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Rice World Gas Trade Model: Russian Natural Gas and Northeast Asia

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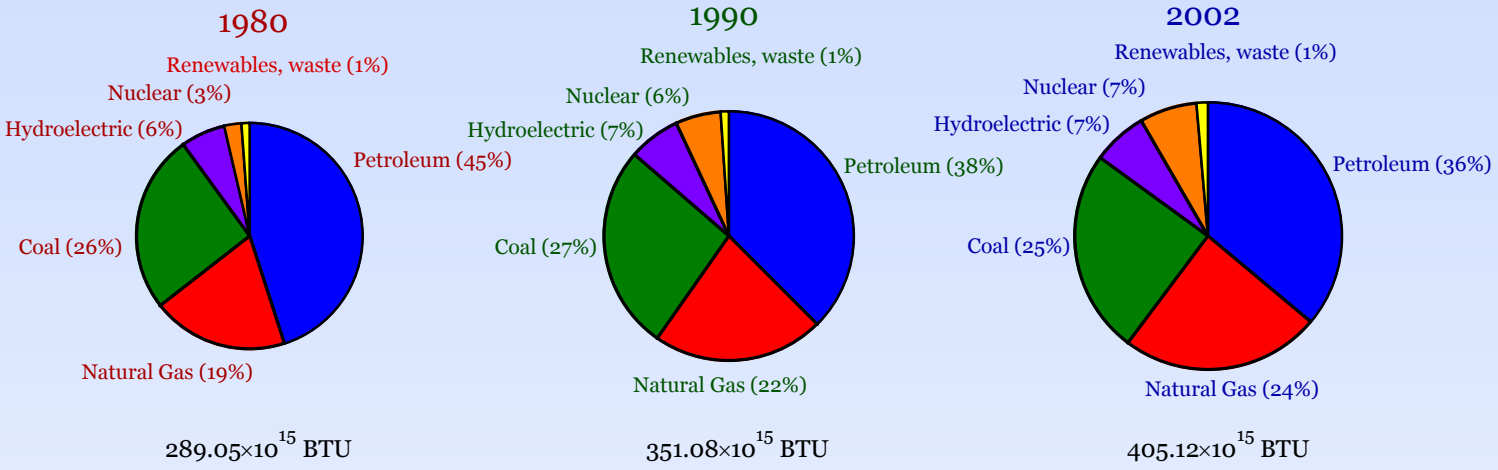
Overview and motivation

- Worldwide, the demand for natural gas is rising:



Source: EIA

- Key reasons for the demand increase:
  - Environmental pressure for cleaner fuels
  - Wholesale electricity market competition raised the demand for smaller scale electricity plant, which CCGT satisfied
- The share of gas may continue to rise:
  - Gas may supply transport fuel needs (GTL, oil shale, fuel cell)
  - A possible contrary influence is that coal gasification, solar, hydro and/or nuclear power, perhaps assisted by falling costs of HVDC, could displace gas in electricity generation

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Overview and motivation

- World gas supply potential is large, but:
  - It is concentrated in areas remote from markets
  - Production and transport infrastructure is required
  - Prices need to rise in real terms to finance the investments
  - Unstable political regimes may make investments unattractive
- Russia could be a big supplier of natural gas to both Europe and Asia, making developments there critical
- Demand growth in China, Japan and South Korea also make Northeast Asia critical to the world gas market
- The Rice World Gas Trade Model, based on economic and geological fundamentals, can be used to examine political and economic influences on the world market for natural gas

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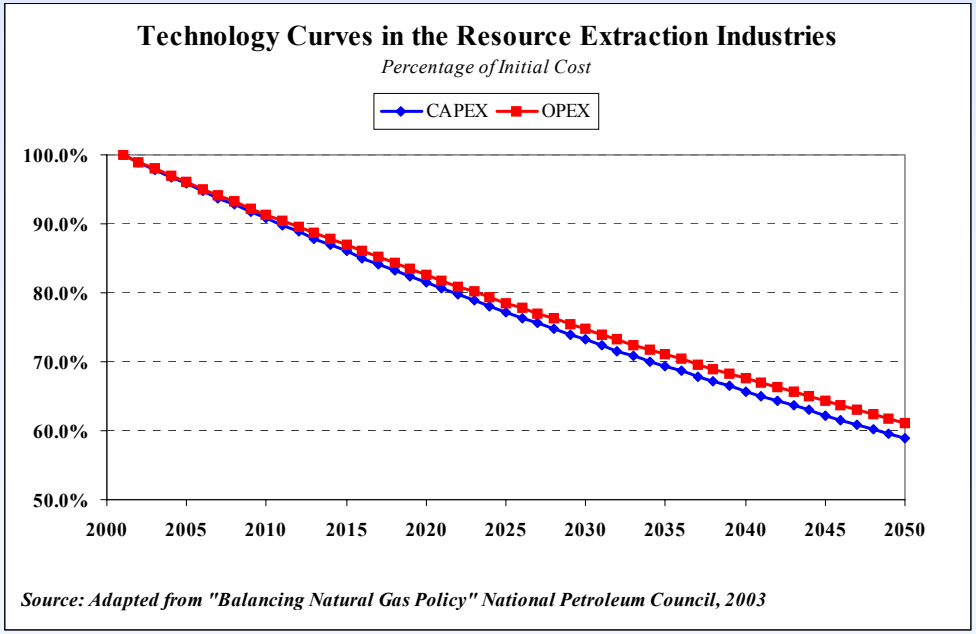
Rice World Gas Trade Model

- Model framework: *Market Builder* from Altos Partners calculates equilibrium prices and quantities for fixed locations and periods
- Supply data is based on the USGS World Resource Assessment
  - associated and unassociated natural gas resources,
  - conventional and CBM gas deposits in North America and Australia, and
  - conventional gas deposits in the rest of the world

  assessed in three categories:
  - proved reserves (updated 2003 Oil & Gas Journal estimates)
  - growth in known reserves (P-50 USGS estimates)
  - undiscovered resource (P-50 USGS estimates)
- Econometric model for forecasting demand developed using EIA, IEA and World Bank data related gas demand to:
  - The level of economic development (GDP/capita)
    - Energy demand increases with GDP/capita but at a decreasing rate
    - Natural gas share in primary energy demand increases with development
  - Population
  - Country-specific effects reflecting, for example, resource endowments or climate
  - Prices (wholesale industrial $/BTU) of natural gas, oil and coal
- From 2030, allow demand to be lost to new technologies at prices above $5 with up to 2.5% lost at $5.50 and 5% lost at $10
  - Each year, the proportion of demand vulnerable to the backstop at each price above $5 increases until in 2040 all base case demand could be satisfied at a price of $10

More detail on supply

- Cost estimates for North America (including Canada and Mexico) were applied elsewhere based on geological characteristics
  - The North American estimates (developed for the NPC) include:
    - capital cost of development,
    - operating and maintenance costs, and
    - cost changes by region and deposit type as resources deplete
- We also allowed for technological change in mining:



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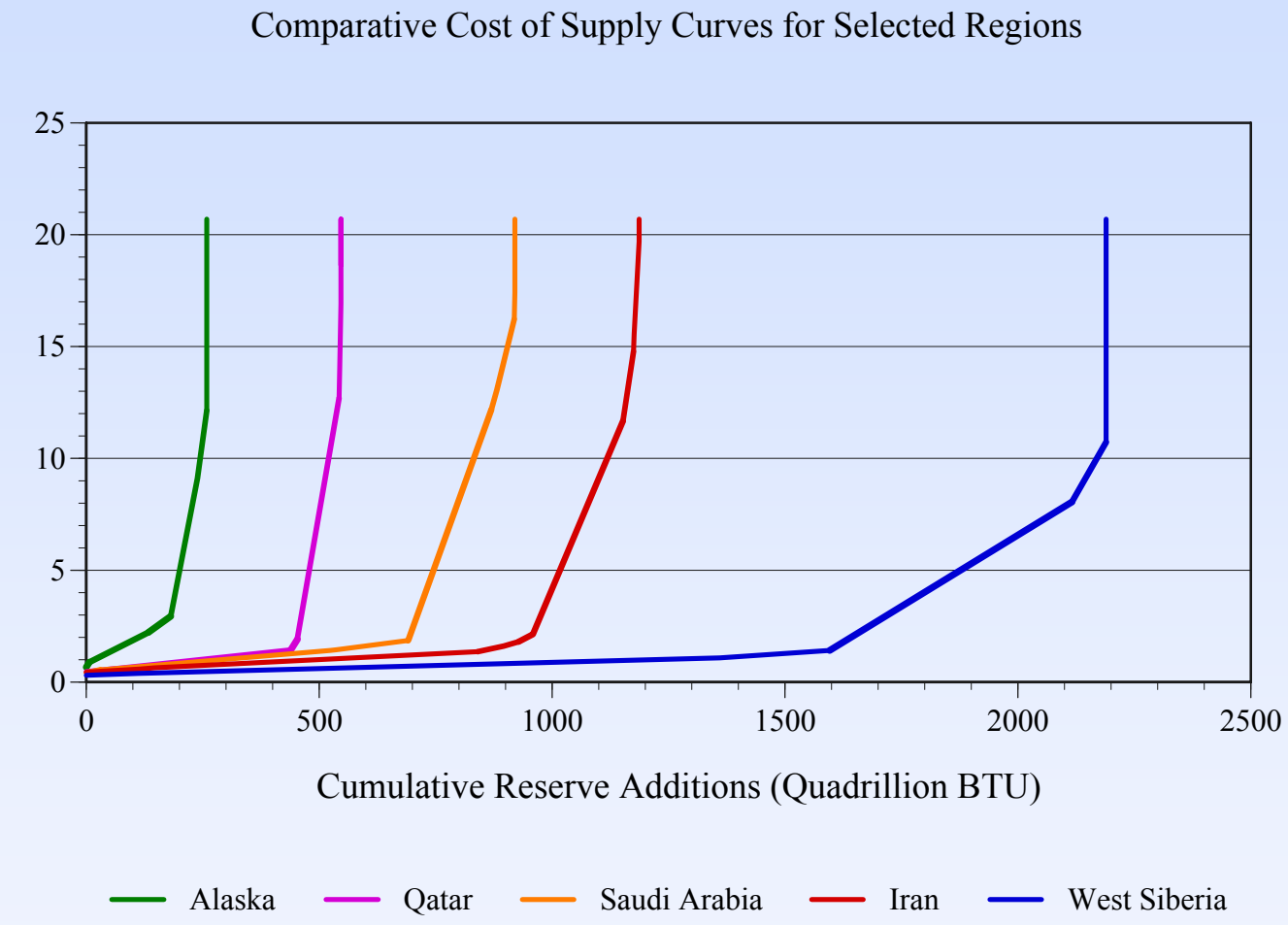
Example cost of 2002 supply curves



Sources: USGS, EIA, author calculations

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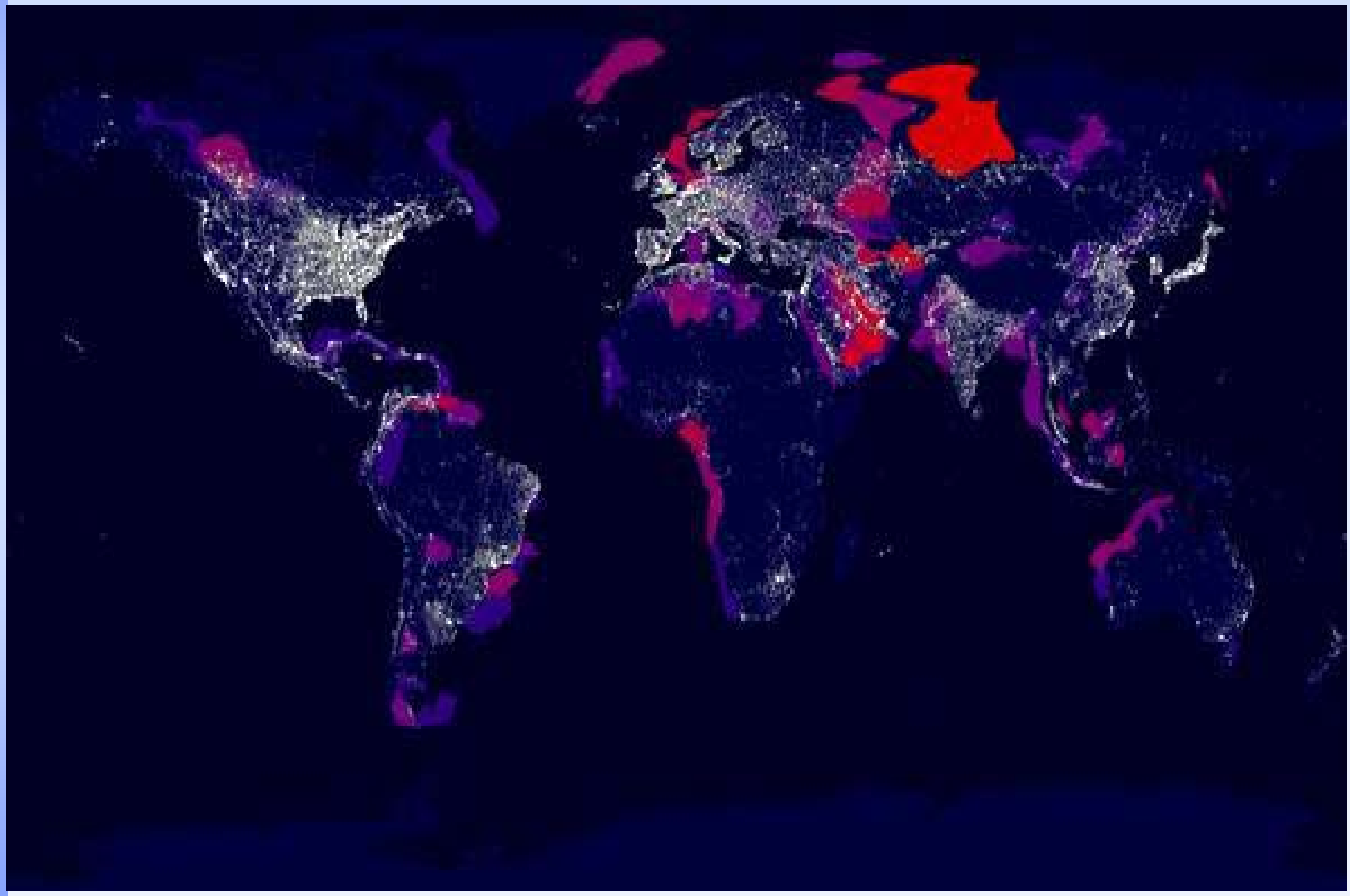
Linking supply with demand



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Representing transport networks

- The North American and European pipeline networks are now the main transport systems
  - LNG is only about 5% of world demand, but is important in Japan & Korea, and increasing elsewhere
  - To facilitate calculations:
    - supplies and demands are aggregated into discrete “nodes”,
    - parallel pipes are aggregated into a single link,
    - LNG routes are represented by hubs and spokes, and
    - minor distribution and gathering pipes are ignored
- The model chooses new or expanded transport capacity from supply sources to demand sinks based on:
  - capital costs of expansion, and
  - operating and maintenance costs of new and existing capacity
- Transport links are inherently discrete
  - We allow many potential pipeline links including ones that have been discussed and others that might appear profitable at prices calculated in initial iterations of the model
  - The hub and spoke representation for LNG allows for many potential trading partners

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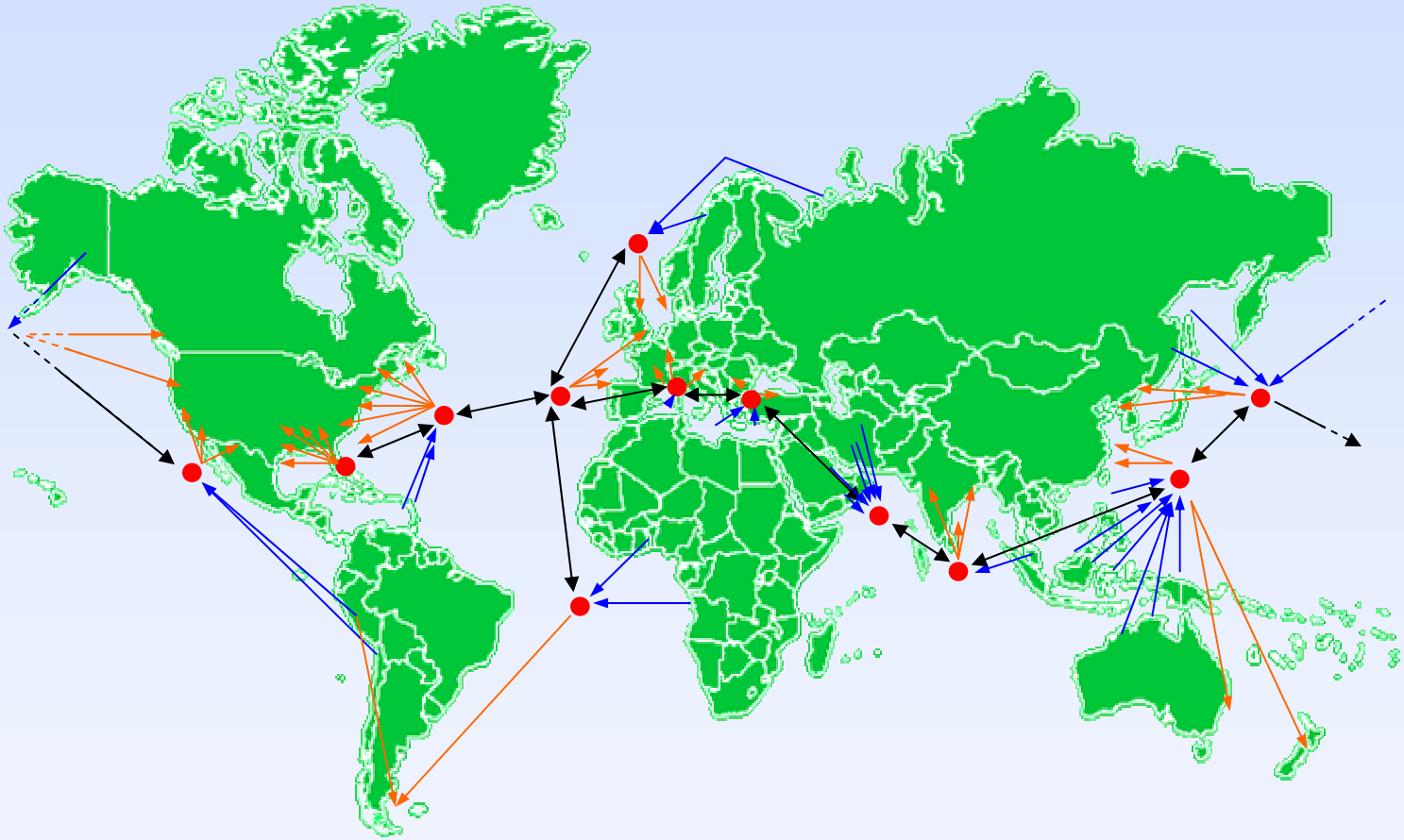
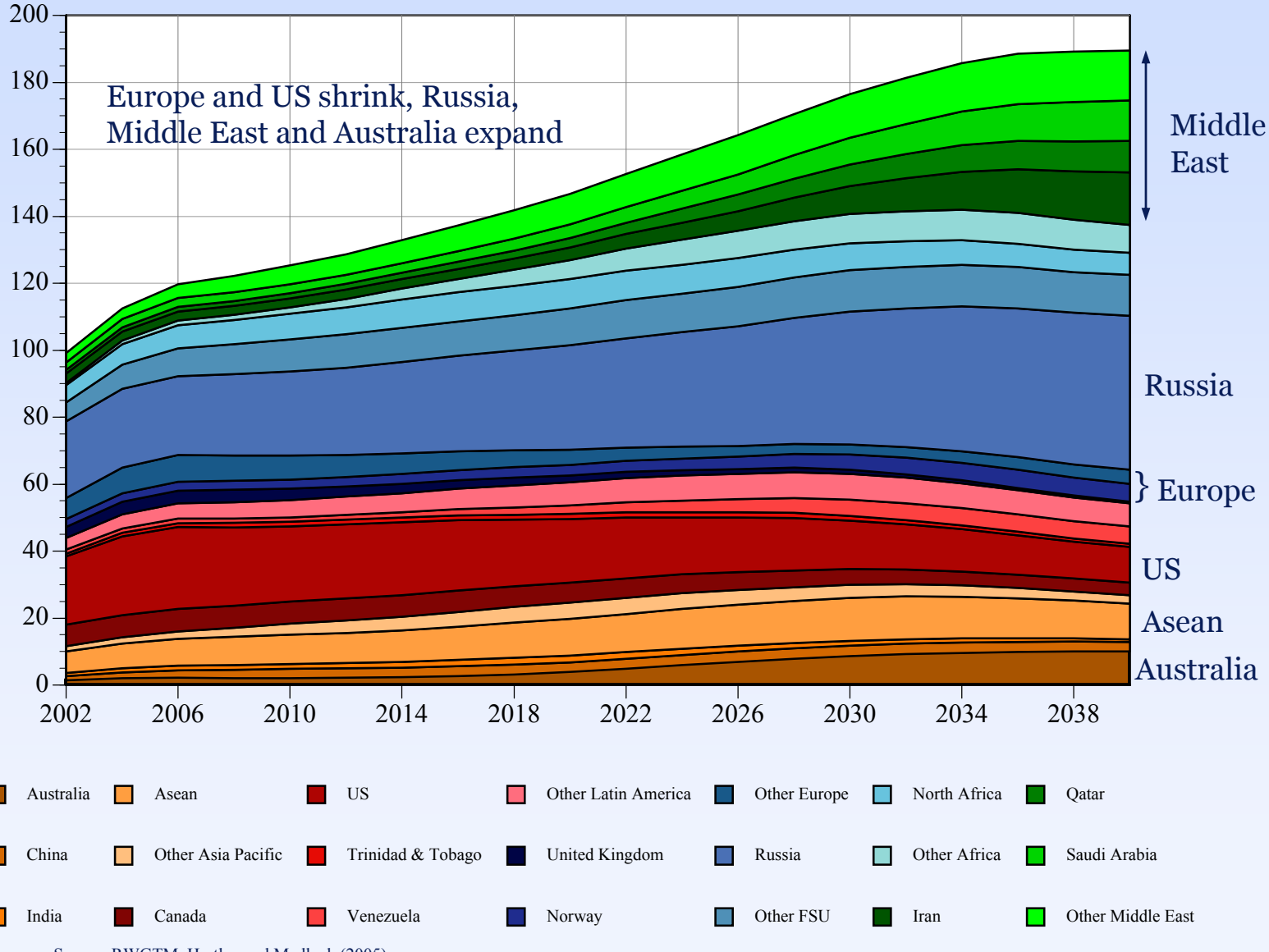
LNG transportation network



Pipeline and LNG costs

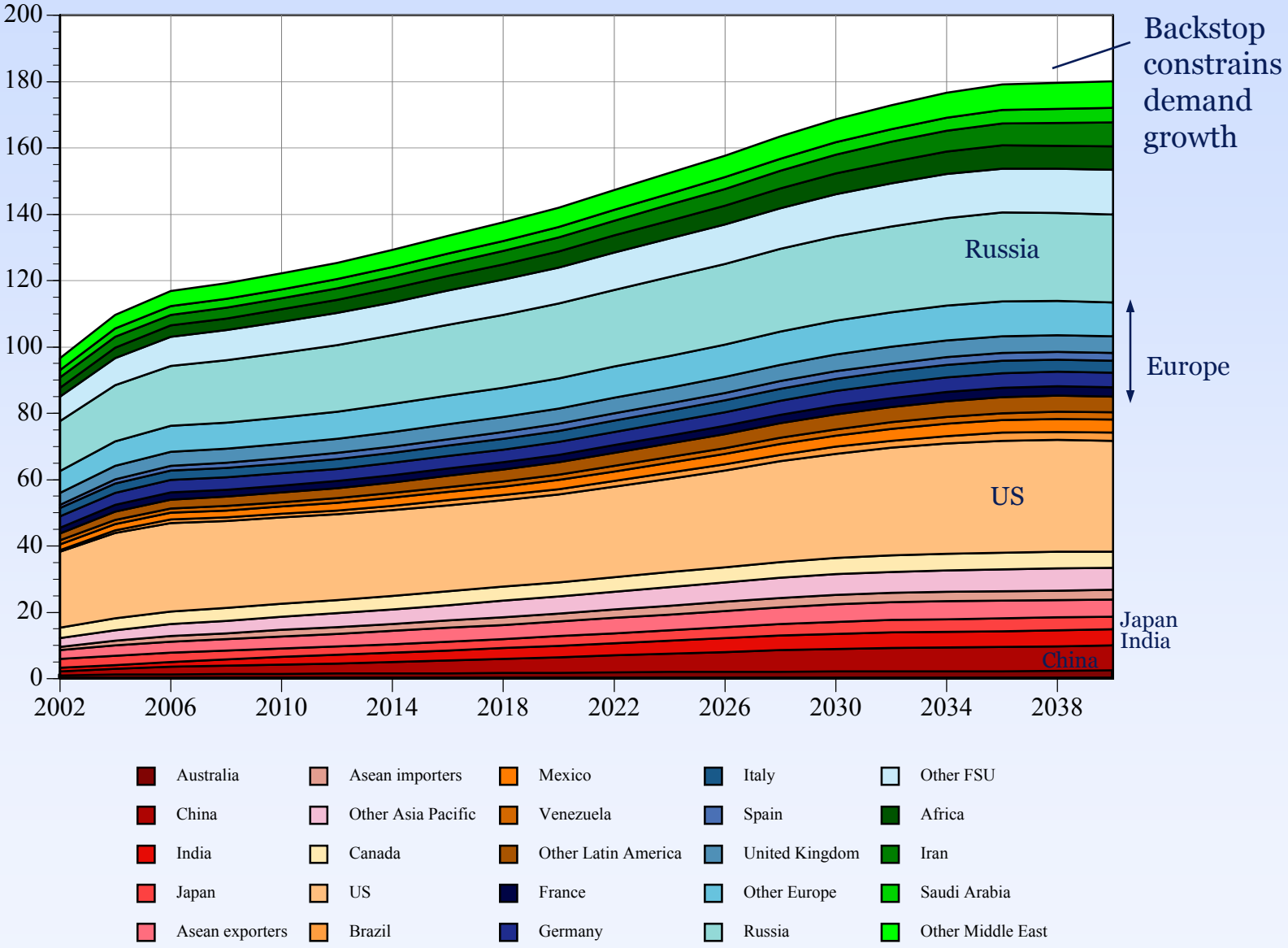
- Regressed EIA cost data (annual cost per unit of capacity) for 52 pipeline projects on:
  - Pipeline length
  - Pipeline capacity
    - Higher capacity reduces per unit costs as a result of scale economies
  - Indicator variables for whether the pipeline
    - crosses mountains;
    - moves offshore or crosses a lake or sea; or
    - crosses more populous areas
- LNG costs from 2003 EIA report and industry sources
  - Shipping costs split into a fixed capital cost for ship development plus operating costs of:
    - 2.25% of fixed cost of development
    - fuel use during transit (0.15% per day)
  - Liquefaction costs are a fixed cost ($4.11/mcf/yr) plus a variable feed gas cost (model calculated)
  - Regasification costs vary by location (primarily because land costs vary)
  - Allowed for technological change to reduce LNG costs at rates of change based on a statistical fit to the IEA World Energy Investment Outlook

Supply Projections



Source: RWGTM, Hartley and Medlock (2005)

Demand projections



Source: RWGTM, Hartley and Medlock (2005)

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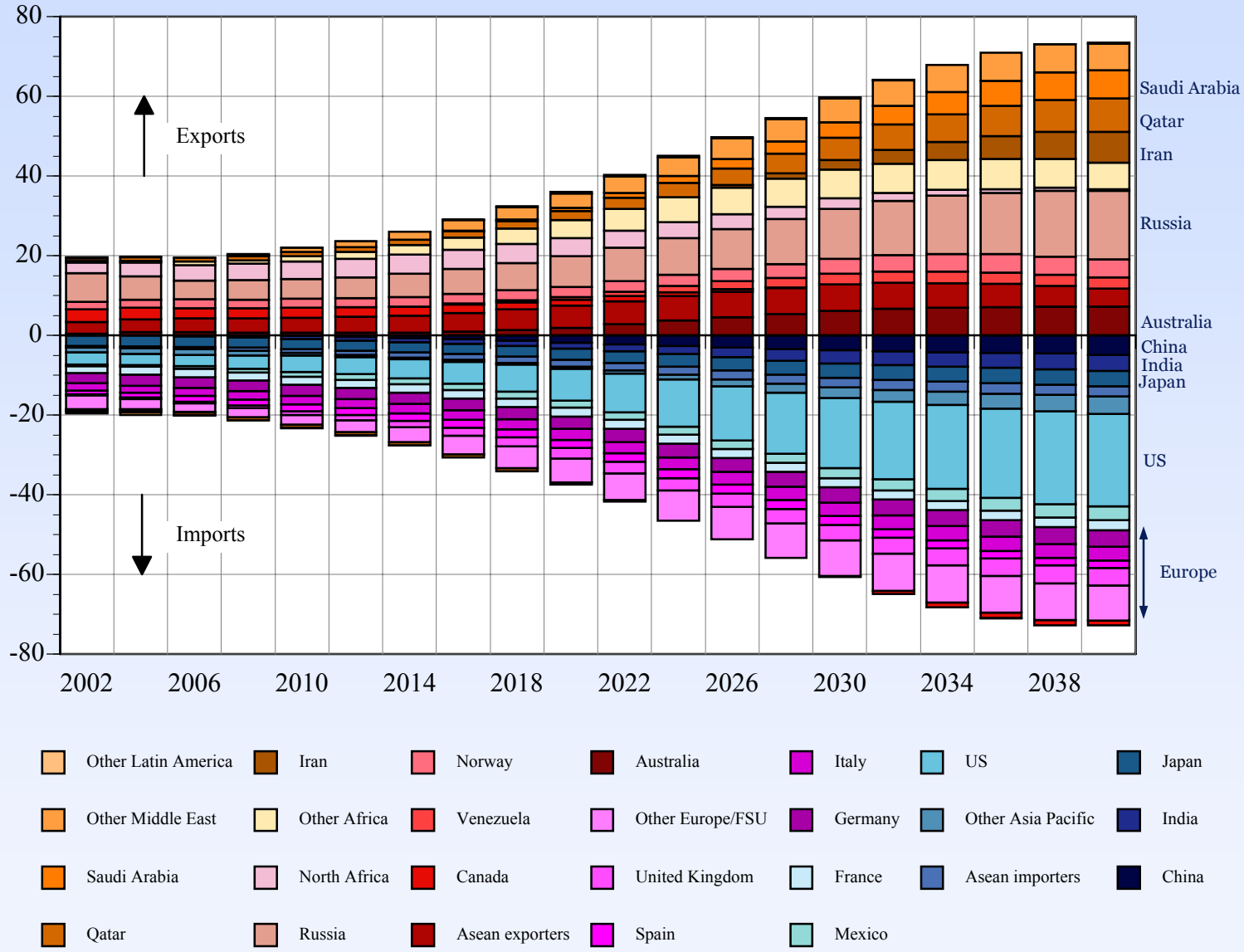
Natural gas trades



Source: RWGTM, Hartley and Medlock (2005)

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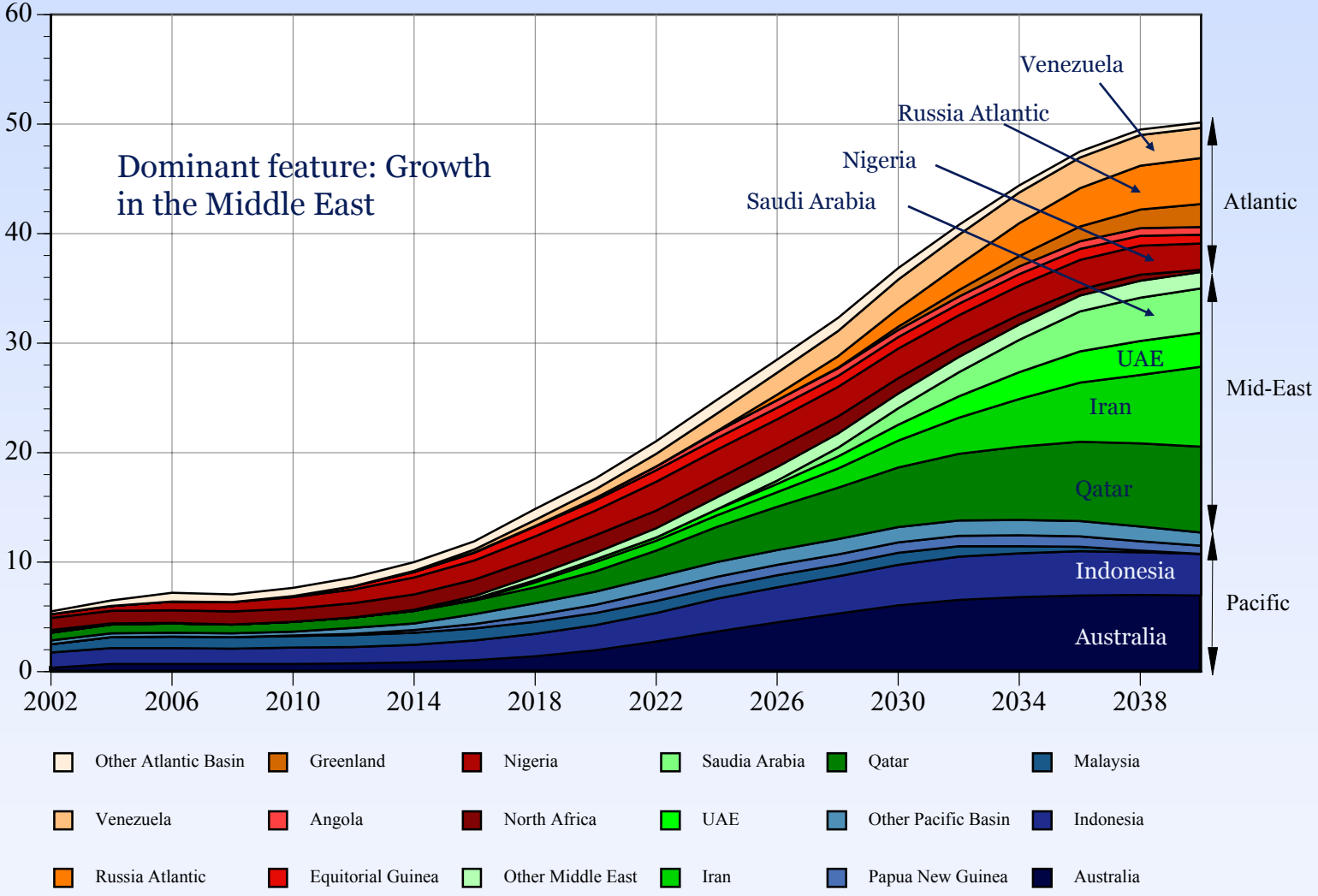
LNG export projections



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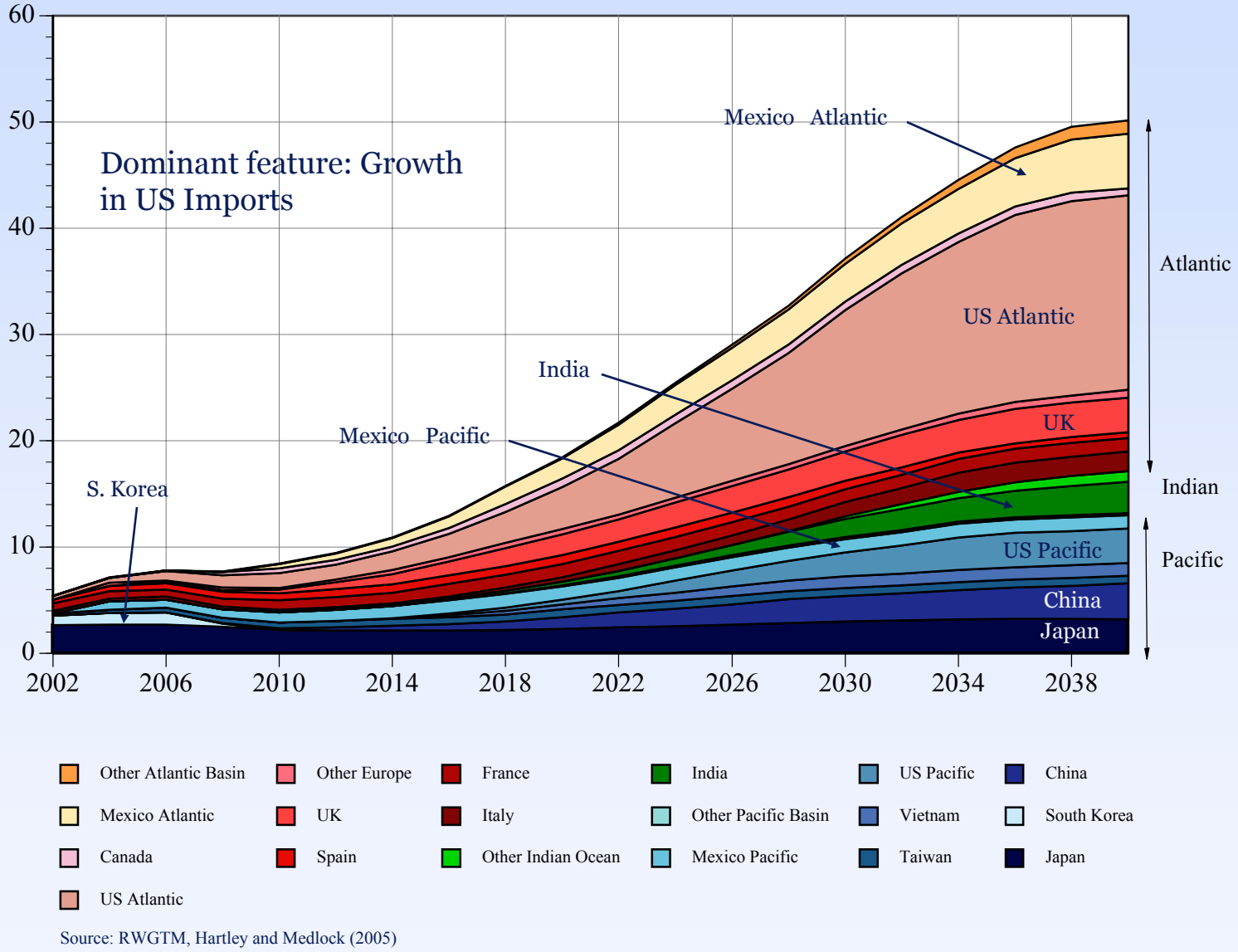
LNG import projections



Source: RWGTM, Hartley and Medlock (2005)

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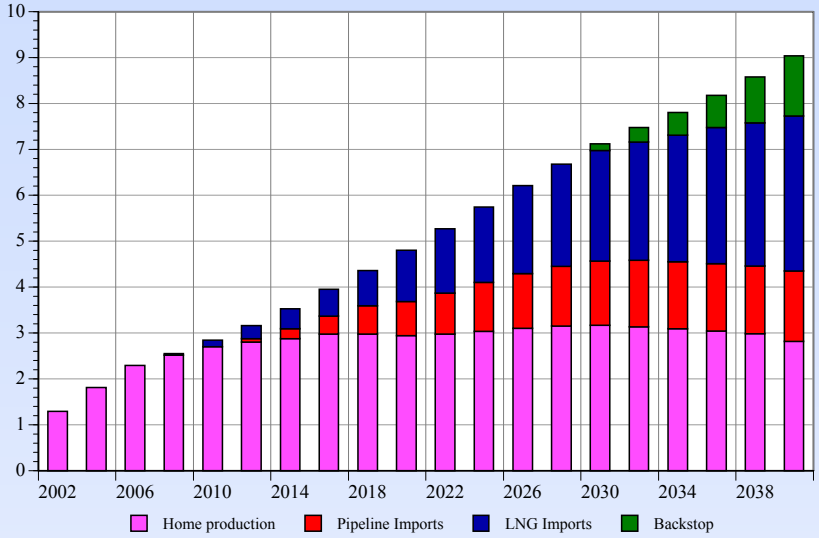
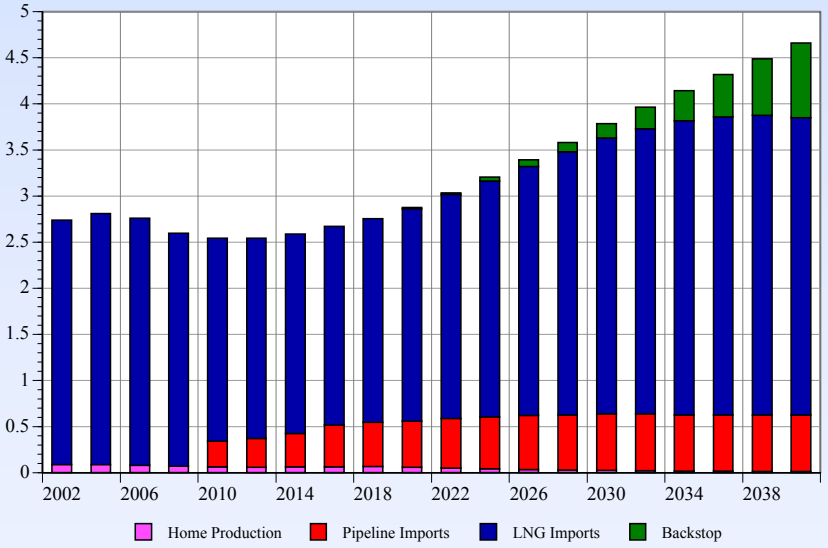
Northeast Asian Sources of Supply

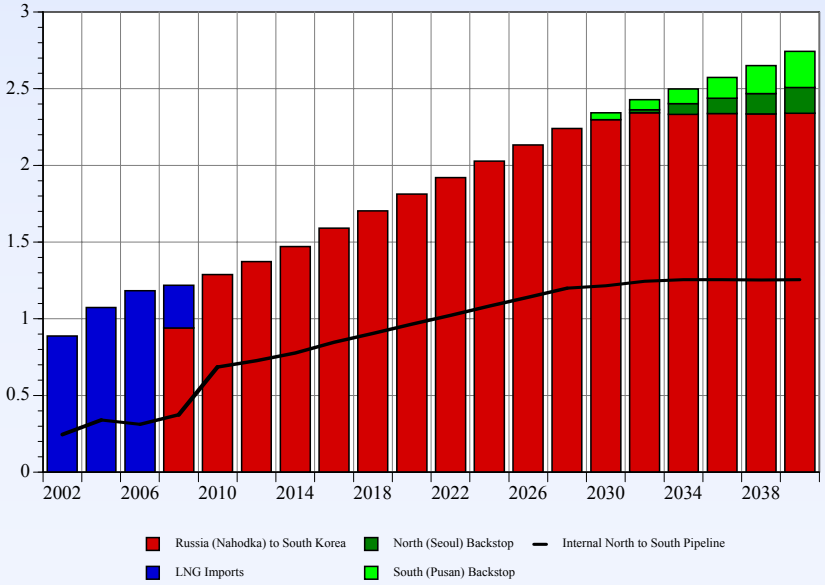
China



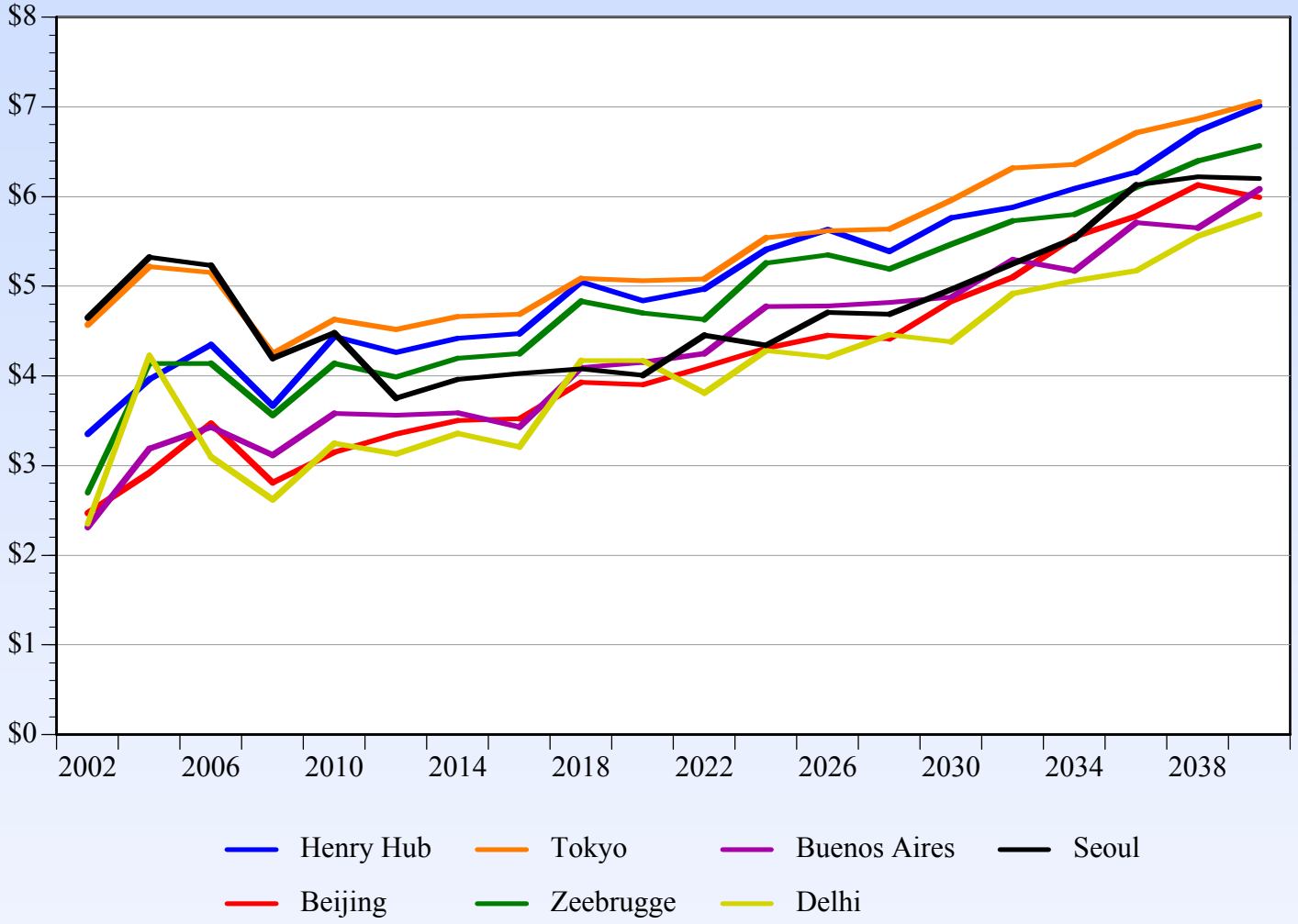
Japan



Korea



Selected price projections



Source: RWGTM, Hartley and Medlock (2005)

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Some implications of the Reference Case

- Russia becomes the dominant exporter in the global gas market
  - Russian pipeline gas continues to be important for Europe
  - Russia also becomes a major supplier of natural gas to China, Korea and Japan
    - Sakhalin gas goes to Korea and Japan and East Siberian gas goes to China next decade
    - Korea shifts to pipeline gas from Russia and stops importing LNG
    - Gas is also piped east from West Siberia in the 2030's
    - Japan continues to import LNG as a national gas grid is prohibitively costly
  - Russia also enters the LNG market possibly supplying the US
    - "Net-back" prices in Russia have to be equilibrated
- Middle East will also become an important supply region, exporting both LNG and pipeline gas
  - Major exporters in the region are Qatar, Iran, UAE and later on Saudi Arabia
  - From 2002-2040 Australia, Qatar and Indonesia are the largest suppliers of LNG (>40% of total), but in 2040 Iran, Russia and Saudi Arabia join Australia and Qatar to supply more than 60% of LNG exports
- Other long-haul international pipelines are constructed
  - The trans-Saharan pipeline (Nigeria to Algeria) is constructed in 2012
  - India imports Iranian gas via pipeline from 2020
  - Europe also imports gas from Iran, Iraq and Saudi Arabia via Turkey in substantial amounts from 2020
  - A pipeline from West Siberia to East Siberia is constructed in the mid 2030's to supply NE Asia
- North America becomes a major importer of LNG
  - Alaskan gas replaces declines in other North American production with little effect on prices
  - Gas prices in the US eventually exceed prices in Japan
  - Russia, Middle East, Australia retain low gas prices
- Europe also imports more LNG than Northeast Asia from the middle of next decade
- South American gas is consumed primarily in South America
  - Trinidad LNG export growth is limited to the near term, but Venezuela is significant later
  - Brazil imports Bolivian and Venezuelan supplies
  - Argentina imports Bolivian supplies before importing LNG
- A backstop technology is implemented almost everywhere by 2040, but is used most heavily in the US, western Europe and Japan

Two scenario analyses

1. Pipelines from Nahodka & NE China through North Korea are blocked
   - Political relations with North Korea prevent them
   - An undersea pipeline to South Korea from China can still be built
   - Sakhalin pipeline to Japan still is possible
     - Connections between South Korea and Japan are also permitted, but these are too expensive to use
2. Russia to China pipelines also don't get built
   - Political difficulties may also prevent this development
   - We also rule out the pipeline from Uzbekistan to China
     - It otherwise provides an indirect route for gas sales from the Volga-Urals region in Russia to China
   - Sakhalin pipeline to Japan with an extension to Korea still is possible

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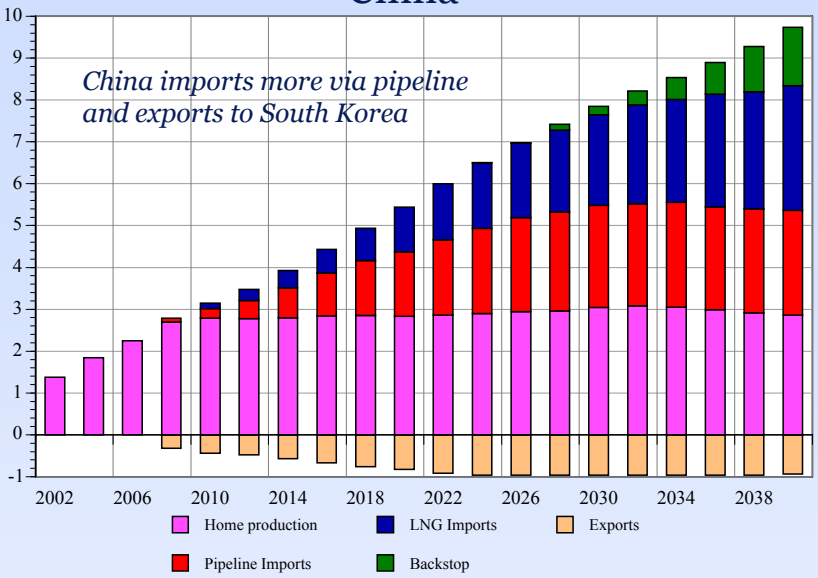
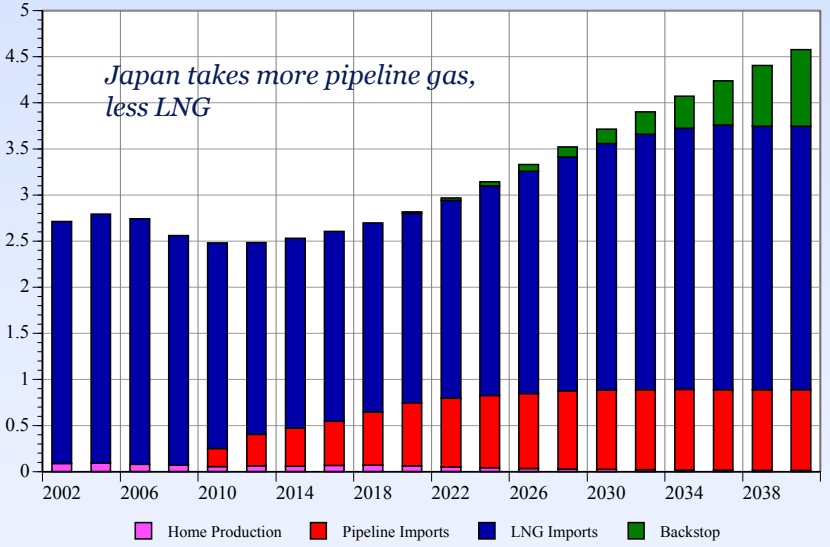
No North Korea pipes: Effects on NE Asia

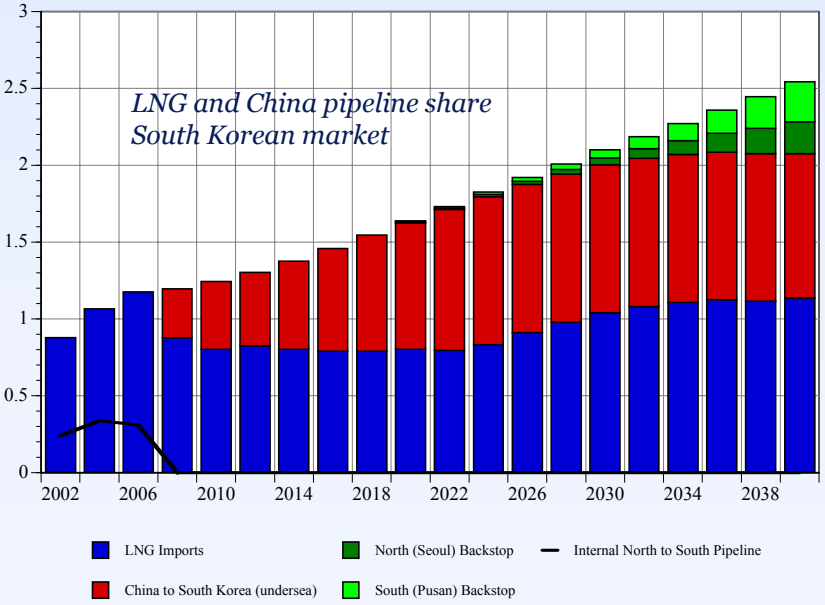
China



Japan



Korea



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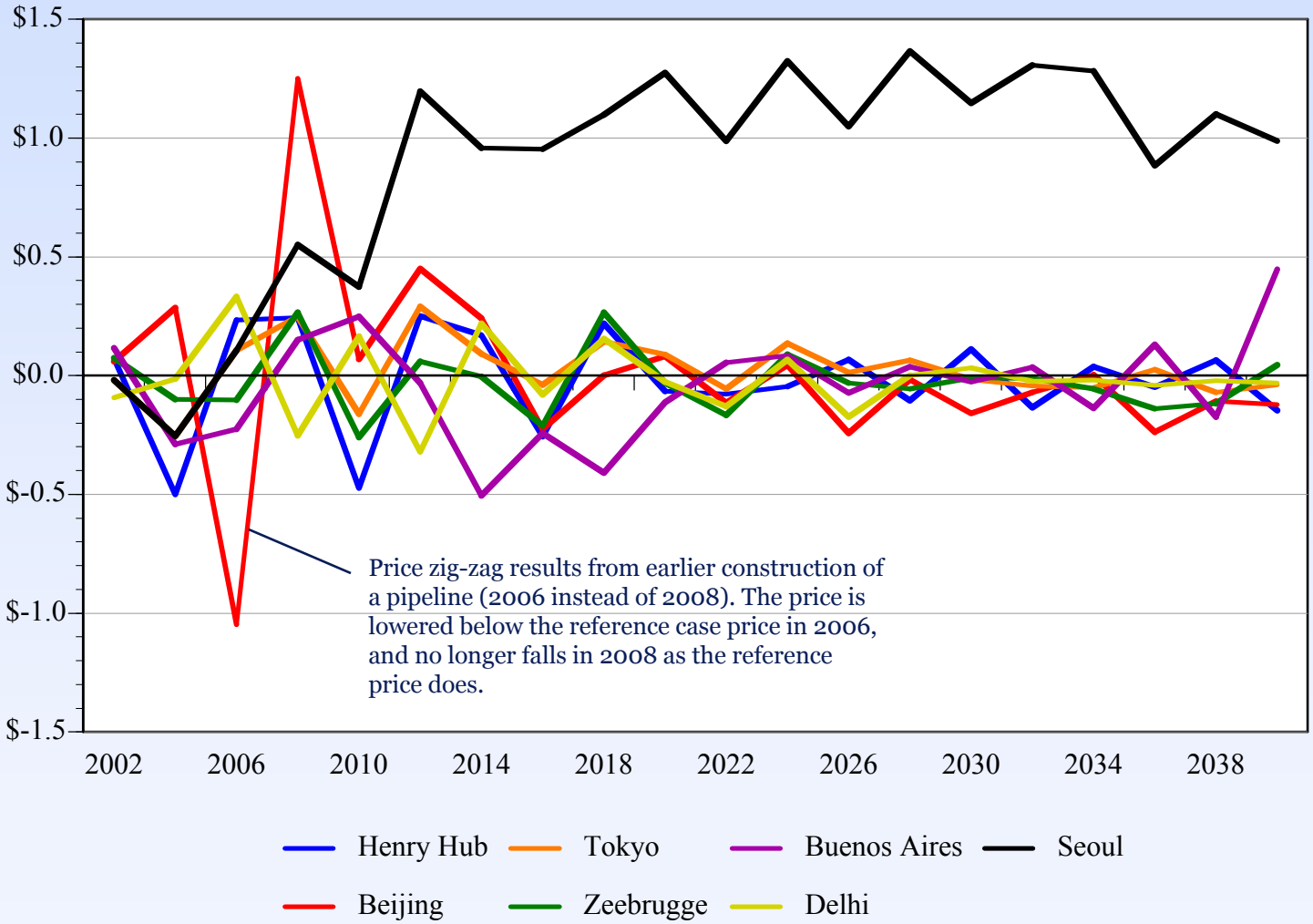
No North Korea pipes: Changes in Selected Prices



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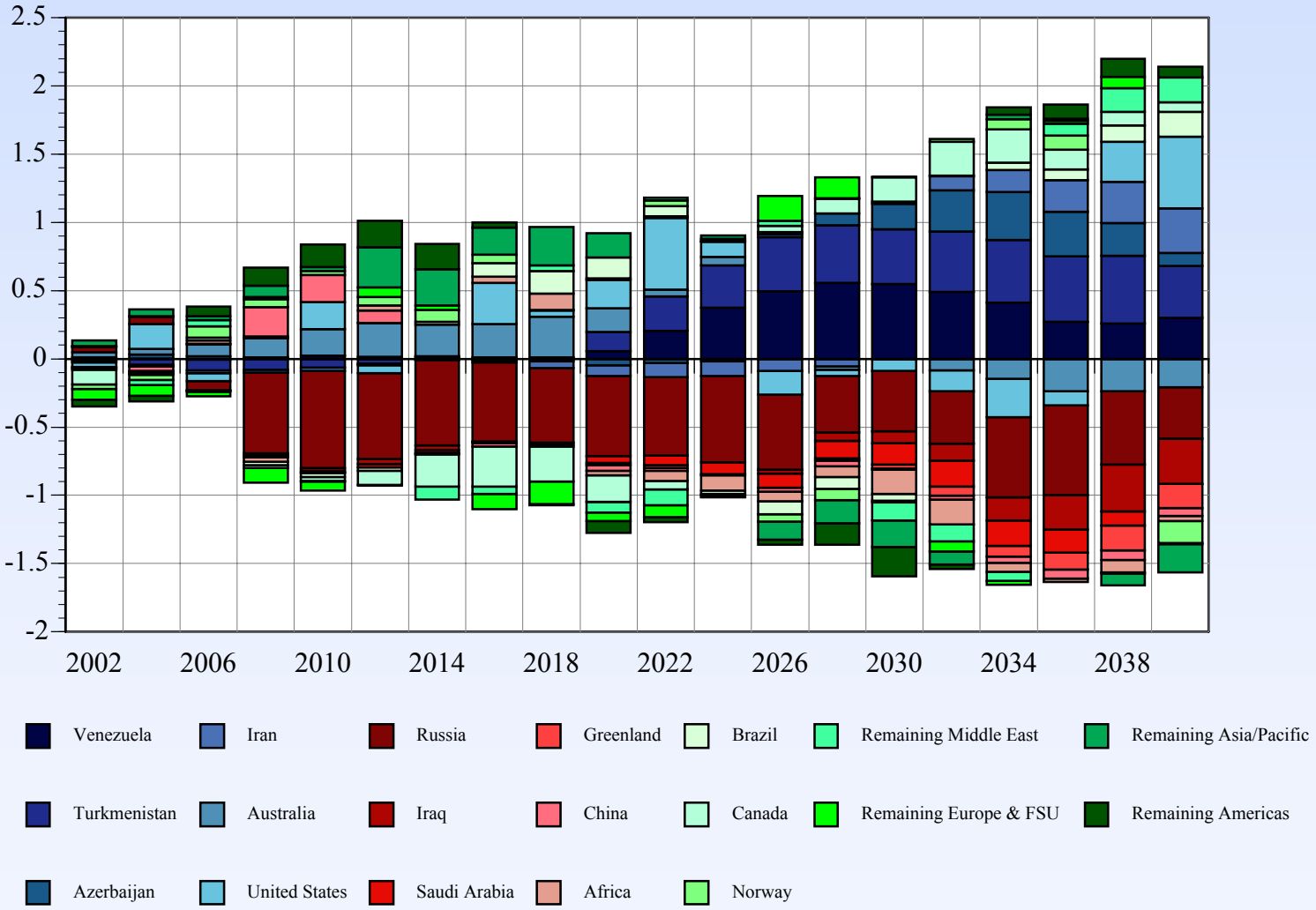
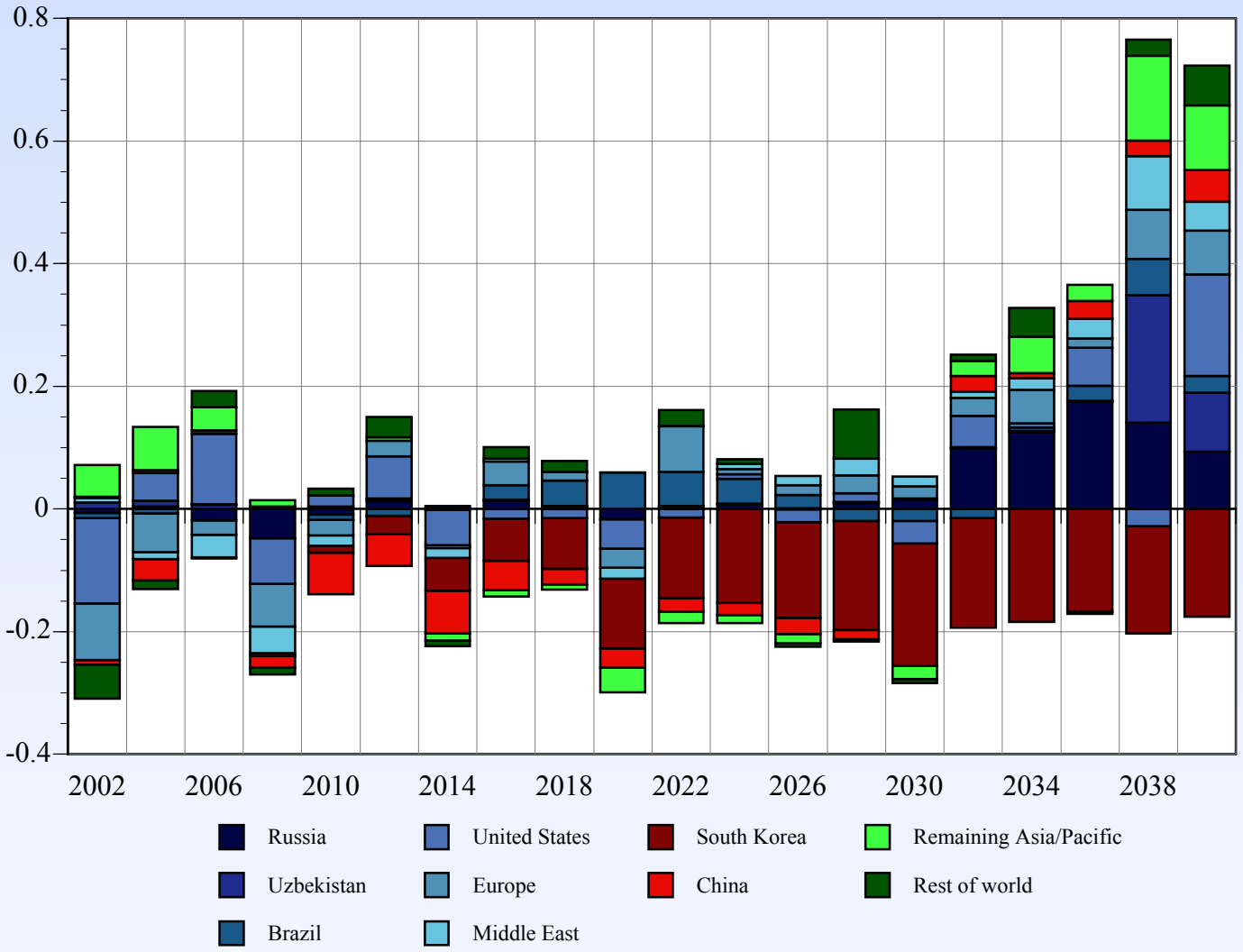
No North Korea pipes: Major Supply Changes

- Net supply changes most years are small
- Russian output declines most, but increased Russian exports to Europe also displace some Middle East pipeline exports



No North Korea pipes: Major Demand Changes

- Higher prices stifle South Korean, and to some extent Chinese, demand
  - Demand reductions in other countries are more than compensated in other years
- Largest net demand increases are in Russia, Central Asia and Europe



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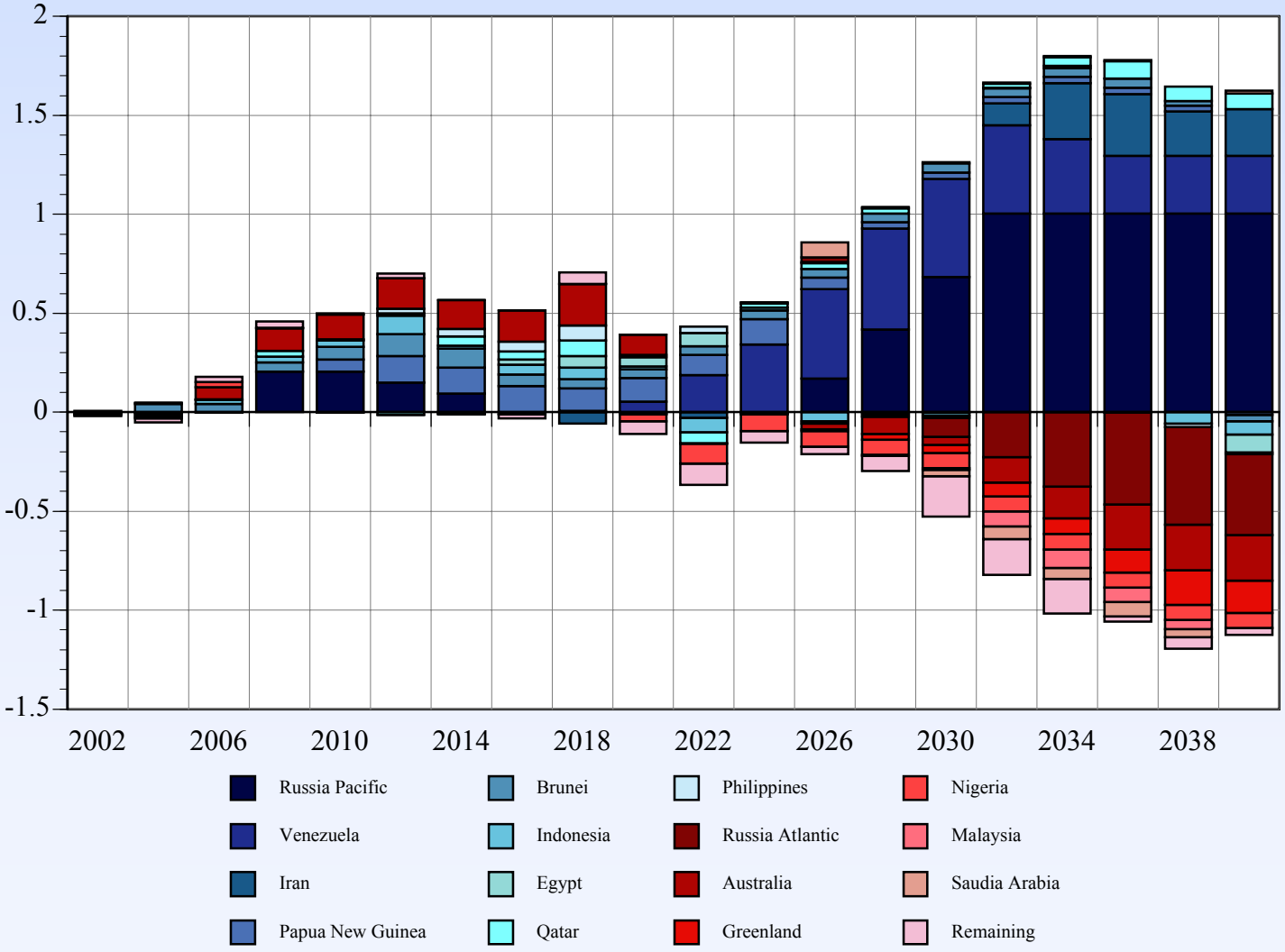
No North Korea pipes: Major Changes in LNG Supply

- Sakhalin LNG exports after 2030 displace some Australian and Saudi exports
- Exports from Russian Atlantic and Greenland decline, and from Venezuela and Iranian expand, after 2030
- Australian and Southeast Asian exports expand up to 2020



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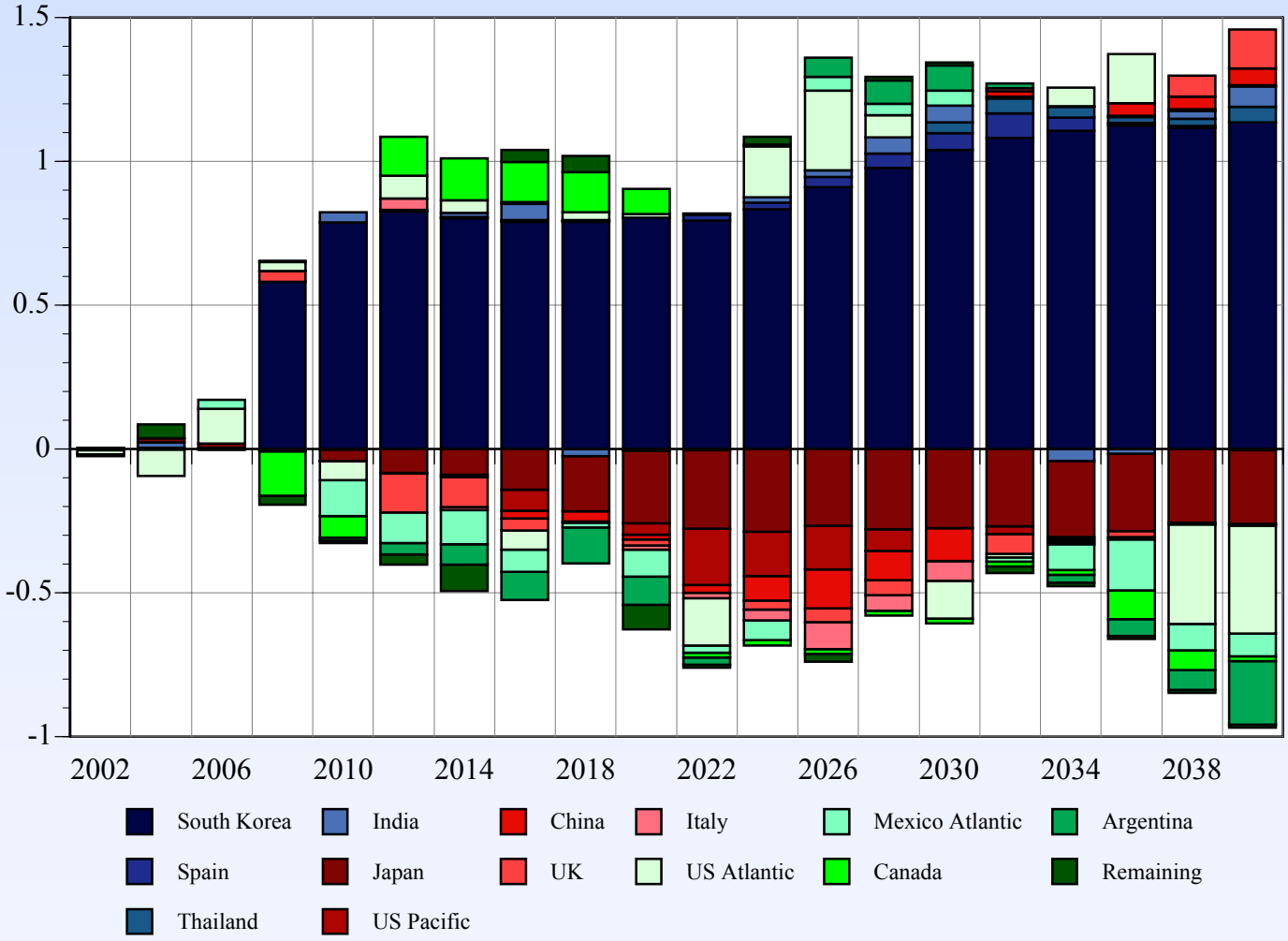
No North Korea pipes: Major Changes in LNG Demand

- Korea is the only country to have a sustained increase in demand for LNG
- Other Pacific Basin importers – especially Japan, and to a lesser extent the US Pacific and China, experience reduced demand
- In most other countries, demand shifts are intertemporal



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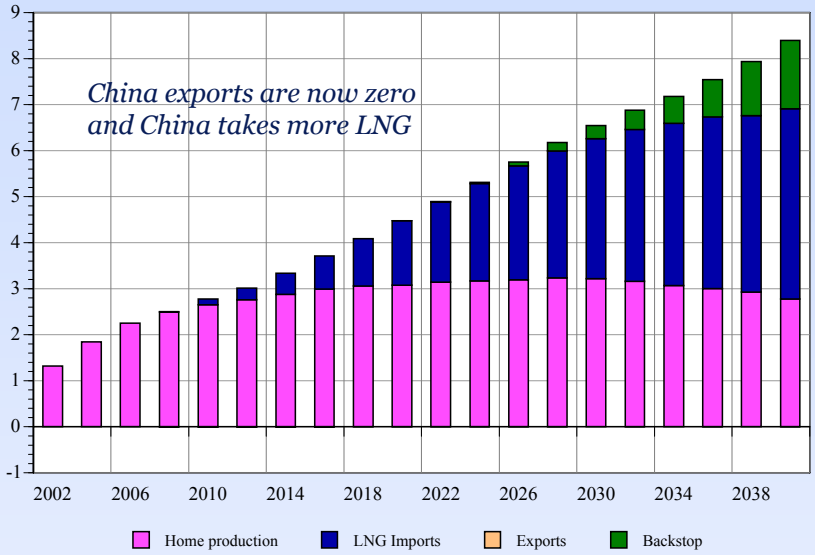
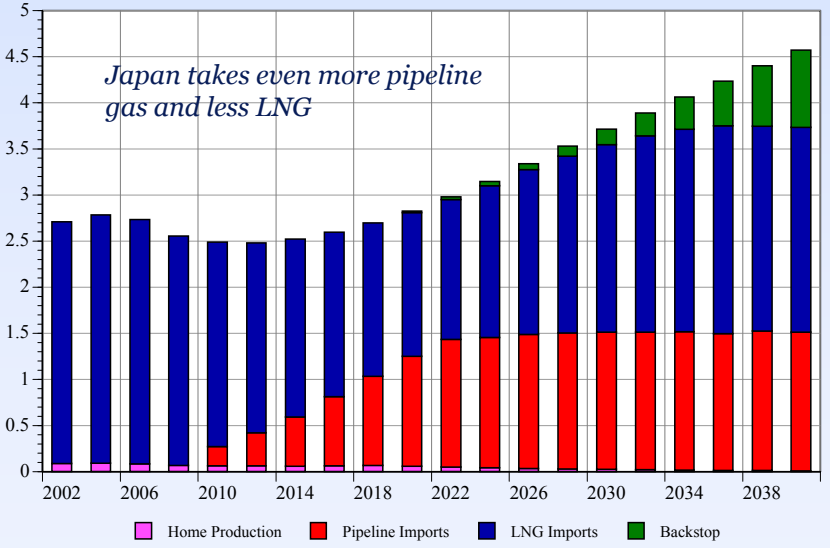
China & Korea pipes off: Effects on NE Asia

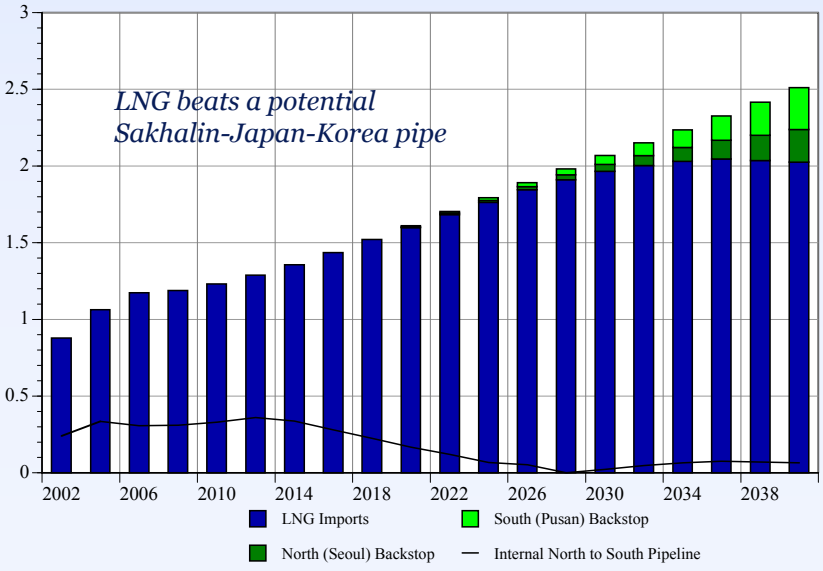
China



Japan



Korea



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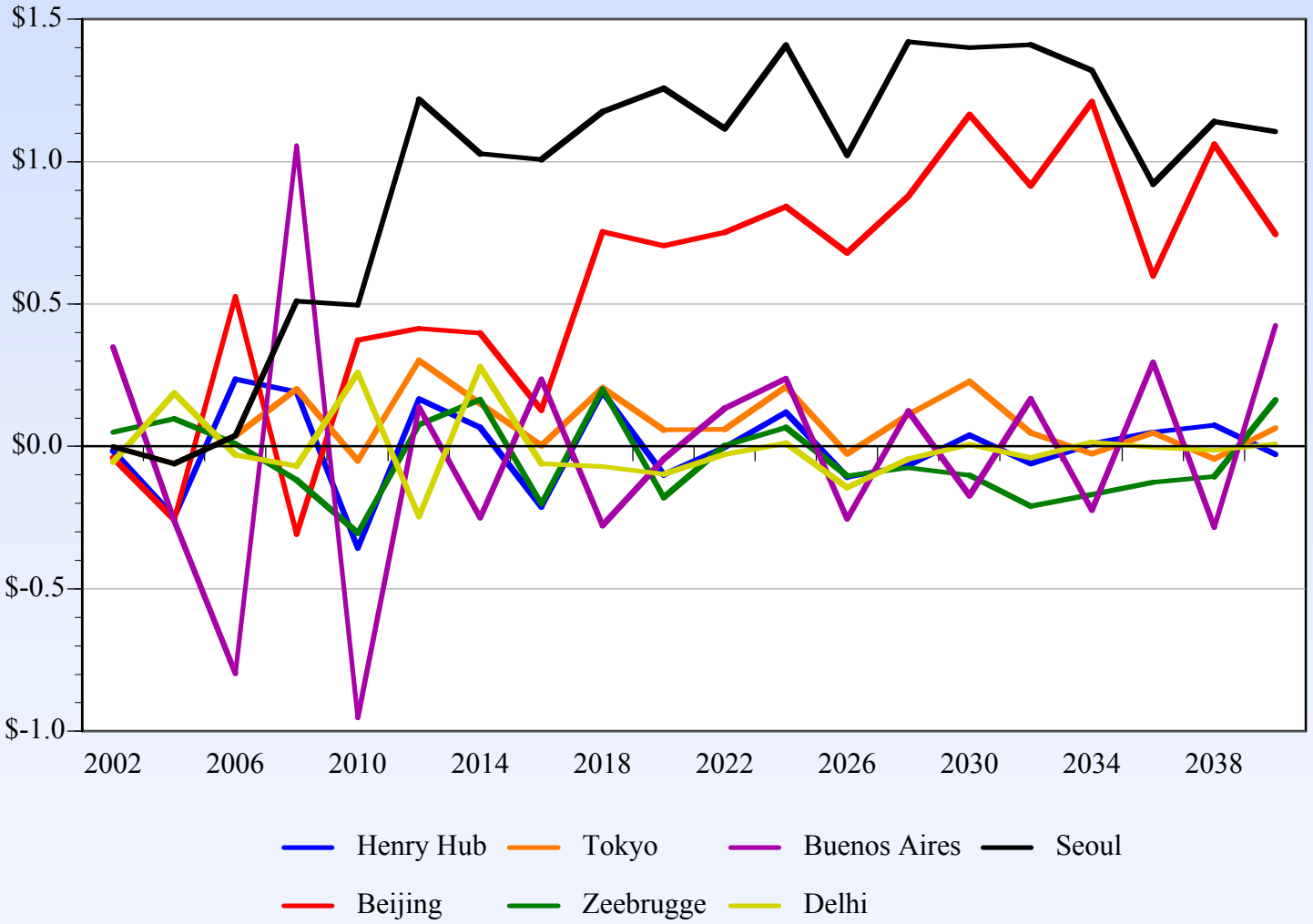
China & Korea pipes off: Changes in Selected Prices



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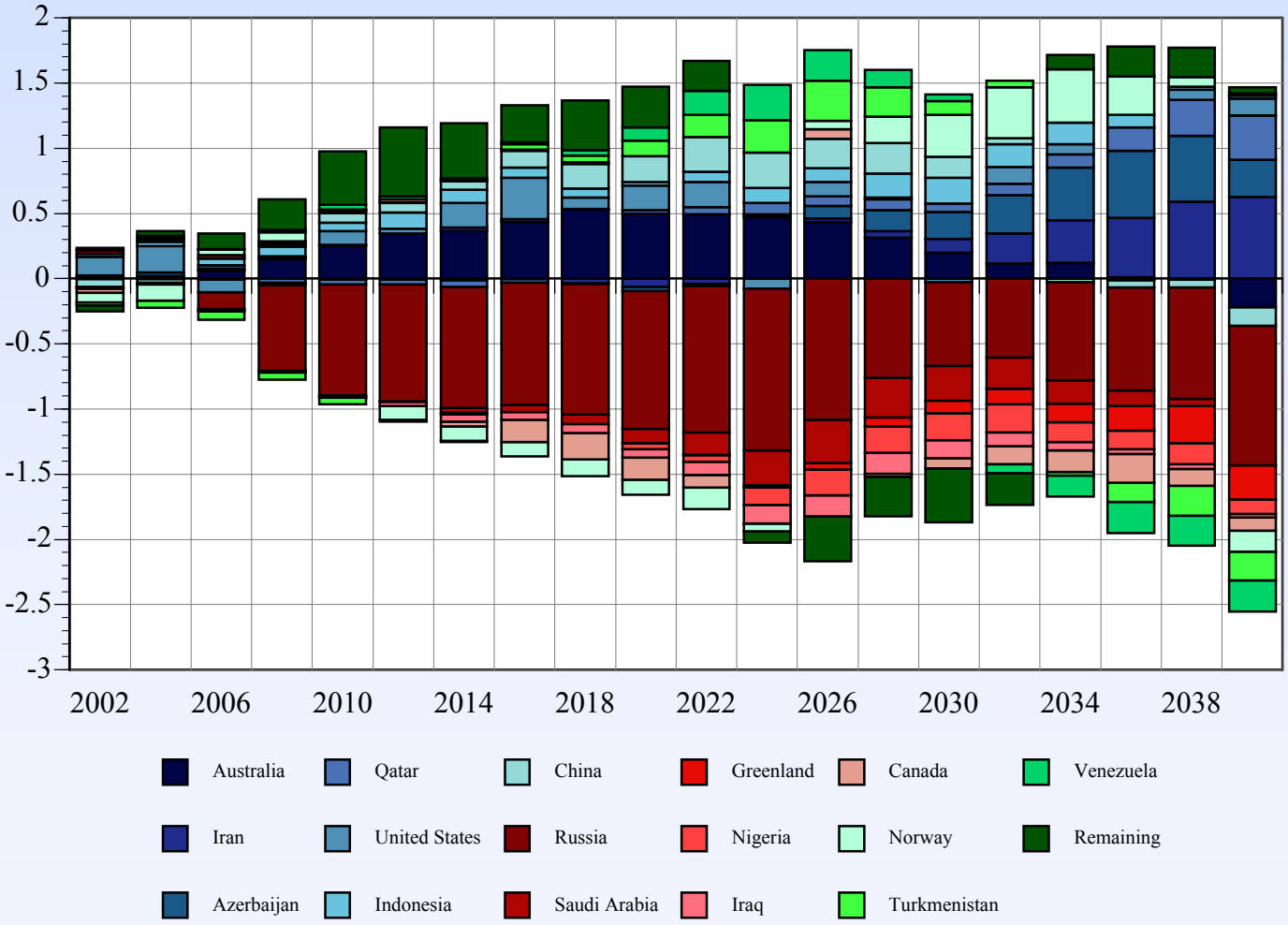
China & Korea pipes off:Major Supply Changes

- Higher overall LNG demand leads to sustained expansions in the main LNG exporters (Australia, Iran, Qatar, Indonesia)
- US, Central Asian and Chinese domestic supply expand
- Largest reduction is in Russia, but outputs in Saudi Arabia, Nigeria, Greenland and Canada also fall in most years



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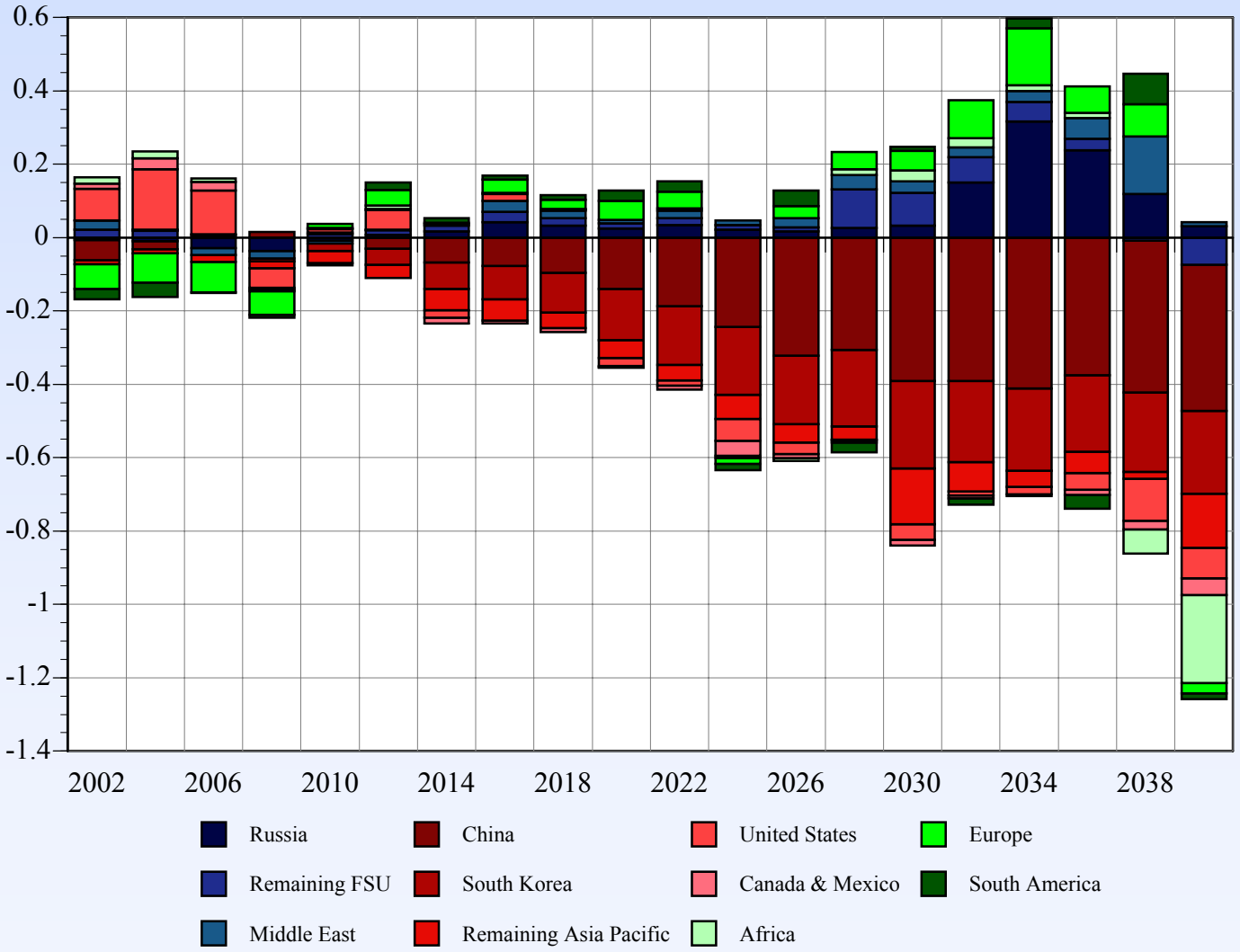
China & Korea pipes off: Major Demand Changes

- Now Chinese demand decline exceeds the Korean one; remaining Pacific Basin importers are again adversely affected
- Main demand increases occur in Russia, Europe and the Middle East



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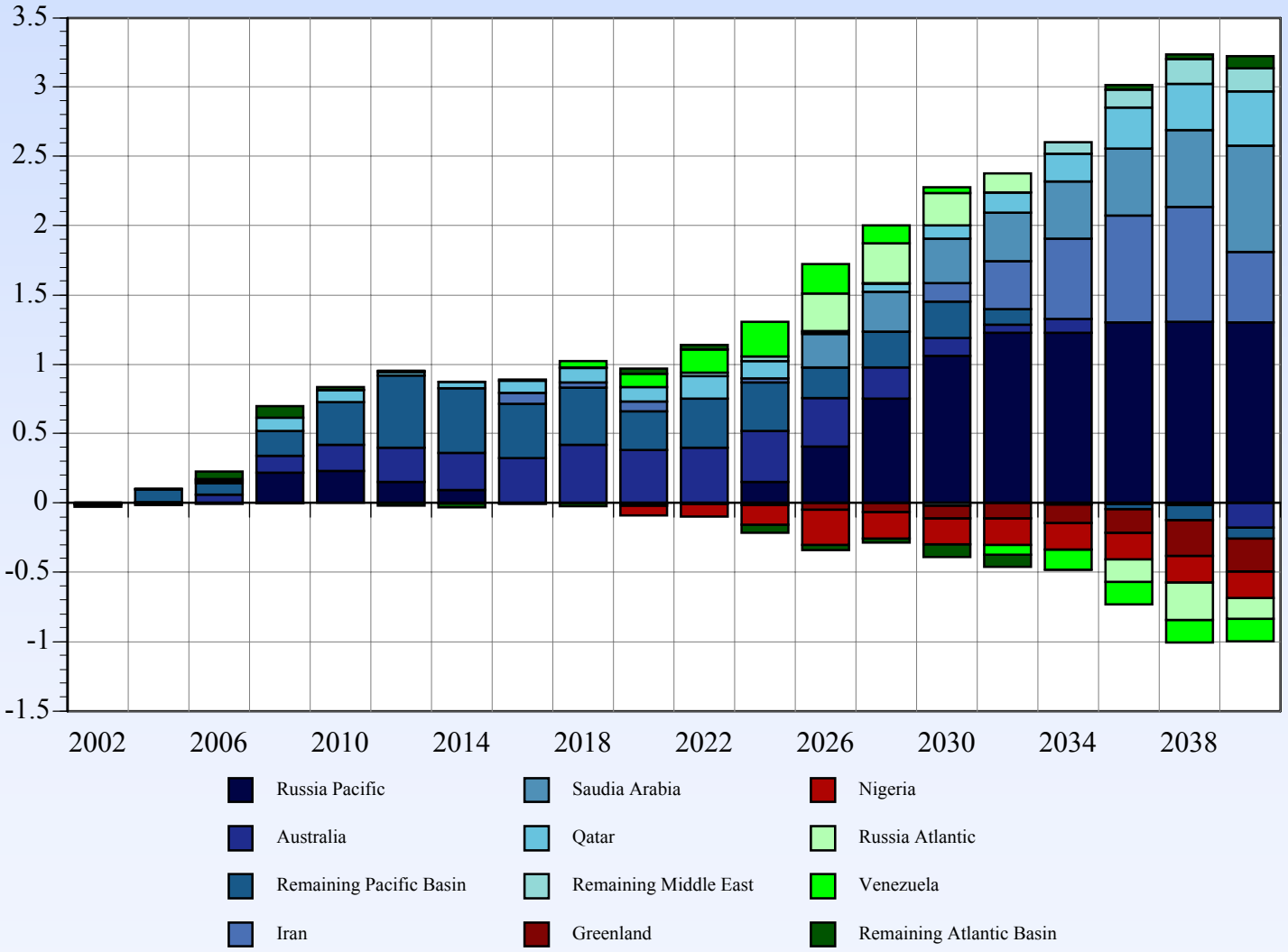
China & Korea pipes off: Major Changes in LNG Supply

- Again Sakhalin LNG exports rise, but now the overall LNG market expands enough that few (only Greenland and Nigeria) LNG exports decline



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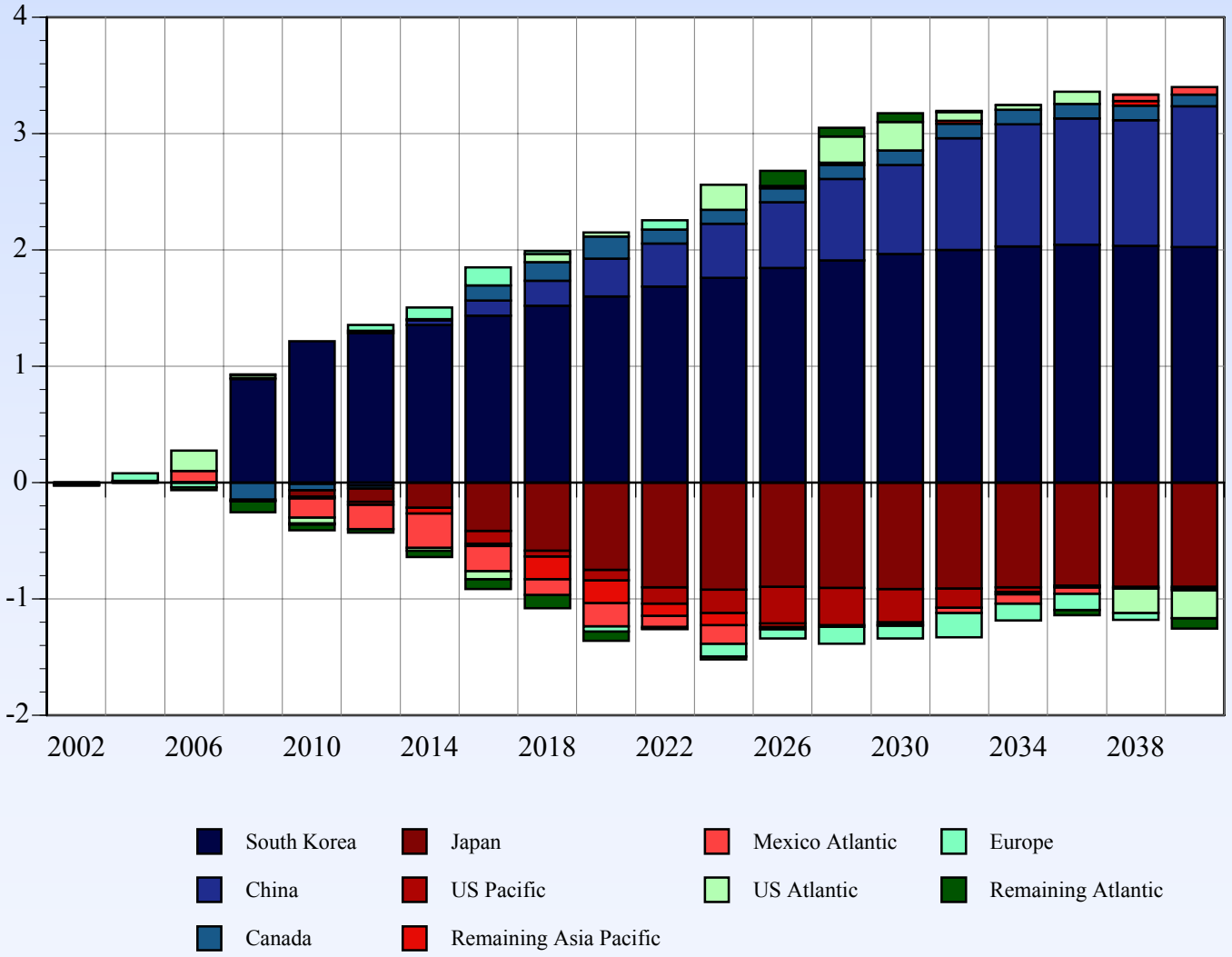
China & Korea pipes off: Major LNG Demand Changes

- Increased Korea and China LNG demand displaces other Pacific Basin importers
- North America Atlantic imports increase (mainly via Canada)
- Mexico shifts to pipeline imports from northern South America



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Some implications of the Results

- In the coming worldwide market for natural gas, political disturbances in one area have global effects
- The results illustrate the key role Russia will play in the future world gas market
  - Russia not only has a lot of gas
  - It also is strategically placed to ship gas either east or west and hence in a position to arbitrage between European and Asian markets
  - Toward the end of the horizon, Russia also becomes a significant exporter of LNG, thus helping to solidify the link between LNG prices and pipeline gas prices around the world
- North America and the Middle East also link Pacific and Atlantic gas markets
  - Middle East producers can export LNG east or west, and also can ship gas via pipeline to Europe or the Indian sub-continent
  - In North America, if Pacific Basin gas prices rise, more Atlantic Basin LNG is imported and the arbitrage point moves toward the west coast
- Japan is a close competitor to South Korea for Pacific Basin LNG and increased Korean demand raises Japanese prices