# LONG-TERM TECHNOLOGY STRATEGY DEVELOPMENT FOR A NEWLY-INDUSTRIALIZED COUNTRY A CASE STUDY

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# BACKGROUND OF THE CASE STUDY

A newly-industrialized Asian country is interested in the effective development of a *long-term* industry technology strategy for the next 15 years as a *part of the overall industry development strategy* for the country.

As a senior advisor on planning methodology for the study, the author was asked to help develop a *practical planning approach that is rational and systematic yet can be easily understood and utilized* by major stakeholders in the society who would participate in the strategy planning process.

# TECHNOLOGY AND INDUSTRY DEVELOP-MENT STRATEGY: A PRACTICAL APPROACH

Industry technology development strategy planning is *an art and a creative process*.

Our practical approach emphasizes a *structured process* to systematically and iteratively *integrate reasoned and informed judgments* and *build consensus* among *diverse, intelligent, and knowledgeable professionals*.

This approach has proven to particularly powerful in dealing with highly complex and uncertain issues, such as industry technology portfolio planning.

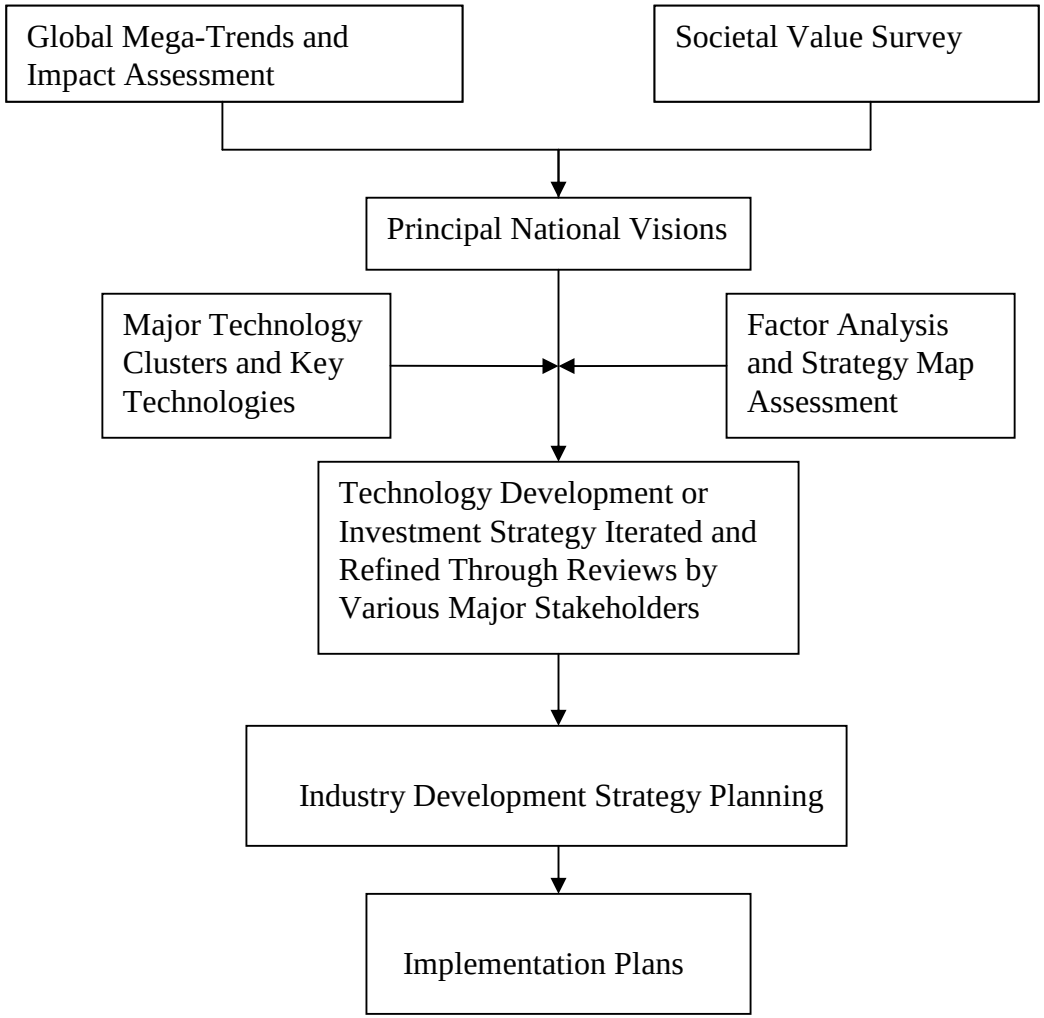
Specifically, we strive to:

-Reduce bias, broaden perspective, and stimulate creativity through *diversity*

-Develop logical and structured reasoning through *intelligent participants*

-Generate informed judgments through *knowledgeable professionals*

# OVERALL INDUSTRIAL DEVELOPMENT STRATEGY PLANNING STRUCTURE



# INDUSTRY TECHNOLOGY STRATEGY PLANNING PROCESS

As an *integral* part of *industry development strategy planning,* the industry technology strategy planning process consists of the following steps:

1. Analyze global mega-trends
2. Specify societal values
3. Create future national visions

Technology strategy planning starts:

4. Identify candidate technologies
5. Generate major technology clusters
6. Assess technology cluster positions
7. Develop industry technology portfolio

# INDUSTRY TECHNOLOGY STRATEGY PLANNING: GLOBAL MEGA-TRENDS

Global Mega-trends:

- Society:
  - -Knowledge society
  - -Aging population
  - -Continued urbanization
  - -Urban crowding
  - -Income polarization
- Politics:
  - -Regional competition & cooperation
  - -International organizations
  - -Terrorism

* Economy:
  - - Expansion of multi-nationals
  - - Revolution of industrial processes
  - - Rise of miniaturization industry
  - - Shifting sources of human skills
  - - Changes in consumption patterns

* Environment:
  - - Environment without political boundaries
  - - Global climatic changes
  - - Limitations of natural resources
  - - Widespread of diseases and plagues

- Technology:
  - -Global environmental pollution
  - -Biotechnology
  - -Information and communications technology
  - -Nanotechnology'
  - -Intelligent materials

# INDUSTRY TECHNOLOGY STRATEGY PLANNING: SOCIETAL VALUES

Societal Values obtained from a large group of opinion leaders in the society, including top public officials, key industry and business executives, senior technology researchers and social scientists, major media representatives and artists:

- Economic prosperity
  - -Economic growth
  - -Economic stability
  - -Increase in value added
- Social equity
  - -Narrowing of income gaps
  - -Social welfare improvement
  - -Low unemployment rate
  - -Care of aged and disabled population
- Life quality (Environmental sustainability)
  - -Environmental quality
  - -Balance of work and leisure
  - -Quality of life

# INDUSTRY TECHNOLOGY STRATEGY PLANNING: FUTURE VISIONS

Future National Visions created from the responses of these opinion leaders:

*A. Key Innovator of Knowledge Economy*

In this vision, the country will take advantage of its leadership in information technology to continue as a key innovator in the global knowledge economy providing advanced technology developments as well as aesthetic designs.

*B. Value Initiator and Champion for New Production Technologies*

In this vision, the country will go beyond providing advanced information and communication technology developments and become the value initiator and champion for developing new technologies for the revolution in economic production.

*C. Regional Transportation and Communication Hub and Resource Integrator*

In this vision, the country will expand its current advantageous position as the communication hub of the Asian region to be also the transportation center and resource integrator of the region.

*D. Pioneer of New Lifestyle*

In this vision, the country will expand its aesthetic sense and design capability to become a pioneer in new lifestyle for the world community.

# INDUSTRY TECHNOLOGY STRATEGY PLANNING: TECHNOLOGY CLUSTERING

The objective of technology clustering is to integrate the large number of potential individual technologies into *meaningful, insightful, and manageable* clusters.

There are two basic approaches:

Top-down: In this case, the participants, through their knowledge and experience, identify the relevant and important technology clusters

Bottom-up: In the case, the participants are given a large list of technologies to be integrated into various major clusters.

In the current planning process, we use the Bottom-up approach.

To initiate cluster formation, we first divided the list of technologies into major areas: biotech, materials, energy, semiconductors, and information and communications.

To further facilitate clustering, we asked the experts to sort technologies by
- Shared technology root or developmental processes
- Common practical application or market demand
- Integrated support to societal values and visions

# TECHNOLOGY CLUSTERING BASIS

- By *technology root* or *interactions* in development process:
  - Research by scientists in the same field
  - Development by engineers of the same discipline
  - Overlapping or connected developmental processes
  - Manufacturing by similar processes
- By *practical application* or *market demand*:
  - Serving similar end-use needs
  - Supplied through similar distribution channels
- By *relevance and support* to societal values and visions
  - Economic prosperity
  - Social equity
  - Life quality (environmental sustainability)

# TECHNOLOGY CLUSTERING: Results of Bottom-Up Process

- 200 technologies were sorted into 6 bins:
  - Biotech
  - Materials Technology
  - Energy Technology
  - Semiconductor Technology
  - Information and Communications Technology
  - Other
- Each bin yielded multiple clusters (groupings of several technologies); Top clusters attractive to the Country were selected.

The initial technology clusters were reviewed again by technology experts to ensure definition clarity and content agreement. Through iterative discussion, differences of expert judgments were reduced and unified. A final set of 29 technology clusters emerged.

# INDUSTRY TECHNOLOGY STRATEGY PLANNING: PORTFOLIO DEVELOPMENT

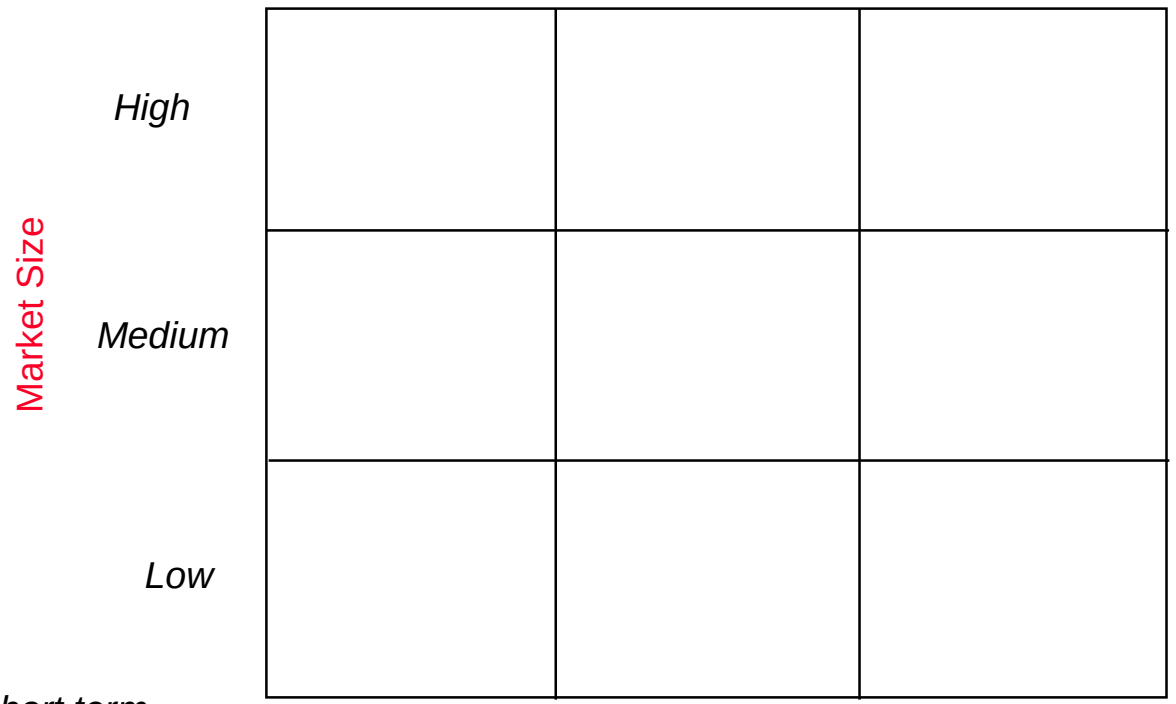
## OVERALL APPROACH

- Emphasis on a *structured, systematic, and logical process*
- Factor analysis:
  Develop a set of relevant factors
  Assess individual technology clusters
- Typical factors:
  *Importance:* market size, societal values
  *Risks:* technical, competitive position
- Assessment basis:
  - Importance:
  -- Market size (< US$1 billion, US$1-10 billion, >US$10 billion globally)
  -- Societal values (weakly relevant, moderately relevant, highly relevant)
  - Risks:
  -- Technical risk (unproven, proven, well-developed)
  -- Competitive position (uncompetitive, moderately competitive, strongly competitive)
  - Market timing: (short-term ≤ 10 years, long-term > 10 years)

To ensure *meaningfulness, insightfulness, innovativeness, and credibility*, a set of templates will be developed and used to structure and record the participating experts' reasoning process and judgmental basis.

# STRATEGY MAP 1:
# Market Size vs. Societal Values

Use the *Analysis of a Pair of Factors* to position all top clusters on strategy maps; assess these cluster positions to develop *technology policy insights and program ideas.*




*Red-short term*
*Green-long term*

*Legend of Top Cluster Names:*

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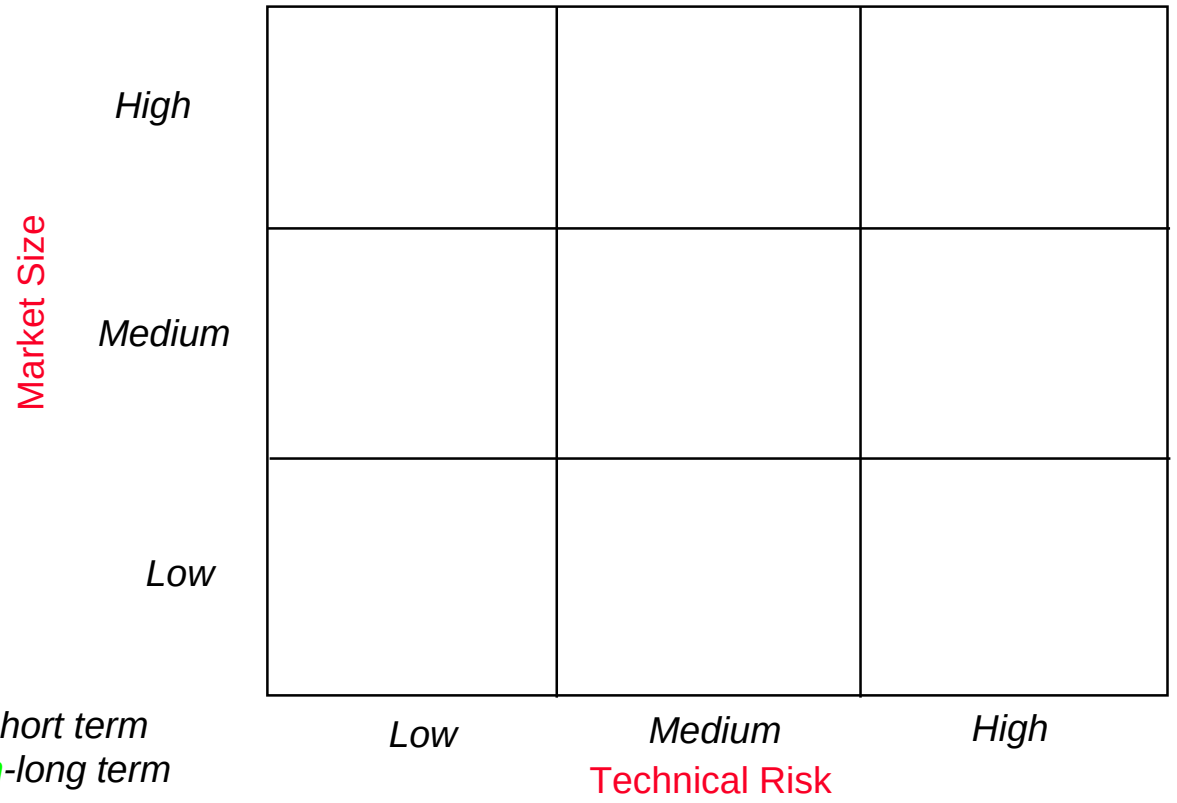
# STRATEGY MAP 2:
# Market Size vs. Technical Risk

Use the *Analysis of a Pair of Factors* to position all top clusters on strategy maps; assess these cluster positions to develop *technology policy insights and program ideas.*

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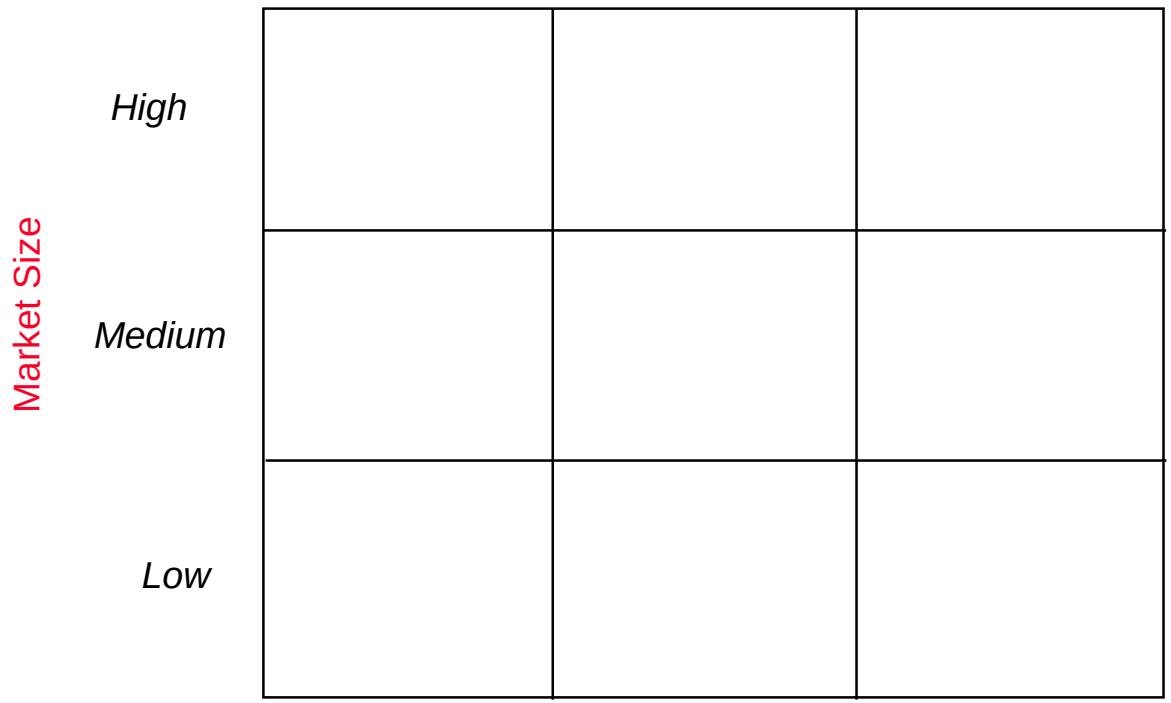
# STRATEGY MAP 3:
# Market Size vs. Competitive Position

Use the *Analysis of a Pair of Factors* to position all top clusters on strategy maps; assess these cluster positions to develop *technology policy insights and program ideas.*

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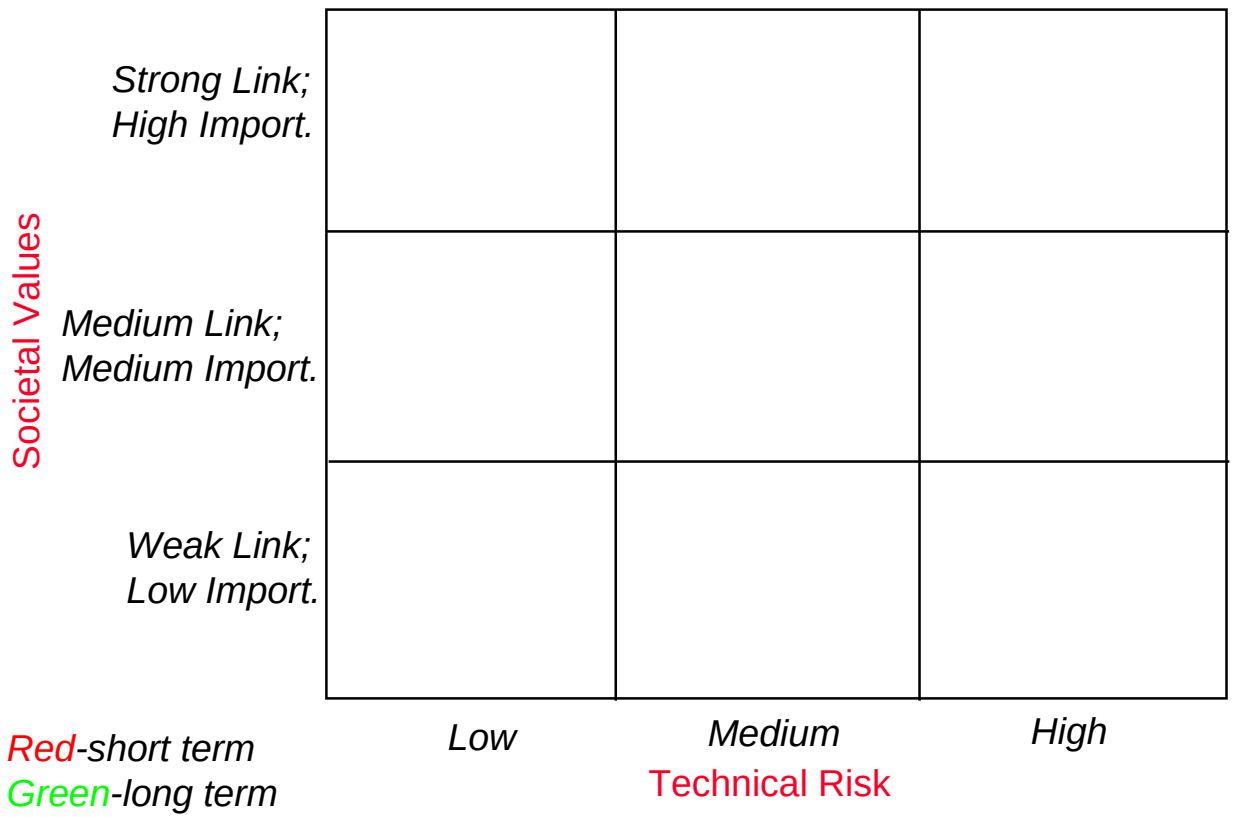
# STRATEGY MAP 4:
# Societal Values vs. Technical Risk

Use the *Analysis of a Pair of Factors* to position all top clusters on strategy maps; assess these cluster positions to develop *technology policy insights and program ideas.*




*Legend of Top Cluster Names:*

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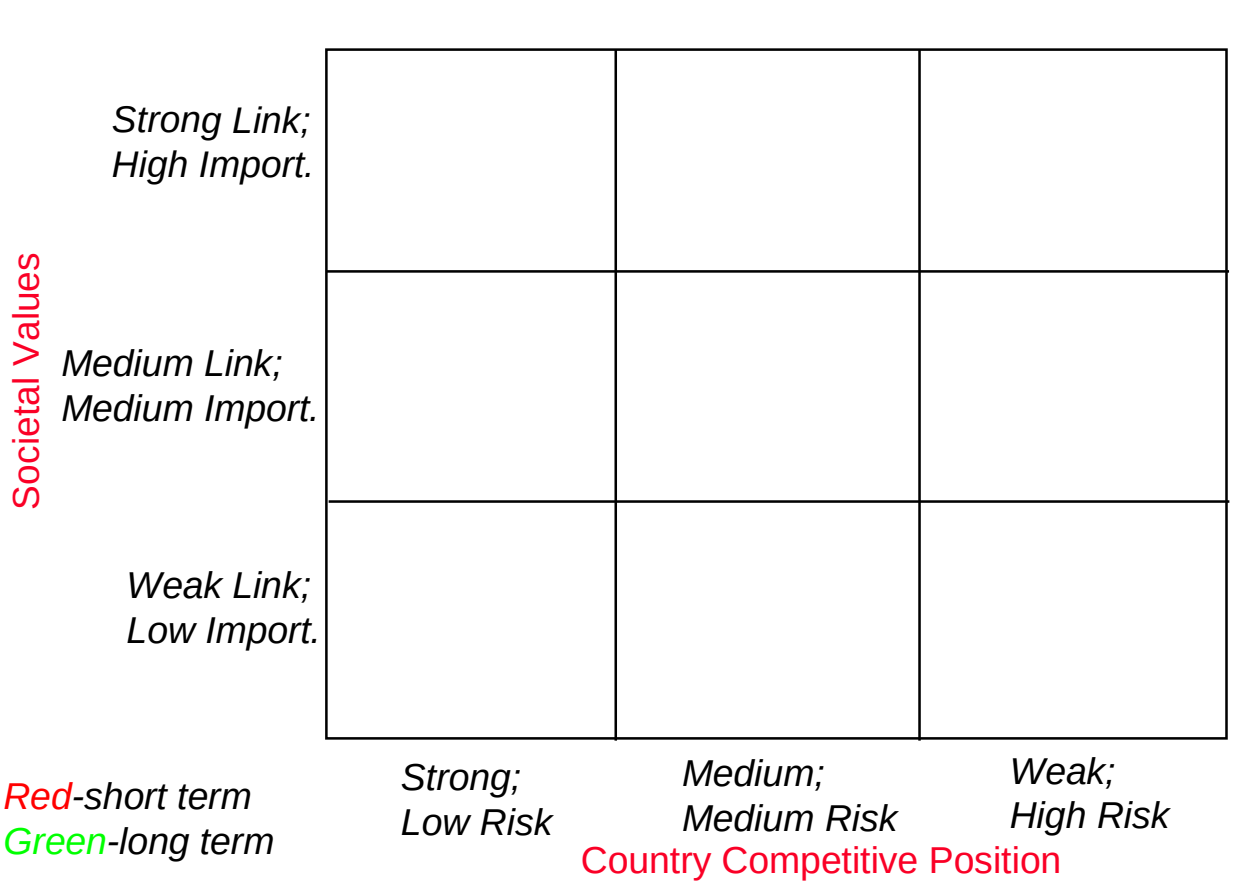
# STRATEGY MAP 5:
# Societal Values vs. Competitive Position

Use the *Analysis of a Pair of Factors* to position all top clusters on strategy maps; assess these cluster positions to develop *technology policy insights and program ideas.*

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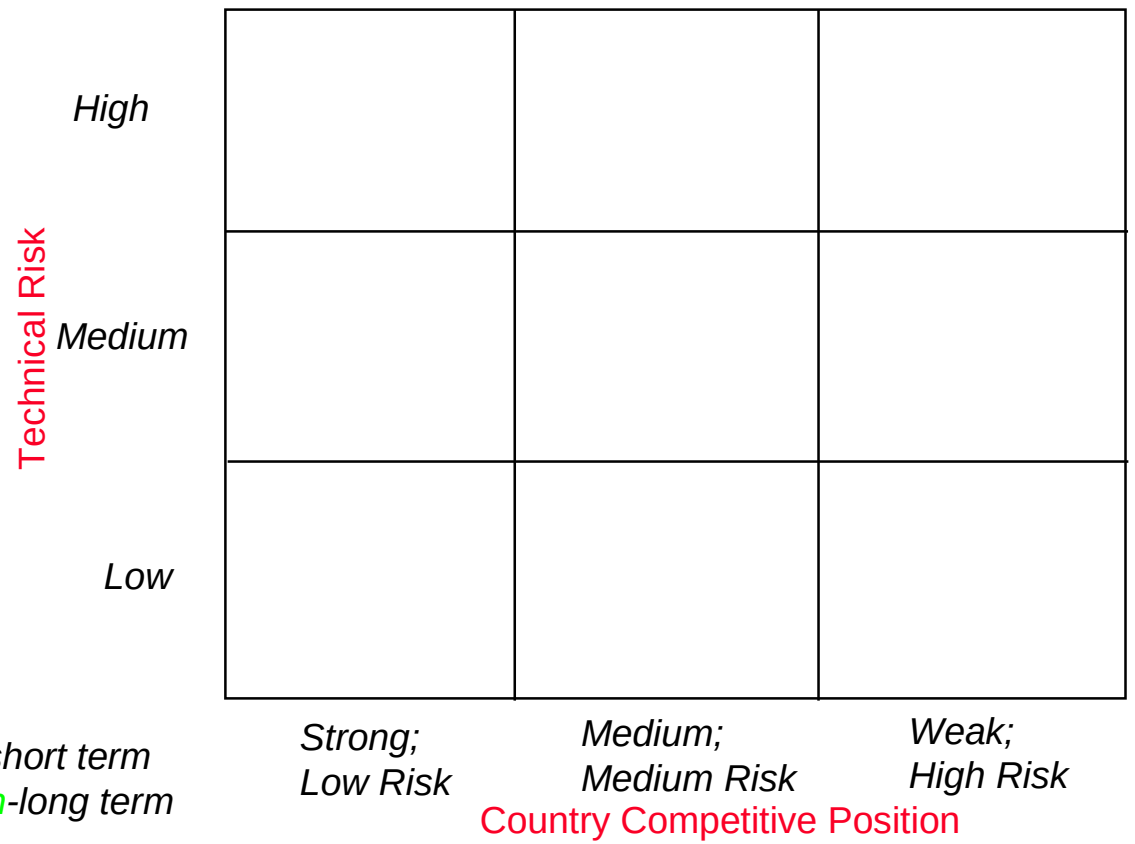
# STRATEGY MAP 6:
# Technical Risk vs. Competitive Position

Use the *Analysis of a Pair of Factors* to position all top clusters on strategy maps; assess these cluster positions to develop *technology policy insights and program ideas.*

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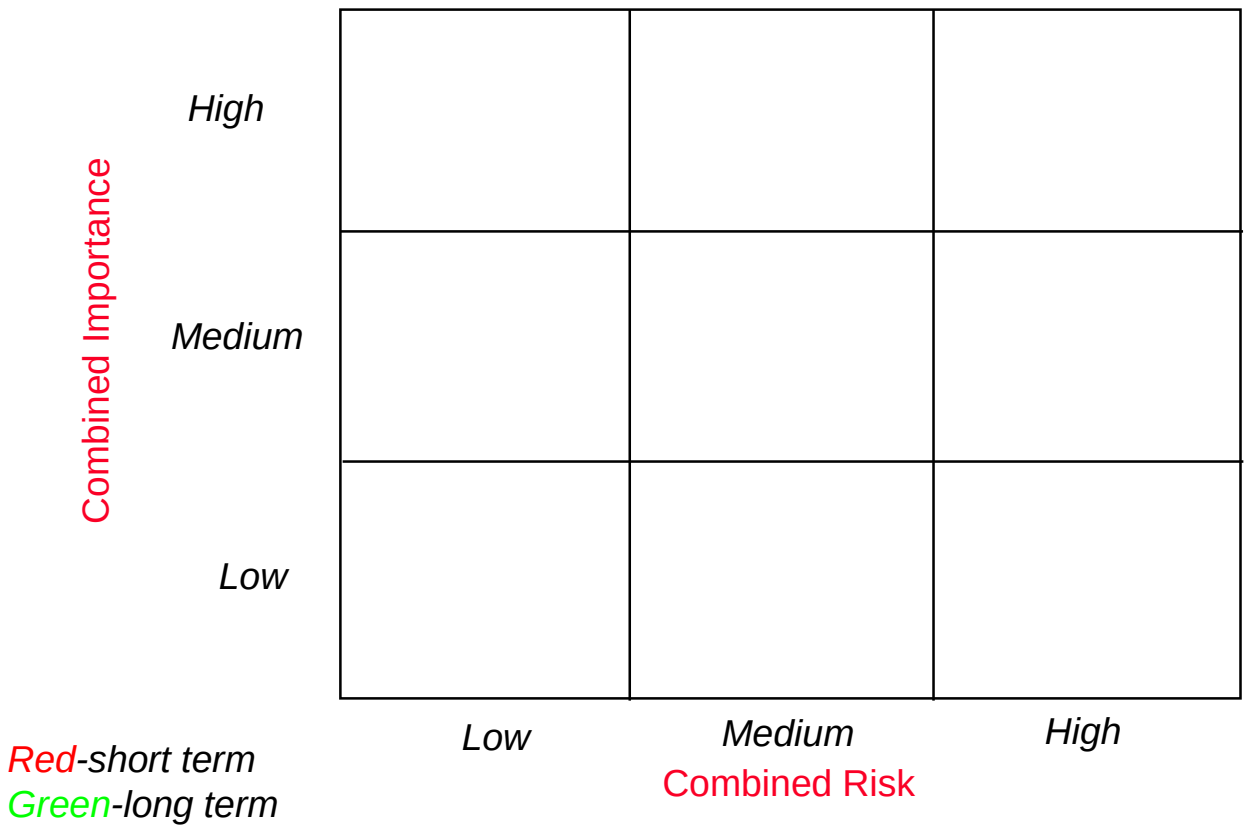
# SUMMARY STRATEGY MAP: Importance vs. Risk

Use the *Analysis of Combined Factors* to position all top clusters on a composite strategy map; assess these cluster positions to develop *technology policy insights and program ideas.*

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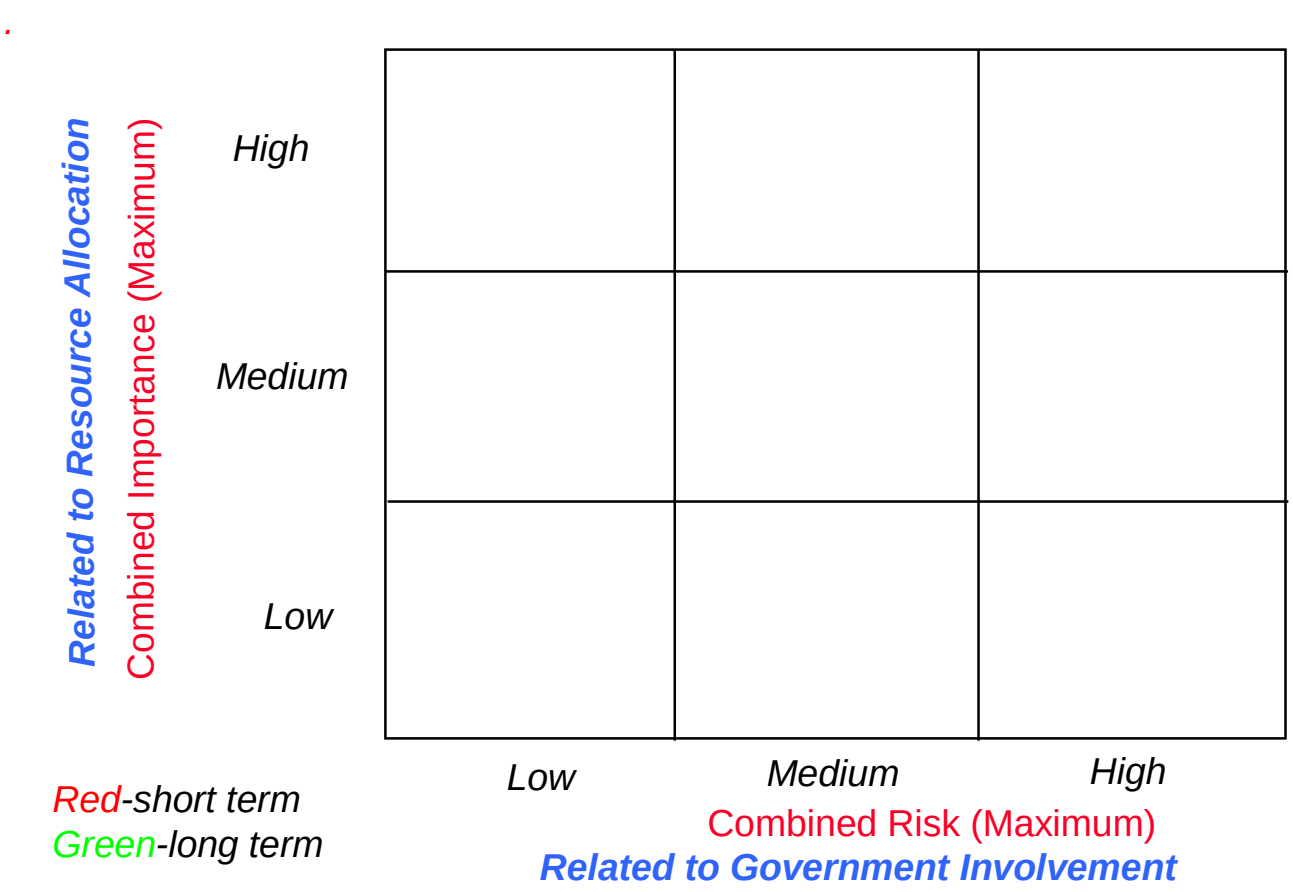
# GENERAL IMPLICATION OF THE SUMMARY STRATEGY MAP

The horizontal axis relates to the *degree of government involvement* needed to reduce technology development risk and promote technology commercialization.

The vertical axis relates to *level of resources* required to achieve the return from the technology development..

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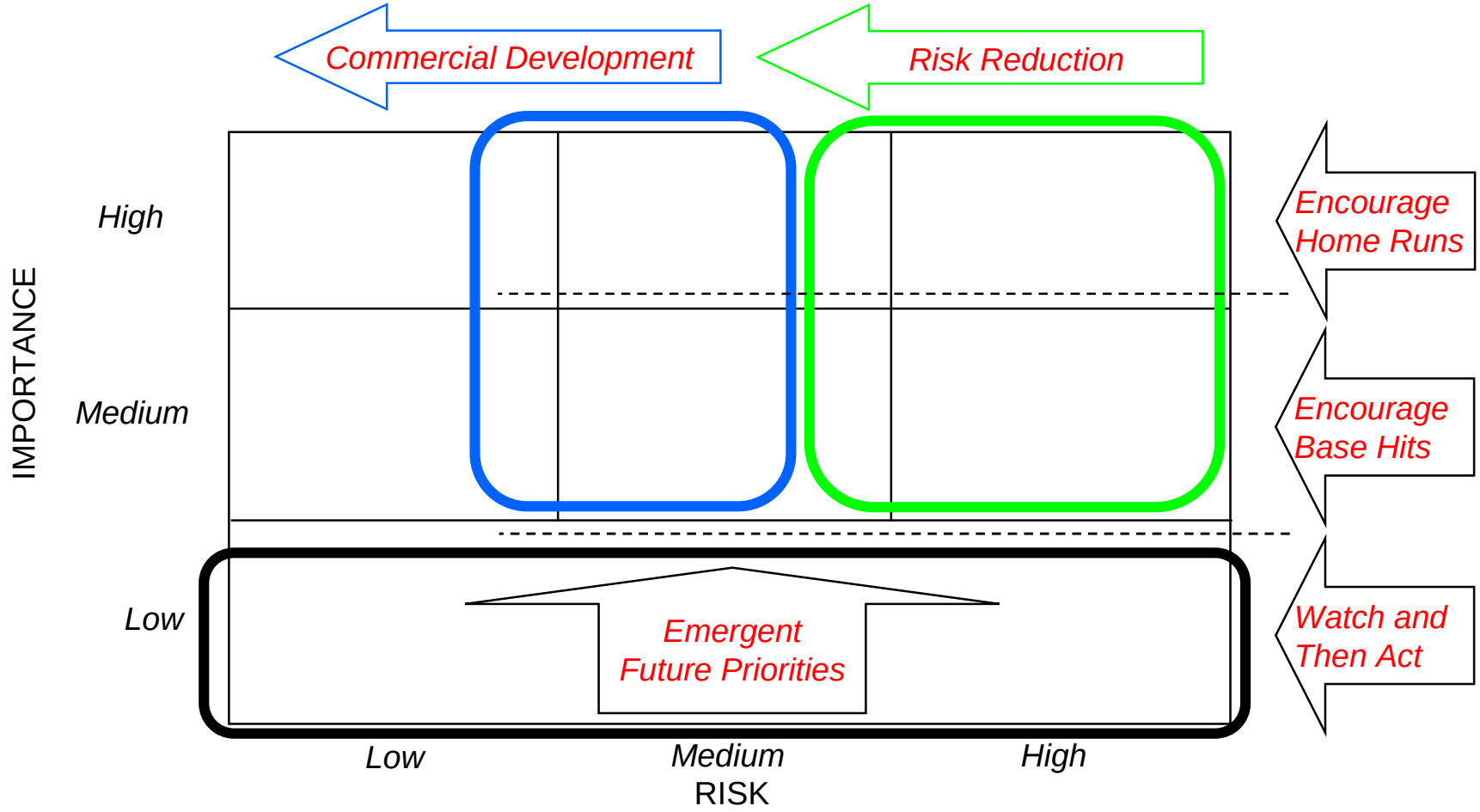
# GENERAL IMPLICATION OF THE SUMMARY STRATEGY MAP

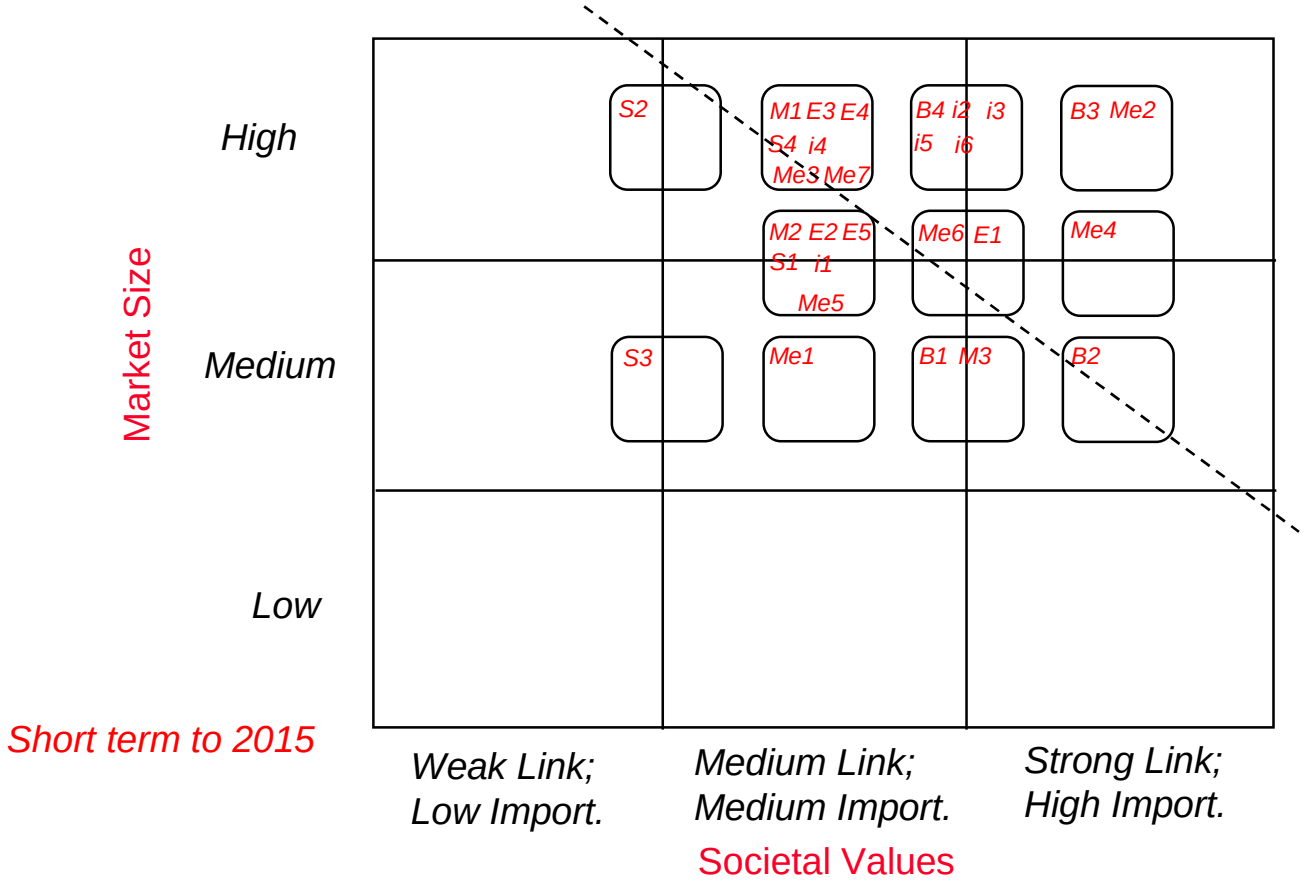
Government Technolgy Policy Opportunities Map

*Support For Visions: A: country as "Innovator" and C: Country as "Integrator"*



# SELECTED STRATEGY MAP RESULTS: Market Size vs. Societal Values (version 2)

Clusters in the northeast corner are important in both market size and societal values.

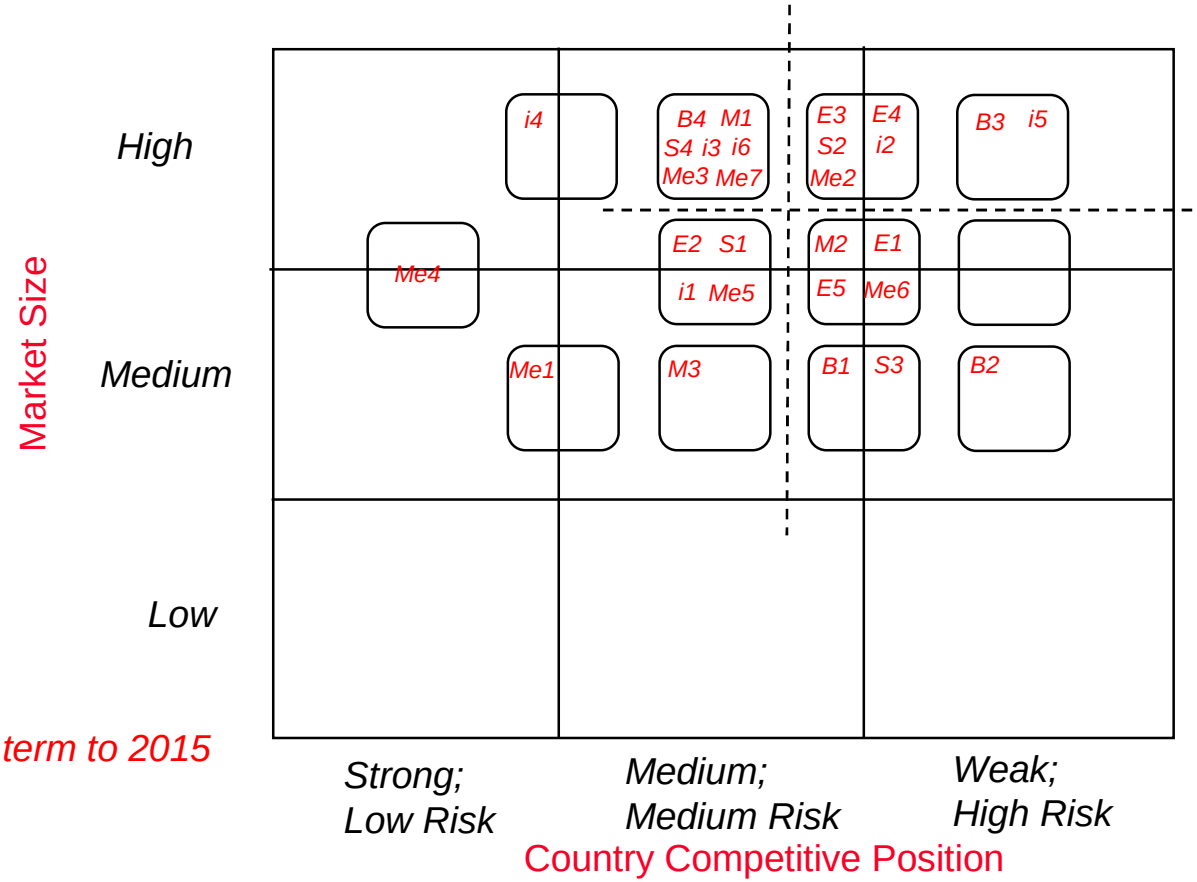



**Top Clusters:**

*B1 Prevent, Predict, Personal Molec. Diagnostic*
*B2 Emerging Infect. Disease Management*
*B3 Regenerative Medicine & Well Being for Aging Population*
*B4 Agricultural Biotechnology*
*M1 Nano Materials and Systems*
*M2 Smart Materials and Systems*
*M3 Materials for Advanced Energy Systems*
*E1 Clean Fossil Fuel Conversion & Emission Reduction*
*E2 Next Generation Solar Energy*
*E3 Green Vehicles & Alternative Fuels*
*E4 Efficient Energy End Use device*
*E5 Advanced Fuel Cells for Non-Propulsion*
*S1 High Complexity IC's*
*S2 Next Gen. Semiconductor Fabrication & Process Tools*
*S3 Flexible Electronics*
*S4 Future Computing devices*
*I1 Recognition and Interpretation Software*
*I2 Smart Enterprise Computing*
*I3 Networked Multi-Media*
*I4 Broadband Communications*
*I5 Intelligent Transportation System*
*I6 Digital Home*
*Me1 Ubiquitous Wireless Technologies*
*Me2 Distributed Health Care Systems*
*Me3 Advanced Optical Display Systems*
*Me4 Sustainable Buildings*
*Me5 Robotics*
*Me6 Environmental & Resources Management*
*Me7 Precision Machining Tools & Products*

# SELECTED STRATEGY MAP RESULTS: Market Size vs. Competitive Position

Use the *Analysis of a Pair of Factors* to position all top clusters on strategy maps; assess these cluster positions to develop *technology policy insights and program ideas.*




Short term to 2015

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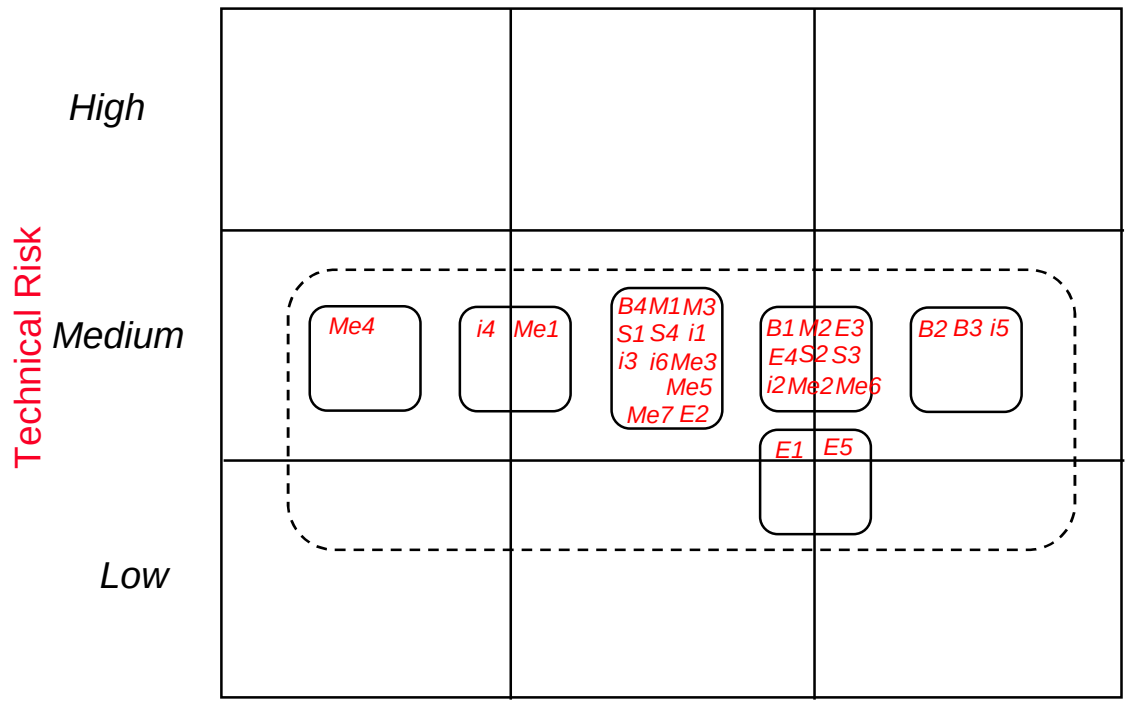
# SELECTED STRATEGY MAP RESULTS: Technical Risk vs. Competitive Position

Risk variation is almost all in Country's competitive position.

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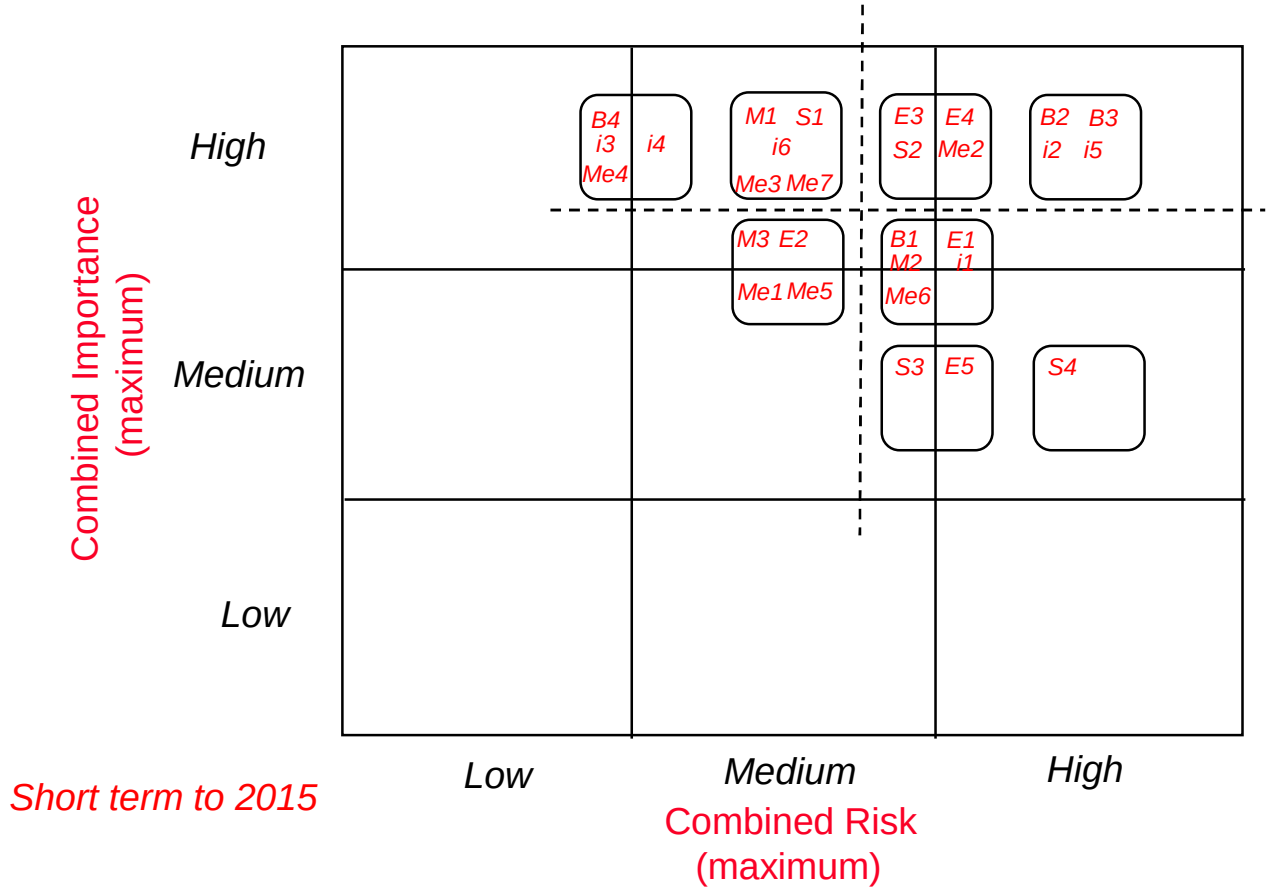
# SUMMARY STRATEGY MAP: Combined Importance vs. Combined Risk

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# VARIOUS GOVERNMENT ROLES AND POLICY LEVERS

Reduce technical and financial risks:
- Market intelligence and technology foresight
- Government support/sponsored R&D/Center of Excellence/National R&D Center
- Educational scholarships
- Recruit foreign talents
- International joint research
- IP planning and development
- Building infrastructure
- M&A foreign companies

Promote commercialization:
- Regulation
- Promote industry standards
- Grants to enterprise for R&D or technology transfer
- Active incubators
- Government procurement
- Tax incentives/tax holiday
- Shareholder partnership
- Government supported projects
- Promoting local industry alliance

# VARIOUS GOVERNMENT ROLES AND POLICY LEVERS

Remove barriers:

- Deregulation
- Remove access barriers to standardization

Invest in start-ups

- Support for small business start up
- Providing innovation grants

Develop technology capability

- Public awareness program
- Public education sites
- K-12 curriculum and teacher development

# POLICY LEVERS MAINLY FOR RISK REDUCTIONS OF HIGH RISK CLUSTERS

## Risk Reduction Portfolio (16 Clusters)

***High Risk Clusters:***

*B2 Emerging Infect. Disease Management*
*B3 Regenerative Medicine &*
*Well Being for Aging Population*
*E3 Green Vehicles & Alternative Fuels*
*E4 Efficient Energy End Use device*
*S2 Next Gen. Semiconductor Fabrication & Process Tools*
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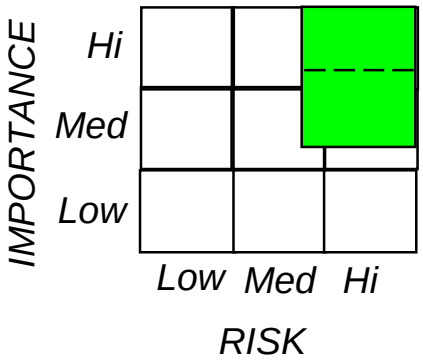


***Government Technology Strategy for High Risk Clusters***

| | *Support Innovator Vision* | *Support Integrator Vision* |
|---|---|---|

*Top Impact Tech. Policy Levers:*

- Recruit foreign talent
- Government Support/ sponsored R&D/ Center of Excellence / National R&D center
- International Joint Research & Cooperation
- Market Intelligence / Technology Foresight
- IP Planning & Development

# POLICY LEVERS MAINLY FOR COMMERCIA-LIZATION OF MEDIUM RISK CLUSTERS

## *Commercial Development Portfolio (13 Clusters)*

***Medium Risk Clusters:***

*B4 Agricultural Biotechnology*
*M1 Nano Materials and Systems*
*S1 High Complexity IC's*
*I3 Networked Multi-Media*
*I4 Broadband Communications*
*I6 Digital Home*
*Me3 Advanced Optical Display Systems*
*Me4 Sustainable Buildings*
*Me7 Precision Machining Tools & Products*

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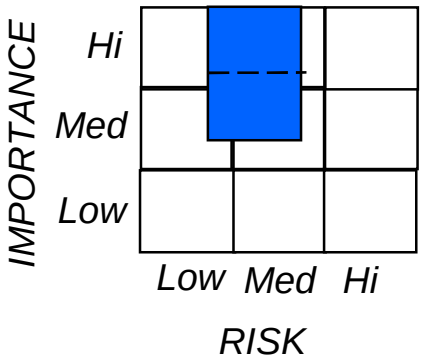


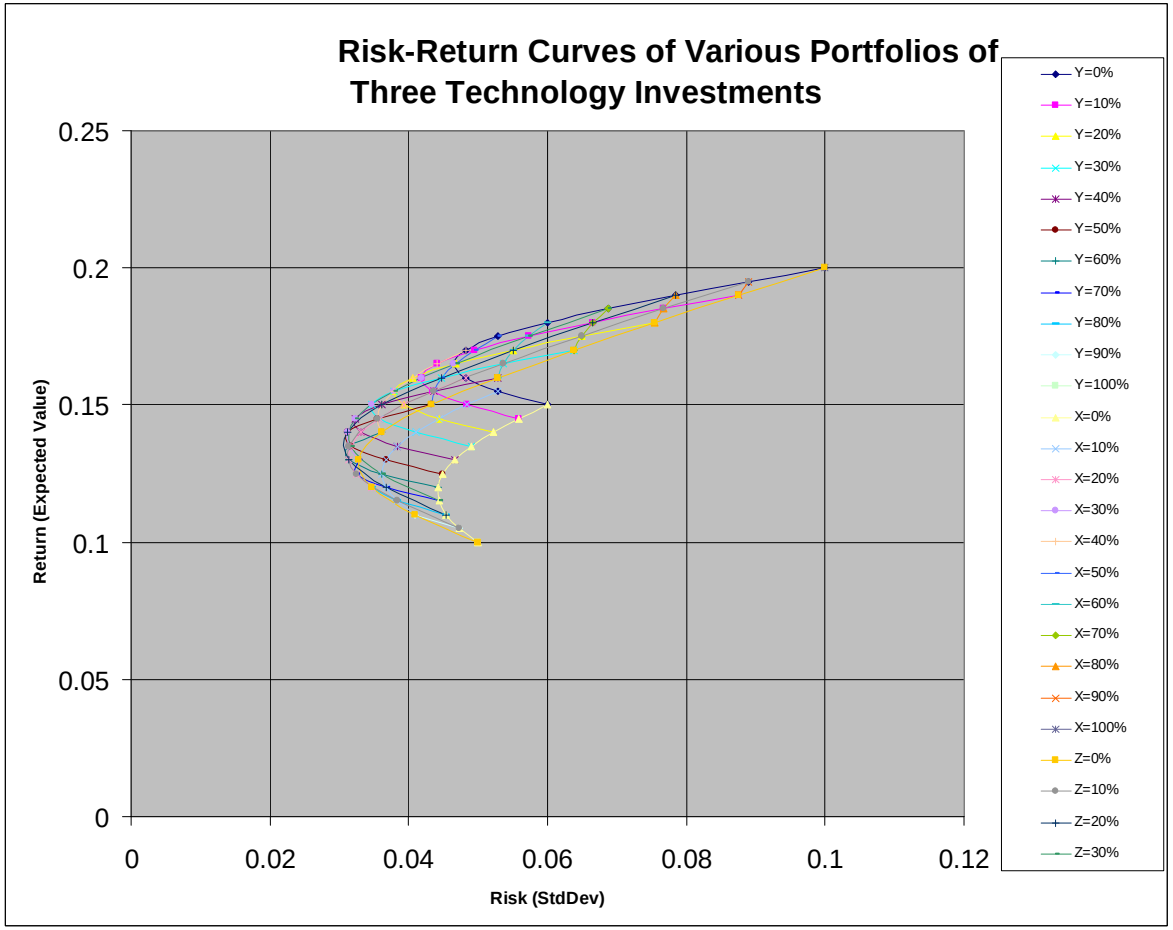

***Government Technology Strategy for Medium Risk Clusters***

| | *Support Innovator Vision* | *Support Integrator Vision* |
|---|---|---|

*Top Impact Tech. Policy Levers:*

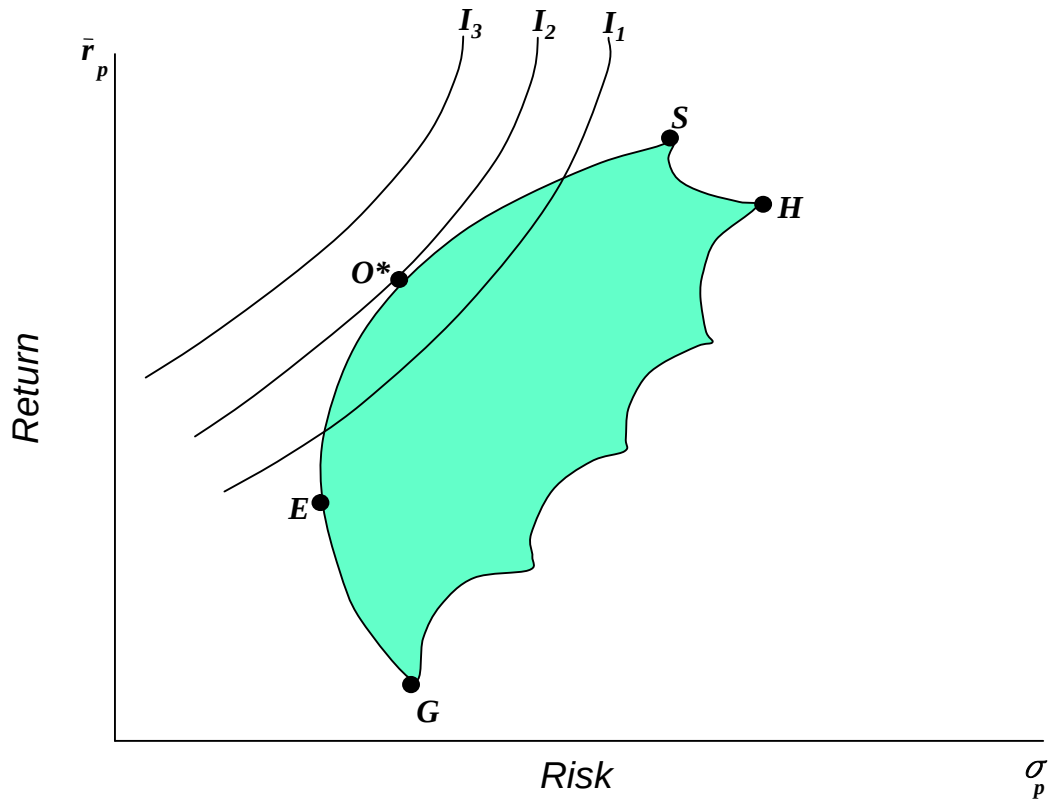
- Infrastructure building
- Regulation/Deregulation
- Active Incubators
- Tax incentives /Tax holidays
- Promote local industry alliance
- Grant to enterprise for R&D or technology transfer

# MODERN PORTFOLIO ANALYSIS: THE IMPACT OF DIVERSIFICATION



# RESOURCE ALLOCATION METHODOLOGY: MODERN PORTOFLIO ANALYSIS

In a simplified way, optimal portfolio selection is the *best balance* between return and risk for a decision-maker, which occurs at the *tangential point of the indifference curves and the efficient frontier* as shown below.

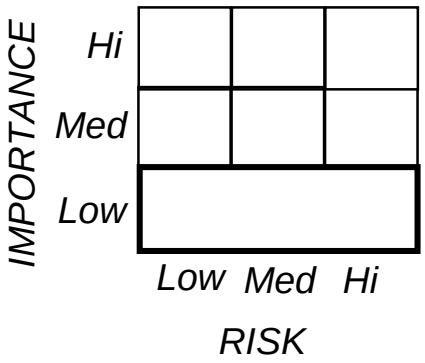


# POLICY LEVERS MAINLY FOR ASSISTING LOW IMPORTANCE CLUSTERS

## *Emergent Opportunities Portfolio (11 Clusters)*

***Low Importance Clusters:***

*B5 Implant. & Min. Invasive Medical Devices*
*M5 Medical Materials*
*M6 Fibers*
*M7 Catalysts*
*E6 Advanced Batteries for Non-Propulsion*
*E7 Alternative Liquid Fuel Production*
*E8 Wind and Ocean Power*
*S5 Energy Semiconductor*
*S6 Trusted System*
*I7 Pervasive Learning*
*Me7 Exotic Transportation*




***Government Technology Strategy for Emergent Clusters***

| | *Support Innovator Vision* | *Support Integrator Vision* |
|---|---|---|

*Top Impact Tech. Policy Levers:*

- Market Intelligence / Technology Foresight

- Public education sites/ Public awareness (K-12 Curriculum & Teacher development & Science education for public)

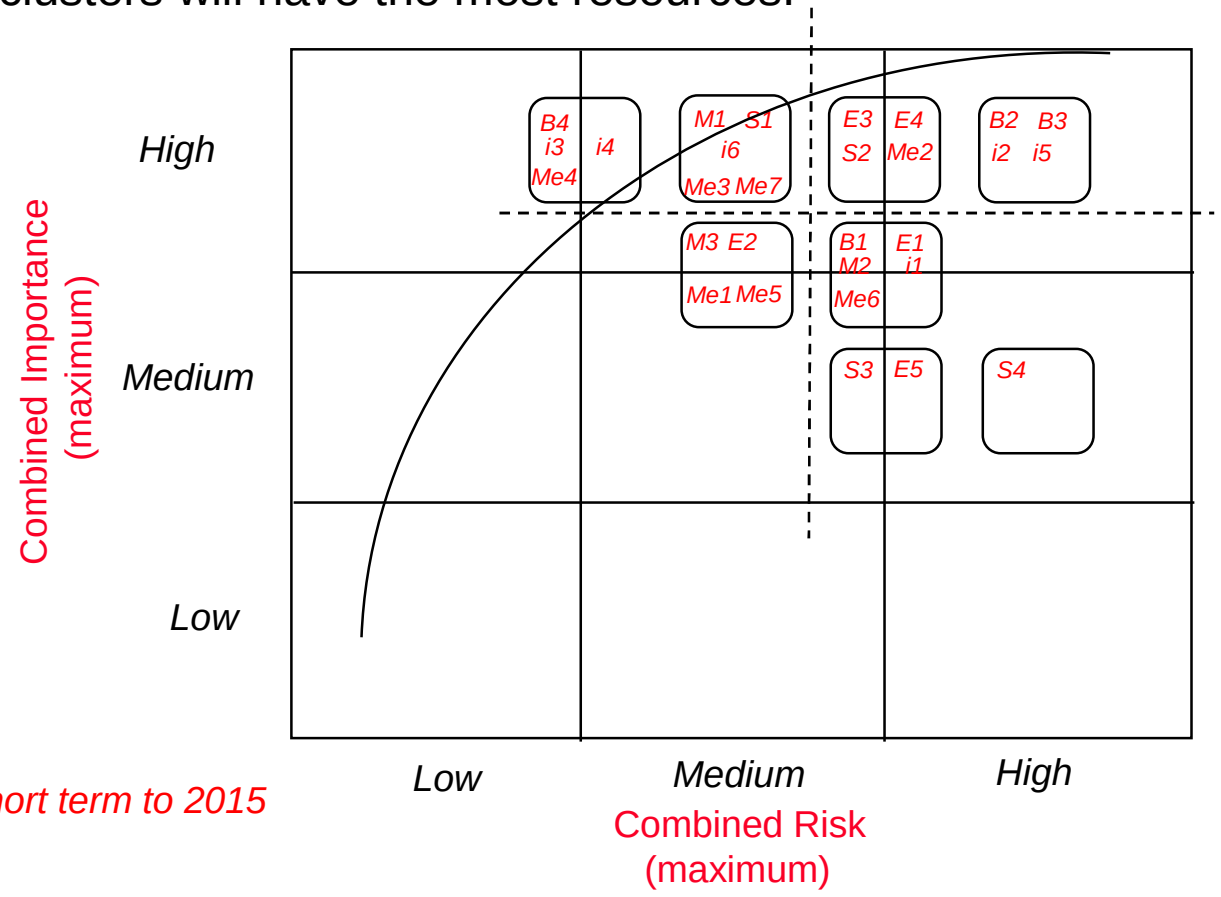
- Support for small business start-ups

- International Cooperation

- Recruit foreign talent

# TECHNOLOGY PORTFOLIO PLANNING BASED ON SUMMARY STRATEGY MAP (version 3)

If the government is willing to make large investment for the high risk home runs, then high importance and high risk clusters will have the most resources; if the government is interested in mainly base hits and commercialization, then medium importance and risk clusters will have the most resources.

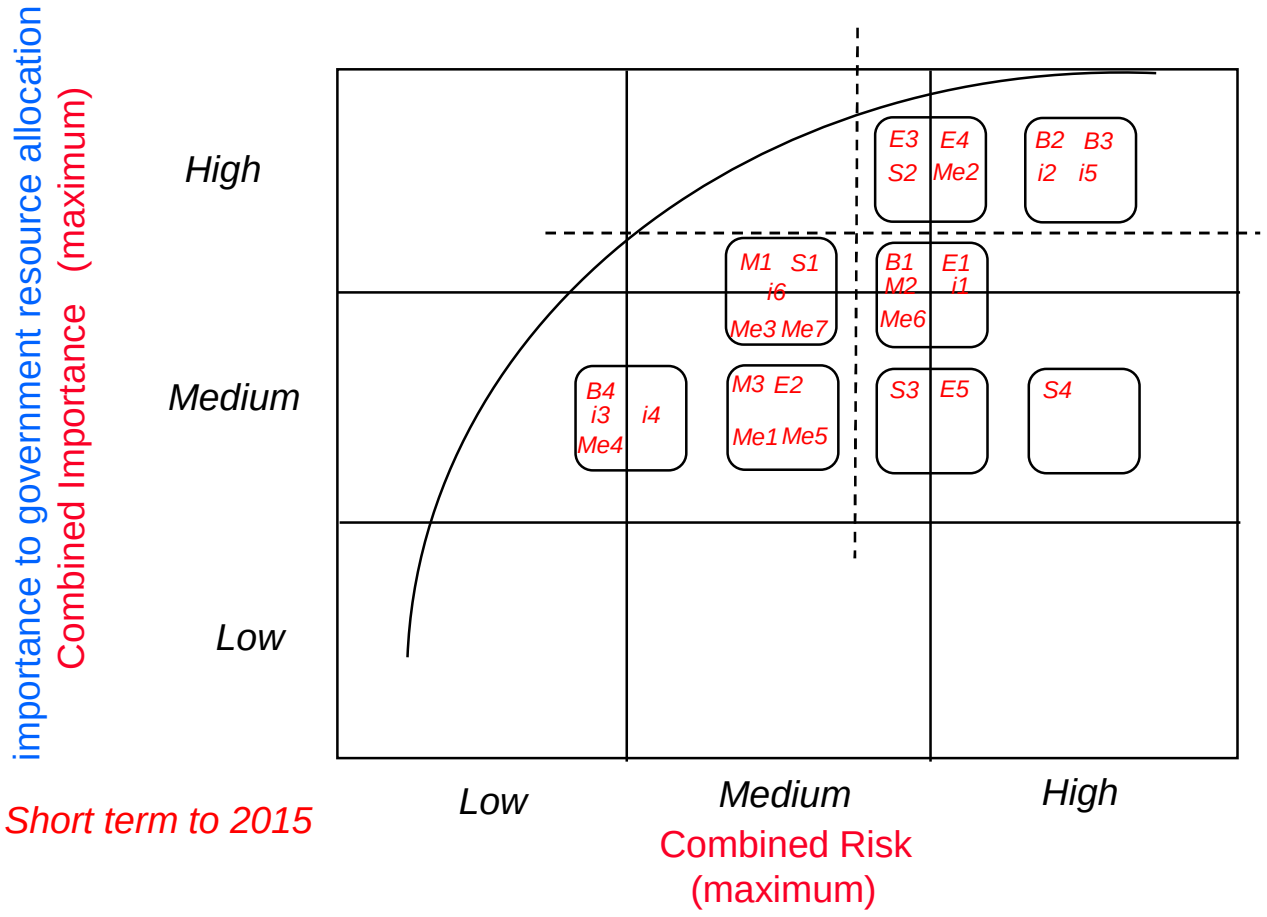



**Top Clusters:**

*B1 Prevent, Predict, Personal Molec. Diagnostic*
*B2 Emerging Infect. Disease Management*
*B3 Regenerative Medicine & Well Being for Aging Population*
*B4 Agricultural Biotechnology*
*M1 Nano Materials and Systems*
*M2 Smart Materials and Systems*
*M3 Materials for Advanced Energy Systems*
*E1 Clean Fossil Fuel Conversion & Emission Reduction*
*E2 Next Generation Solar Energy*
*E3 Green Vehicles & Alternative Fuels*
*E4 Efficient Energy End Use device*
*E5 Advanced Fuel Cells for Non-Propulsion*
*S1 High Complexity IC's*
*S2 Next Gen. Semiconductor Fabrication & Process Tools*
*S3 Flexible Electronics*
*S4 Future Computing devices*
*I1 Recognition and Interpretation Software*
*I2 Smart Enterprise Computing*
*I3 Networked Multi-Media*
*I4 Broadband Communications*
*I5 Intelligent Transportation System*
*I6 Digital Home*
*Me1 Ubiquitous Wireless Technologies*
*Me2 Distributed Health Care Systems*
*Me3 Advanced Optical Display Systems*
*Me4 Sustainable Buildings*
*Me5 Robotics*
*Me6 Environmental & Resources Management*
*Me7 Precision Machining Tools & Products*

# REVISED TECHNOLOGY PORTFOLIO PLANNING BASED ON SUMMARY STRATEGY MAP

For government viewpoint, it will be more meaningful to use the importance to government resource allocation.

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*Me3 Advanced Optical Display Systems*
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*Me6 Environmental & Resources Management*
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# RESOURCE ALLOCATION METHODOLOGY: PARETO/ABC ANALYSIS

Italian economist Pareto empirically observed that 80% of land was owned by 20% of the population, which gives rise the popular 80-20 rule.

Based on Pareto's Law, the ABC analysis would develop an effective investment portfolio by allocating approximately:

60% resource to Class A technologies (high importance)

30% resource to Class B technologies (medium importance)

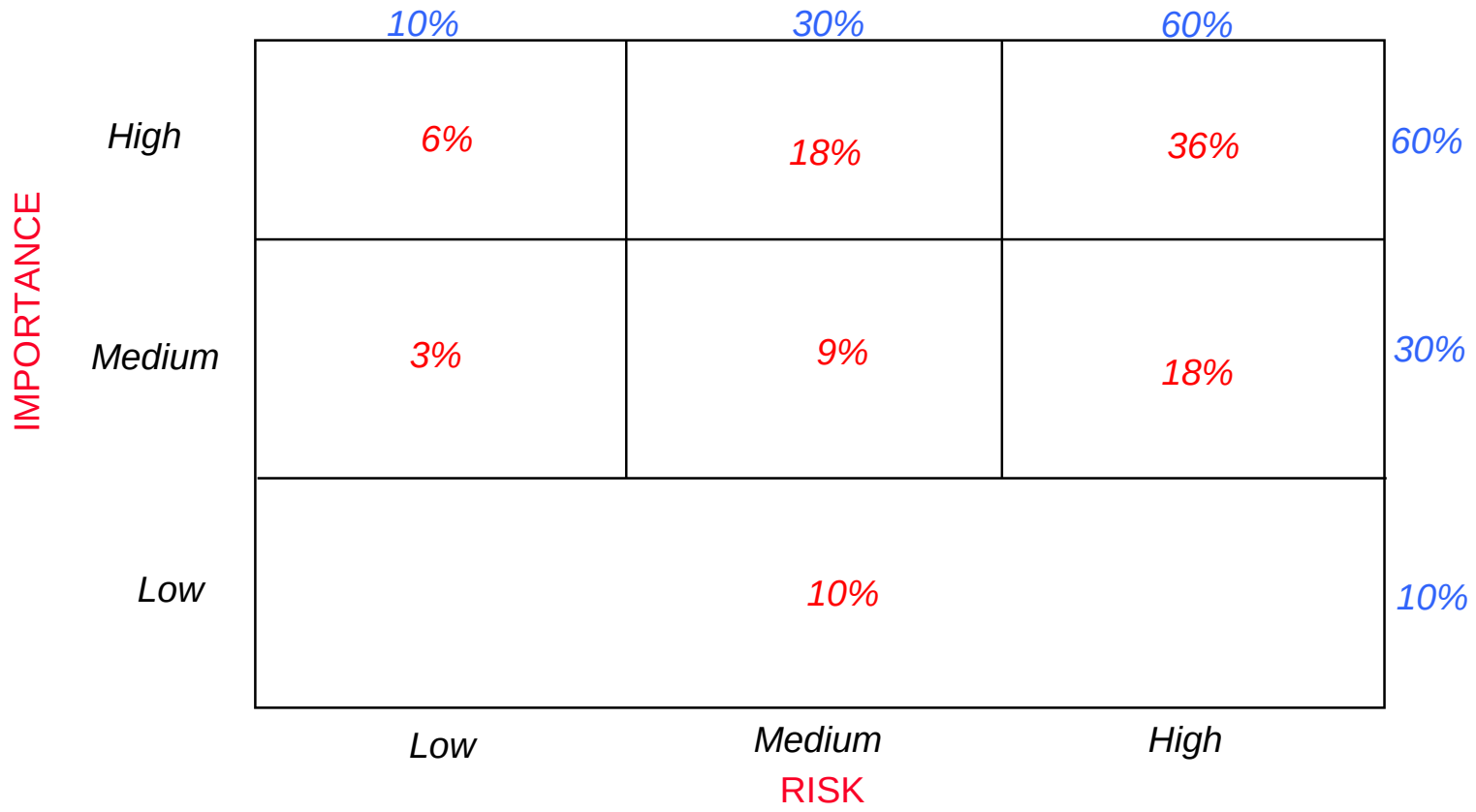
10% resource to Class C technologies (low importance)

The classes A,B, and C will depend on the investor's value function and risk attitude

# RESOURCE ALLOCATION TOP-DOWN EXAMPLE 1

Hypothetical Total Gov't Resource Allocation for the next 10 years:

- Emphasis on support of high risk clusters ("risk reduction")
- Emphasis on support of high importance clusters ("home runs")



# RESOURCE ALLOCATION TOP DOWN EXAMPLE 2

Hypothetical Total Government Resource Allocation in the next 10 years:

- Emphasis on support of medium risk clusters (“commercial development”)
- Emphasis on support of medium importance clusters (“base hits”)