

# Are There Laws of Innovation?

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Global Leaders Forum

Innovation and Persistence: In the Global Transformation

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\*\*\*All opinions expressed herein are the authors' own and do not necessarily reflect the views of any of the organizations with which the authors are affiliated.

# Outline

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- ◆ Introduction
- ◆ Investment in R&D
- ◆ Indicators of Success in Innovation
- ◆ The Relationship between Patent Grants and R&D Capital Stock
- ◆ The Share of Basic Research
- ◆ Concluding Remarks

# Introduction

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- ◆ One important indicator of national economic strength, in addition to real GDP, is its innovative capacity. Sustained investment in research and development (R&D) (and in human capital) is essential for the occurrence of innovation in an economy.

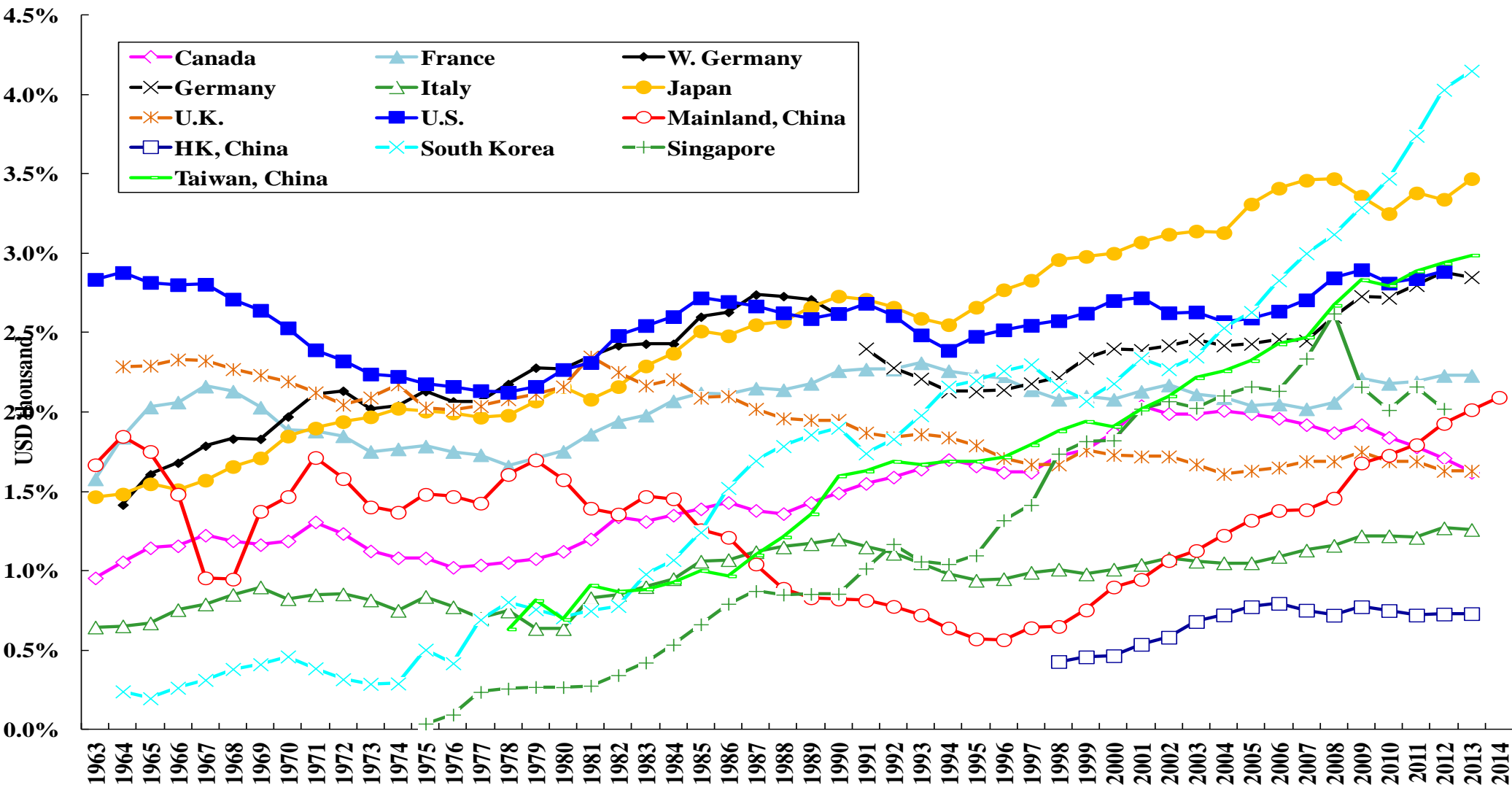
# Investment in Research and Development (R&D)

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- ◆ There are significant variations in the extent of investment in R&D across economies.
- ◆ The stock of real R&D capital, defined as the cumulative past real expenditure on R&D, less depreciation of ten percent per year, is a useful summary measure of the current potential capacity of innovation, as it typically takes years of cumulative efforts before investment in R&D pays off in terms of new discoveries and inventions.

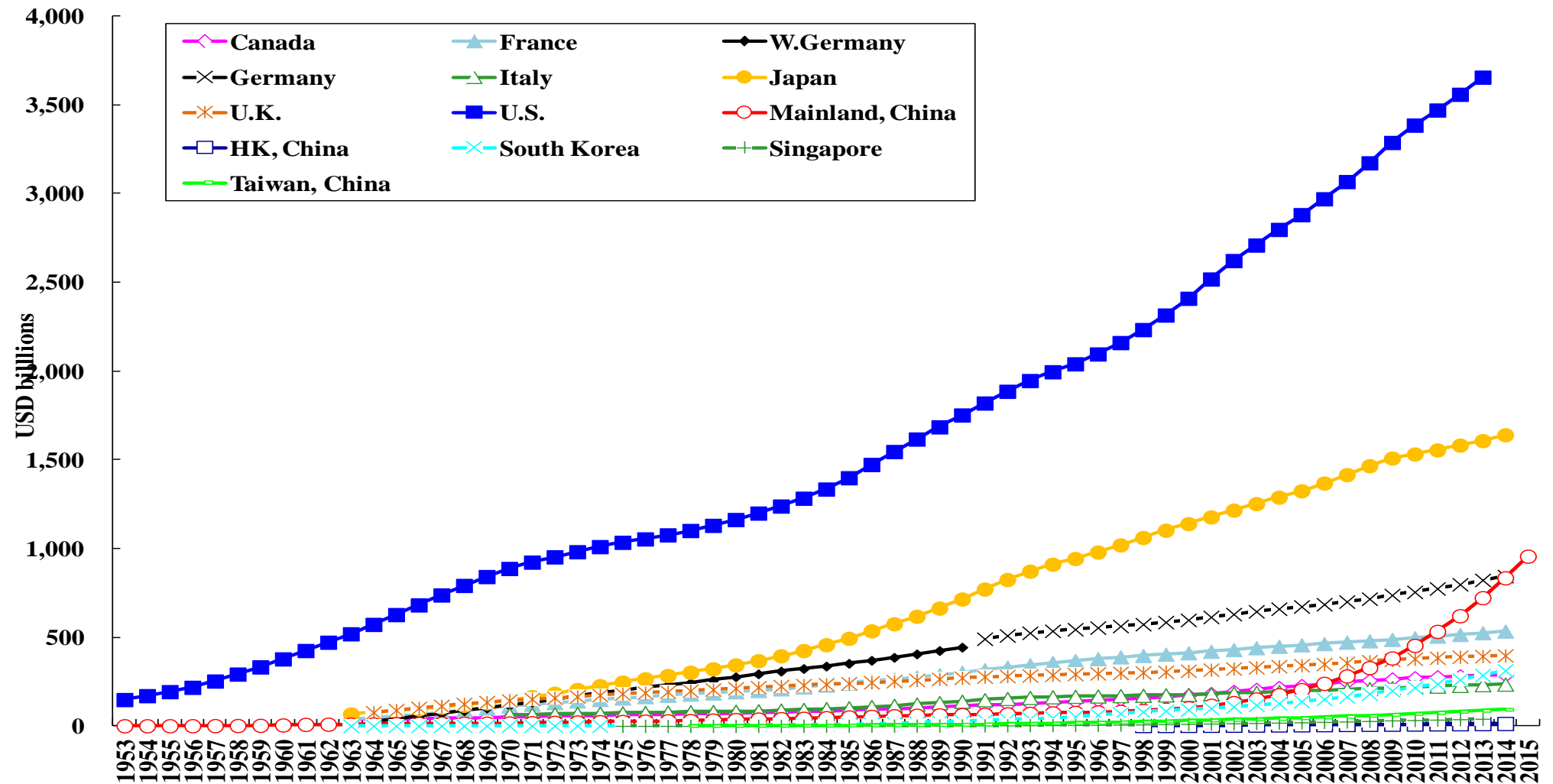
# R&D Expenditure as a Percent of GDP: G-7 Countries, 4 East Asian NIEs and China

R&D Expenditure as a Percent of GDP: G-7 Countries, 4 East Asian NIEs and China



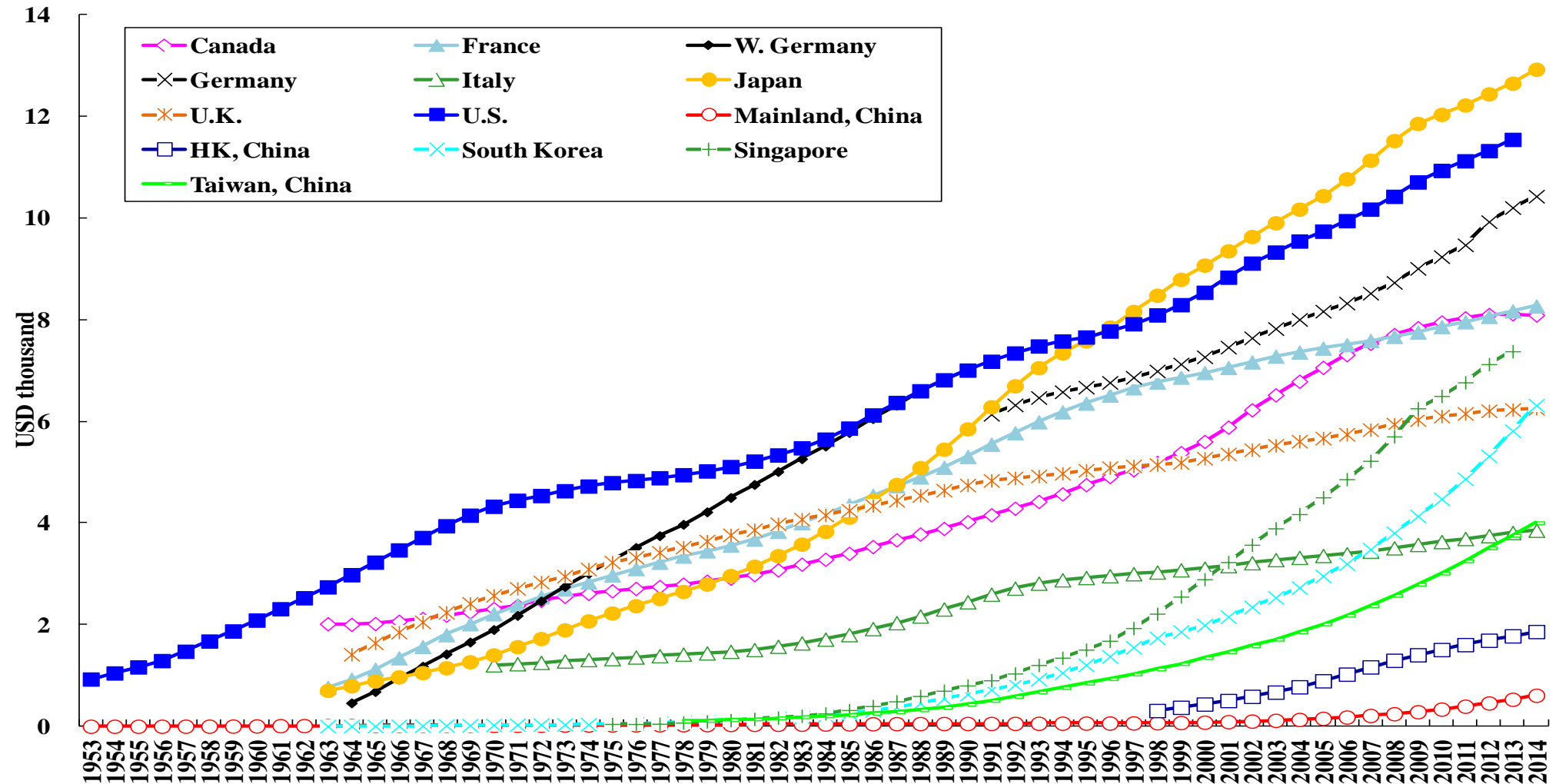
# Real R&D Capital Stocks: G-7 Countries, 4 East Asian NIEs and China (Billion 2012US\$)

Real R&D Capital Stocks: G-7 Countries, 4 East Asian NIEs and China  
(Billion US\$, 2012 Prices)



# Real R&D Capital Stocks per Capita: G-7, 4 East Asian NIEs and China (Thou. 2012 US\$)

Real R&D Capital Stocks per Capita: G-7 Countries, 4 East Asian NIEs and China  
(Thousand US\$, 2012 Prices)



# Indicators of Success in Innovation

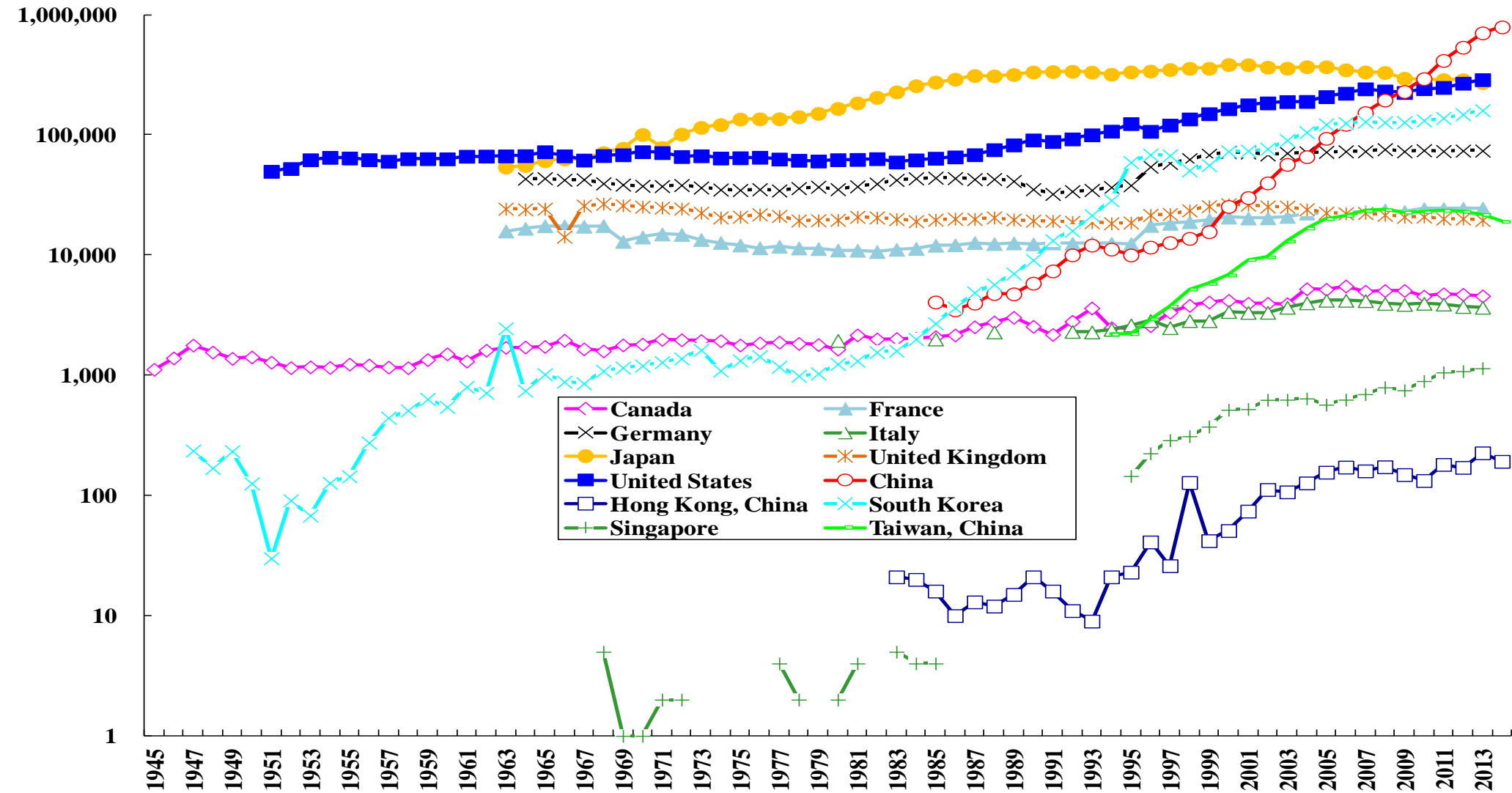
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- ◆ A number of indicators are possible: for example: the number of patent applications submitted, both domestically and abroad, each year, and the number of patents granted, either domestically or in another country or region, each year.



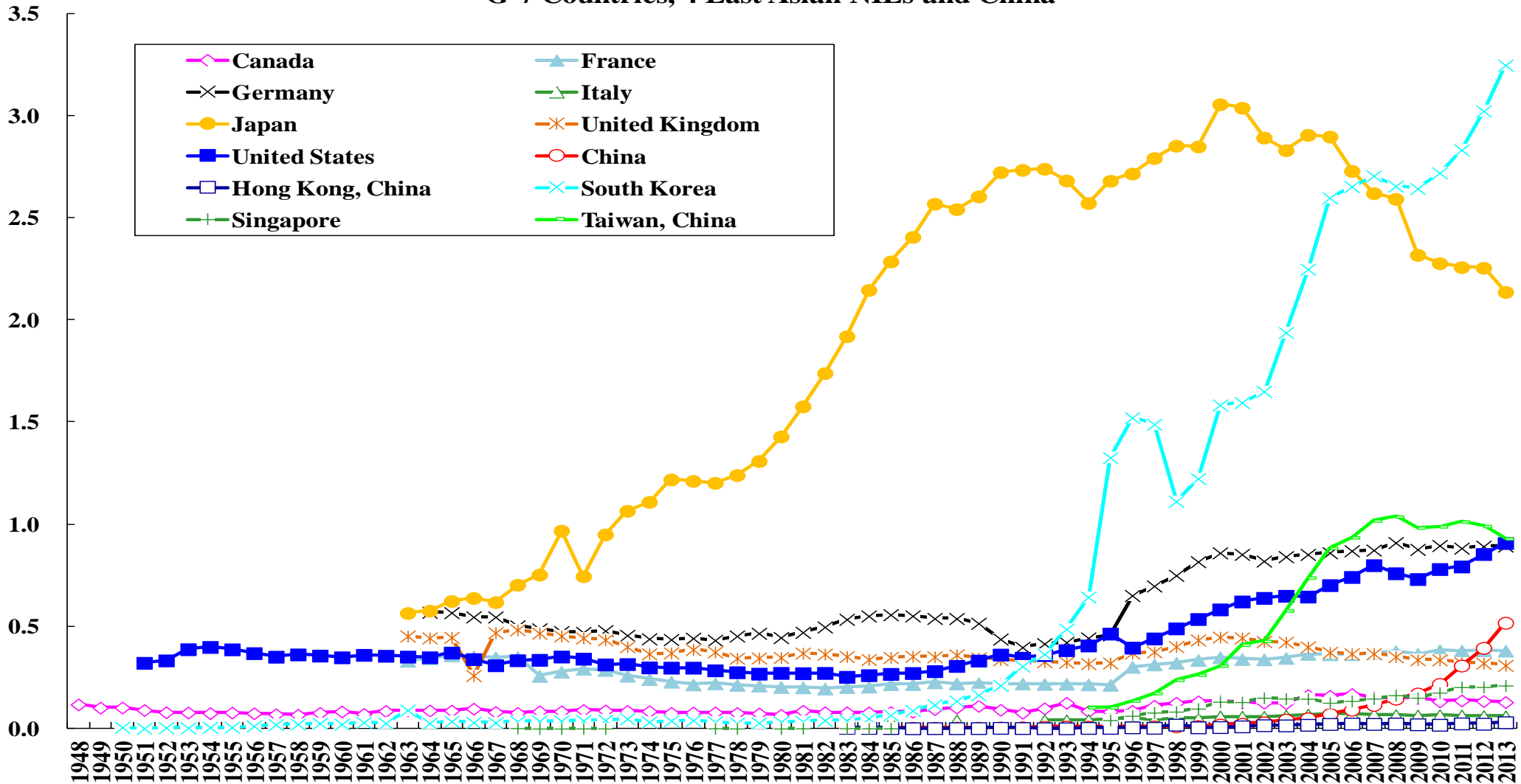
# Domestic Patent Applications Filed Annually: G-7 Countries, 4 East Asian NIEs and China

Domestic Patent Applications Filed Annually: G-7 Countries, 4 East Asian NIEs and China



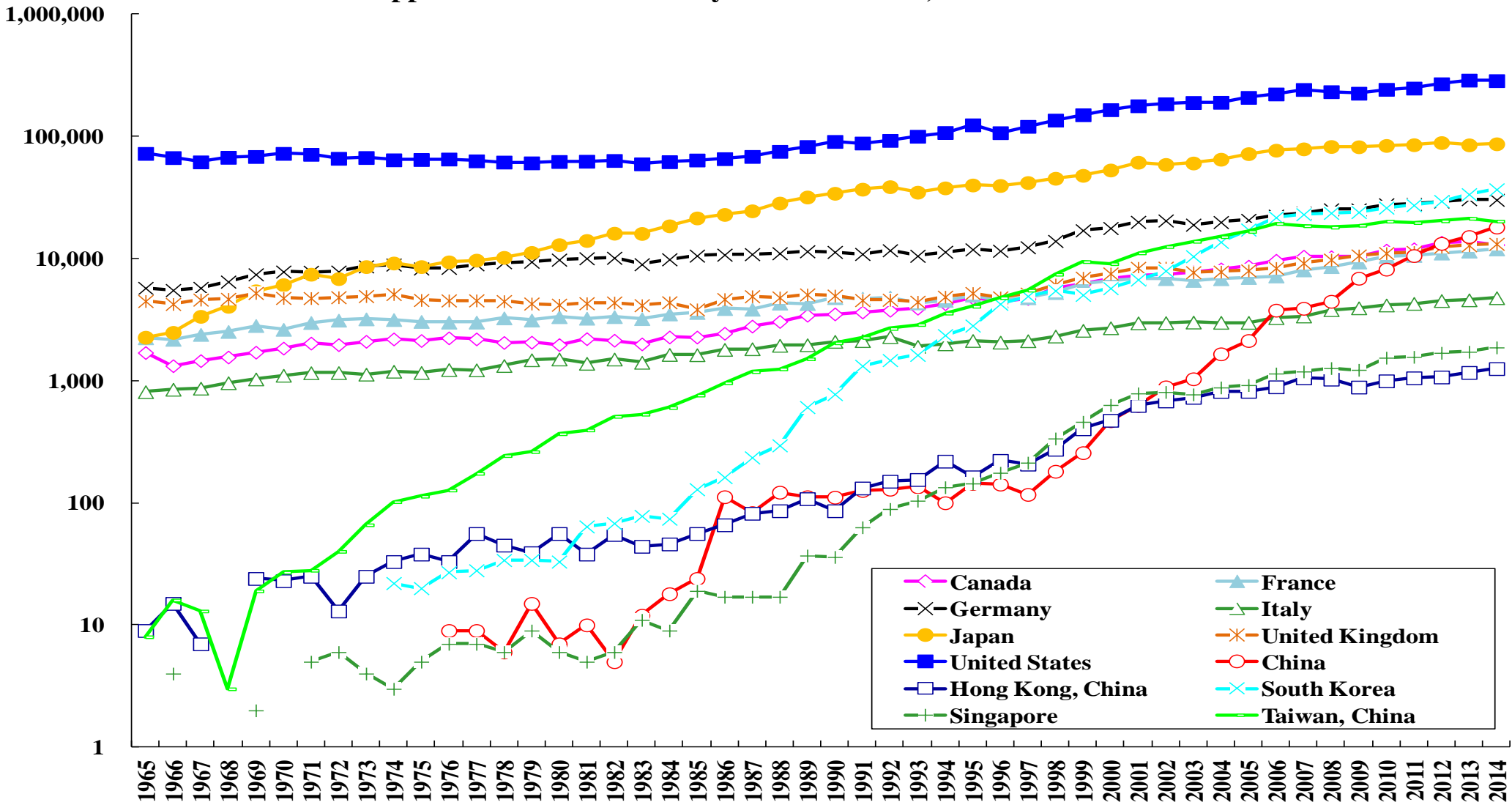
# Domestic Patent Applications per Thousand Persons: G-7, 4 East Asian NIEs and China

Domestic Patent Applications per Thousand Persons:  
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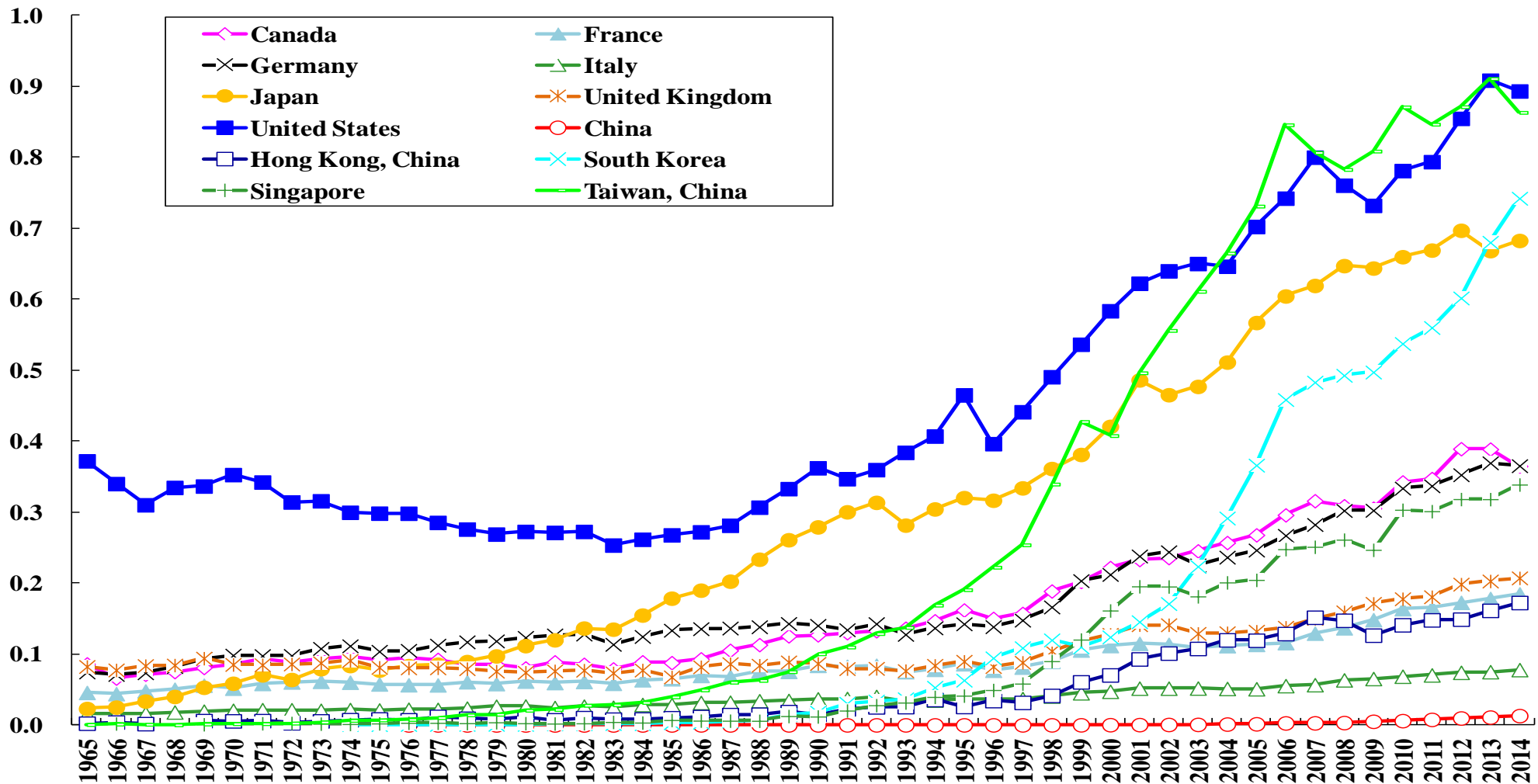
# U.S. Patent Applications Filed Annually: G-7 Countries, 4 East Asian NIEs and China

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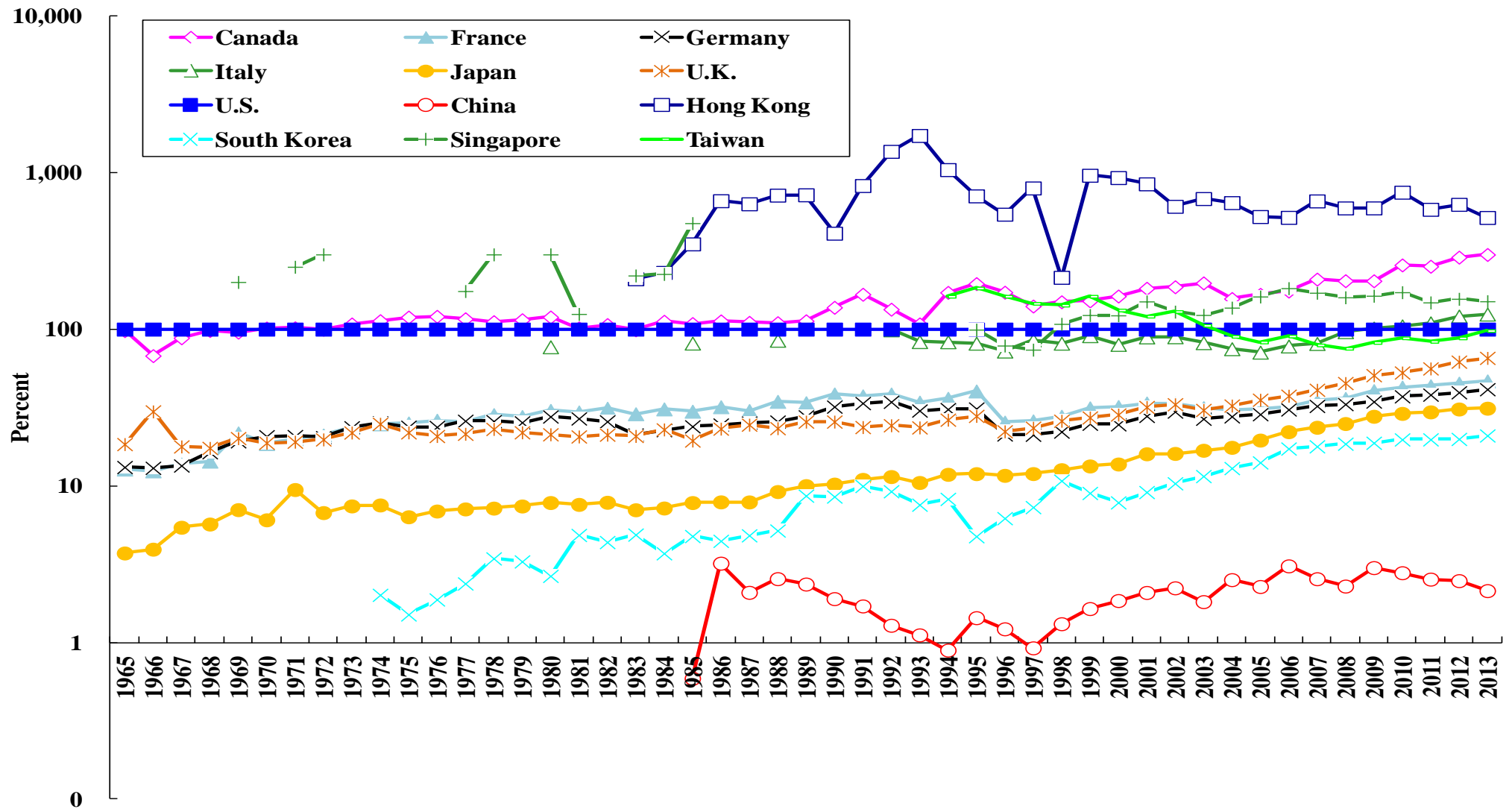
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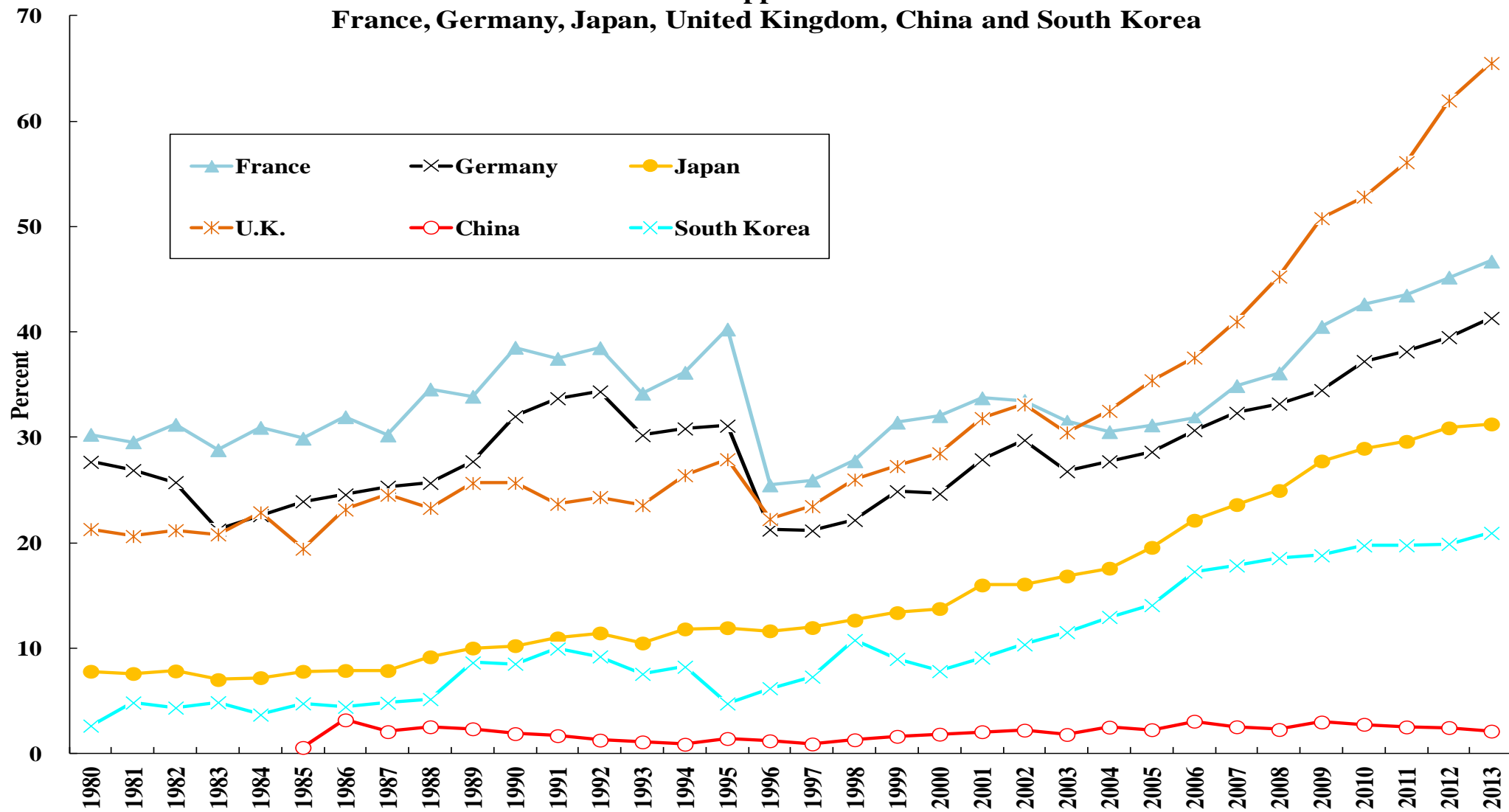
# U.S. Patent Application Rates: G-7 Countries, 4 East Asian NIEs and China

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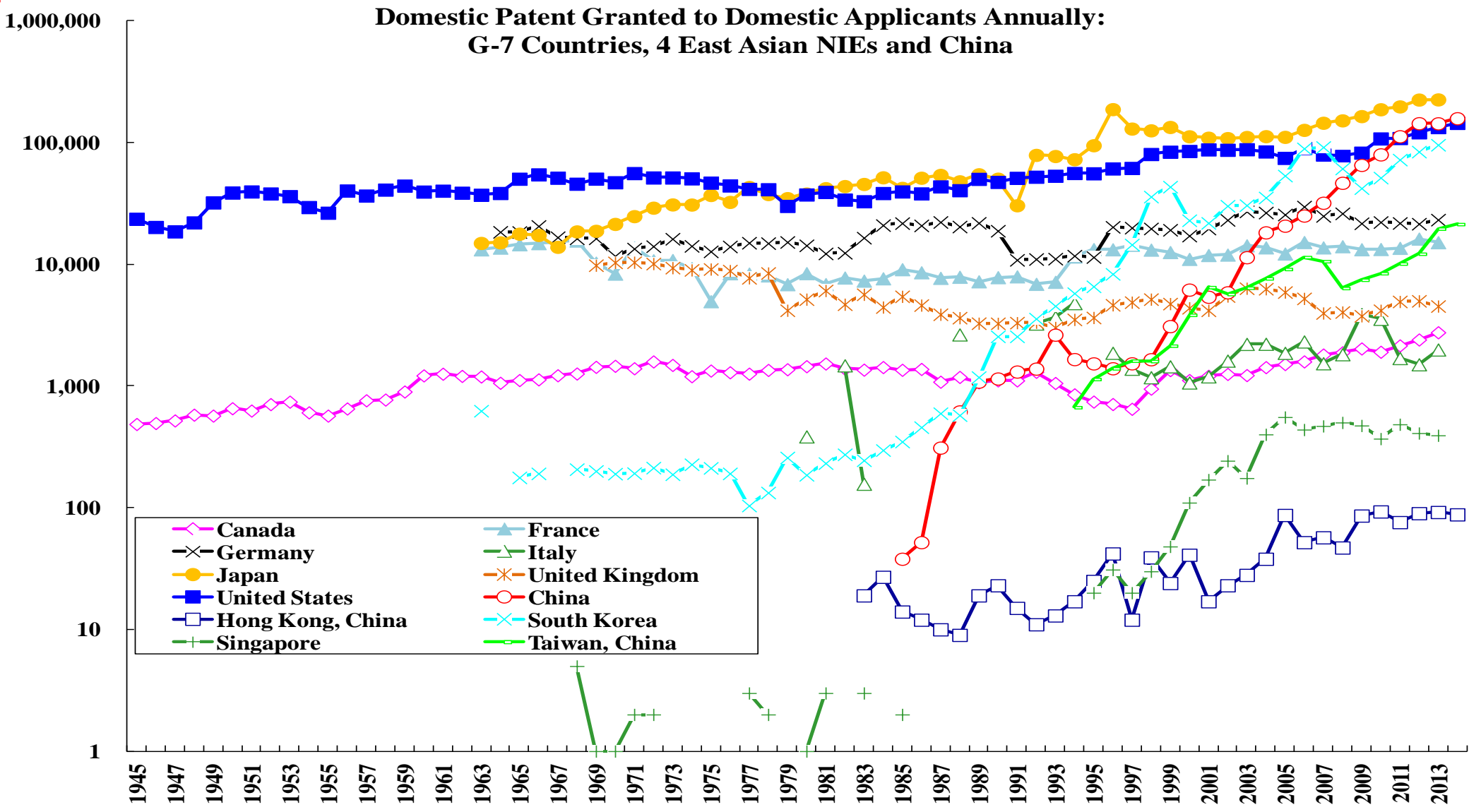


# U.S. Patent Application Rates: France, Germany, Japan, the U. K., China and Korea

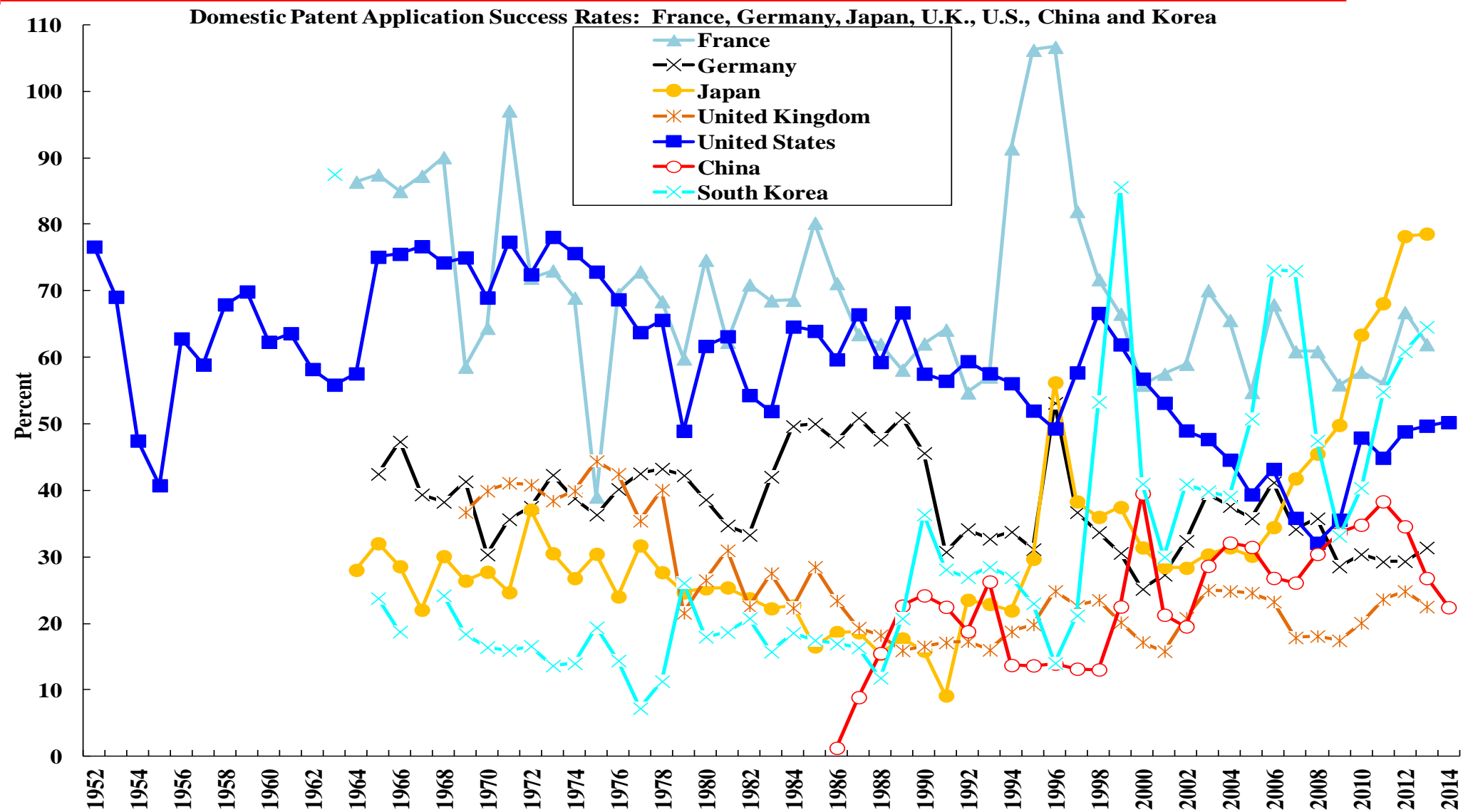
U.S. Patent Application Rates:  
France, Germany, Japan, United Kingdom, China and South Korea



# Domestic Patents Granted to Domestic Applicants: G-7, 4 EANIEs and China



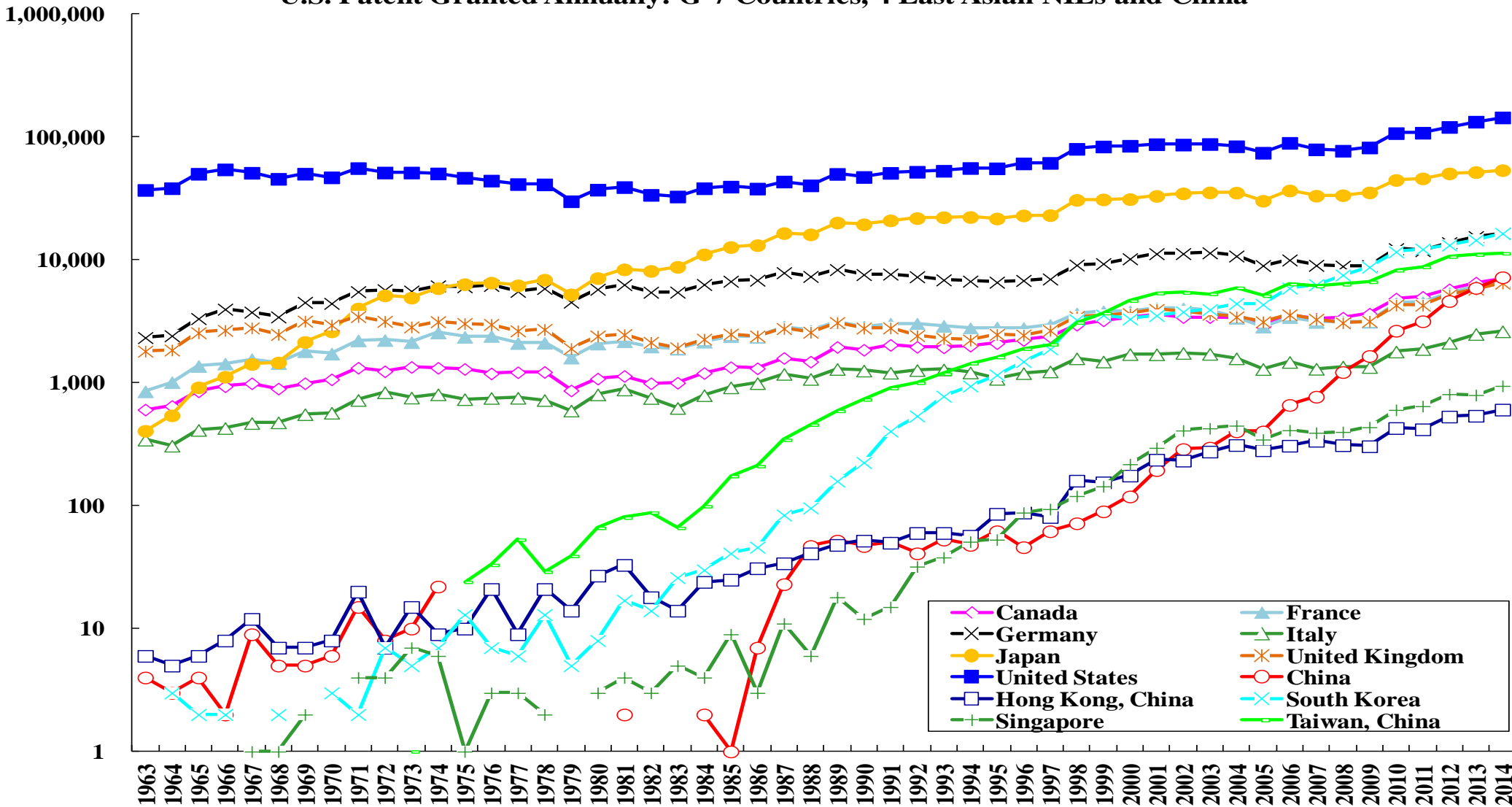
# Domestic Patent Application Success Rates: Fra., Ger., Japan, U.K., U.S., China & Korea





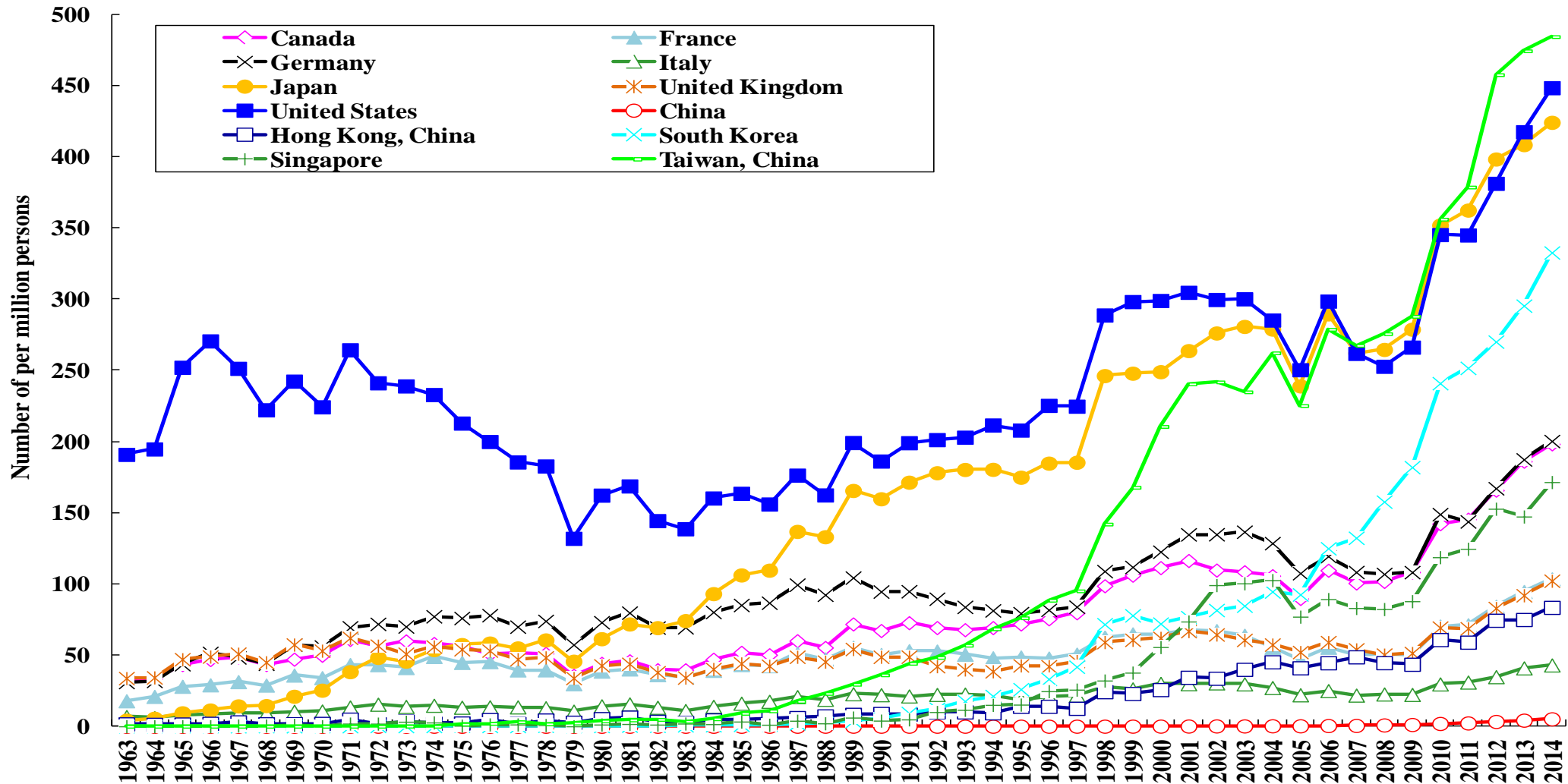
# U.S. Patents Granted Annually: G-7 Countries, 4 East Asian NIEs and China

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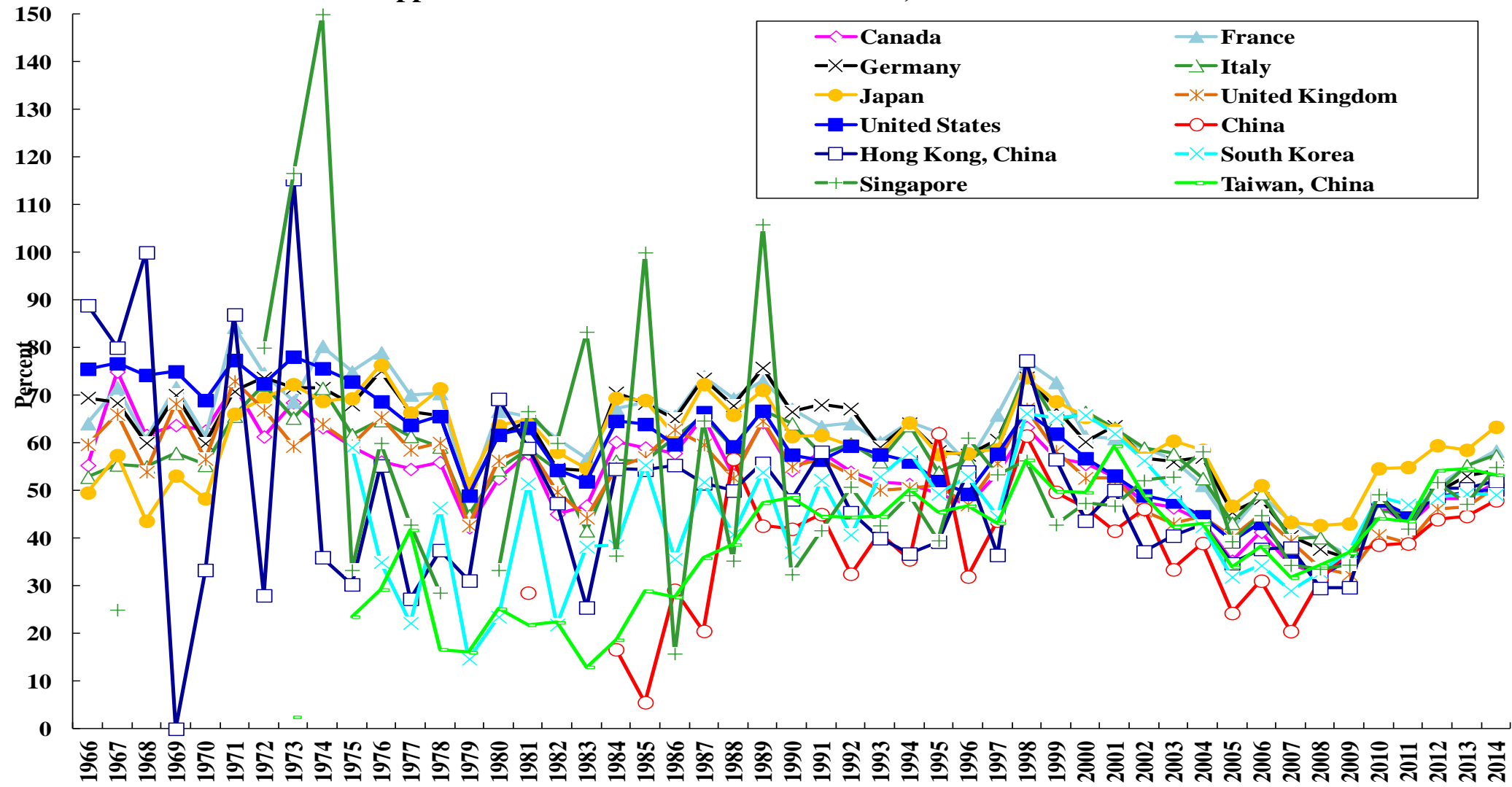
# U.S. Patent Granted Per Million Persons: G-7 Countries, 4 East Asian NIEs and China

U.S. Patent Granted Annually Per Million Persons:  
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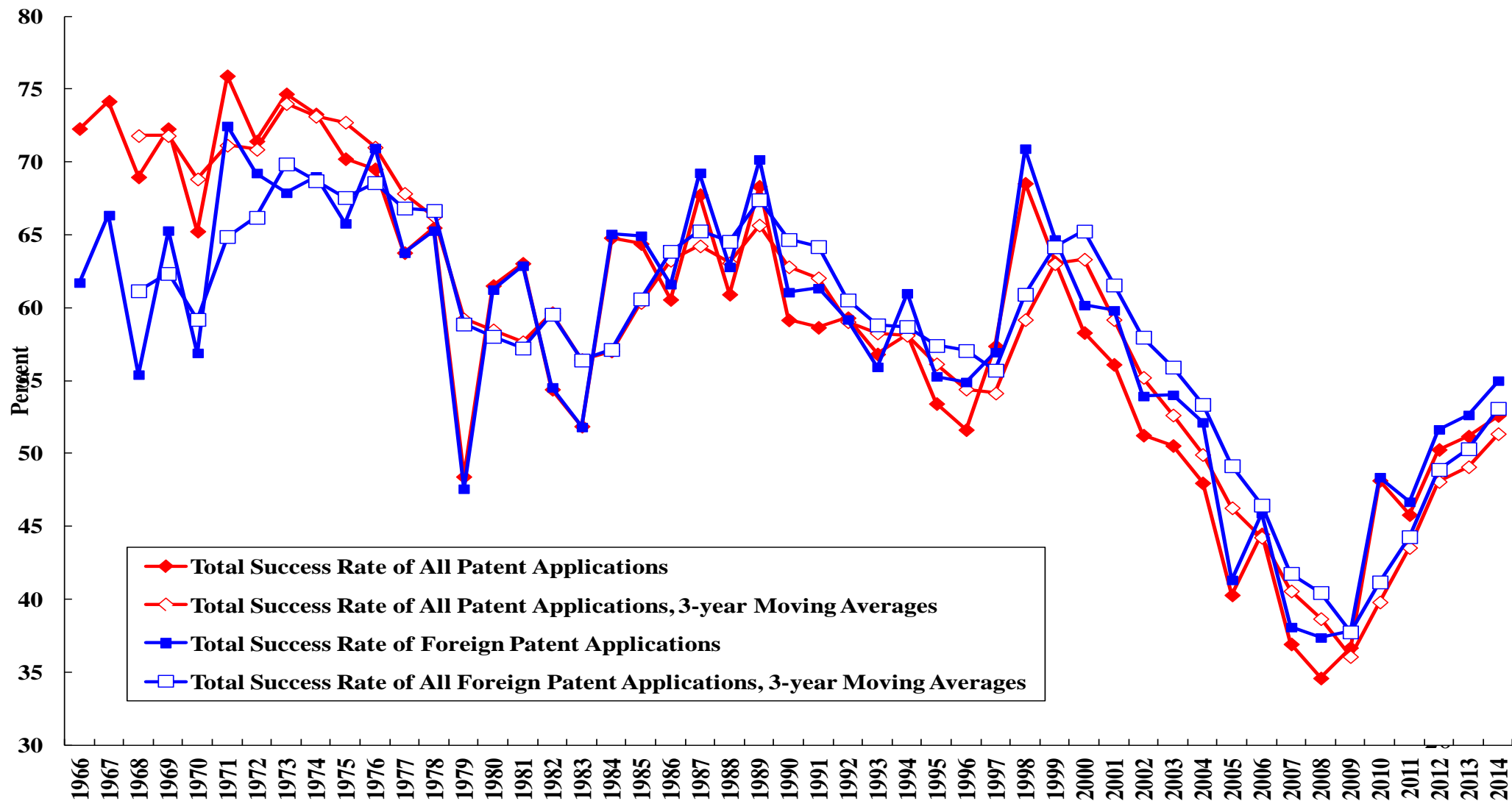
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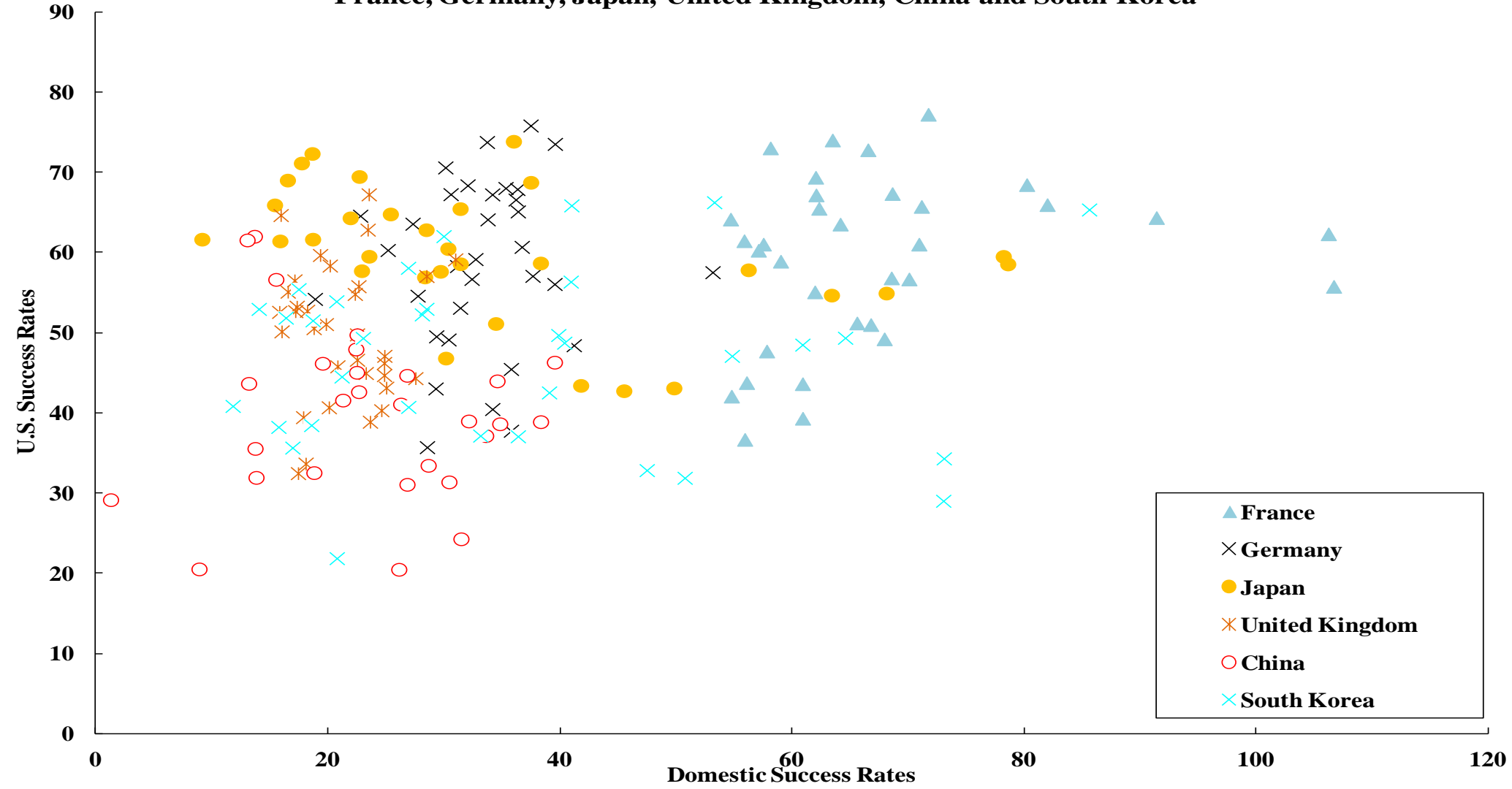
# U.S. Total Patent Grant Rates

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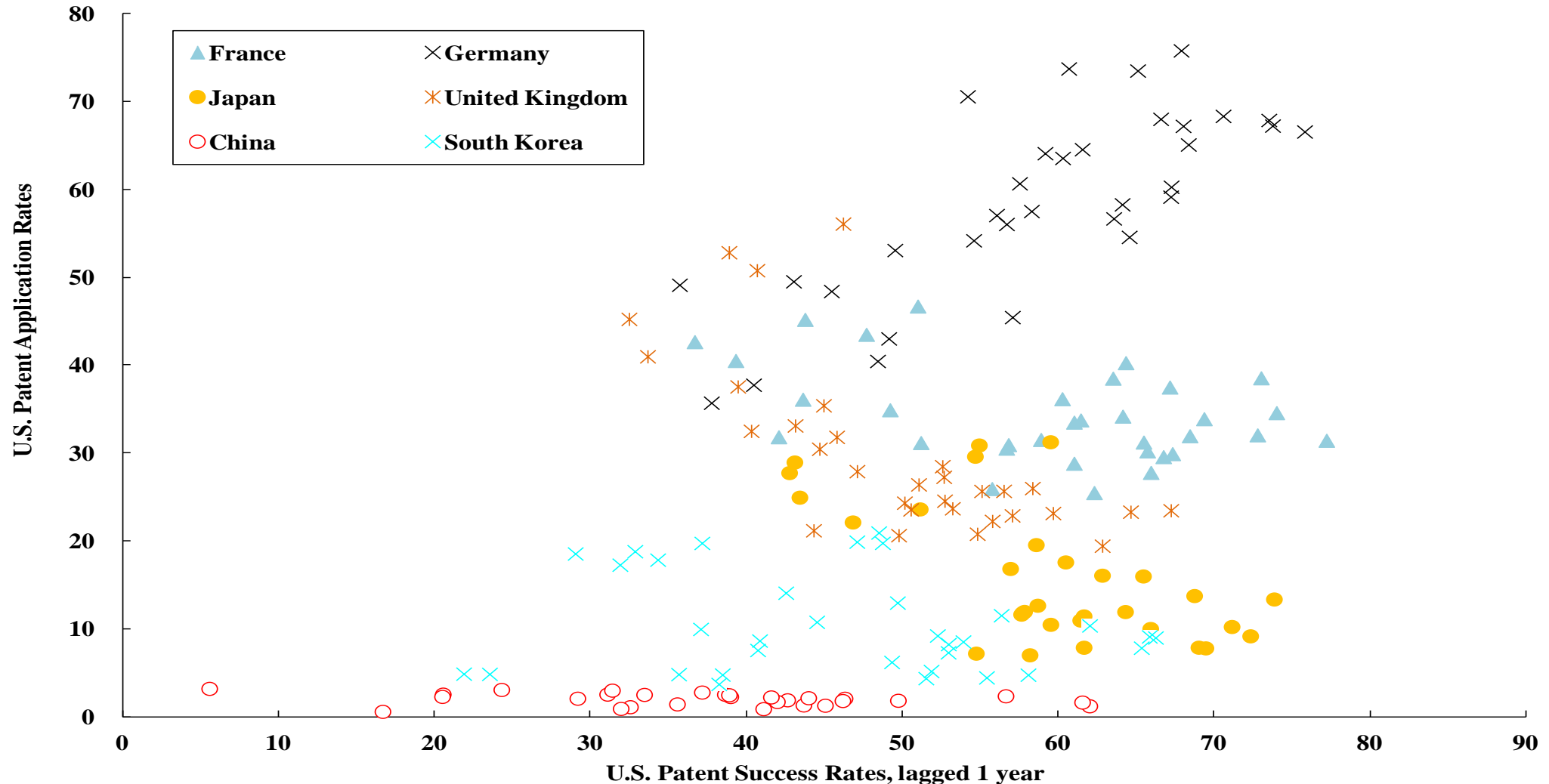
# Scatter Diagram between U.S. and Domestic Patent Application Success Rates

Scatter Diagram between U.S. and Domestic Patent Application Success Rates:  
France, Germany, Japan, United Kingdom, China and South Korea



# Scatter Diagram between U.S. Patent Application and Lagged Success Rates

Scatter Diagram between U.S. Patent Application and Lagged Success Rates:  
France, Germany, Japan, the UK, China and South Korea



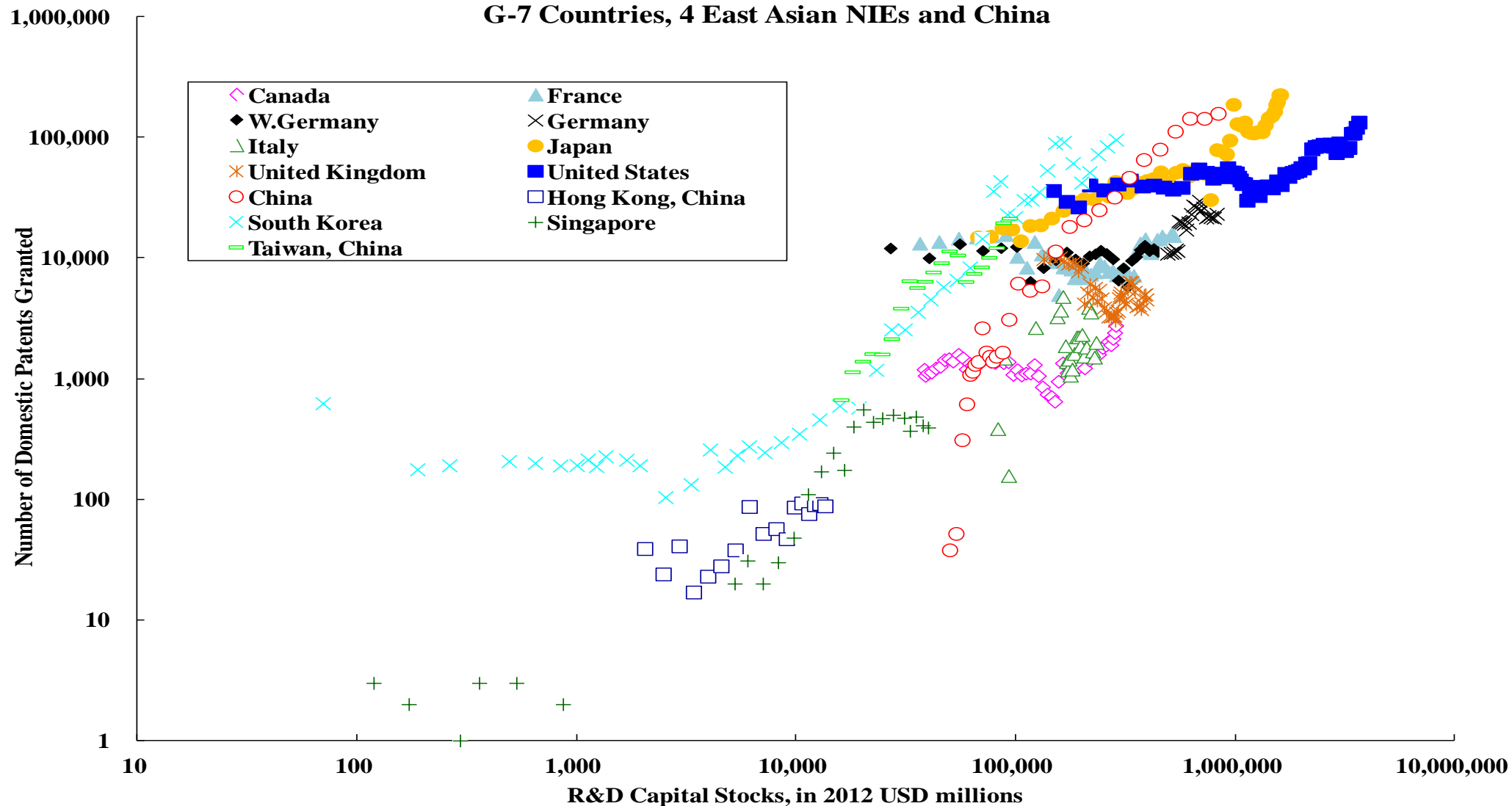
# The Relationship between Patent Grants and R&D Capital Stock

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- ◆ The real R&D capital stock can be shown to have a direct causal relationship to the number of patents granted. In the following charts, the numbers of the domestic and U.S. patents respectively granted to the citizens of a country or region are plotted against its real R&D capital stock at the beginning of that year.
- ◆ Both charts show clearly that the higher the level of the real R&D capital stock of an economy, the higher is the number of domestic and U.S. patents granted to it. On an economy-by-economy basis, the positive correlation may not be so obvious (see, for example, France, West Germany and the U.K. as well as the early phases of South Korea and Singapore and even the U.S.). However, taken as a whole, with data pooled across all of the economies, the overall positive correlation is the most apparent, especially for U.S. patent grants.

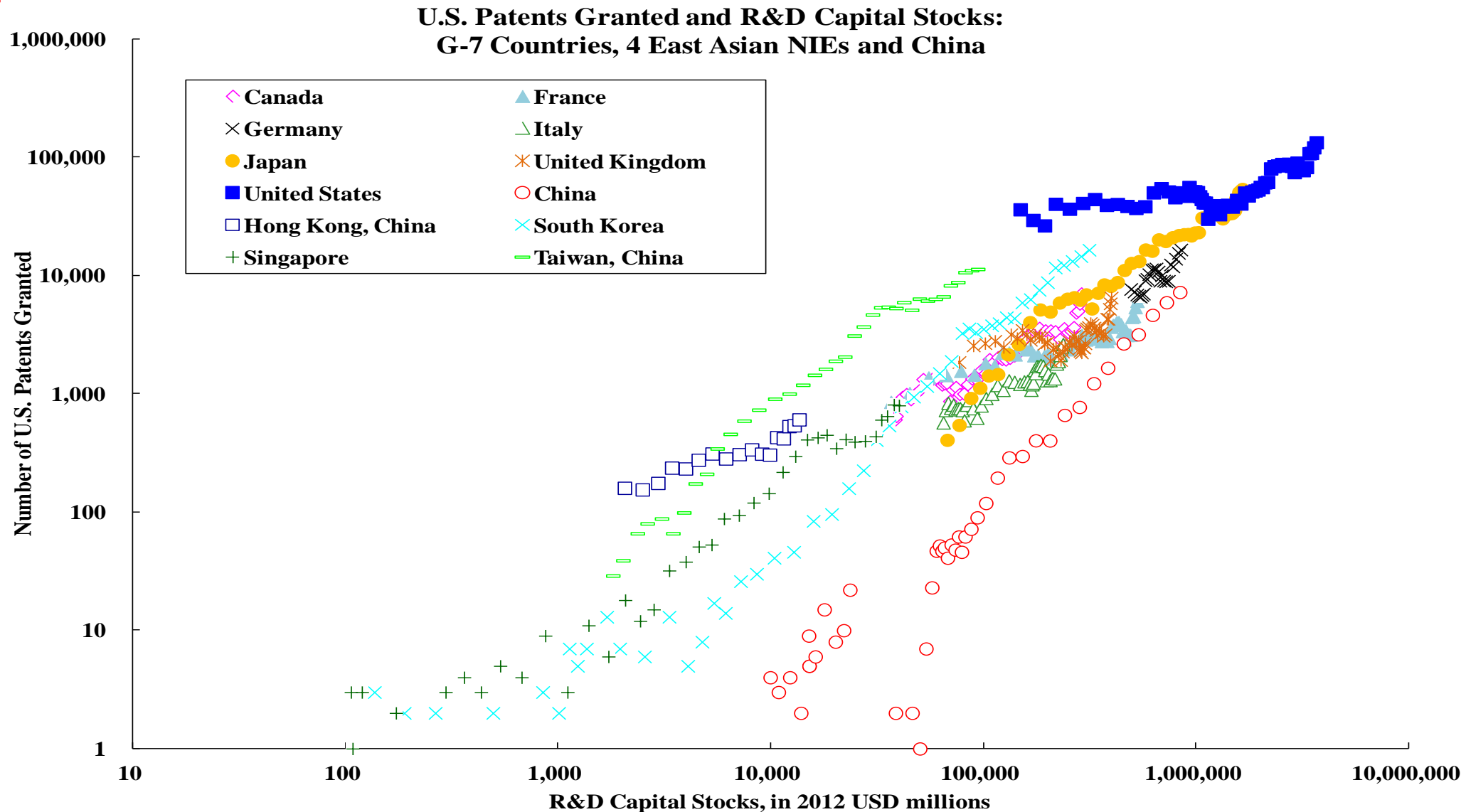
# Domestic Patents Granted and Real R&D Capital Stocks: G-7, 4 EANIEs and China

Domestic Patents Granted and R&D Capital Stocks:  
G-7 Countries, 4 East Asian NIEs and China





# U.S. Patents Granted and Real R&D Capital Stocks: G-7, 4 EANIEs and China



# The Relationship between Patent Grants and R&D Capital Stock

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- ◆ We may also note that there exist significant systematic differences in the efficiency in the generation of domestic and U.S. patent grants across economies, in the sense that for a given level of real R&D capital stock, the number of domestic or U.S. patents granted can be quite different across economies.
- ◆ For domestic patent grants, South Korea, China and Japan appear to have the highest efficiencies, and Italy, Canada, the U.K., Germany and the U.S. appear to have the lowest efficiencies.
- ◆ For U.S. patent grants, China appears to have the lowest efficiencies and the U.S. and Taiwan seem to have the highest efficiencies.
- ◆ We believe that the relative efficiencies in the generation of U.S. patent grants are probably more reliable because all economies face the same uniform standards of the USPTO as opposed to the possibly differing standards maintained by the respective domestic patent offices.

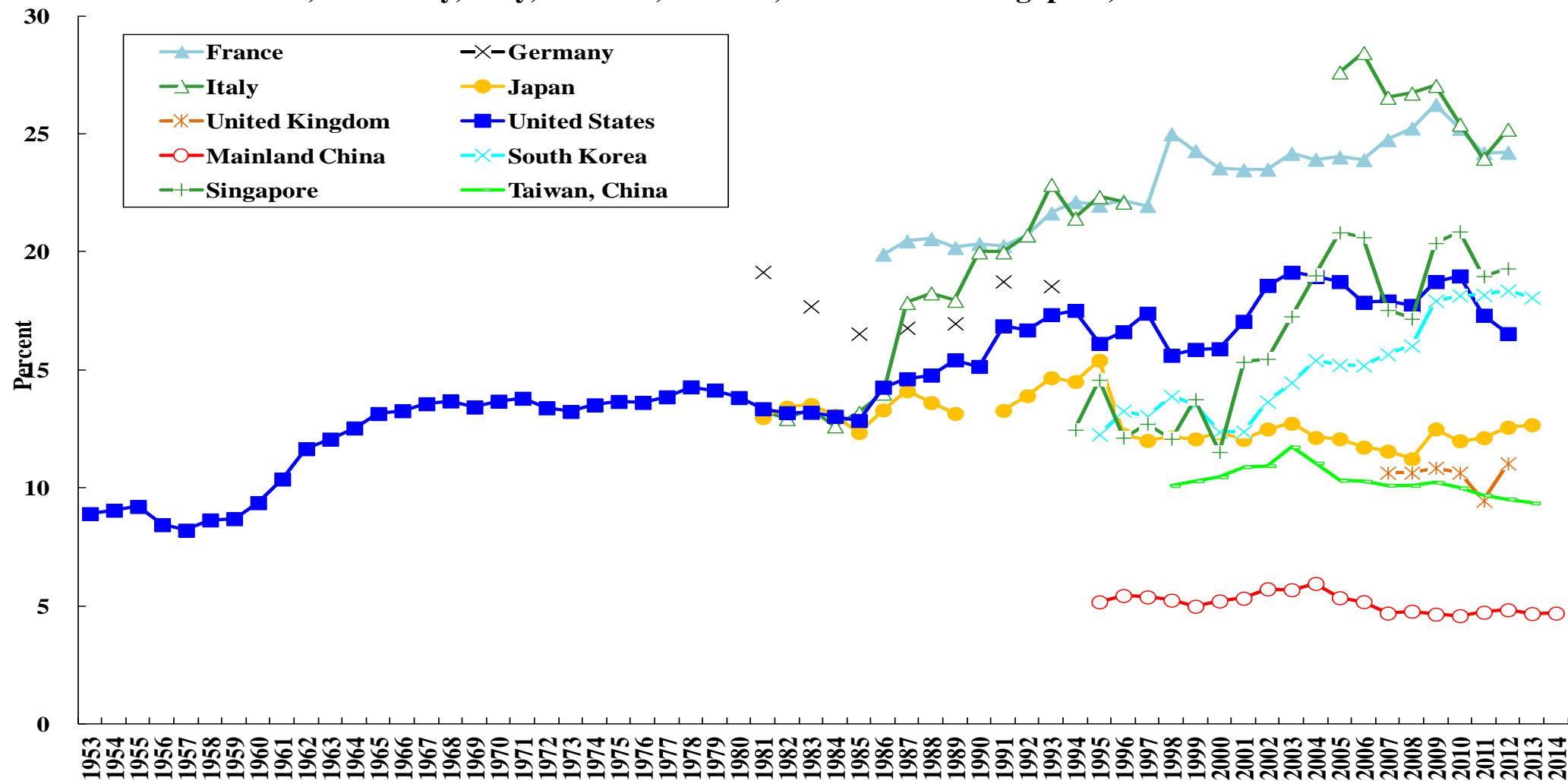
# The Share of Basic Research

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- ◆ Among R&D expenditures, different categories may be distinguished: basic research, applied research and development.
- ◆ It is well known that “break-through” discoveries and innovations can only consistently occur in an economy with a strong foundation of basic research.
- ◆ Italy and France led the group of economies under study with a basic research ratio of around 25%. The United States ratio has averaged almost 20% over the past ten years, whereas Japan and the U.K. have ratios in the low teens. The Taiwan ratio is around 10%. China has the lowest ratio at around 5%.

# The Share of Basic Research in Total R&D Expenditure: Selected Economies

The Share of Basic Research Expenditure in Total R&D Expenditure: France, Germany, Italy, the U.K., the U.S., South Korea, Singapore, Taiwan and China



# Concluding Remarks

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- ◆ Innovation results from sustained investment in intangible capital, including R&D capital and human capital.
- ◆ One measure of national innovative capacity is the magnitude of the real R&D capital stock.
- ◆ The magnitude of the R&D capital stock of an economy has a significance positive causal effect on the number of domestic and U.S. patents granted to the nationals of that economy.
- ◆ However, the relative number of patent grants do not necessarily translate directly into the relative commercial success in terms of innovation.
- ◆ Basic research can be critical for the occurrence of “break-through” innovation. However, cultural factors may play an important role as well.