Designing an Adaptive Economic Future

Positioning Phoenix for Stronger Comebacks

Greater Phoenix Economic Council

Michael M. Crow
President, Arizona State University
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“One of the biggest myths is that in order to foster economic development, a community must accept growth. The truth is that growth must be distinguished from development: growth means to get bigger, development means to get better”

—Local Government Commission, 2004
Entrepreneurs introducing new innovations create "gales of creative destruction" that strike "not at the margins of the profits and the outputs of existing firms but at their foundations and their very lives."

—Schumpeter, 1942
## Existential Threats Come from Everywhere

<table>
<thead>
<tr>
<th>Metro</th>
<th>Industry</th>
<th>Threat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pittsburgh, PA</td>
<td>Steel</td>
<td>Electric Arc Furnaces</td>
</tr>
<tr>
<td>Seattle, WA</td>
<td>Aviation &amp; Forestry</td>
<td>Globalization</td>
</tr>
<tr>
<td>Raleigh, NC</td>
<td>Textiles</td>
<td>Globalization</td>
</tr>
<tr>
<td>Rochester, NY</td>
<td>Optics</td>
<td>Digital Imaging</td>
</tr>
<tr>
<td>Phoenix, AZ</td>
<td>Real Estate</td>
<td>Banking Regulation</td>
</tr>
<tr>
<td>Atlantic City, NJ</td>
<td>Gaming &amp; Entertainment</td>
<td>Gaming Laws, Cultural Changes</td>
</tr>
<tr>
<td>Houston, TX</td>
<td>Petroleum</td>
<td>Electric vehicles</td>
</tr>
<tr>
<td>All Metros</td>
<td>Services &amp; Transportation</td>
<td>Autonomous Vehicles</td>
</tr>
</tbody>
</table>
Fragile

“The quality of being easily broken or damaged”

—The Oxford Dictionary
“the capacity of a system to absorb disturbance and re-organize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks”

—Walker et al., *Ecology and Society*, 2004
Antifragile

Something that “thrives and grows when exposed to volatility, randomness, disorder, and stressors and loves adventures, risk, and uncertainty”

—Nassim Taleb, author of The Black Swan, 2007
Fragile, Resilient, and Antifragile in Metro Economies

Per Capita Real GDP

- Antifragile
- Resilient
- Fragile

Year:
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015
- 2016
Fragile, Resilient, and Antifragile in Metro Economies

Per Capita Real GDP

Seattle

Pittsburgh

Phoenix

Antifragile

Resilient

Fragile
Fragile, Resilient, and Antifragile in Metro Economies

- Antifragile
- Resilient
- Fragile

Per Capita Real GDP

- Low
- High

Cities:
- Seattle
- Pittsburgh
- Phoenix
- Bismarck
# Policy Design for Fragile, Resilient, and Antifragile Metro Economies

<table>
<thead>
<tr>
<th>Policy Area</th>
<th>Fragile Metro</th>
<th>Resilient Metro</th>
<th>Antifragile Metro</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Political Attitudes</strong></td>
<td><strong>Economic Development</strong></td>
<td><strong>Risk</strong></td>
<td><strong>Technological and Economic Change</strong></td>
</tr>
<tr>
<td></td>
<td>Zero-sum view; focuses on businesses</td>
<td>Mitigates risks</td>
<td>Embraces stability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Aspires to predict change</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Aspires to create change</td>
</tr>
<tr>
<td><strong>Public Resources</strong></td>
<td>Conserves resources</td>
<td>Reconfigures resources</td>
<td>Invests and transforms resources</td>
</tr>
<tr>
<td><strong>Economic Policies</strong></td>
<td><strong>Focus of economic policy</strong></td>
<td><strong>Management and Support of Economic Actors</strong></td>
<td><strong>Role of Tax Policy</strong></td>
</tr>
<tr>
<td></td>
<td>Growth through corporate relocations, tourism, real estate, and service industry expansion</td>
<td>Decentralized control and adequately-resourced</td>
<td>Seen as singularly important policy tool</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decentralized control and well-resourced by central entity</td>
<td></td>
</tr>
<tr>
<td><strong>Economic Outcomes</strong></td>
<td><strong>Type of technology in economy</strong></td>
<td><strong>Labor Force</strong></td>
<td><strong>Business “Stickiness”</strong></td>
</tr>
<tr>
<td></td>
<td>Little, low-value or mature technologies</td>
<td>Moderately skilled labor</td>
<td>Attracts businesses that can be lured to other locations with incentives</td>
</tr>
<tr>
<td></td>
<td>Indeterminate</td>
<td></td>
<td>Indeterminate</td>
</tr>
<tr>
<td></td>
<td>Specialized in emerging technologies</td>
<td></td>
<td>Attracts and develops businesses that are deeply anchored to local clusters</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Outward-looking; few connections are low-value and underdeveloped</td>
<td>Outward looking; few connections</td>
<td>Outward looking; many deep economic and cultural connections</td>
</tr>
</tbody>
</table>

ASU
The State of the Metro Phoenix Economy
Phoenix Metro Economy Struggling to Match Economic Output of Other Large Metros

Per Capita Real GDP by Metro Area, 2016

Source: BEA
Phoenix Is Concentrated in Lower-Value Industries

Metro Phoenix Location Quotients, 2016

Less Concentrated Industries

More Concentrated Industries

- Nondurable goods manufacturing
- Mining, quarrying, and oil and gas
- Agriculture, forestry, fishing
- Information
- Management of companies
- Government and government enterprises
- Transportation and warehousing
- Construction
- Educational services
- Wholesale trade
- Finance and insurance
- Health care and social assistance
- Arts, entertainment, and recreation
- Durable goods manufacturing
- Real estate and rental and leasing
- Utilities
- Retail trade
- Administrative and waste management
Pittsburgh Has Large Concentrations in Management, Education, Arts, and Healthcare

Metro Pittsburgh Location Quotients, 2016
Seattle Is Highly Concentrated in Industries that Benefit from Automation, Network Effects, and Globalization

Metro Seattle Location Quotients, 2016
Phoenix Has Momentum in Several High Value Industries

Growth of Industrial Output Relative to 2009

Contracting Industries
- Mining, quarrying, and oil
- Nondurable goods manufacturing
- Construction
- Utilities
- Government
- Educational services
- Transportation and warehousing
- Accommodation and food services
- Real estate and rental and leasing
- Professional, scientific, and technical services

Growing Industries
- Durable goods manufacturing
- Health care and social assistance
- Administrative and support services
- Arts, entertainment, and recreation
- Management of companies
- Finance and insurance
- Agriculture, forestry, fishing, and hunting
# Majority of Phoenicians are Dissatisfied with the State of the Metro Phoenix Economy

Arizona’s ability to compete with other areas and states to attract new companies and jobs

<table>
<thead>
<tr>
<th></th>
<th>Very Satisfied</th>
<th>Somewhat Satisfied</th>
<th>Somewhat Dissatisfied</th>
<th>Very Dissatisfied</th>
<th>Not sure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10%</td>
<td>41%</td>
<td>29%</td>
<td>15%</td>
<td>5%</td>
</tr>
</tbody>
</table>

Availability of good paying jobs in the greater Phoenix region

<table>
<thead>
<tr>
<th></th>
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<th>Somewhat Dissatisfied</th>
<th>Very Dissatisfied</th>
<th>Not sure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7%</td>
<td>33%</td>
<td>34%</td>
<td>22%</td>
<td>5%</td>
</tr>
</tbody>
</table>

The state of the economy in the greater Phoenix region

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4%</td>
<td>38%</td>
<td>39%</td>
<td>17%</td>
<td>3%</td>
</tr>
</tbody>
</table>
# Majority of Phoenicians Support Economic Initiatives

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Strongly Favor</th>
<th>Somewhat Favor</th>
<th>Somewhat Oppose</th>
<th>Strongly Oppose</th>
<th>Not Sure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attract companies working in new technologies to the greater Phoenix region</td>
<td>64%</td>
<td>28%</td>
<td>3%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>Develop resources to help small businesses in the region bring new products to market</td>
<td>60%</td>
<td>31%</td>
<td>4%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>Create high tech corridors in the greater Phoenix region in advanced industries like bioscience, alternative energy and advanced materials</td>
<td>56%</td>
<td>28%</td>
<td>7%</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>Develop resources to help high tech start-up companies in the region</td>
<td>50%</td>
<td>36%</td>
<td>5%</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>Initiative</td>
<td>Strongly Favor</td>
<td>Somewhat Favor</td>
<td>Somewhat Oppose</td>
<td>Strongly Oppose</td>
<td>Not sure</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>----------------</td>
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<td>-----------------</td>
<td>---------</td>
</tr>
<tr>
<td>Develop community college system into a world class technical and training institution for computer sciences and ICT</td>
<td>69%</td>
<td>24%</td>
<td>3%</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>Create R&amp;D partnerships between ASU and high tech companies in the region</td>
<td>66%</td>
<td>26%</td>
<td>4%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Elevate ASU’s engineering school to be one of the top five programs in the country, attracting new faculty and increasing the number of outstanding graduates for new and specialized jobs</td>
<td>55%</td>
<td>33%</td>
<td>5%</td>
<td>3%</td>
<td>5%</td>
</tr>
</tbody>
</table>
It’s time to connect policy to public preferences.
# It Is Being Done Elsewhere

## Science & Technology Center

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
</table>
| - Government/industry contracts  
- Private endowments  
- University partnerships | - $1B K-12 grant funding  
- Materials science, metallurgy, nuclear energy discoveries  
- Major consumer inventions |

## Battelle

*The Business of Innovation*  
(Ohio)

- Government/industry contracts  
- Private endowments  
- University partnerships  
- $1B K-12 grant funding  
- Materials science, metallurgy, nuclear energy discoveries  
- Major consumer inventions

## CICAR

(South Carolina)

- $300M state, industry, academia investment  
- Industry-sponsored endowed professorships  
- 232 companies, 22,000 employees, $600M+ capital

## SEMATECH

(Texas)

- $600M DARPA grant  
- $100M annually from member firms  
- UT-Austin talent & support  
- Revitalization of US semiconductor industry  
- 120,000 more tech sector employees  
- $1B investment in local semiconductor facilities

## Georgia Tech

Enterprises Innovation Institute  
(Georgia)

- Georgia Tech support  
- Collaboration/investment from NSF, Georgia ATDC, VCs, other flagship universities  
- $228M in new contracts for minority-owned business  
- $2.7M in Small Business Innovation Research Awards  
- $270M in sales for assisted manufacturers  
- 21 faculty startups securing $143M

## CICP

(Indiana)

- Private and corporate endowments  
- Strong public sector advocacy  
- Regional university collaboration  
- $450M in funding to 40 Indiana-based companies  
- 6 startup initiatives, a research institute and innovation district
Science and Technology Centers
Velocity

Blueprint for transforming greater Phoenix into an innovation economy
Transforming Regional Economic Development Requires:

Human Capital
- High-performing education system available to learners of every age
- Skilled and entrepreneurial workforce

Assets
- Entrepreneurial, risk-taking and collaborative public organizations
- World-class and nation’s largest engineering school
- Modern, reliable and sustainable infrastructure and built environment

Economic Environment
- Risk-taking and collaborative economic culture anchored to technology development
- Networked clusters of related firms
- Diverse ecosystem of business partners
Velocity: Strategic Foci

• Advance a world-class engineering school

• Support technology development through Science and Technology Centers

• Enhance foreign-direct investment
Research expenditures have doubled every six to eight years

FY98 = $92.0M
FY01 = $202.0M
FY06 = $405.2M
FY10 = $546.5M
FY12 = $604M (similar to MIT’s research activity)
FY13 = $815M

FY17 = >$604M
FY18 = $815M
FY25 Metric = $815M

ASU: World-Class Research University
Fulton Schools of Engineering

918 Students
759 Undergraduate
159 graduate

6,735 Students
5,276 Undergraduate
1,459 graduate

3,324 Students
2,340 Undergraduate
984 graduate

3,820 Students
3,154 Undergraduate
666 graduate

1,734 Students
1,321 Undergraduate
422 graduate

5,454 Students
5,088 Undergraduate
366 graduate

- Biomedical Engineering
- Biological Design
- Computer Engineering
- Computer science
- Computer systems Engineering
- Engineering Management
- Industrial engineering
- Informatics
- Robotics
- Software Engineering
- Electrical Engineering
- Computer Engineering
- Robotics
- Aerospace Engineering
- Chemical Engineering
- Materials Science and Engineering
- Mechanical Engineering
- Robotics
- Solar Energy Engineering and Commercialization
- Civil Engineering
- Construction Engineering
- Construction Management
- Environmental Engineering
- Sustainable Engineering
- Aviation Programs
- Engineering Programs
- Environmental and Resource Management
- Global Technology and Entrepreneurship
- Graphic Information Technology
- Human Systems Engineering
- Information Technology
- Robotics
- Management of Technology
- User Experience
## FSE Progress since 2009

<table>
<thead>
<tr>
<th>Category</th>
<th>Fall 2009</th>
<th>Fall 2018 est.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total enrollment</strong></td>
<td>6,407</td>
<td>22,367</td>
</tr>
<tr>
<td><strong>Undergraduates</strong></td>
<td>4,253</td>
<td>17,940</td>
</tr>
<tr>
<td><strong>Graduates</strong></td>
<td>2,154</td>
<td>4,427</td>
</tr>
<tr>
<td><strong>Degrees granted</strong></td>
<td>1,391</td>
<td>4,197</td>
</tr>
<tr>
<td><strong>Research expenditures</strong></td>
<td>$73M</td>
<td>$104M</td>
</tr>
<tr>
<td><strong>T/TT faculty</strong></td>
<td>214</td>
<td>350</td>
</tr>
</tbody>
</table>

FY: Fiscal Year
Evolution of Research and Innovation Organizations

Mission Focus

Traditional Focus

Early Stage

Discovery

Scope, Scale and Funding

Industry “Pull”

Faculty “Push”

Centers & Institutes

ERCs

Proto Centers

FDC

STCs
Research, Education, and Outreach Around Three Strategic Thrusts
• Terawatt-Scale Silicon Photovoltaics
• Tandem Integration with Silicon Technologies
• Fundamentals for High Efficiency Photovoltaics

Government/Industry/University Partnership
• From foundational discovery to translation to application

Industry Consortia Benefits
• Access to faculty, interns, and university lab facilities
• Non-exclusive, royalty-free IP license rights
• Company-specific PV educational workshops
• Collaborative graduate or postdoc student
Goal:
Increase the competitiveness of metro Phoenix by creating a new breed of R&D centers for applied research and prototype development of new technologies

Concept:
Baseline funding from local sources to support contract research business model that draws sustaining resources from private and other sources
Velocity: Current Regional Strengths and Potential
Associated Technology Opportunities
Potential Regional STCs Built on Technology Opportunities

- Wearable Devices & Sensor Technologies
- Robotics & Autonomous Systems
- Internet of Things
- Advanced Manufacturing
- Smart Cities
Metro Phoenix Science and Technology Center Model

**ASU Assets**
- Faculty and Staff
- Postgrads
- Graduate Students
- Centers
- Facilities
- Instruments and Equipment
- Intellectual Property

**STC Center Activities**
- Application-oriented Fundamental Research
- Contract Research
- Confidential Co-Development and Engineering Services
  - Design and Modeling
  - Technology Validation
  - Prototype Development
  - Pilot Production
  - Durability Testing
  - Quality Analysis
- Research Translation and Technology Commercialization
- Workforce Training and Student Internships

**Industrial Partners**
- Private Funds

**University Funds**

**Government/University/Private Funds**
How STCs support an Antifragile Economy

- Increase the adaptability and skills of the local workforce
- Increase the stock of knowledge in the local economy
- Catalyze research discoveries
- Develop new industries here instead of relocating existing businesses from elsewhere
- Reduce the cost of local firms to find, develop and exploit new knowledge
- Improve the competitiveness of existing companies
- Attract new companies and venture capital