevan Dufty’s district, and we advanced that first revolving loan fund. It was just a few thousand dollars. You wouldn’t have thought it’d make all the difference in the world, but that little beauty shop was opened with that small microloan. \$1.8 million was put up in that initiative.

“We expanded our outreach into making sure that companies who were eligible for federal tax breaks—enterprise tax breaks, state tax breaks—were actually taking advantage of it. We had a concentrated effort in our office of economic development, and this year we saw a 46 percent increase in the number of businesses taking advantage of state and federal tax credits that most were unaware they qualified for. We initiated marketing programs, like Shop SF and staycations, and started to make a case that we don’t just need to market the city overseas or market the city out of state, but we could start marketing the city in our own back yard. We started to focus on neighborhood revitalization, advancing the reach and the investment in our community benefit districts, while also doing the same with our neighborhood marketplace initiative.”

...

“Working with Supervisor David Campos and others, we initiated a first-of-its-kind outreach to get specific and provide a framework of support for those businesses. Soon, we’ll be doing something that I think is pretty extraordinary, though we’re waiting for a waiver from Housing and Urban Development. We will develop a \$23 million loan fund, taking money

that was coming in and was going to go out in the same old traditional way. We're reconstituting and creating an innovation fund. We're putting \$11.5 million in framing the city with an innovation corridor that will span from the Central City down to Mission Bay, the central waterfront, and all the way out to Bayview, Hunters Point, and the shipyard. We will focus on those new businesses that are struggling and those businesses that want to get into this city and provide loans. In addition to that, another \$11.5 million will be put into the mid-Market corridor. I know this is long overdue. We've all been talking about mid-Market for many, many years."

...

"Now, I want to be fair here, but I also want to challenge. There are three pieces of legislation that I haven't been able to pass. In fact, I have had a hard time even getting them calendared at the Board of Supervisors, and I say this with respect and admiration. We all have different points of view, but I need the Board of Supervisors to immediately calendar these three pieces of legislation. One is a payroll tax exemption on all net new jobs over the next two years. The second is a tax credit for businesses between 20 and 49 employees who are providing health care for their employees under Healthy San Francisco. And third is an extension of the extraordinarily successful biotech tax credit that the Board wisely passed a number of years ago. Incidentally, we had two biotech companies five years ago. We now have 56. This tax credit is working, it's making a difference, and it needs to be extended. So, I am hopeful."

...

"Now, as you know, we are not waiting around for these things. We've done something already that I think is really extraordinary and meaningful. It's a program called Jobs Now. We believe in Jobs Now. No other big city has done this. L.A. just found out about it and just started to do it. I'll be going up to the Governor's office literally tomorrow at 4:00 PM for a meeting because I can't believe that the State of California is not doing something about it. \$1.7 billion exists in federal money. Guess how much money has been drawn down in the State of California to subsidize private- and public-sector jobs? \$21 million. This is \$1.7 billion of free money for the State of California as part of the economic stimulus, 100 percent wage subsidy. If you pay someone \$70,000, we'll take care of it. We have someone making \$135,000. We will subsidize 100 percent of that. It's too good to be true, and that's why people don't believe it. I'm very pleased that as of yesterday—and I'm going to round up, because tomorrow I'm confident we'll meet this number—we've helped employ 1,495 people. Tomorrow I'm sure we'll have over 1,500 people employed under this Jobs Now program. It's extraordinary, and I want to ask—Where are you guys? There they are. You guys stand up."

Source: Gavin Newsom, City and County of San Francisco, 2010.

Excerpt from Maryland Governor O'Malley's Speech Announcing Bio 2020

"Which brings me to why we're all here today. We seek to take a giant step forward in harnessing all of the potential that is already within our grasp. So today we are announcing what we are calling our Bio 2020 Initiative. It is a \$1.1 billion dollar investment in Maryland's bioscience industry that will represent, to our knowledge, the largest per capita investment in the biosciences made by any State in the country.

"Now together, these investments will leverage a projected \$6.3 billion for our State in private and federal investments, resulting in \$7.4 billion in total investments in our bioscience

industry by 2020. And they will produce thousands and thousands of new jobs. And they may also produce something even more lasting and more important, which are the cures that can alleviate suffering, early death—those things which cripple economies in developing nations.

“The initiative has nine major components. Everybody ready to count them off? Sharpen your pencils, here we go.

“Number one. Borrowing from our neighbors in North Carolina, where they have done this very well, we are going to create the Maryland Biotechnology Center, a one stop shop to promote and support biotechnology innovation and entrepreneurship in Maryland, and consolidate the various State, academic and private sector ventures.

“We are going to bring together TEDCO’s tech transfer initiatives, DLLR’s industry regulatory functions and various initiatives from the University of Maryland. And we’ll use the Center, also, to house a statewide science and technology marketing group. Something we don’t do very well in Maryland is promote the greatness that we have. Industry experts housed at the Center will expand our State’s relationships with federal labs, universities, private sector companies and also private sector investors.

“Number two. We are going to double our Biotech Investment Tax Credit in the next year and we are going to double it again in the five years ahead of that, leading to an increase of 400 percent, or \$24 million in the next five years.

“By our projections what does that mean? Increasing the tax credit will allow our State to leverage \$50 million each year in private investment for Maryland biotechnology companies.

“Number three. We will grow our technology incubator network and increase incubator space by 50%. By investing \$60 million over the next ten years, we can leverage together \$120 million in private and federal investment funds. And we will be able to create anywhere from 5,000 to 10,000 new jobs. This follows, by the way, a recent TEDCO study which found a strong demand for additional space. I’ll be darned, some of those Government programs actually work.

“Number four. We will invest \$300 million in—that can’t be right. (Laughter.)

“We will be investing—fact check here—we will be investing millions of dollars in capital projects for life science facilities, including the Science and Technology Park and the East Baltimore Development Initiative, which I just mentioned, just north of us. And Jack Shannon is here from EBDI.

“In addition, we will be making new investments in the University of Maryland Baltimore Health Sciences Facility III, which is near and dear to Dan Reese’s heart. UMB Howard Hall, UMBI Center for Agricultural & Environmental Biotechnology, the Montgomery College Bioscience Center, and the TEDCO/Maryland Stem Cell Research Fund.

“Most of those things are already in our capital budget. Others will have to be put into our capital budget. All of them create that cutting edge of this new economy and it is essential that we undertake them.

“Number five. We will expand our efforts to assist with intellectual property valuation and protection services. Many start-ups cannot afford professional legal services for intellectual property protection. This would be an expansion of a successful program at the University of Maryland School of Law, one of the best and greatest law schools in all the land, that works with entrepreneurs to help them validate and protect their intellectual property in order to commercialize them. Dean Karen Rothenberg is here from the University with us today. The Dean cut short her vacation just to be with us and I thank you for that, Dean.

“Number six. We are going to continue to invest at least \$20 million a year in stem cell research, moving forward so we can keep going what’s already started here. (Applause.)

“Little known fact, for—you know, while there are other States that are bigger than us, Maryland actually has now one of the top three largest stem cell funds in the entire United States of America. And unlike the funds in some other States, our funds are actually hitting the labs and doing the work and doing the research that is propelling us forward like I just saw upstairs.

“Number seven. We will enhance our State’s investment in nanotechnology. Our one Maryland is already one of the nation’s leading research centers for nanotechnology and nano/biotechnology. By offering more grants and faculty attraction resources, we can leverage the vast opportunities that exist in this field, which is expected to permeate all technology industries in the years ahead.

“Number eight. We will increase technology transfer by strengthening the Maryland Technology Transfer Fund. By helping universities and federal labs to get their innovations to market, we would be able to significantly increase the number of start-up companies coming out of our universities and research institutions, leveraging \$3.7 billion in private and federal investment.

“Number nine. We are going to augment the Maryland Venture Fund, which provides challenge grants to start-up companies and makes equity investments in more established companies, something that the MIBC has had some experience with, by increasing aggregate public investment to \$152 million by 2019, we can leverage nearly \$2 billion in private equity to help these companies succeed.

“Now, through the Venture Fund, we’ve made approximately 50 investments in bioscience companies and they have leveraged 15 times the value of our investments through our network of venture capital partners.

“As an example of the potential for these investments, our Department of Business and Economic Development, led by David Edgerley, is partnering with JBG/Scheer Partners to leverage \$1 million in State investment to create a \$100 million pool for building life science facilities in Greater Washington. And I’m told Henry Bernstein is here representing Scheer Partners. And, Henry, we thank you for being here.”

Source: Office of Governor Martin O’Malley, 2008.

GDD Project Survey Methodology and Results

Motivation

The RAND Corporation, together with the Guangzhou Development District, developed a survey named “GDD-RAND Knowledge City Innovation System Research Project Survey” (herein referred to as “the survey”) to help GDD outline a strategy for attracting world-class science, engineering, and entrepreneurial talent to and nurturing high-technology companies in the planned Knowledge City development. The survey aims to understand current conditions faced by high-technology companies in other parts of GDD, as well as the challenges and opportunities GDD encounters in accelerating and promoting the innovation and development of these companies.

Survey Methodology

The survey took approximately 7.5 months (from June 2011 to January 2012) to design, implement, and analyze. Figure D.1 shows the survey process, from questionnaire design, piloting, and revision, to survey distribution and collection, and then to data processing and analysis. In this appendix, we will explain the methods we used in each step.

Questionnaire Design

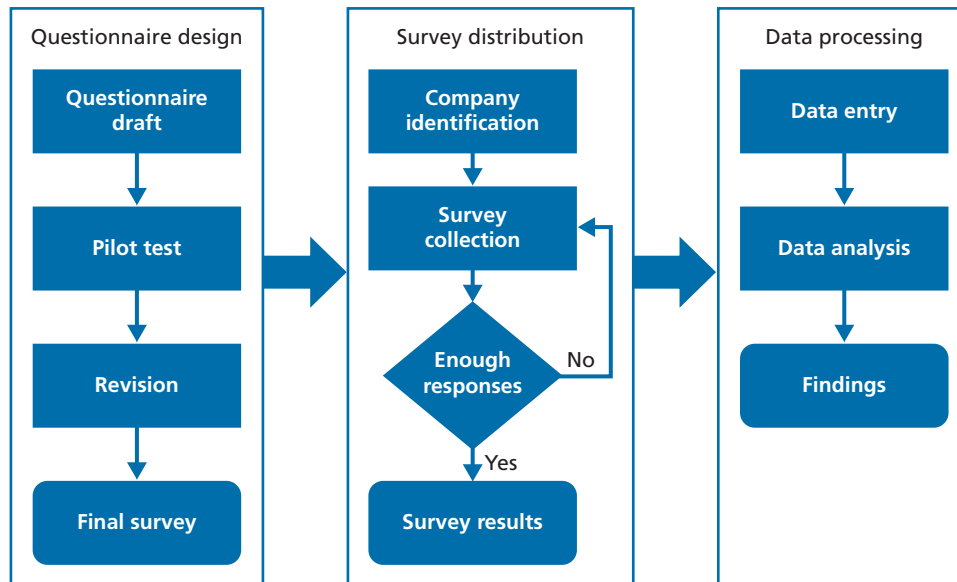
The first phase was to design a questionnaire that could help us to understand the status of GDD’s current high-technology companies, as well as some of their concerns.

Identification of population of interest

Since our goal was to identify current conditions faced by high-technology firms in GDD, we used China’s national high-technology industry catalogue to identify nine high-technology industries.¹ After targeting these industries, we then designed the questions and choices based on the materials we collected about GDD and our interviews with GDD’s government officials, high-technology companies, industrial alliances, research institutes, universities, and international investors.

¹ The nine industries are (1) electronics and information technology, (2) biological and pharmaceutical technology, (3) new materials, (4) optical, mechanical, and electronic integration, (5) alternative energy and energy efficiency, (6) environmental protection, (7) aerospace and aviation, (8) geological, space, and marine engineering, and (9) nuclear technology.

Figure D.1
GDD-RAND Knowledge City Innovation System Research Project Survey Process



RAND TR1293-D.1

Questionnaire draft

Starting with our innovation system framework, we designed the questions based on six aspects of firm operations: (1) basic information, (2) people, (3) environment for innovation, (4) financing, (5) suppliers, buyers, and support network, and (6) government support.

To better capture both characteristics of and perceptions from the high-technology companies in GDD, we drafted the survey so that it included both objective and subjective questions. For example, we included the question, “What share of your staff has a science or engineering bachelor’s degree or above?” This is an objective question that illustrates the characteristics of the company. In contrast, we also included the question, “Do you agree it is easy for employers to lay off employees?” This is a subjective question that asks for the respondent’s perception of one aspect of GDD’s business environment.

Moreover, we included several question types based on the information we wanted to understand:

1. “Single choice” questions only allow one answer to be chosen. The choices provided are mutually exclusive and the results are often used to identify basic company characteristics.
2. “Choose all that apply” questions assume that at least one answer will be chosen by the companies. We typically used this format when the choices are not mutually exclusive, and multiple characteristics fit one company.
3. “Rank the most important ones” questions allow companies to rank their priorities or difficulties. We included these questions to help us identify issues considered important by respondents.
4. “Yes or no” questions are used to illustrate whether companies agree with various statements about aspects of GDD’s innovation environment.

In addition, we inserted “other (please specify)” options into some questions where the choices we provided might not rule out all the possibilities. These open-ended choices allow respondents to identify additional issues that are not included in the standard responses.

For companies to better understand the significance of the study, as well as their rights in filling out the surveys, we also attached a cover page describing the survey’s purposes, addressing confidentiality issues, and providing our contact information. This process involved several rounds of back and forth edits between RAND and GDD on both the English and Chinese versions of the survey questionnaire. In addition, we submitted this survey to RAND’s Human Subjects Protection Committee which deemed that the survey was considered exempt from further review.

Pilot Test

In the next step, we pilot-tested the draft questionnaire with a small sample of firms chosen by GDD. The purpose of the pilot test was to gather feedback about the draft survey, including whether the questions could be easily interpreted and answered and whether the length of the survey was reasonable. We received very helpful feedback from six firms based on the pilot survey. Their suggestions largely pertained to clarifications of the questions and answers; respondents also suggested reducing the length of the questionnaire.

Revision

GDD and RAND revised the questionnaire to incorporate feedback from the pilot test. We changed the wording of a number of questions and answers. We also reduced the length of questionnaire by about half, to reduce the amount of time and personnel involved in filling it out, while still keeping the most relevant questions. GDD and RAND finalized the design of the survey questionnaires in mid-August 2011.

Survey Distribution

After finalizing the survey questionnaire, GDD was responsible for conducting the survey, which included identifying the companies to be surveyed, sending out survey questionnaires, following up with these companies, and collecting survey questionnaires.

Company Identification

Before identifying and contacting the companies, we first calculated the sample size likely to produce statistically significant results with a desired margin of error, using a simple method for determining sample sizes for testing proportions. In the two equations below, ss indicates the minimum required sample size, z is the Z-value based on our desired confidence level, c is the desired confidence interval (also called the margin of error), p represents the percentage making the choice, and pop denotes the population. Since ss is based on a very large population, we then correct the sample size for a finite population (*New ss*).

$$ss = \frac{z^2 p(1-p)}{c^2}$$

$$New\ ss = \frac{ss}{1 + \frac{ss-1}{pop}}$$

We assumed a 95 percent confidence interval (yielding a Z-value of 1.96), a 5 percent margin of error ($c = 0.05$), and a p value of 0.5. GDD also indicated that the population size, i.e., the number of high-technology companies, was about 800 ($pop = 800$). Given these parameters, we estimated that the minimum sample size (*New ss*) needed was approximately 260.

After identifying the nine high-technology industries recognized by the central government, GDD obtained a list of 786 local high-technology companies and started to contact them.

Survey Collection

The survey distribution and collection process can be divided into two phases. First, GDD contacted a random sample of companies using the list. However, the response rate was relatively low. As of November 2011, GDD had contacted 610 high-technology companies; 260 (43 percent) had agreed to take the survey and 103 (40 percent) had finished and returned the surveys. The questionnaires were mainly distributed by email and fax and were usually followed up with phone calls from the GDD staff. In general, the email response rate (75 percent) was much higher than the fax response rate (16 percent). The GDD team encountered some difficulties throughout the process of survey distribution, including lack of or incorrect contact information, lack of a respondent to fill out the questionnaire, inability of the respondent to provide data (e.g., they were too busy or did not know the information), or lack of awareness of RAND as a nonprofit institute.

After the first list of companies was exhausted, the number of survey responses had not reached the required minimum sample size. Therefore, GDD staff managed to find a new list of 2,005 companies but found that some of these companies were no longer in business. In the end, GDD ultimately was able to deliver approximately 1,500 surveys.² This suggests that the population size ranged from 1,500 to 2,005. With this new population size, the target sample increased to between 306 (for a population of 1,500) and 323 (for a population of 2,005). GDD successfully collected 305 valid surveys by the end of November, a response rate of 20.3 percent, which is acceptable for surveys such as this. However, it is slightly below the targeted sample size requirement. Survey distribution and collection were finished by the end of November 2011.

Data Processing

The next and final phase was to turn the information from the questionnaires into digital data and translate these data into research findings.

Data Entry

When questionnaires were collected by email or by fax, each company was randomly assigned a number, which was documented on the top of each page of the survey questionnaire. Company names were hidden on the questionnaires when data were entered, to ensure confidentiality.

Several interns from Zengcheng College were carefully selected and trained by GDD and RAND to enter the data on RAND's MMIC™ system, an online tool for self-administered surveys, where data are manageable and downloadable.³

² Unfortunately, there is no record of the exact number of surveys delivered.

³ <https://mmic.rand.org/>.

Data Analysis

After the 305 surveys were digitally entered, the RAND team began to analyze the survey data. We primarily used Stata, a data analysis and statistical software, to clean the raw data and perform data analysis. The actual maximum number of responses for questions applicable to all companies was 303 and the minimum was 217. With a population of 2,005, total response of 303 results in a margin of error of 0.0519 at a 95 percent confidence interval; a response rate of 217 results in a margin of error of 0.0628 at a 95 percent confidence interval. With a population of 1,500, total response of 303 results in a margin of error of 0.0503 at a 95 percent confidence interval; a response rate of 217 results in a margin of error of 0.0615 at a 95 percent confidence interval.⁴

Time Line

The time line from the start of questionnaire design to the end of data analysis was about 7.5 months. The initiation of the survey occurred during RAND's visit to GDD in June 2011, and the final results were presented during RAND's trip to GDD in February 2012. In Table D.1, we present a time line of the entire process.

Implications and Future Research

The survey would not have been possible without the cooperation of the GDD staff and the high-technology companies that participated in the survey. To our knowledge, this survey is the first to probe the innovation assets of GDD's high-technology companies by capturing both objective characteristics and subjective perceptions. Part of the survey questionnaire could also be developed as a periodic survey and used by GDD's government officials and deci-

Table D.1
Time Line of the GDD Project Survey

Survey Time Line	2011						2012	
	June	July	August	September	October	November	December	January
Questionnaire design								
Questionnaire draft	■	■						
Pilot test		■	■					
Questionnaire revision			■					
Survey distribution								
Phase I: received 103 surveys out of 786			■	■	■			
Phase II: received remaining 202 surveys out of 1,500				■	■	■		
Data processing								
Data entry				■	■	■		
Data analysis							■	■

⁴ Margins of error were computed using the Sample Size Calculator of Creative Research Systems.

sionmakers to monitor GDD's performance with respect to various elements of the innovation system framework we developed.

Summary of Results

Many of the research findings are presented in charts in Part III. Below, we list all the questions asked in the survey, the choices provided, the number of responses we received, and the distribution of answers.

Number of Responses/

Share of each answer

Questions and answers

(A) Basic Information

297	A1 In what year was this company founded? _____ [results presented by company age]
3.70%	<1
14.81%	1–3
15.82%	4–5
36.03%	6–10
27.27%	11–20
1.01%	21–30
1.35%	>30
297	A2 In what industry does this company mainly operate? (single choice)
40.74%	(1) Electronics and information technology
22.22%	(2) Biological and pharmaceutical technology
7.07%	(3) New materials
6.40%	(4) Optical, mechanical, and electronic integration
2.02%	(5) Alternative energy and energy efficiency
2.36%	(6) Environmental protection
0.67%	(7) Aerospace and aviation
0.34%	(8) Geological, space and marine engineering
0.34%	(9) Nuclear technology
17.85%	(10) Other high-tech industry (please specify)
302	A3 Is your company a subsidiary of another company?
24.17%	(1) Yes
75.83%	(2) No (skip to A4)
73	A3.1 If your company is a subsidiary, where are your headquarters located? (single choice)
14.86%	(1) Headquarters are located in GDD
12.16%	(2) Headquarters are located in Guangzhou, outside of GDD
8.11%	(3) Headquarters are located in another place in Guangdong province
20.27%	(4) Headquarters are located outside of Guangdong province but in China
44.59%	(5) Headquarters are located outside of China
227	A4 This company was (single choice):

65.45%	(1) Originally founded in GDD
31.56%	(2) Moved to GDD from elsewhere in Guangzhou, outside of GDD
1.00%	(3) Moved to GDD from within Guangdong Province, outside of Guangzhou
0.00%	(4) Moved to GDD from outside Guangdong Province
0.00%	(5) A spinoff from another company in GDD
1.33%	(6) A spinoff from another company in Guangzhou, outside of GDD
0.00%	(7) A spinoff from another company within Guangdong Province, outside of Guangzhou
0.66%	(8) A spinoff from another company outside Guangdong Province

289**A5 Company founder (choose all that apply)**

42.56%	(1) This is the first time the founder started a company
26.30%	(2) The founder previously started companies in Guangzhou (including GDD)
22.14%	(3) The founder previously started companies outside of Guangzhou
10.72%	(4) The founder previously worked for an established firm in Guangzhou (including GDD)
1.04%	(5) The founder previously worked for a start-up firm in Guangzhou (including GDD)
14.88%	(6) The founder previously worked for an established firm outside of Guangzhou
4.50%	(7) The founder previously worked for a start-up firm outside of Guangzhou

256**A6 What was your revenue in 2010? _____ (10,000) RMB**

Mean 42126.58, Standard deviation 266018.4, Minimum 0, Maximum 4040000

(B) People**279****B1 When your company was founded, how many employees did it have?**

14.70%	0–4
16.49%	5–9
19.35%	10–19
27.24%	20–50
10.39%	51–100
5.02%	101–250
3.23%	251–500
3.23%	501–1,000
0.00%	1,001–2,500
0.36%	2,501–5,000
0.00%	>5,000

279	B2 How many employees does your company have now? _____
1.79%	0–4
2.87%	5–9
10.75%	10–19
22.22%	20–50
17.20%	51–100
19.35%	101–250
12.54%	251–500
4.66%	501–1,000
3.94%	1,001–2,500
3.94%	2,501–5,000
0.72%	>5,000
299	B3 What share of your staff has a science or engineering Bachelor’s degree or above? (single choice)
10.03%	(1) Less than 10 percent
25.08%	(2) 10 to 25 percent
28.09%	(3) 25 to 50 percent
36.79%	(4) More than 50 percent
302	B4 What share of your staff has a degree from a technical secondary school or Junior College? (single choice)
14.90%	(1) Less than 10 percent
24.17%	(2) 10 to 25 percent
33.77%	(3) 25 to 50 percent
27.15%	(4) More than 50 percent
289	B5 What share of your staff has a management degree (college-level or MBA)? (single choice)
55.71%	(1) Less than 10 percent
33.56%	(2) 10 to 25 percent
7.61%	(3) 25 to 50 percent
3.11%	(4) More than 50 percent
266	B6 How many employees in your company have a Master’s degree? _____
	Mean 10.71, Standard deviation 39.64, Minimum 0, Maximum 500
257	How many employees in your company have an earned doctoral degree (Ph.D., Sc.D., M.D., or other earned doctorate)? _____
	Mean 1.61, Standard deviation 5.69, Minimum 0, Maximum 83

300

B7 How do you identify qualified staff? (choose all that apply)

- 57.33% (1) Recruit on university campuses
- 25.33% (2) Recruit at technical schools
- 65.33% (3) Job fairs
- 26.33% (4) Use a search firm that specializes in finding management staff
- 17.33% (5) Use a search firm that specializes in finding technical staff
- 72.33% (6) Place advertisements online or in local newspapers or other outlets
- 29.33% (7) Follow recommendations from current staff members
- 6.33% (8) Recruit existing employees of suppliers or customers
- 7.67% (9) Recruit existing employees of competitors
- 0.00% (10) Other (please specify)

303

B8 From where do you recruit staff? (choose all that apply)

- 80.20% (1) Guangzhou (including GDD)
- 74.26% (2) Guangdong Province, outside of Guangzhou
- 16.17% (3) Beijing or Shanghai
- 58.42% (4) Southern or central China
- 9.24% (5) Hong Kong, Taiwan, and Macao
- 38.94% (6) Other places in China except those listed above
- 14.85% (7) Chinese nationals who graduated from overseas universities
- 4.29% (8) Foreigners who graduated from overseas universities

301

B9 What is your biggest difficulty in recruiting staff? (choose a number from the list below):

What is your second biggest difficulty in recruiting staff? (choose a number from the list below):

- 55.81% (1) Salary
- 40.53% (2) Commuting time
- 7.64% (3) Educational opportunities for children
- 9.63% (4) Other family reasons
- 1.66% (5) Reluctance to live in Guangzhou city
- 24.25% (6) Reluctance to live in GDD
- 1.33% (7) Language or cultural barriers
- 11.96% (8) Housing price
- 11.30% (9) Company reputation
- 22.26% (10) Other (please specify) _____

300 B10 What is your biggest difficulty in retaining staff? (choose a number from the list below):

What is your second biggest difficulty in retaining staff? (choose a number from the list below):

- 59.33% (1) Salary
- 26.00% (2) Commuting time
- 13.67% (3) Educational opportunities for children
- 22.33% (4) Other family reasons
- 1.67% (5) Reluctance to live in Guangzhou city
- 18.00% (6) Reluctance to live in GDD
- 1.00% (7) Language or cultural barriers
- 23.33% (8) Housing price
- 3.00% (9) Company reputation
- 2.67% (10) Other (please specify) _____

284 B11 When qualified personnel leave, what is the most common place they go? (choose a number from the list below):

When qualified personnel leave, what is the second most common place they go? (choose a number from the list below):

- 31.34% (1) One of your competitors in Guangzhou (including GDD)
- 16.20% (2) One of your suppliers or customers in Guangzhou (including GDD)
- 27.82% (3) One of your competitors in another part of China or abroad
- 10.56% (4) One of your suppliers or customers in another part of China or abroad
- 39.44% (5) An unrelated company (not a competitor, supplier, or customer) in Guangzhou (including GDD)
- 23.60% (6) An unrelated company (not a competitor, supplier, or customer) outside of Guangzhou
- 29.58% (7) Unknown

294 B12 Availability of qualified technical personnel (single choice)

- 10.88% (1) I can always find new technical employees in Guangzhou (including GDD) who are qualified to work immediately
- 73.13% (2) I can find new technical employees in Guangzhou (including GDD) who are qualified to work only after training
- 15.99% (3) I have a hard time finding technical employees in Guangzhou (including GDD) who are qualified to work even after training

302 B13 Availability of qualified management personnel (single choice)

- 20.86% (1) I can always find new management team members in Guangzhou (including GDD) who are qualified to work immediately
- 64.24% (2) I can find new management team members in Guangzhou (including GDD) who are qualified to work only after training

14.90% (3) I have a hard time finding management team members in Guangzhou (including GDD) who are qualified to work even after training

(C) Environment for Innovation

- 301 C1 How do you market new innovations? (choose the most important one)**
- 37.54% (1) Contact potential costumers yourself
- 16.61% (2) Go to trade fairs or symposia
- 6.31% (3) Through associations and alliances
- 23.59% (4) Provide samples or trial versions to customers
- 15.95% (5) Other (please specify) _____
- 298 C2 How do you originate your own innovations? (choose the most important one)**
- 28.86% (1) Allow scientists and engineers to develop original ideas
- 12.42% (2) Have top scientists or executives define ideas and then form teams to develop them into products or services
- 11.74% (3) Identify innovations from universities or research organizations that may be commercialized
- 27.18% (4) Our company was founded to develop one particular, existing innovation and we are still in the process of commercializing it
- 9.40% (5) Customers encourage innovation through funding, access to equipment, feedback on existing products, or other methods
- 10.40% (6) Another way that is not listed (please specify) _____
- 301 C3 How do you protect your innovations? (choose all that apply)**
- 82.39% (1) Patent your innovations
- 35.22% (2) Set up special intellectual property (IP) protection department or hire IP lawyers
- 68.44% (3) Employees have to sign non-disclosure agreements
- 19.27% (4) Employees have to sign non-compete agreements
- 4.32% (5) Consult government if there is patent infringement
- 5.65% (6) Negotiate directly with entity that used your innovation without your permission
- 8.97% (7) Go to court
- 4.65% (8) Other (please specify) _____
- 296 C4 Do you collaborate with these entities in innovation? (choose all that apply)**
- 63.51% (1) Chinese universities
- 11.49% (2) Overseas universities
- 55.07% (3) Chinese research institutions

17.23%	(4) Overseas research institutions
28.04%	(5) Other Chinese companies
17.90%	(6) Overseas companies
22.64%	(7) Industry associations
8.78%	(8) Other (please specify) _____

C5 Do you agree with the statements listed below? Please put a check mark (“√”) in the “yes” or “no” box.

	Do you agree with the statements listed below?	Yes	No
<i>The difficulties of running a company</i>			
280	It is easy to complete the paperwork and other necessary measures to start a company in GDD.	83.93%	16.07%
217	It is easy to complete the paperwork and other necessary measures to shut down a company in GDD.	63.59%	36.41%
220	If I try to start a company and it fails, it will be difficult to start a new company.	39.55%	60.45%
<i>Labor market</i>			
275	I would hire someone who has previously worked for a competitor.	82.91%	17.09%
266	I would hire someone who has previously worked for one of my suppliers or customers.	86.09%	13.91%
267	If one of my employees were to leave my company and go to work for one of my competitors, that would be acceptable.	72.66%	27.34%
265	If one of my employees were to leave my company and go to work for one of my suppliers or customers, that would be acceptable.	86.42%	13.58%
263	It is easy for employers to lay off employees.	15.21%	84.79%
267	It is easy for employees to move between companies within GDD.	61.80%	38.20%

(D) Finance

293 D1 What was the source of your initial investment? (choose all that apply)

88.40%	(1) Your own money
6.48%	(2) Friends
4.10%	(3) Family
2.39%	(4) Angel investors
7.17%	(5) Private investment funds
12.97%	(6) Government funds
0.68%	(7) Government purchase orders
21.16%	(8) Bank loans
3.07%	(9) Other (please specify)

290**D2 As the company has grown, where have you gotten additional financing? (choose all that apply)**

56.55%	(1) Your own money
5.17%	(2) Friends
3.10%	(3) Family
22.07%	(4) Retained earnings
1.72%	(5) Angel investors
1.34%	(6) Private investment funds
21.38%	(7) Government funds
3.79%	(8) Government purchase orders
45.52%	(9) Bank loans
17.93%	(10) Initial Public Offering (IPO)
7.24%	(11) Selling minority equity share
5.52%	(12) Other (please specify)

296**D3 Please think about the first round of outside funding your company received. If you have not received any outside funding, please skip to E1.**

27.70%	(1) Yes
72.30%	(2) No (skip to E1)

63**D3.1 How many months elapsed between founding the company and receiving the first round of outside funding? _____**

33.85%	<7 months
15.38%	7–12 months
24.62%	13–24 months
9.23%	25–36 months
16.92%	>36 months

65	D3.2 What was the company's first source of outside funding? _____
49.32%	Bank
15.07%	PE/VC/Other Investor
6.85%	Government
5.48%	Parent company
5.48%	Angel
4.11%	IPO
1.37%	Sales
12.33%	Other
73	D3.3 What was the approximate amount of the company's first source of outside funding? _____ (10,000) RMB
¥ 1,566	Bank
¥ 797	PE/VC/Other Investor
¥ 3,268	Government
¥ 1,187	Parent company
¥ 825	Angel
¥ 170,000	IPO
¥ 600	Sales
¥ 1,227	Other
77	D3.4 How was the company's first source of outside funding structured? (single choice)
33.77%	(1) Collateralized loans
10.39%	(2) Non-collateralized loans
37.66%	(3) Investor owns equity in company
6.49%	(4) Advanced payment for products
5.19%	(5) Research funds
1.30%	(6) Interest-free loan or grant
5.19%	(7) Other (please specify) _____
43	D4 If your company has ever received funding from an outside investor, what role(s) does (or did) that investor play? (choose all that apply)
25.58%	(1) Has a seat on the board
16.28%	(2) Actively takes part in management decisions
25.58%	(3) Provides advice to the management team
6.98%	(4) Provides connections to other companies the investor is involved with

- 0.00% (5) Has the ability to replace the management team
- 25.58% (6) Other (please specify)_____

(E) Suppliers, Buyers and Support Network

E1 In designing and developing your product(s) or service(s), do you agree with the statements listed below? Please put a check mark (“√”) in the “yes” or “no” box.

	Do you agree with the statements listed below?	Yes	No
284	You can find local suppliers (in Guangzhou, including GDD) from whom you can purchase the inputs you need.	67.61%	32.39%
274	Your buyers are located nearby (in Guangzhou, including GDD) so that you can interact with them to get feedback on your product(s) or service(s).	43.43%	56.57%

E2 Do you find it easy to obtain the following services? Please put a check mark (“√”) in the “yes” or “no” box.

	Do you find it easy to obtain this service?	Yes	No
272	Accounting	88.24%	11.76%
272	Intellectual property issues	80.51%	19.49%
255	Legal issues	76.08%	23.92%
254	Finding management talent	49.61%	50.39%
252	Finding technical talent	40.48%	59.52%
246	General advice regarding starting or growing a company	60.16%	39.84%
243	Technology transfer	46.50%	53.50%
248	Investment advice	65.73%	34.27%
7	Other (please specify)	28.57%	71.43%

(F) Government support

F1 Does the GDD administration help you in any of the areas listed below? Please put “√” into the box of “yes” or “no”.

	Does the GDD administration help you in any of the areas listed below?	Yes	No
256	Provide financing	35.55%	64.45%

254	Rent out incubator space	48.43%	51.57%
262	Sell land or lease land	61.07%	38.93%
255	Rent out buildings	45.49%	54.51%
254	Provide preferential leasing terms	58.27%	41.73%
256	Provide preferential tax policies	68.36%	31.64%
251	Help to apply for patents	46.22%	53.78%
244	Help to connect to other companies or investors	40.98%	59.02%
243	Help to connect to customers	20.16%	79.84%
247	Help to set up a new company	33.20%	66.80%
243	Help to enforce contracts with suppliers or customers	16.05%	83.95%
241	Help to enforce intellectual property or patent rights	39.83%	60.17%
240	Help to enforce non-disclosure agreements or non-compete clauses	25.00%	75.00%
239	Help with initial public offering (IPO)	14.64%	85.36%
263	Help to recruit talent	53.61%	46.39%
258	Help to train talent	47.67%	52.33%
275	<p>F2 From the choices below, please choose the most important new policy that should be adopted by the GDD administration. (choose a number from the list below): _____</p> <p>From the choices below, please choose the second most important new policy that should be adopted by the GDD administration. (choose a number from the list below): _____</p> <p>From the choices below, please choose the third most important new policy that should be adopted by the GDD administration. (choose a number from the list below): _____</p>		
47.64%	(1) Increase government venture capital		
67.27%	(2) Increase research funds		
74.54%	(3) Provide preferential tax policies		
20.73%	(4) Provide networks to find new customers		
10.91%	(5) Provide support services such as legal or accounting advice		
40.73%	(6) Provide more help with talent, including recruiting and training workers		
13.09%	(7) Enhance collaboration with universities in Guangzhou (including GDD) to provide a source of qualified talent for GDD companies		

9.82%	Other (please specify) _____
267	F3 Besides GDD, which place do you think is the most suitable for you to develop your business? (single choice)
13.48%	(1) Beijing
13.11%	(2) Shanghai
30.71%	(3) Yangtze River Delta (except Shanghai)
28.46%	(4) Other cities within Guangdong Province
14.23%	(5) Other cities outside Guangdong Province (except Beijing, Shanghai, and Yangtze River Delta)

NOTES: Firms could give more than one answer to Questions A5, B7, B8, B9, B10, B11, C3, C4, D1, D2, D4, and F2, so the total may sum to more than 100 percent for each question. The first column of Question D3.3 shows the average amount of the company's first source of outside funding in 10,000 RMB. Although only 73 firms responded to Question D3.2, an additional two firms provided information about how their first outside investment was structured (Question D3.4), so we used this information to impute their answers to Question D3.2.

Indicators of Innovation

The companion report, *An Outline of Strategies for Building an Innovation System for Knowledge City*, presents 12 priority indicators that GDD can use to measure progress toward the goal of creating and encouraging growth of high-technology firms. In this appendix, we present a more complete list of 54 indicators for gauging progress. These measures include indicators of direct progress toward the desired goal of growth among high-technology firms, as well as indirect progress toward creating inputs needed to achieve firm growth. Measuring progress toward the creation of inputs can shed light on what elements of the innovation environment should be targeted for improvement.

We present indicators that may be used to measure progress toward the goal of creating and growing high-technology firms, as well as toward the inputs of human capital and finance (Table E.1). For each goal or input, we suggest several ideal measures and suggested metrics for capturing, to the extent possible, those ideal measures. For example, one ideal measure of human talent would be the number of talented individuals and returnees drawn to Knowledge City. Since it is difficult to measure talent directly, we suggest several metrics that may be used as proxies for talent, including the number of local graduates with science, technology, engineering, and mathematics (STEM) degrees, management degrees, and finance degrees; the number of Knowledge City employees and overseas returnees with STEM, management, and finance degrees; the number of Knowledge City employees with degrees from top universities; and the number of Knowledge City residents with STEM, management, or finance degrees.

For each suggested metric, we identify potential methods for collecting the required data. Many of these metrics require firm surveys, although several can be drawn from administrative data. We also discuss each metric's strengths and weaknesses. For the above example, the number of local graduates with specific degrees can be drawn from administrative data, making it easy to collect, but this metric does not account for the fact that some graduates may leave the area. In contrast, measuring the number of Knowledge City employees with specific degrees would likely require a firm survey, making it more difficult to collect but providing more accurate information about the local workforce.

We then suggest how each metric should be prioritized. These priorities are based on the priority and sequencing of actions related to the metrics and on the specific strengths and weaknesses of each. In the example above, we have suggested that the number of Knowledge City employees and returnees with STEM, management, or finance degrees be given high priority, because it reflects the specific skills of the local workforce; that the number of local graduates in STEM, management, or finance be given medium priority, because although it is easy to measure, it does not pertain to Knowledge City specifically; and that the number of employees from top universities be given low priority, because it does not reflect specific skills.

While these indicators were developed specifically for Knowledge City, we have taken care to ensure that many of them reflect similar indicators used by other organizations. Whenever relevant, we point out similar metrics that are found in the Index of Silicon Valley (published by Joint Venture and the Silicon Valley Community Foundation) or the statistical indicator database maintained by OECD. These indicators will provide a solid start for GDD in its efforts to monitor its inputs into the development of Knowledge City and the outcomes that will result.

**Table E.1
Indicators of Innovation**

Ideal Measure	Suggested Metric	How to Measure	Strength and Weakness of Suggested Metric	Priority	Similar Metric Used in Silicon Valley or OECD Indices (If Applicable)
Goal: Attract High-Technology Companies and Enable Their Growth					
<i>Action: Attract Anchor Institutions and Market Knowledge City</i>					
Attractiveness of Knowledge City to anchor tenants	Number of anchor tenants located in Knowledge City	Administrative data	<i>Strength:</i> Easy to measure <i>Weakness:</i> May not reflect ability of anchor tenants to grow or attract other firms	High	
Success of anchor tenants	Number of firms that report locating in Knowledge City to be close to another firm that is already in Knowledge City	Firm survey	<i>Strength:</i> Measures one key aspect of an anchor tenant's role <i>Weaknesses:</i> Relies on perceptions of person filling out survey for firms' reasons for locating in Knowledge City; depending on survey question/ responses, may not indicate which firms attract others to Knowledge City	Medium	
	Number of local spinoffs from Knowledge City firms	Firm survey	<i>Strength:</i> Measures one key aspect of an anchor tenant's role <i>Weakness:</i> Can be difficult to classify firms as spinoffs, especially if started by former employees of another firm	Medium	
Attractiveness of Knowledge City to companies	Number of firms in high-technology sectors	Administrative data	<i>Strength:</i> Relatively easy to measure <i>Weakness:</i> Does not reflect ability of companies to survive or grow	High	Silicon Valley Index (number of establishments), OECD (number of enterprises by sector)
Growth of companies	Domestic sales (level and growth), by sector	Firm survey	<i>Strength:</i> Measures commercial potential <i>Weakness:</i> May not reflect innovative or high-value-added products or services	High	OECD

Table E.1—Continued

Ideal Measure	Suggested Metric	How to Measure	Strength and Weakness of Suggested Metric	Priority	Similar Metric Used in Silicon Valley or OECD Indices (If Applicable)
	Exports (level and growth), by sector	Firm survey	<i>Strength:</i> Measures commercial potential <i>Weakness:</i> May not reflect innovative or high-value-added products or services	High	OECD
	Market share of products or services	Firm survey combined with administrative data	<i>Strength:</i> Measures commercial potential <i>Weakness:</i> May not reflect innovative or high-value-added products or services	Low	OECD (production, sales, exports, imports in various industries, and related market shares)
	Net job creation, by sector	Firm survey	<i>Strength:</i> Measure of local employment <i>Weakness:</i> May not reflect employment in innovative firms	High	Silicon Valley Index (employment, number of jobs, unemployment rate, employment by industry, nonemployer firm growth), OECD (various measures of employment) Note: Nonemployers are generally self-employed people
	Number of new products or services launched	Firm survey	<i>Strength:</i> Reflects some measure of innovation <i>Weaknesses:</i> Relatively difficult to measure; may not reflect future success of products or services; may not reflect high-value-added products or services	Low	
Value-added total factor productivity	Value added per employee	Firm survey	<i>Strengths:</i> Reflects high-value-added products or services; relatively simple to measure <i>Weakness:</i> Does not take into account the productivity of other factors (capital, materials)	High	Silicon Valley Index (value added per employee), OECD (labor productivity, total factor productivity)
	Average salaries	Firm survey	<i>Strength:</i> Salaries should reflect value provided by labor <i>Weakness:</i> May not reflect innovative or high-tech activity	Medium	Silicon Valley Index (per capita income, median household income), OECD (wages, gross domestic product per capita)

Table E.1—Continued

Ideal Measure	Suggested Metric	How to Measure	Strength and Weakness of Suggested Metric	Priority	Similar Metric Used in Silicon Valley or OECD Indices (If Applicable)
Number of innovations with strong potential for commercialization	Number of patents registered worldwide	Collect administrative data from various patent databases or conduct firm survey	<p><i>Strength:</i> Global; easily quantifiable</p> <p><i>Weaknesses:</i> May require intensive effort to assemble statistics from multiple sources; may not capture quality of innovation; may not capture potential for commercialization</p>	Low	OECD (number of patents filed with various agencies)
	Number of patents registered in the United States	Collect administrative data from USPTO or conduct firm survey	<p><i>Strengths:</i> Relatively easy to collect administrative data; data generally identify inventor’s city; captures quality of innovation to some extent</p> <p><i>Weaknesses:</i> May be more difficult to identify patents associated with Knowledge City specifically; may not capture potential for commercialization</p>	Medium	Silicon Valley Index (number of patent registrations, number of patent registrations by technology area), OECD
<i>Action: Improve the Overall Innovation Environment: Taxes and Non-Tax Measures</i>					
Number of firms that located in Knowledge City because of tax or nontax incentives	Firms’ perceptions about ease of obtaining tax and nontax incentives	Firm survey	<p><i>Strength:</i> Captures some measure of usefulness of incentives</p> <p><i>Weaknesses:</i> Does not reflect perceptions of firms that did not choose to locate in Knowledge City; relies on perceptions of person filling out survey for why firm located in Knowledge City</p>	High	
<i>Action: Improve the Overall Innovation Environment: Intellectual Property Rights</i>					
Strength of IPR enforcement	Firms’ perceptions about IPR enforcement	Firm survey	<p><i>Strength:</i> Captures key measure of business climate that could help to differentiate Knowledge City from other regions in China</p> <p><i>Weaknesses:</i> May be difficult to quantify; does not reflect perceptions of firms that choose not to locate in Knowledge City because of IPR challenges</p>	High	

Table E.1—Continued

Ideal Measure	Suggested Metric	How to Measure	Strength and Weakness of Suggested Metric	Priority	Similar Metric Used in Silicon Valley or OECD Indices (If Applicable)
Ease of patenting (particularly international)	Number of patents registered in the United States	Collect administrative data from USPTO or conduct firm survey	<i>Strength:</i> Quantitative measure of innovation <i>Weakness:</i> Does not reflect ability of firms to enforce patents	Medium	Silicon Valley Index (number of patent registrations, number of patent registrations by technology area), OECD
	Number of patents produced by local university and institute researchers	Collect administrative data from various patent databases or conduct survey of institutions	<i>Strength:</i> Quantitative measure of innovation by local research institutions <i>Weaknesses:</i> May require intensive effort to assemble statistics from multiple sources; does not reflect ability of institutions to enforce patents	Medium	OECD (number of patents filed with various agencies)
<i>Action: Improve the Overall Innovation Environment: Other Business Climate Issues and Enlarging the Size of the Market</i>					
Overall attractiveness of business climate	Supply and vacancy rates for commercial space	Administrative data	<i>Strength:</i> Relatively easy to measure <i>Weakness:</i> Only reflects real estate aspects of business climate	Medium	Silicon Valley Index (change in supply of commercial space, rate of vacancy, new commercial development)
	Commercial rents	Administrative data	<i>Strength:</i> Relatively easy to measure <i>Weakness:</i> Reflects only the real estate aspects of business climate	Medium	Silicon Valley Index (commercial rent)
Amount of “creative destruction”—opening of new firms and closing of firms that are competing poorly	Number of startup firms in high-technology industries	Firm survey or administrative data	<i>Strength:</i> Relatively easy to measure <i>Weakness:</i> Does not measure quality of firms or potential for innovation	High	Silicon Valley Index (number of new establishments), OECD (enterprise birth rate)
	Establishment turnover (firm births as a fraction of total firms, firm deaths as a fraction of total firms)	Firm survey	<i>Strength:</i> Captures elements of creative destruction <i>Weakness:</i> Identifying firm births and deaths may be difficult for small or young firms	Medium	Silicon Valley Index (establishment churn, job churn, firms and employment entering and leaving Silicon Valley), OECD (enterprise birth and death rates)

Table E.1—Continued

Ideal Measure	Suggested Metric	How to Measure	Strength and Weakness of Suggested Metric	Priority	Similar Metric Used in Silicon Valley or OECD Indices (If Applicable)
Sufficient local demand for innovative products and services	Exports to Taiwan, Hong Kong, Korea, Japan	Firm survey	<p><i>Strength:</i> Reflects access to sophisticated markets</p> <p><i>Weakness:</i> May not reflect whether products sold are sophisticated</p>	Low	OECD (exports to various markets)
Goal: Attract and Retain People					
<i>Action: Improve Quality of Life</i>					
Overall quality of life	Share of workforce in Knowledge City that does not consider quality of life issues a concern	Worker or firm survey	<p><i>Strength:</i> Measures an important input for attracting and retaining human capital</p> <p><i>Weaknesses:</i> If a firm survey is used, respondent may not have accurate understanding of workers' preferences; worker survey requires additional data collection effort; does not reflect preferences of workers who chose not to locate in Knowledge City because of quality of life issues</p>	Medium	
	Share of firms that do not report that quality of life issues present a challenge in recruiting or retaining workers	Firm survey	<p><i>Strength:</i> Reflects firms' perceptions about workers who may not choose to locate in Knowledge City because of quality of life issues</p> <p><i>Weakness:</i> Firms may not accurately perceive workers' concerns</p>	High	
	Number of top local schools	Administrative data	<p><i>Strength:</i> Easy to measure</p> <p><i>Weakness:</i> May not capture how well the schools serve the local population</p>	High	Silicon Valley Index (various measures of educational strength including graduation rates, test scores)
	Population residing in Knowledge City	Administrative data	<p><i>Strength:</i> Relatively easy to measure</p> <p><i>Weakness:</i> May not capture population involved with innovative activities</p>	High	Silicon Valley Index (population, migration)

Table E.1—Continued

Ideal Measure	Suggested Metric	How to Measure	Strength and Weakness of Suggested Metric	Priority	Similar Metric Used in Silicon Valley or OECD Indices (If Applicable)
	Commuting times	Worker or firm survey	<p><i>Strength:</i> Reflects a key concern identified in firm survey</p> <p><i>Weaknesses:</i> If a firm survey is used, respondent may not have accurate understanding of workers' commuting times; worker survey requires additional data collection effort</p>	High	Silicon Valley Index (vehicle miles traveled per capita, means of commute, transit use)
	Housing costs	Administrative data	<p><i>Strength:</i> Reflects a key concern identified in firm survey and interviews</p> <p><i>Weakness:</i> Housing costs are typically high in innovative clusters so high costs may not signal a concern</p>	Medium	Silicon Valley Index (home price, home affordability, residential density, housing near transit, rental rates compared to household income)
	Age distribution of population	Administrative data (population census)	<p><i>Strengths:</i> Easy to measure; captures attractiveness of area to young population</p> <p><i>Weakness:</i> Indirect measure of attractiveness for innovative population</p>	Low	Silicon Valley Index
<i>Action: Attract Talented Individuals and Returnees</i>					
Number of talented individuals and returnees	Number of local graduates with bachelor's or advanced degrees in STEM, management, or finance	Administrative data from universities	<p><i>Strength:</i> Relatively easy to measure</p> <p><i>Weaknesses:</i> May not reflect quality of graduates or whether graduates' skills match firms' needs; graduates may leave area</p>	Medium	Silicon Valley Index (science and engineering degrees conferred), OECD (tertiary education graduation rates)
	Number of Knowledge City employees with bachelor's or advanced degrees in STEM, management, or finance	Firm survey	<p><i>Strength:</i> Reflects local workforce</p> <p><i>Weakness:</i> May not reflect quality of workers or whether workers' skills match firms' needs</p>	High	Silicon Valley Index (educational attainment of population), OECD (tertiary educational attainment)
	Number of employees who are overseas returnees with bachelor's or advanced degrees in STEM, management, or finance	Firm survey	<p><i>Strength:</i> Reflects a pool of potentially highly skilled employees with international connections</p> <p><i>Weakness:</i> May not reflect whether returnees' skills match firms' needs</p>	High	

Table E.1—Continued

Ideal Measure	Suggested Metric	How to Measure	Strength and Weakness of Suggested Metric	Priority	Similar Metric Used in Silicon Valley or OECD Indices (If Applicable)
	Number of employees from top universities	Firm survey	<i>Strength:</i> Reflects some measure of worker quality <i>Weakness:</i> May not reflect whether workers' skills match firms' needs	Low	
	Number of Knowledge City residents with bachelor's or advanced degrees in STEM, management, or finance	Household survey	<i>Strength:</i> Reflects potential pool of local workers <i>Weakness:</i> May not reflect quality of workers or whether workers' skills match firms' needs	Medium	Silicon Valley Index (educational attainment of population), OECD (tertiary educational attainment)
Ability of firms to find sufficient high-quality, skilled labor	Number of researchers hired by local firms	Firm survey	<i>Strength:</i> Reflects firms' ability and desire to hire researchers <i>Weakness:</i> May not reflect ability of firms to find sufficient, skilled researchers	Medium	OECD (number of R&D personnel)
<i>Action: Improve Labor Flexibility</i>					
Ease of doing business	Firms' perceptions of ease of starting up and shutting down	Firm survey	<i>Strength:</i> Captures measure of overall business climate <i>Weaknesses:</i> May be difficult to quantify; does not reflect perceptions of firms that choose not to locate in Knowledge City because of difficulty in starting up or shutting down	Medium	
	Firms' perceptions of ease of laying off workers	Firm survey	<i>Strength:</i> Reflects a key challenge in business climate identified in firm survey <i>Weaknesses:</i> May be difficult to quantify; does not reflect perceptions of firms that choose not to start up or locate in Knowledge City because of challenges in laying off workers	Medium	OECD (strictness of employment protection)
Labor mobility	Share of firms using noncompete clauses	Firm survey	<i>Strength:</i> Relatively easy to quantify; Reflects some measure of ease of labor mobility <i>Weakness:</i> May not reflect actual employee movement between firms	Medium	

Table E.1—Continued

Ideal Measure	Suggested Metric	How to Measure	Strength and Weakness of Suggested Metric	Priority	Similar Metric Used in Silicon Valley or OECD Indices (If Applicable)
	Share of firms with employees who previously worked for other local firms	Worker or firm survey	<p><i>Strength:</i> Captures actual labor mobility</p> <p><i>Weaknesses:</i> If a firm survey is used, respondent may not have accurate understanding of workers' histories; worker survey requires additional data collection effort</p>	Low	
<i>Action: Foster Networks</i>					
Networks: Being part of the global innovation network	Number of foreign subsidiaries or employment	Firm survey	<p><i>Strength:</i> Relatively simple to measure</p> <p><i>Weakness:</i> May not reflect innovative connections</p>	Low	
	Number of foreign collaborations	Firm survey	<p><i>Strength:</i> Could reflect collaborations with foreign entities in China and abroad</p> <p><i>Weaknesses:</i> Difficult to quantify; may not reflect quality of foreign collaborations</p>	Low	
Networks: Being regionally connected	Connections with business, industry, academia in Guangzhou	Firm survey	<p><i>Strength:</i> Reflects strength of local network</p> <p><i>Weaknesses:</i> Difficult to quantify; may not reflect quality of connections</p>	Low	
Networks: Local	Number of local patents that cite other local patents	Administrative patent data from USPTO	<p><i>Strength:</i> Can be quantified</p> <p><i>Weaknesses:</i> Potentially intensive data collection effort; may be difficult to identify spillovers within Knowledge City (rather than within Guangzhou as a whole)</p>	Low	
	Number of workers who previously worked for another firm in Knowledge City	Worker or firm survey	<p><i>Strength:</i> Measures labor mobility and indicates potential for local networks</p> <p><i>Weaknesses:</i> If a firm survey is used, respondent may not have accurate understanding of workers' histories; worker survey requires additional data collection effort</p>	Medium	

Table E.1—Continued

Ideal Measure	Suggested Metric	How to Measure	Strength and Weakness of Suggested Metric	Priority	Similar Metric Used in Silicon Valley or OECD Indices (If Applicable)
	Number of local spinoffs from Knowledge City firms	Firm survey	<p><i>Strength:</i> Reflects potential for local connections</p> <p><i>Weakness:</i> Can be difficult to classify firms as spinoffs, especially if started by former employees of another firm</p>	Medium	
Goal: Financing					
<i>Action: Ensure the Availability of Innovation-Oriented Finance</i>					
Ability of firms to find sufficient early-stage financing	Amount of private venture financing (or share in total investment)	Firm survey	<p><i>Strength:</i> Can be measured midway through firm life cycle</p> <p><i>Weakness:</i> May not reflect whether firms can find sufficient funding</p>	High	Silicon Valley Index (amount of venture capital, venture capital by industry, share of venture capital in total U.S. venture capital)
	Amount of foreign venture financing (or share in total investment)	Firm survey	<p><i>Strengths:</i> Reflects foreign confidence in Knowledge City firms; can be measured midway through firm life cycle</p> <p><i>Weaknesses:</i> May not reflect whether firms can find sufficient funding; reflects only foreign funding</p>	Medium	
	Amount of angel investment (or share in total investment)	Firm survey	<p><i>Strengths:</i> Reflects a missing component in GDD funding; can be measured early in firm life cycle</p> <p><i>Weakness:</i> May not reflect whether firms can find sufficient funding</p>	High	
	Number and size of angel investor networks	Administrative information or interviews with local business leaders	<p><i>Strengths:</i> Reflects a missing component in GDD funding; relatively easy to measure; also reflects local networks</p> <p><i>Weaknesses:</i> Does not reflect funding amount; does not take individual angel investors into account</p>	High	

Table E.1—Continued

Ideal Measure	Suggested Metric	How to Measure	Strength and Weakness of Suggested Metric	Priority	Similar Metric Used in Silicon Valley or OECD Indices (If Applicable)
	Amount of small business loans (or share in total funding)	Firm survey	<i>Strength:</i> Can be measured early in firm life cycle <i>Weakness:</i> Firms in GDD already receive much external financing in the form of bank loans	Low	Silicon Valley Index (growth of small business loans)
<i>Action: Make Other Types of Funding More Available</i>					
Ability of firms to find sufficient R&D funding	Amount of (nongovernment) R&D funding secured by firms or universities (or share in total funding)	Firm survey	<i>Strength:</i> Can be measured early in firm life cycle <i>Weakness:</i> May not reflect commercialization potential	Medium	Silicon Valley Index (number of small business research awards per \$1 million gross domestic product), OECD
	Amount of firm R&D expenditures (or share of firm R&D expenditures in total expenditures)	Firm survey	<i>Strength:</i> Measures firms' commitment to R&D <i>Weakness:</i> May not reflect commercialization potential	Medium	OECD (various measures of expenditures on R&D by industry and government)
Ability of firms to find sufficient late-stage financing	Number of IPOs	Firm survey or administrative data from various public and private sources	<i>Strength:</i> Concrete measure of successful exit <i>Weaknesses:</i> Relatively rare occurrence; can be measured only late in firm life cycle	Low	Silicon Valley Index (number of IPOs, share of IPOs in global IPOs)
	Number of mergers and acquisitions	Firm survey or administrative data from various public and private sources	<i>Strength:</i> Concrete measure of successful exit <i>Weaknesses:</i> Relatively rare occurrence; can be measured only late in firm life cycle	Low	Silicon Valley Index (number of deals, share of deals in overall U.S. deals)

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