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Today we are delighted to announce the release of the first NYCEDC Innovation Index. The Index could not come at a more relevant time. New York City has emerged from the recent financial crisis with enormous momentum and has reaffirmed its leadership role as a center for innovation and growth in the global economy. But recent years have also seen an exciting new trend. The City's strongest industries, from media to financial services, are attracting a new breed of entrepreneurs that are at the forefront of revolutionary developments in high-tech, engineering and science. This process of combining traditional strengths with future opportunities is at the core of the City's ability to continuously reinvent itself, and we are witnessing it today once more. The NYCEDC Innovation Index will be a critical tool in tracking this economic transformation and we are proud of our contribution to its development.

Sincerely,

John Borthwick, CEO and Co-Founder, Betaworks
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If there is one thing that is predictable about New York City, it is its ability to reinvent itself. From its founding, the City has undergone constant transformation driven by the ingenuity, energy and diversity of its people. This essential spirit of New York City has always been strongest when economic challenges have been the greatest.

For example, the seeds of the City’s great manufacturing industries of the 19th and 20th centuries took root amongst the bustling quarters of its port, which was a global hub for trade. In the 1970s, as manufacturing experienced substantial decline, the City’s globally dominant finance, professional services, and media industries began to flourish in new and dramatic ways.

Today, as some of the City’s traditional industries are experiencing an increasingly competitive landscape, a new seed is once again being planted – one that we ultimately hope, when it blossoms, will reveal New York as the world leader in innovation and entrepreneurship.

Anecdotaly, there is evidence that New York City is becoming a hot spot for technological breakthroughs that will revolutionize the way we communicate, how we do business, and how we understand the world around us. New York-based tech companies like Foursquare, Tumblr and Meetup are literally changing how we interact and communicate. Meanwhile, New York-based companies like Etsy, ChallengePost and MakerBot are reinventing the marketplace from the ground up. And, at the same time, scientists at the City’s hospitals, universities and R&D incubators – including the Audubon Incubator at Columbia University, the Advanced Biotechnology Incubator at SUNY Downstate Medical Center, the Alexandria Center for Life Science at East River Science Park and BioBAT at Brooklyn Army Terminal – are making groundbreaking scientific discoveries that will lead to life-changing medical treatments.

Recognizing that this anecdotal evidence seemed to indicate a new trend, several years ago, working with leaders in business, science and the arts, we acted to galvanize this process. To this end, in 2010, we created the Center for Economic Transformation. Since then, we have launched over 60 initiatives to create a vibrant innovative environment. These initiatives include the New York City Entrepreneurial Fund, which seed funds early-stage companies, and our business incubators that host a wide range of promising start-ups. We have also initiated a multi-year process to attract a major science and engineering university to the City or catalyze its development by an existing in-City player, an initiative that will be one of the keystones for the City’s future success as a global innovation capital.

With the launch of the NYCEDC Innovation Index today, we are now moving our work to the next level. For the first time ever, the NYCEDC Innovation Index will provide hard evidence of the City’s transformation in progress, allowing us to move from the art of anecdote to the science of hard numbers. This, in turn, will allow us to assess the City’s progress and to tailor NYCEDC’s future work more closely to meet the needs of the innovators that call our City home.

Most significantly though, the Innovation Index will show how the City is changing once more. It is impossible to tell today what the City will look like in the future. But as home to one of the world’s most productive, most creative and most entrepreneurial populations, one thing is certain – the City’s future will be bright.
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The 2011 NYCEDC Innovation Index provides an analytical, comprehensive depiction of innovation activity in New York City. The data presented in this year’s Index and subsequent updates will inform policies geared to unleash New York City’s enormous potential for innovation.

The NYCEDC Innovation Index offers a new approach to innovation measurement in two respects. First, it is focused solely on New York City. Second, it tracks innovation activity over time to uncover its trends and characteristics.

The Index gives us a granular understanding of the drivers of innovation:

- **Input Indicators.** The Index examines the City’s environment for innovation along three dimensions: research and development (R&D) spending, finance, and human capital. These input indicators give us insight into, for example, how much universities are spending on R&D or how much venture capital is being invested in the area’s firms.

- **Output Indicators.** The Index shows the success of innovation investments through the analysis of intellectual property, production in high-tech sectors and entrepreneurship. Measuring these output indicators is critical in order to understand whether ideas become economic realities. They include, among others, measures on the success of start-ups and the high-tech sectors’ share of the City’s economy.

The results of the Index support the premise that New York City is turning into a center for innovation, particularly with regard to high-tech sectors. **Overall, innovation-related activity increased by 12% between 2003 and 2009, a trend that preliminary data and estimates suggest persisted in 2010 to reach 14%.** This means that, collectively, entrepreneurs, businesses and research institutions are spurring innovation in the City and leading its economic transformation. The Index also shows that innovation inputs grew more than outputs over the period considered. Because inputs tend to be leading indicators, their strong performance indicates that the Index outputs are expected to rise in the near future.

The Index measures the growth of input and output indicators and highlights key trends in the City’s innovation economy:

- Venture capital (VC) funding in the New York metro area totaled $1.9 billion in 2010, with firms in the City accounting for 64% of this activity. Both the number and value of VC deals increased at a significantly higher rate than in the rest of the nation between 2003 and 2010.

- New York City’s small businesses received a total of $30 million in federal grant dollars for innovation and research in 2009. The value of the grants to the City’s firms more than doubled between 2003 and 2009.

- The high-tech sectors’ share of the Gross City Product (GCP) increased by almost 25% between 2003 and 2009. In 2009, GCP per worker in the City’s high tech sectors was more than $200,000, which was among the highest level of any sector.

- The City’s universities invested $1.8 billion in R&D in 2009. R&D spending at these institutions increased 13% since 2003 and accounted for approximately 3.5% of all academic R&D spending nationally.

- In 2009, the City’s universities were home to nearly 27,000 graduate and post-doctorate students in Science and Engineering (S&E) disciplines. This represented a 3.9% share of all such students in the U.S. and is up from 3.5% in 2003, demonstrating the City’s learning and research institutions’ growing influence in these fields.

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* 2010 data are preliminary
With nearly 179,000 people employed in S&E occupations in 2009, the City's workforce is becoming more concentrated in these jobs. The number of workers increased by 9% between 2003 and 2009, while their share of total private employment grew by 4%.

There were approximately 1,100 patents awarded to New York City inventors in 2009. This was an increase of 23% from 2003.

In the aggregate, input indicators grew 2.2% annually between 2003 and 2009, led by venture capital and research grants to small businesses. Output indicators showed lower annual growth of 1.7% over the same period, led by GCP in high-tech sectors.

Capitalizing on the quality of New York City's labor force and new entrepreneurial initiatives, the Index shows that more innovative small businesses entered the market to ignite and drive growth in the City's economy. Barriers to firm creation and access to capital appear to have lowered in the past few years, even as the recession took hold of the economy.

Accelerating the trend toward economic transformation will be critical to secure the City's future prosperity and economic growth, particularly given the challenges of competing in the global economy. It is especially important to ensure that the City's entrepreneurs are able to access the necessary inputs: research institutions, financial and human capital, knowledge and networks. The City's policies for innovation should make sure government intervention is targeted to alleviate the constraints and market failures that limit the creation and survival of innovative firms.

| NYCEDC Innovation Index | Cumulative Growth 2003-2009 | Annual Growth* 2003-2009 | Trend 2009 vs. 2008 | Trendlines 2003-2009 |
|-------------------------|-----------------------------|--------------------------|---------------------|---------------------|
| Input Indicators        |                             |                          |                     |                     |
| R&D                     | 4.8%                        | 0.8%                     | ↑                   | ↑                   |
| Finance                 | 23.0%                       | 3.5%                     | ↑                   | ↑                   |
| Human Capital           | 13.2%                       | 2.1%                     | ↑                   | ↑                   |
| Output Indicators       |                             |                          |                     |                     |
| Intellectual Property   | -1.8%                       | -0.3%                    | ↑                   | ↑                   |
| High-tech sector GCP    | 27.6%                       | 4.1%                     | ↑                   | ↑                   |
| Entrepreneurship and employment dynamics | 6.3% | 1.0% | ↑ | ↑ |

* Compound Annual Growth Rate (CAGR)
1. INTRODUCTION

The key to New York City’s success lies in the ability to continuously reinvent itself. From its origins as a hub for trade, through the industrial phase dominated by sugar refining, publishing and the garment trade, to today’s role as a center for finance, professional services and creative industries, innovation has always been at the heart of the City’s economic success. Diversifying the City’s economic base and being at the forefront of emerging sectors is necessary for sustained growth in the future.

Cities and urban areas – especially those as vibrant and diverse as New York City – are magnets for highly skilled, entrepreneurial talent; they are dense hubs that fuse knowledge, financial resources, firms and markets, and they offer the thriving cultural environment that galvanizes creativity.

The 100 largest metropolitan areas in the U.S. hold two-thirds of the nation’s total population, jobs, and research universities, and they account for three-quarters of graduate degree holders, GDP, and patents; four-fifths of research and development (R&D)-related employment; and virtually all venture capital funding. Additionally, cities are more likely to produce start-ups, entrepreneurs and small businesses that turn ideas into new products and create new markets. Cities are the perfect breeding ground for innovation. But how successful is New York City at harnessing its innovation potential?

The NYCEDC Innovation Index was created for the purpose of tracking the City’s success as a center of innovation and entrepreneurship.

To ensure that New York City stays among the most innovative places in the world, there is a clear need for city-level measurement. Tracking innovation activity over time to uncover trends, understanding its drivers, and identifying areas of strength and weakness will also be critical to create a policy and regulatory environment that does not inhibit, but rather unleashes the City’s innovative forces. The NYCEDC Innovation Index, for the first time, gives us the tools to do this.

The Index will also provide the evidence necessary to evaluate and improve policies designed to spur innovation and to lay the foundation for the City’s future prosperity. In doing this, the Index also sheds light on the scale and pace of the City’s transformation.

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**Innovation matters**

The U.S. Department of Commerce’s Advisory Committee on Measuring Innovation in the 21st Century defines innovation as “the design, invention, development, and/or implementation of new or altered products, services, processes, systems, organizational structures, or business models for the purpose of creating new value for customers and financial returns for the firm.”

Innovation is a key ingredient to economic growth because it increases the productivity of firms and provides consumers with new choices. Innovation-driven economies push the boundaries of the technological frontier and successfully exploit commercial opportunities in new markets. This makes innovation a critical element to the competitiveness of advanced economies and this is particularly true for New York City’s knowledge-based growth model.

**The success of cities**

The agglomeration of people in cities provides a fertile environment for the conception, development and implementation of ideas and knowledge. In cities, ideas travel faster and can access the resources and services necessary to become business realities. A scientist or inventor alone may not know how to secure funding, but within a city it is easy to find the expertise that can. An innovative product has little value if it is not commercialized, and cities are home to large markets with highly sophisticated consumers who are typically amongst the first to experiment with new technologies and business models. In an area where talented people are able to get together face-to-face in more informal settings, ideas are more likely to be spread than through communication that is limited to email.

Given the benefits of proximity, density and scale, it is no surprise that cities that specialize in the production of knowledge are better able to adapt to and take advantage of technological and economic changes.
2. THE NYCEDC INNOVATION INDEX

The NYCEDC Innovation Index is tailored to track the critical aspects of New York City’s innovation economy in two respects. First, the data collected provides a standardized and comprehensive picture of innovation activity associated with the City’s economic transformation. As a result, the Index captures various aspects of innovation activity to provide its high-level overall trend. Second, the Index components provide insights on specific trends affecting and resulting from innovation. Both sides of the Index are critical to developing a full understanding of innovation in the City.

The results of the Index show that, within the broader City economy, entrepreneurs are establishing new businesses and more start-ups are securing venture capital and federal funding. This development is eased by the concentration of highly skilled talent across numerous industries, providing an ideal environment to exchange and cross-pollinate ideas. The City’s universities continue to be the engine driving research and knowledge creation, as well as training a highly-skilled workforce. Meanwhile, more patents are awarded to the City’s inventors each year.

Overall, the Index documents that the barriers to business creation for high-tech and innovative firms are lower today than just a few years ago, and continue to decrease as more entrepreneurs are attracted to the City and make it a center for high-tech innovation.

Using composite indicators

Composite indicators like the NYCEDC Innovation Index and rankings are tools capable of summarizing complex and multi-dimensional information in an easily accessible way. Composite indicators can uncover differences in overall innovation activity across regions or, in our case, trends in innovation activity over time.

There are drawbacks to the creation and use of composite indicators. They generally fall short of achieving the level of rigor of other types of quantitative evaluations, and may sometimes resemble an educated art. For this reason, an innovation index should be used carefully and attention should be paid to each of the variables and clusters that comprise the Index.

Some of the most promising candidates for growth are in the technology sector, with many firms developing new products based on advanced science and engineering solutions. Unlike Silicon Valley or Boston, New York City has been slow to attract a vibrant high-tech community. But as the NYCEDC Innovation Index shows, this is changing. The emergence of a New York City tech industry is a critical development towards ensuring its future prosperity and economic growth.

While the overall trends in the City point towards higher levels of innovation, the individual Index indicators suggest a more complex view. Investments in innovation, which are inputs like research and development (R&D) and Venture Capital (VC) funding, have increased sharply since 2003. Investments in innovation have uncertain returns that do not necessarily or immediately translate into innovation outputs. Several years may be needed for ideas to be patented or commercialized. But with inputs continuing to rise, there is reason to be optimistic about the City’s future performance.
The data for the Index are collected from a large variety of sources and can be broadly split between innovation inputs and outputs. More details are provided in the technical appendix to this report. Within inputs and outputs, the variables are assigned to a cluster. The information used for the construction of the Index is summarized on page 6, where the 32 variables used are listed and assigned to their clusters.

Inputs are observable measures of resources invested or available for innovation. They include measures like R&D spending, venture capital investments, federal grants for Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) and human capital, as measured by the availability of skilled labor.

Outputs are more difficult to measure and somewhat less intuitive. It should be noted at the outset that outputs do not measure the broad economic impact of innovation or innovation policy, which is the subject of a number of research initiatives.

Our output measures go beyond simply using counts of patents as a measure of innovation. The Index includes, to our knowledge for the first time, evidence of patents granted to the City's inventors and assigned to private businesses, including their dispersion across technological fields and firms. We also built indicators of patent originality and generality based on citations made and received in order to gauge their quality. Trends in university technology transfers round up the measurement of intellectual property produced in the City.

Entrepreneurship is perhaps the most difficult aspect to measure, and the Index takes a broad approach: It looks at the dynamic process of business creation and destruction that is spurred by entrepreneurship, for high-tech sectors in particular. Included are measures of the quality and feasibility of the City's entrepreneurs' ideas, which is the success rate of firms securing further financing in VC and SBIR/STTR funding. Similarly, NASDAQ market share of New York City-headquartered firms is meant to capture the success of larger firms that tend to be technology-oriented.

The value of production and the share of City value in high-tech sectors complete the output variables used in the construction of the Index.

While the final Index contains preliminary data and estimates for 2010, the discussion that follows focuses on 2003 to 2009. The variables used in the construction of the index represent dollar amounts, counts, shares, and other types of indicators. To achieve comparability, they need to be expressed in a single unit of measurement and we use growth rates because of their intuitive appeal and their tractability.
| Variable                                                                 | Cluster                    | Sub-Index | Index |
|------------------------------------------------------------------------|----------------------------|-----------|-------|
| 1. R&D spending: R&D spending at NYC institutions (2009$)              | R&D                       |           |       |
| 2. R&D spending: NYC institutions’ share of U.S. spending              |                           |           |       |
| 3. VC: funding amounts in NY metro area (2009$)                        | Finance                   | Inputs    |       |
| 4. VC: number of deals in NY metro area                                |                           |           |       |
| 5. VC: NY metro share of U.S. funding amount                           |                           |           |       |
| 6. VC: NY metro share of U.S. total number of deals                    |                           |           |       |
| 7. SBIR/STTR: amounts of grants to NYC firms (2009$)                  |                           | Inputs    |       |
| 8. SBIR/STTR: number of grants to NYC firms                            |                           |           |       |
| 9. SBIR/STTR: NYC share of U.S. grant amount                           |                           |           |       |
| 10. SBIR/STTR: NYC share of U.S. total number of grants                |                           |           |       |
| 11. S&E occupations: employment in NYC                                 | Human Capital             |           |       |
| 12. S&E occupations: S&E employment share of NYC total private employment |                           |           |       |
| 13. Graduate students in S&E disciplines: number of students at NYC institutions |                         |           |       |
| 14. Graduate students in S&E disciplines: NYC institutions’ share of U.S. total number of students |                         |           |       |
| 15. Patents: total number issued to NYC inventors                      |                           |           |       |
| 16. Patents: technological diversity index                              |                           |           |       |
| 17. Patents: firm diversity index                                       |                           |           |       |
| 18. Patents: patent originality index                                   |                           |           |       |
| 19. Patents: patent generality index                                   |                           |           |       |
| 20. University licenses: licensing income to NYC institutions (2009$)  |                           |           |       |
| 21. University licenses: NYC institutions’ share of U.S. licensing income |                           |           |       |
| 22. University licenses: NYC institutions’ share of U.S. total number of licenses |             |           |       |
| 23. High-tech GCP: GCP per worker in high-tech sector (2005$)          | High-tech Gross City Product | Outputs   |       |
| 24. High-tech GCP: high-tech sectors’ share of NYC GCP                |                           |           |       |
| 25. Employment dynamics: NYC job reallocation in high-tech sectors     | Entrepreneurship and employment dynamics |         |       |
| 26. Employment dynamics: NYC employer churning in high-tech sectors    |                           |           |       |
| 27. Employment dynamics: NYC share of job creation by new businesses in high-tech sectors |             |           |       |
| 28. SBIR/STTR: 2-year probability of accessing Phase 2                |                           |           |       |
| 29. SBIR/STTR: share of total amount raised in Phase 2                |                           |           |       |
| 30. VC: 2-year probability of accessing higher rounds of funding       |                           |           |       |
| 31. VC: share of total amount raised in higher rounds of funding       |                           |           |       |
| 32. NASDAQ: average market capitalization share of NYC-headquartered firms |                           |           |       |
3.1 R&D

R&D spending is a measure of investment in the creation and development of new ideas. Spending on R&D represents the value of innovation to firms and institutions, but it also supports jobs in these fields which contribute to overall economic vitality.

The Index measures R&D expenditures in Science & Engineering (S&E) fields at academic institutions. These funds are available to academic institutions from government, institutional, and industry channels, which are all captured by our measure. The federal government provides approximately 70% of the funding to New York City institutions, and has recognized the need to innovate in order to grow the national economy by appropriating additional resources under the American Recovery and Reinvestment Act. What the Index does not capture, and would benefit from, is a measure of R&D at private firms.

Universities and colleges play a major role in the nation’s basic research and account for 13% of its total R&D. Research at academic institutions is an important driver of innovation in the private sector, though it is difficult to pinpoint the magnitude of the effect because of the different avenues through which the research is spread.

To develop the R&D cluster, we combine measures of the amount of spending at New York City institutions and their share of total U.S. spending. By including the City’s share of national spending, we are able to gauge its performance relative to the rest of the country.

Academic R&D expenditures at New York City institutions reached $1.8 billion in 2009, up from $1.6 billion in 2003. However, the City’s share of national R&D spending actually shrank from 3.6% to 3.5% between 2003 and 2009, contributing to a smaller overall increase in the R&D cluster at 4.8%.
3.2 Finance

Financing for new and emerging small firms is critical for their growth. Resources beyond the traditional banking system allow businesses to take bigger risks, providing for bigger payoffs if they are successful. Growing businesses take on more employees and are more able to create innovative products with this additional human capital.

We observe financing in two ways: VC funding and federal funding through small business grants.

Venture Capital measures cash-for-equity investments by firms in private companies at various stages in their development. VC funding may also provide an additional incentive for firms to grow, as they are responsible for maximizing returns for their investors as well as for themselves.

Federal funding through SBIR and STTR grants provides capital for small businesses to create innovative products. SBIR funding is available from 11 federal departments, while five fund the much smaller STTR program. Phase I grants are given to a relatively large pool of applicants and allow the study of the feasibility of ideas. The most successful firms move to Phase II, where the funding amount jumps. Phase III is commercialization, for which private funding is required.

There were 350 VC deals in the New York area in 2010, with a total value of $1.9 billion. This represents 10.7% of the total number of deals in the US and 8.6% of the total value. New York City accounted for 64% of total amount and number of deals in the New York area in 2010. Additionally, 62 New York City small businesses received a total of $30.5 million in SBIR/STTR funding in 2009, which was more than double the level recorded in 2003. The growth in the number of VC deals in the area was the main driver of the overall increase in the finance cluster. VC funding received more weight in the cluster because of its relative magnitude and the fact that firms receiving investments are closer to the commercialization stage.

“The Silicon Alley”

At the end of the 1990s, a wave of entrepreneurs attracting VC investments emerged in the City, located on a relatively narrow corridor on Broadway in the neighborhoods of Flatiron, SoHo, and Tribeca. The moniker “Silicon Alley” may have aptly described the geography, but less so the focus of the firms, which was mainly in the City's traditional strengths of advertising and media (notable among them are DoubleClick, MediaMind, and Meetup). Today’s start-ups, while still locating close to each other, have grown into an economic reality beyond the confines of one small area. The City's start-ups in social media and web-based services have risen to particular attention. The World Economic Forum’s Technology Pioneers 2011 list included 13 companies in Information Technologies and New Media. Of the 7 based in the U.S., 3 were located in New York City: Foursquare, Knewton, and SecondMarket.

Recent evidence suggests that small firms engage in R&D with the objective of creating new products and capturing market share, whereas larger firms tend to concentrate their R&D efforts on improving their existing product lines. As a consequence, new and small firms contribute relatively more to economic growth.

The innovation index measures venture capital and SBIR/STTR investments from different angles: by their total annual amount and U.S. share (as innovation inputs), and by the quality of the ideas being funded (as innovation outputs). Proxies for quality are the share of firms successful enough to attract more investment within a span of two years (e.g. a phase 2 SBIR grant or a series B venture capital) and the share of total funding attributable to such later investments.
3.3 Human Capital

Highly-skilled workers, or human capital, are the lifeblood of innovation because no other inputs matter without the people behind the ideas. It is necessary for New York City to attract and retain human capital if innovative high-tech sectors are to flourish.

A large pool of skilled labor results in better matches between labor supply and demand. Finding skilled employees quickly is desirable for firms and a key factor for their growth. In this regard, we measure the level and share of employment in science and engineering (S&E) occupations in the City.

Graduate and post-doctorate enrollment in S&E disciplines represents the potential workforce that can be tapped by New York City’s innovative firms. While the City’s labor market can import and export human capital and data about origin and destination of graduates is not available, it stands to reason that the student population would be more likely to stay if the right opportunities were available.

S&E employment in New York City was 178,970 in 2009, up 8.7% from its 2003 level. At the same time, the share of S&E employment in the City rose from 5.7% in 2003 to 5.9% in 2009, in spite of the overall employment decline in S&E between 2008 and 2009. Nationally in 2009, the share of employment in S&E occupations was 5.4%.

Immigration, innovation and entrepreneurship

Immigration is a key factor in sustaining New York City’s innovation advantage. Immigrants contribute a disproportionately large share of patents in the U.S. — and patenting would increase only further with increased immigration. By one analysis, a one percentage point increase in the share of immigrant college graduates in the U.S. population would increase patents per capita by 6%.18

But immigrants do not only stimulate inventions, they are also an important driver for entrepreneurship. Sixteen percent of the high-impact, high-tech companies in the U.S. had one or more immigrants on their founding teams.19 In Silicon Valley, more than half (52.4%) of engineering and technology startups between 1995 and 2005 that had achieved more than $1 million in sales or employed more than 20 people had immigrants among their key founders.20

This highlights the enormous stakes for New York City. As a destination point for immigrants from the world over, the City has benefited from newcomers since its founding. In 2009, the City was home to nearly three million immigrants. At 36% of the population, immigrants represented almost half of all entrepreneurs in the City in 2000. Between 1990 and 2000, immigrants accounted for all growth in the City’s entrepreneurial population. While the number of immigrants who were self-employed increased by 53 percent, the number of native-born entrepreneurs decreased by 7 percent.21

For innovation to thrive in the future, it will be critical for the City to continue to attract immigrants and provide an environment for them to succeed. International students represented 31.5% of graduate students in S&E disciplines in the City’s universities in 2009 (compared to 28.0% in 2003).

The City added graduate and post-doctorate students in S&E disciplines every year between 2003 and 2009, reaching a total of 26,903. At a nearly 30% growth rate, this trend drove the overall increase in human capital.
### 3.4 Intellectual Property

New ideas are at the core of innovation. Quantifying these ideas, or intellectual property, is therefore essential if we are to accurately gauge innovation activity. We measure intellectual property through patents and university technology transfers, which are lagged measures of R&D investment.

Patent activity, perhaps the most widely agreed-upon measure of innovation output, is often used as its proxy. Patents are inventions that may be translated into new technologies or products in the market and lead to firm growth. We concentrate on utility patents assigned to private firms where at least one inventor was a New York City resident.\(^{22}\)

University technology transfers represent the transformation of research activity at institutions into marketable solutions. This licensing activity generates income for the university, which can be used as a barometer of the success of inventions and ideas from these institutions.

1,104 patents were awarded to inventors in the City in 2009. This was a nearly 23% increase from the number in 2003. New York City inventors’ share of U.S. patents was 0.7% in 2009, up 18% from 2003. However, the patents showed a higher concentration across technological categories and firms. The City’s institutions were estimated to receive $488 million in licensing revenue in 2009, or about 8% of the national total. However, this share was down from 11.5% in 2003. Overall the total decline of the intellectual property cluster was approximately 1.8% between 2003 and 2009.

### 3.5 High-Tech Gross City Product (GCP)

A measure of the value of high-tech sectors to the City’s economy, both in amount and in significance, is necessary to track its innovative success. The dynamic nature of high-tech sectors forces firms to constantly develop new products; the growth of these sectors is therefore directly linked to the emergence of new products.

Our measure of economic activity in the high-tech sectors is Gross City Product (GCP), or the value of production in the City’s economy, which we include on a per capita basis as well as looking at the share of the City’s overall economic activity (total GCP).

In 2009, New York City GCP per worker in its high-tech sectors was more than $200,000, up nearly 30% from the 2003 level, and among the highest level of any sector. Over the period, the high-tech share of total New York City GCP increased by nearly 25%.

#### High-tech focus

The rationale for focusing on high-tech innovation is powerful: companies within high-tech sectors produce tradable goods and services with enormous growth potential nationally and in global markets.\(^{23}\) Companies that grow at 20% annually for more than three consecutive years are concentrated in high-tech sectors. These high-impact companies account for almost all employment and revenue growth in the U.S., but New York City today has disproportionately few of them.\(^{24}\) Innovation in high-tech sectors also enables innovation across the entire economy (like software or communication technologies), thereby increasing overall productivity and consumer choice. Most importantly, however, the economic diversification high-tech sectors can provide will be critical to the City’s long-term growth prospects.
3.6 Entrepreneurship and Employment Dynamics

Several theories of economic growth link innovation to the rate of employers’ births, deaths, expansions and contractions in a process known as “creative destruction.”

We measure entrepreneurship and employment dynamics by examining these changes in high-tech sectors combined with measures of entrepreneurial success and NASDAQ market capitalization.

Employment dynamics in high-tech sectors examine job reallocation, employer churning, and the share of job creation accounted for by births among small employers in the City. These indicators, taken together, show as comprehensive as possible a picture of creative destruction as possible.

Measuring entrepreneurship

Entrepreneurship is a tangible outcome of innovation: the birth, death, growth and failures of businesses in the marketplace. Such a process of “creative destruction” is at the heart of innovation. However, quantifying entrepreneurship is difficult.

Self-employment is often used as a proxy for entrepreneurship as it covers both employers and non-employers. The Kauffman Index of Entrepreneurial Activity measures business creation in the U.S. and smaller geographical areas between 1996 and 2010 using this approach. Although the Kauffman Index is not available for subsectors of the economy, its behavior is not dissimilar from the result of the entrepreneurship cluster. The number of workers per firm has also been used as a proxy, with a lower average signaling the presence of smaller scale entrepreneurs. This measure too suffers from the lack of distinction between types of firms or industries.

The importance of small firms for job creation has been confirmed in recent research, in particular highlighting the positive role of business startups. Such firms, particularly in the high-tech sector, are also likely to increase productivity and push economic growth.

The relationship between innovation and job creation may however not be linear. According to Inc. 2010 rankings, 7 out of the top 10 firms in terms of job creation specialized in business process outsourcing, staffing and third-party business logistics. Arguably, while innovative and productivity-enhancing, such organizational changes may lead to job growth at the expense of larger firms’ internal structures. A more direct measure of success is revenue growth. The same rankings showed that the New York City area led the country in this respect, driven by media and advertising, two of the bedrocks of the City’s economy.
4. CONCLUSIONS

The NYCEDC Innovation Index provides an analytic, timely and detailed measure of innovation in New York City to help identify the strengths and weaknesses of the City’s innovation system. Most strikingly, the Index shows the City’s economic transformation and documents its attractiveness and pull on high-tech entrepreneurs around the globe. By linking innovation inputs and outputs, the Index will provide the guidance for prioritizing efforts to support innovative businesses.

The results lead to four distinct recommendations for policy-makers:

1. Innovation and economic transformation must be prioritized as the key to New York City’s future growth and prosperity. For the City to flourish in the face of increased global competition and accelerating technological change, the City must remain what it has been since its founding: the ideal environment for entrepreneurs and innovators from around the world to succeed and grow.

2. The City’s strong innovation environment must be leveraged to accelerate its economic transformation. The City is in a globally unique position of unifying – on only a few square miles – finance, knowledge and a workforce among the most productive and creative in the world. Regulations and policies that keep the City open to inflows of capital, goods and talent are critical for innovation. Additional initiatives that facilitate exchange and interaction among entrepreneurs, scientists, business leaders and bankers can further catalyze innovation activity.

3. Existing barriers to innovation and entrepreneurship must be aggressively confronted and reduced to accelerate innovation, ranging from the availability of affordable space to training to the provision of capital, when appropriate.

4. Innovation policies must be based on robust data and tailored toward solving specific issues. The NYCEDC Innovation Index will contribute to the design of evidence-based innovation policies.
APPENDIX A: MEASURING INNOVATION

Overall, the variables used for the NYCEDC Innovation Index are broadly in line with past efforts to measure innovation, although few of them were readily available for New York City. A more detailed explanation of the variables, methodology, sources and additional evidence is available in the technical appendix to this report. Appendix B summarizes some recent related publications. All data used for the Index are available from 2003 to 2009, with some variables available for 2010, albeit subject to revisions. To extend our estimates to 2010, we used such preliminary data, as well as estimates based on each variable's time trend.

The construction of composite indicators relies on a choice of weights for its components, ideally chosen to be representative of their influence on the object being measured. If data limitations do not allow such an optimal choice of weights, robustness tests can be conducted to assess the results’ sensitivity. We chose the latter strategy. The Innovation Index is derived by averaging the clusters presented in the report, themselves averages of the underlying variables. The results show a steep increase in innovation inputs in 2010, driven by venture capital. The increase in inputs determines the overall increase in the Index between 2009 and 2010.

We also surveyed academic experts in the field of innovation and asked them to provide weights to the clusters and to their sub-components. Therefore, the survey yielded two different sets of results: one looked at average weights assigned to the clusters, while the other applied the average survey weights to construct the clusters and the average survey weights assigned to the clusters. The two alternative scenarios paint the same larger picture: innovation increased in the City. Furthermore, the NYCEDC Index falls between the indexes constructed using the survey responses, as the following figure shows.

![NYCEDC Innovation Index and Survey Indexes](image)

The differences between the NYCEDC results and the survey results can be explained as follows. At the cluster level, survey respondents put less weight on Intellectual Property and High Tech GCP and placed a substantially higher emphasis on R&D spending. The higher overall survey weight on inputs is not enough to lift the resulting index above a cumulative growth of 14.6%.

Looking at the variable within clusters, the most notable difference is the respondents’ higher weight on SBIR/STTR grants both within Finance and Entrepreneurship. Using the survey results for the construction of the Index yields essentially the same results as the NYCEDC’s weights until 2008 but a higher index in 2009 and 2010, showing 17.8% cumulative growth.

The average of the survey responses and NYCEDC’s weights are reported in the table on page 14. Notice that, for instance, the two variables measuring S&E employment collectively receive a weight of 8.35% in the Index (50% of 16.7%) and that each variable receives a final weight of 4.175% (50% of 8.35%). Using the survey weights, each S&E employment variable receives a final weight of 5.43% (20.7% times 52.5% times 50%).

Innovation is, by its very nature, difficult to measure. Capturing the novelty of emerging ideas and new technologies requires an adaptable and fluid measurement approach. In future editions, the Index will be refined to respond to arising economic trends and to allow for measurement of the impact of policy initiatives.
## Weights assigned to clusters and variables

| CLUSTERS                      | NYCEDC | Survey  |
|-------------------------------|--------|---------|
| R&D                           | 16.7%  | 27.1%   |
| Finance                       | 16.7%  | 18.6%   |
| Human Capital                 | 16.7%  | 20.7%   |
| Intellectual Property         | 16.7%  | 10.7%   |
| High-tech GCP                 | 16.7%  | 5.7%    |
| Entrepreneurship and Employment Dynamics | 16.7%  | 17.1%   |

| VARIABLES                     |        |         |
|-------------------------------|--------|---------|
| Finance                       |        |         |
| VC                            | 90.0%  | 60.8%   |
| SBIR/STTR                     | 10.0%  | 39.2%   |
| Human Capital                 |        |         |
| S&E Employment                | 50.0%  | 52.5%   |
| Graduate and post-doc students in S&E occupations | 50.0%  | 47.5%   |

| Intellectual Property         |        |         |
| Patents issued                | 25.0%  | 27.5%   |
| Patent technological/firm concentration | 25.0%  | 24.2%   |
| Patent originality and generality | 25.0%  | 26.7%   |
| University Licenses           | 25.0%  | 21.7%   |

| Entrepreneurship and employment dynamics |        |         |
| Creative destruction in high-tech industries | 33.3%  | 25.0%   |
| Flow of start-ups in high-tech industries | 16.7%  | 21.7%   |
| Access to venture capital funding after the first investment | 22.5%  | 24.2%   |
| Access to SBIR/STTR Phase II grants | 2.5%   | 17.5%   |
| Market share of public companies listed on NASDAQ | 25.0%  | 11.7%   |
APPENDIX B: SELECTED RELATED RECENT PUBLICATIONS

2009 INDEX OF THE NEW YORK CITY INNOVATION ECONOMY, CENTER FOR AN URBAN FUTURE
The first index to quantitatively measure the NYC innovation economy, this report examines the City’s performance relative to other cities and regions in nine science and technology-related areas. In particular, attention is focused on individual academic research institutions. Using data for the latest year available, it does not track trends over time, and while it sheds light on performance in individual variables, it stops short of producing a composite indicator of overall innovation activity.

Main findings: New York City has not taken full advantage of the innovative potential of its academic research institutions. It has lagged behind other areas of the country, particularly Silicon Valley and Boston.

STATE NEW ECONOMY INDEX, THE INFORMATION TECHNOLOGY & INNOVATION FOUNDATION
The State New Economy Index benchmarks economic transformation across states. Rather than economic performance, the Index aims to answer the question “To what degree does the structure of state economies match the ideal structure of the new economy?” The indicators of the Index fall into five groups: knowledge jobs, globalization, economic dynamism, transformation to a digital economy, and technological innovation capacity. Massachusetts, Washington and Maryland led the ranking.

Main findings for NYS: New York State was ranked 10th overall in 2010, having improved from 16th since 1999. New York performed best in the share of high-wage traded services, which includes employment in the finance and publishing industries; it was weakest in online population, where the state ranked 34th.

STATE TECHNOLOGY AND SCIENCE INDEX 2010, MILKEN INSTITUTE
This index, published every two years since 2002, ranks each of the 50 states in five categories of technology and science indicators that are often used as innovation measures. As well as comparing states, the Milken index is beneficial in that it addresses how the rankings have changed since the previous release. Additionally, it creates an overall ranking by giving equal weight to each category.

Main findings for NYS: Overall, New York ranked 16th in 2010, but ranked 9th in investment in human capital which includes variables like the share of population with advanced degrees.

INNOVATION INDEX, INDIANA BUSINESS RESEARCH CENTER AT INDIANA UNIVERSITY
First published in 2009, this online tool is designed for comparison of different states, metropolitan areas, counties, and other geographies for the latest year for which data are available. Four categories of indicators are included, including an “economic well-being” sub-index, which includes poverty rate and unemployment rate. By including a wider range of variables, this index adds factors that are important for innovation in the long-term, but that do not necessarily directly measure activity.

Main findings for NYC: The index found that NYC performed slightly worse than the U.S. in its composite indicator. An area of positive performance was productivity and employment, which includes job growth and GCP, among other measures.
APPENDIX C: THE CENTER FOR ECONOMIC TRANSFORMATION AT NYCEDC

The Center for Economic Transformation (CET) at NYCEDC is at the heart of our effort to change the City's economy. Created in early 2010, CET conceives and implements policy and programmatic initiatives that address complex challenges faced by the City's industries. CET uses analysis of current economic trends to understand the needs of the City's business community, and to develop and implement programs that address and resolve the challenges facing each sector. During the past year, CET has launched more than 60 groundbreaking initiatives. These programs have included measures to help “legacy industries” like media, fashion, financial services, and manufacturing transition to 21st century business models, as well as tactics to attract and support “emerging industries” like bioscience, green services, and technology.

CET innovation policies focus on easing the process of business creation and entrepreneurship. By offering incubator space, information portals, training, and business competitions, CET aims to attract talented and creative entrepreneurs to New York City and provide the resources and create an environment where they can grow their businesses.

### Selected CET initiatives for innovation and entrepreneurship

**Access to capital and workspaces**
- NYC Entrepreneurial Fund: a $22 million fund – the first of its kind outside Silicon Valley – to be managed by FirstMark Capital to provide promising New York City-based technology startup companies with early-stage capital. NYCEDC contributed $3 million to establish the fund, and FirstMark Capital, a leading New York City-based venture capital firm, will contribute up to an additional $19 million.
- Business incubators: lower-cost workspaces combined with mentoring and networking services aimed at startups and designed to increase their opportunities for success.

**Information**
- NYC Media Lab: A clearinghouse created with a consortium of top universities that connects companies looking to advance new media technologies with academic institutions undertaking related research.
- NYC Venture Connect: An informational web portal for NYC entrepreneurs that brings together all of the City's business resources in one place.
- Promoting Arts Clusters: A program that promotes NYC neighborhood arts clusters by fostering collaboration between businesses and arts organizations to spur economic activity and increase tourism.
- Urban Technology Innovation Center: Promotes the development and commercialization of green building technologies in NYC, connecting research and academic institutions, companies creating products, and building owners with real-world test sites.
- World to NYC: Promotes trade and investment between New York City and the global economy by hosting business delegations from cities and regions around the world.

**Training**
- Artists as Entrepreneurs: Equips New York City's artists with the necessary business and management skills to successfully market their work. Operated by New York Foundation for the Arts (NYFA) and the Lower Manhattan Cultural Council (LMCC).
- FasTrac: A business training program to help emerging entrepreneurs start new businesses and existing entrepreneurs run their businesses. Created by NYCEDC, in conjunction with Department of Small Business Services, SUNY's Levin Institute, and the Kaufmann Foundation.
- JumpStart Initiatives: A series of programs to retrain City talent to work in emerging industries. Created by NYCEDC in partnership with SUNY's Levin Institute.
- SBIR and Prepare for Success Workshops: Workshops that cover all aspects of National Institutes of Health SBIR and STTR proposal preparation and workshops for technology companies aspiring to launch and grow their businesses in the City.
- Startup Procurement Workshops: Encourages local startups and established firms to team up on bidding for City IT contracts, while promoting other City contracting opportunities for startups.

**Competitions**
- NYC BigApps: Annual competition for individuals or companies to develop innovative online and mobile applications that utilize official City data.
- NYC Next Idea: Annual business plan competition with top international business and engineering schools.
- NYC Venture Fellows: Established with Fordham University to match 20 “rising star” entrepreneurs from around the world with established business leaders to help them scale their businesses in New York City.
Endnotes

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4. Available at http://www.nycedc.com.NewsPublications/NYCEconomics/NYCEDInnovationIndex/Documents/TechnicalAppendix.pdf
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6. Patents are “original” when they cite patents from a wide technological spectrum. Patents are “general” if they are cited by patents from a wide technological spectrum.
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11. Fast Company (2011) The World’s 50 Most Innovative Companies.
12. We include VC funding at the Metropolitan Area level due to data consistency and availability issues. However, the VC-related measure included in the entrepreneurship cluster are based on longitudinal data on New York City firms only.
13. VC funding was given more weight than SBIR/STTR funding in the Index due to its much larger magnitude in funding level.
14. Nearly 30% of the City’s firms receiving VC funding in 2010 were located in Chelsea and the Flatiron District.
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29. Inc. (2010) 2010 Inc. 5000, the job creation ranking is available at http://www.inc.com/vs/inc-5000-top-10-job-creators#0
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31. Note that individual variables receive lower final weight the larger the number of variables within a cluster.
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