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DEMOGRAPHIC TRENDS AND IMPACTS ON INFRASTRUCTURE RETURNS

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Agenda

1.0 **Demographic trends and infrastructure asset prices**

- The view of investors and managers

2.0 **Pricing infrastructure**

- What we have done and what we know now: the asset pricing model for infrastructure
- The link between demographic changes and the drivers of infrastructure prices

3.0 **Practical insight:**

- The economic impact of demographic variables on equilibrium infrastructure prices
- Long-run forecasts of infrastructure prices based on demographic projections

1.0

DEMOGRAPHIC TRENDS AND INFRASTRUCTURE ASSET PRICES

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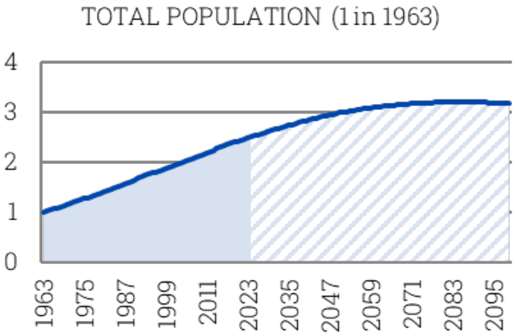
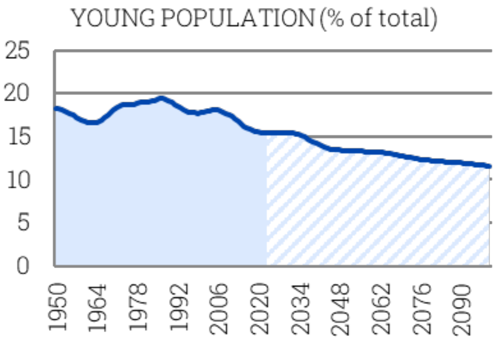
KEY DEMOGRAPHIC TRENDS

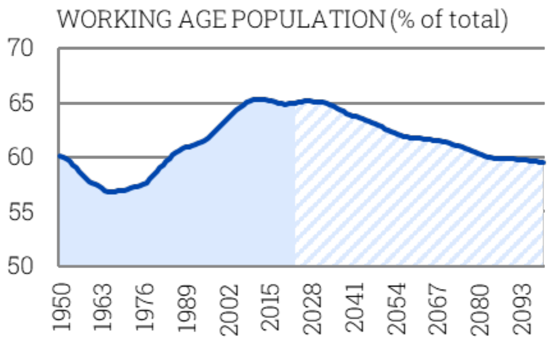
TOTAL POPULATION SIZE (different paces across regions and among Western European countries)

— Larger total population, consistent but slowing growth. Rates declining from 2% to 0.9% by 2023. Trend will continue, in 2087 global decline starts. Fastest growth in Luxembourg and Norway, while Italy is at -0.3% and goes to -0.8% by 2070.

— Larger working age population. In the 1960s, working-age population was 57%, growing to 65% by 2023. Growth will continue for the next decade, then decline to 59% by 2100. Most pronounced in Italy and Spain, dropping to 50% by 2100.







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KEY DEMOGRAPHIC TRENDS

TOTAL POPULATION SIZE (different paces across regions and among Western European countries)

The view of infrastructure investors and managers

- Strain on global infrastructure. Rapid population growth, particularly in developing countries, is driving significant infrastructure demand across sectors, particularly transportation and utilities. The expanding global middle class are boosting demand for air travel, placing pressure on aviation infrastructure and necessitating investment in decarbonization technologies.
- Opportunities in emerging markets. Higher population growth in developing regions will create opportunities for infrastructure development, especially in urbanization, energy, and transport.
- More focus on flexible infrastructure. Slower population growth and demographic shifts in developed countries, like Italy and Spain, call for targeted infrastructure investments in areas like renewable energy, healthcare, and transport systems to accommodate shifts in age demographics along with lifestyles at different life stages.

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KEY DEMOGRAPHIC TRENDS

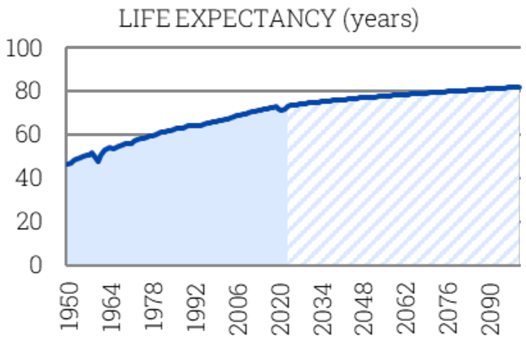
AGEING POPULATION (different paces across regions and among Western European countries)

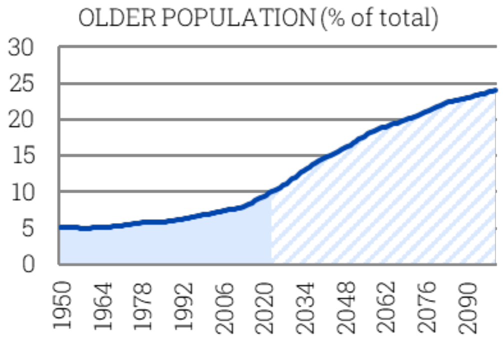
— Growing over-50 population. The global population aged 50+ is expected to grow from 24% to 33% by 2050.

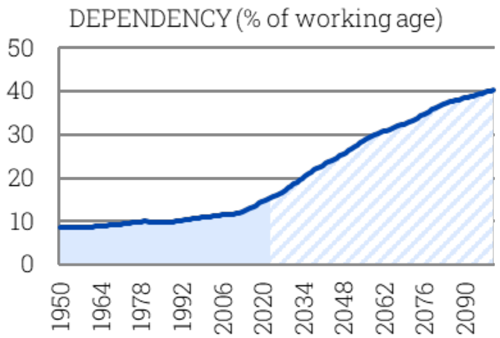
- Contribution to global spending increasing from $35 trillion in 2020 to $96 trillion by 2050 (in Italy 68% of total).

— Healthier population, longer life expectancy. From 54 years in 1960s to 73 today, projected 82 by 2100.

— Rising dependency ratios. Global old-age dependency ratio has increased from 9% in 1964 to 15% today, with projections reaching 40% by 2100. Countries like Italy (75%) and Spain (77%) will face extreme ageing pressures.







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KEY DEMOGRAPHIC TRENDS

AGEING POPULATION (different paces across regions and among Western European countries)

The view of infrastructure investors and managers

- Age structure as a driver of the risk premia. An ageing population presents structural risks for productivity and growth, affecting sovereign finances and driving up healthcare and social care costs.
- Infrastructure returns and ageing populations. Research shows that a growing working-age population boosts infrastructure returns, while an ageing population may reduce them. However, a longer life expectancy can lead to higher saving rates and more sustained demand for a mix of growth and income generating assets with a focus on stability and moderate risk.
- Technological and workplace adaptations. Ageing societies will need investments in technology to adapt work environments for older workers, while infrastructure upgrades are required to support prolonged productivity and well-being.
- Rising demand for healthcare and senior care facilities. Ageing populations will require increased investment in healthcare infrastructure, including hospitals, care homes, and dementia care. There will be a growing need for senior housing with customized solutions, such as barrier-free apartments, accessible transport, and proximity to medical care.

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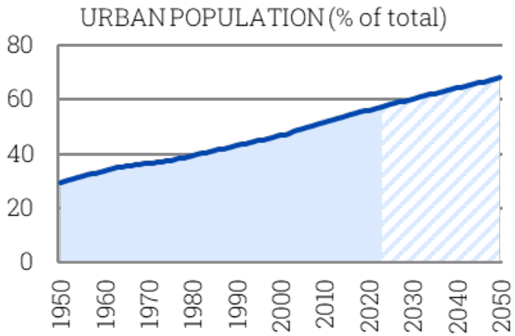
KEY DEMOGRAPHIC TRENDS

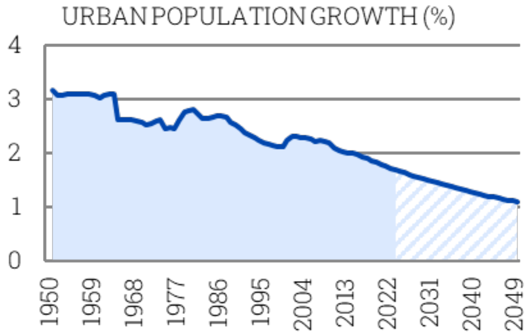
URBANIZATION (different paces across regions and among Western European countries)

— Rising urban populations. 56% of the world's population lives in urban areas, with this figure projected to reach 68% by 2050. In 2000, 46 cities had populations exceeding 5 million, representing 9.1% of the global population (555 million). By 2035, this is expected to nearly triple to 121 cities, with over 1 billion people (13.6% of the world population).

— Energy and resource consumption. Urban areas currently consume 78% of global energy and account for over 60% of greenhouse gas (GHG) emissions.

— Infrastructure strain. Existing infrastructure, particularly in transport and utilities, faces increasing pressure. Urban areas need efficient infrastructure for mass transit, renewable energy, clean water, waste management, and sanitation





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KEY DEMOGRAPHIC TRENDS

URBANIZATION (different paces across regions and among Western European countries)

The view of infrastructure investors and managers

- Demand for renewable energy: As urban populations grow, cities will require more renewable energy sources (solar, wind, battery storage, hydrogen) to meet rising power demand.
- Smart grid technologies: Investments in smart grids will be crucial to manage peak loads, enable flexibility, and integrate renewable energy efficiently, especially as electrification (e.g., EVs) strains the grid.
- Resilience to climate risks: Cities need resilient infrastructure to withstand climate-related threats like floods, droughts, and heatwaves, driving investment in sustainable solutions.
- Sustainable development focus: As urban growth slows in developed regions, cities must prioritize sustainable infrastructure that enhances the well-being of existing populations, shifting from expansion to productivity.
- Digital infrastructure growth: Increased demand for energy-intensive digital infrastructure—mobile networks, data centers, and fiber—will require energy-efficient systems and influence the location and development of future projects, with a focus on energy availability and grid capacity.

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WHAT WE HAVE DONE AND WHAT WE KNOW NOW

FACTOR ERROR CORRECTION MODEL (FECM) WITH ERROR CORRECTION TERMS ECTS

— A statistical framework based on cointegration (i.e., the identification of common stochastic trends) can be used to identify equilibrium values for infrastructure prices from:

- The long-term dynamic of (log-) **prices**

  Long-run trends in infrastructure prices are explained by the dynamic of factor prices (i.e., the values of buy-and-hold portfolios invested into traditional and infrastructure specific risk factors)

$$P_t = \alpha_{0,P} + \alpha_{1,P} t + \boldsymbol{\beta}'_{\boldsymbol{P}} \boldsymbol{F_t} + u_{P,t}$$

- The long-term dynamic of (log-) **factor prices**

  The trends in these factors are related to macroeconomic trends (e.g., productivity, inflation, interest rates, monetary policy, demographics, urbanization, energy consumption, etc..)

$$\boldsymbol{F}_t = \alpha_{0,F} + \alpha_{1,F} t + \boldsymbol{\beta}'_{\boldsymbol{F}} \boldsymbol{X_t} + u_{F,t}$$

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WHAT WE HAVE DONE AND WHAT WE KNOW NOW

KEY INPUTS TO THE MODEL

Prices (P)
(2000-pres.)

Listed infrastructure:
- MSCI World Infrastructure

Unlisted infrastructure:
- Preqin Infrastructure (2008-pres.)
- EDHEC Infra300 Equity (2000-2022)
- MSCI World Private Infrastructure (2008-pres.)
  Power/Water/Communication/Transportation
  Europe/North America/Australia
  Low/Moderate/High Risk
  Economic/Social
  Greenfield/Brownfield
  Contracted/Uncontracted
  Regulated/Partially/Unregulated

Factor Prices (F)
(2000-pres.)

Traditional:
- Market
- Size
- Value
- Profitability
- Investment
- Momentum

Infrastructure specific:
- Regulation
- Illiquidity
  (1967-pres.)
- Leverage
  (1987-pres.)
- Earnings Volatility
  (1988-pres.)

Demographic trends (X)
(1950-2050/2100)

Population size:
- Total population

Age groups:
- % of total population by age group: 15-24 (Young), 15-64 (working age), and 65+ (elderly)

Dependency:
- Ratio of older dependants to working age population

Life expectancy:
- Years a newborn would live based on patterns at birth

Education:
- Mean years of schooling by age group of 20-64

Urbanization:
- Urban population as % of total and
  its annual growth rate

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WHAT WE HAVE DONE AND WHAT WE KNOW NOW

COMMON TRENDS ANALYSIS

— The link between the drivers of infrastructure prices and (5-years ahead) demographic variables: β_F

	Population Size	Urban Population	Urbanization Rate	Working Population	Ageing Population	Old Age Dependency
Market	15.19***	8.27**	12.86***	-21.61***	-0.80*	2.13**
Size	-10.84***	4.10*		10.74***	8.02***	16.37***
Value						
Profitability					0.31*	-1.53*
Investment						
Momentum						
Regulation	-18.92***	-58.95***	22.37***	38.79*	-0.76*	-2.49***
Liquidity						7.38***
Leverage	-4.78***	-3.45*	3.56*		1.24**	1.33**
Earnings Volatility						

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WHAT WE HAVE DONE AND WHAT WE KNOW NOW

FROM PRICES TO RETURNS

— Equilibrium in the model's two equations (i.e., cointegration) implies (in first difference):

- The corresponding factor model of **next-period returns**

$$r_{t+1} = \alpha_{1,P} + \boldsymbol{\beta'_P}\alpha_{1,F} + \boldsymbol{\beta'_P}\boldsymbol{\beta_F}\,\boldsymbol{x_{t+1}} + (\rho_P - 1)u_{P,t} + \boldsymbol{\beta'_P}(\rho_F - 1)u_{F,t} + \varepsilon_{t+1}$$

- Key implications:

The dynamic of asset prices is characterized by price adjustments towards long-term equilibrium prices in response to deviations of factor prices (F) from their equilibrium value implied by demographic trends (X).

For each factor structure for which a long-term equilibrium (i.e., cointegrating) relation holds between factor prices and demographic trends, any deviation from equilibrium determines an adjustment in the following period factor price that strongly affects returns.

The price adjustment is predictable and in addition to any price adjustment due to previous price disequilibria.

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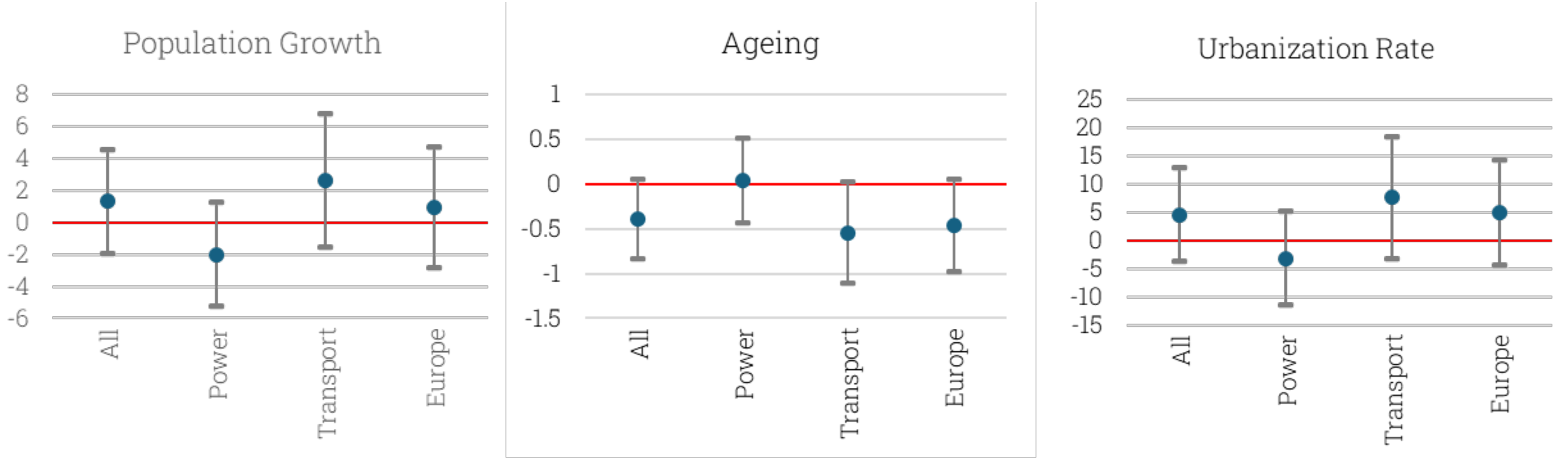
WHAT WE HAVE DONE AND WHAT WE KNOW NOW

EXCERPTS FROM THE ANALYSIS

— The economic impact of demography on equilibrium infrastructure prices.

- Elasticity of prices with respect to population growth, ageing and urbanization (95% c.i.) based on estimated cointegration coefficients (telling us how much prices change in percentage terms in response to demographic change): $\boldsymbol{\beta'_P \beta_F}$



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PRACTICAL INSIGHT

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WHAT CAN WE USE IT FOR?

LONG-TERM PRICE FORECASTING

— The identification of equilibria is useful for long-term price forecasting:

- What are the prices consistent with the factor prices implied by demographic trends?

STEP 1: Forecast the dynamic of returns for a specific type of infrastructure / region / country

Use the cointegration coefficients $\boldsymbol{\beta_F}$ in combination with $\boldsymbol{\beta_P}$ to obtain next period returns based on the projections of demographic variables and the error correction terms.

$$r_{t+1} = \alpha_{1,P} + \boldsymbol{\beta'_P}\alpha_{1,F} + \boldsymbol{\beta'_P}\boldsymbol{\beta_F}\,\boldsymbol{x_{t+1}} + (\rho_P - 1)u_{P,t} + \boldsymbol{\beta'_P}(\rho_F - 1)u_{F,t} + \varepsilon_{t+1}$$

STEP 2: Forecast the long-term dynamic of **prices**

Repeat and cumulate the returns over time, reevaluating in each period deviations from the corresponding equilibrium relations.

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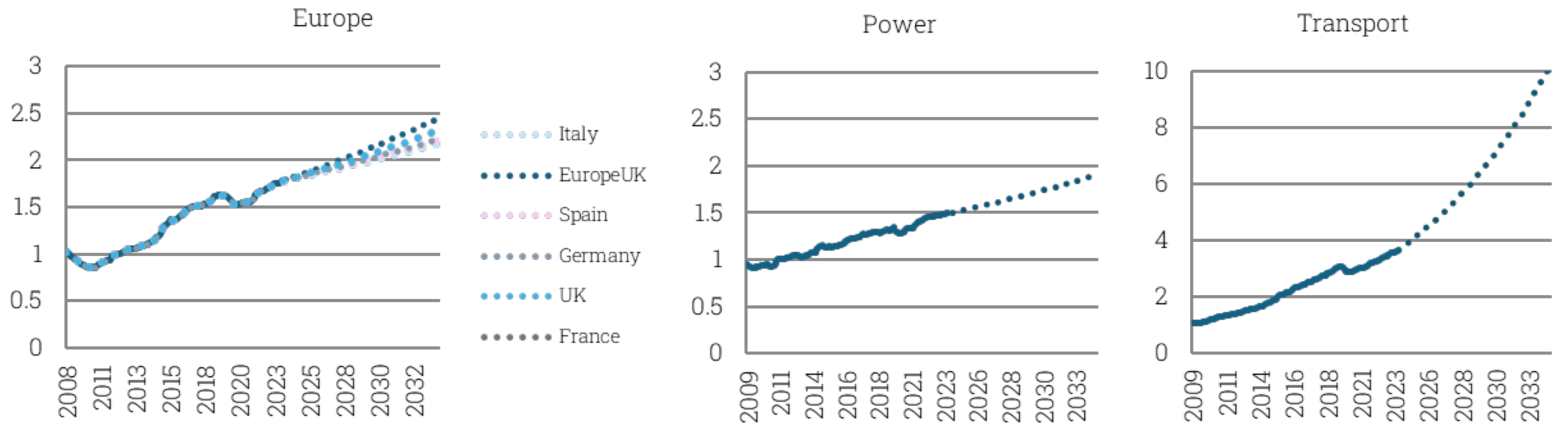
WHAT CAN WE USE IT FOR?

ILLUSTRATIVE EXAMPLE: POPULATION GROWTH

— 10-years ahead forecasts of infrastructure prices based on projections of total population size



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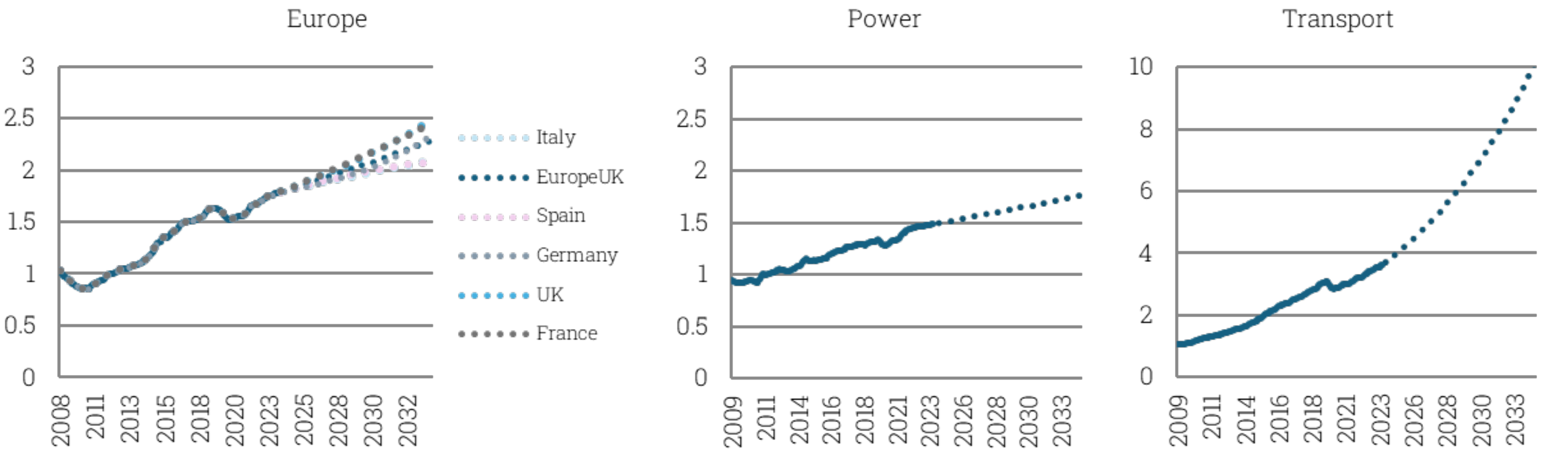
WHAT CAN WE USE IT FOR?

ILLUSTRATIVE EXAMPLE: AGEING POPULATION

— 10-years ahead forecasts of infrastructure prices based on projections of old age dependency



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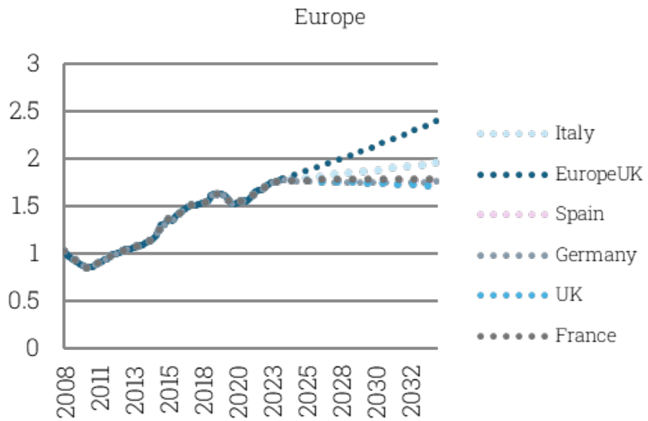
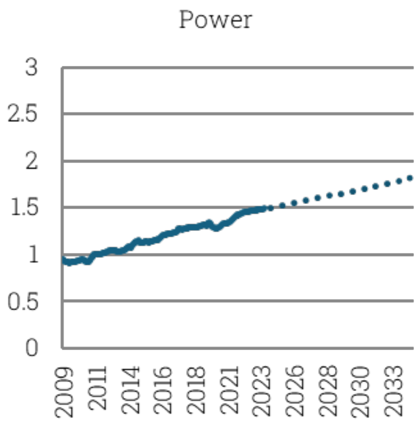
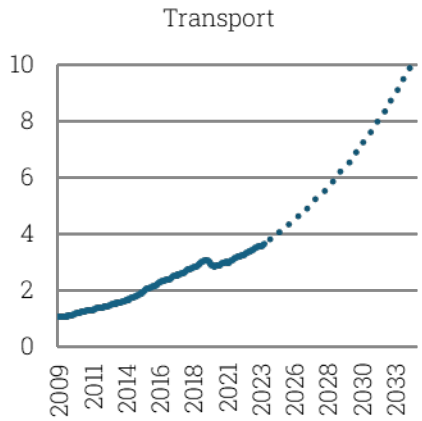
WHAT CAN WE USE IT FOR?

ILLUSTRATIVE EXAMPLE: URBANIZATION

— 10-years ahead forecasts of infrastructure prices based on projections of urbanization rate







THANKS.