Australian National University

# Energy and Economic Growth:

# The "Stylized Facts"

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# Kaldor's Stylized Facts:

*"In 1961, Nicholas Kaldor highlighted six "stylized" facts to summarize the patterns that economists had discovered in national income accounts and to shape the growth models being developed to explain them."*

(Jones and Romer, 2010, *AEJ: Macroeconomics* 2(1): 224)

## Kaldor's Stylized Facts:

In the long-run:

1. GDP and labor productivity grow at a constant rate
2. Increasing capital per worker
3. Constant rate of return on capital
4. Constant capital/GDP ratio
5. Constant shares of wages and profits in GDP
6. Growth rates vary across countries

## Jones and Romer's Stylized Facts:

In the long-run:

1. Increase in the extent of the market
2. Accelerating growth rate
3. Variation in growth rates higher in lower income countries
4. Large variation in income and TFP across countries
5. Increasing human capital per worker
6. Stable return to human capital relative to unskilled wages

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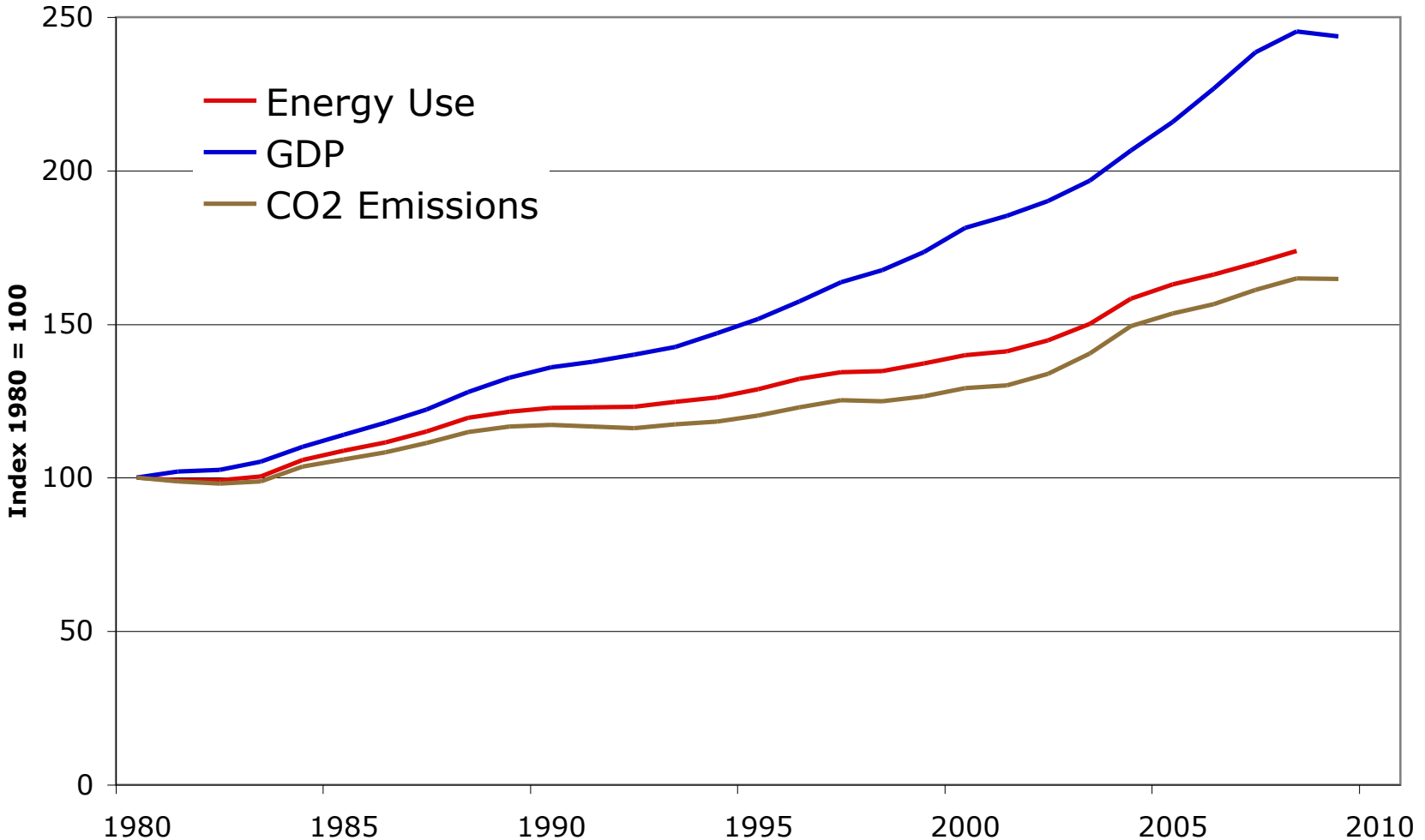
# Energy use per capita increases over time

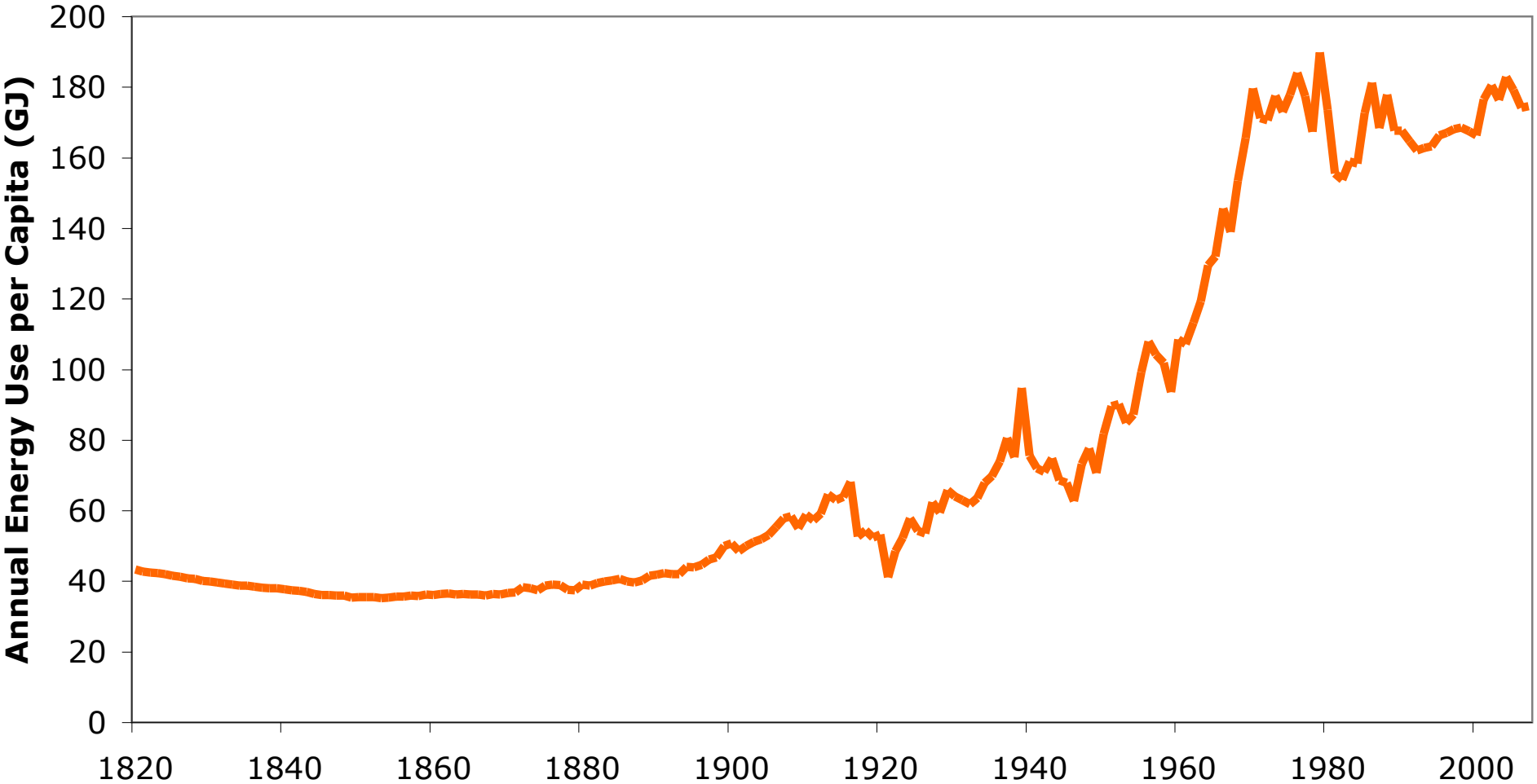
## Energy & Growth:

The Stylized Facts

# World Energy, GDP, and CO2: 1980-2009



# Swedish Energy Use Per Capita 1820-2007



# Energy and Growth Meta-Analysis

- Does increasing energy use cause growth? Or vice-versa?
- Large literature testing energy-growth Granger causality

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| Multivariate Production Function Models | | | |
|---|---|---|---|
| **Model** | **Period** | **Energy -> GDP** | **GDP -> Energy** |
| Multivariate GDP, DE, K, L | 1850-2000 | 2.3686 (0.056) | 1.6173 (0.174) |
| | 1900-2000 | 1.8515 (0.128) | 0.588 (0.672) |
| | 1950-2000 | 1.2092 (0.331) | 3.4115 (0.023) |
| Multivariate GRO, DE, K, L | 1850-2000 | 4.5479 (0.002) | 0.3397 (0.851) |
| | 1900-2000 | 1.5271 (0.203) | 1.4746 (0.218) |
| | 1950-2000 | 2.9842 (0.037) | 2.7127 (0.052) |

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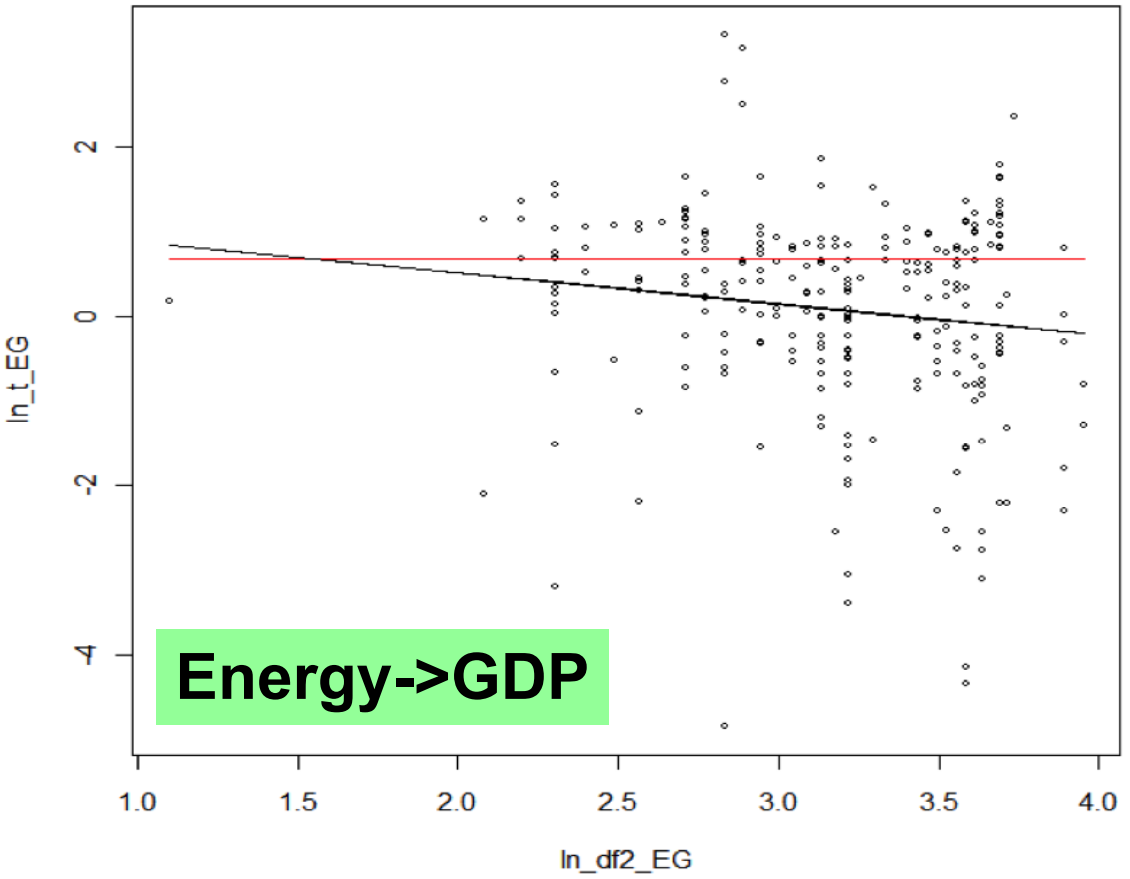
- Large literature testing energy-growth Granger causality
- Meta-significance testing: $\ln|t_i| = \alpha + \beta \ln DF_i + \varepsilon_i$




Christian Gross

Stephan Bruns

Max Planck Jena

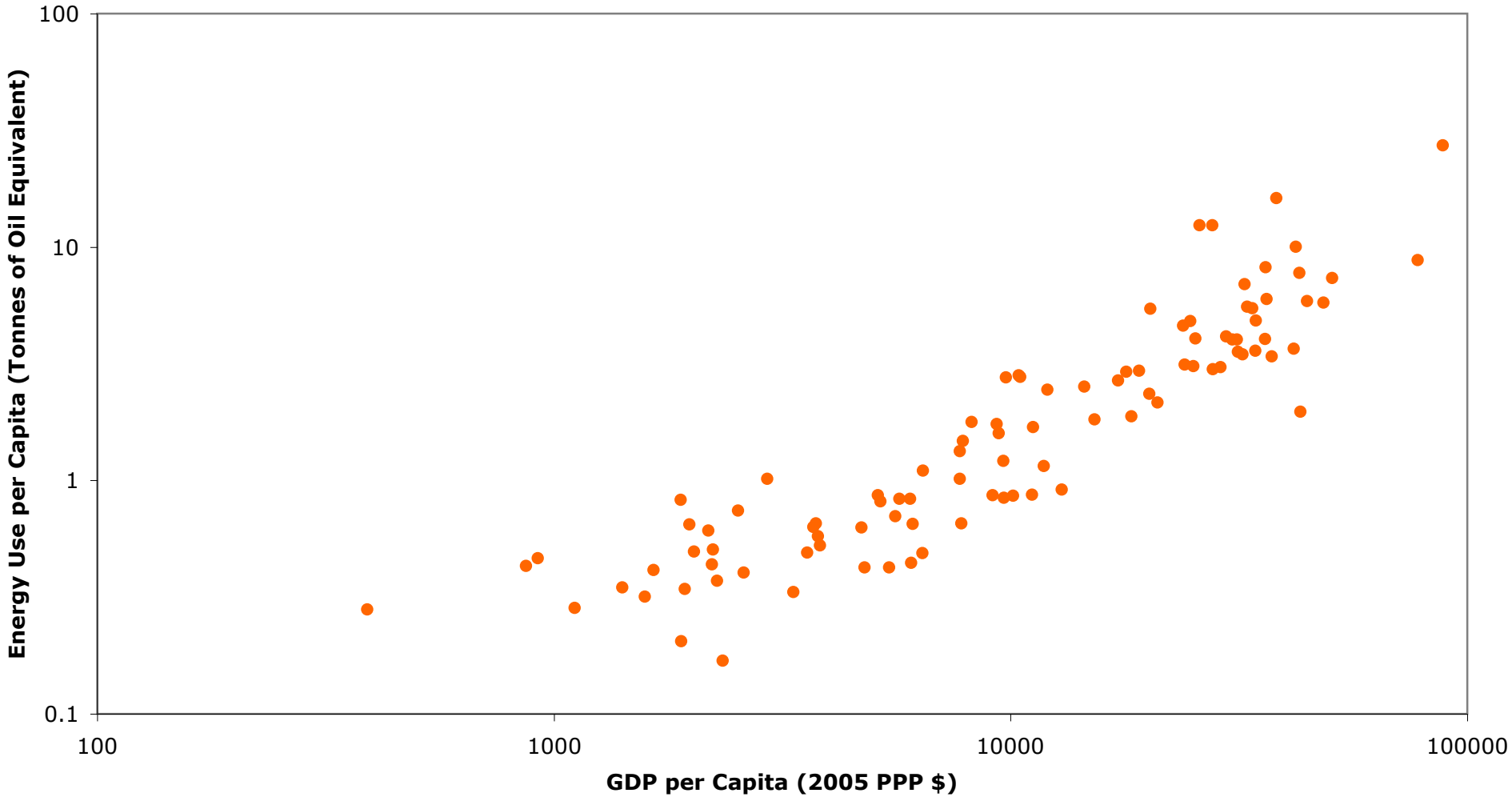
# 2

# Energy use per capita increases with GDP per capita

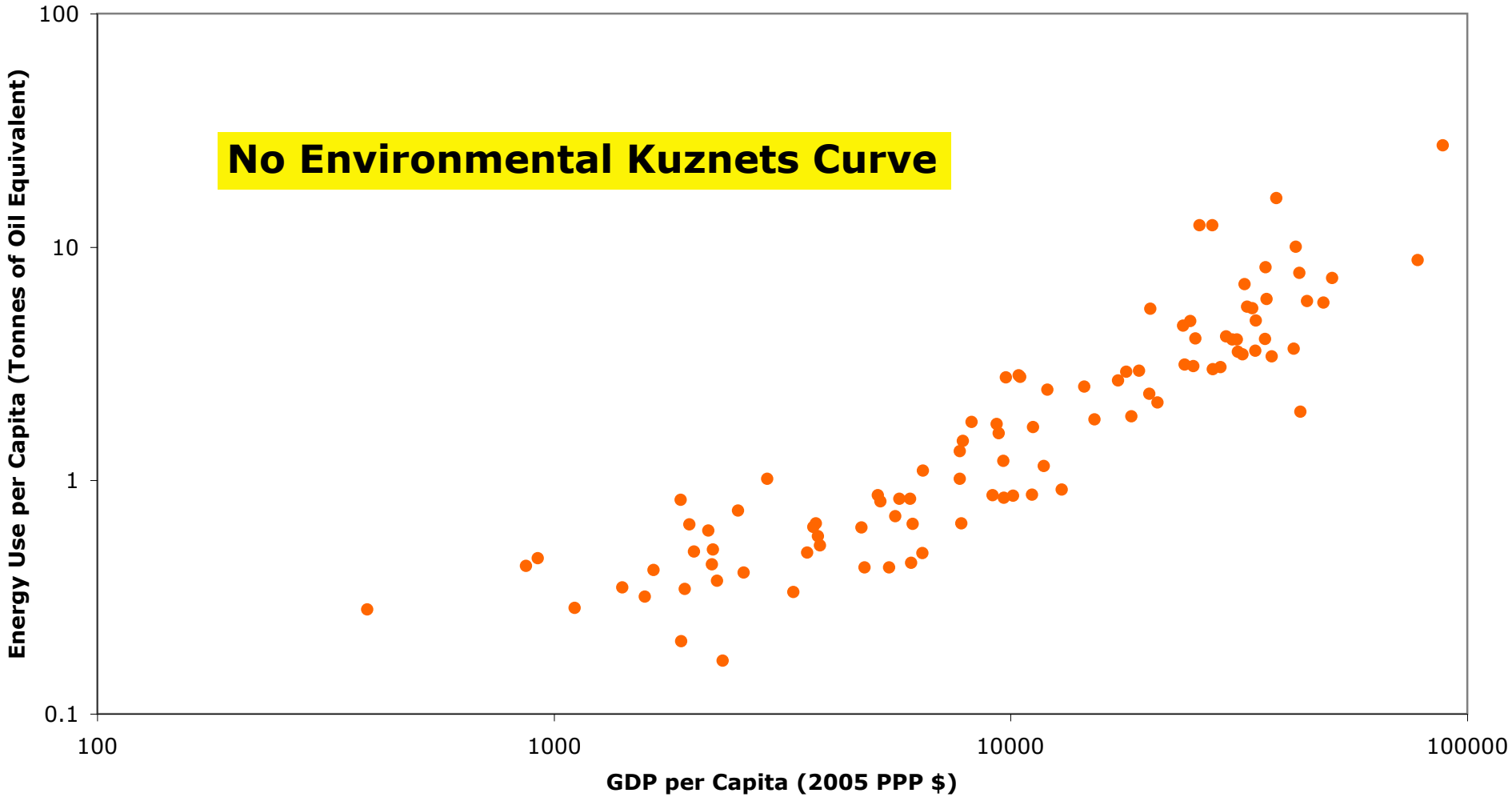
## Energy & Growth:

The Stylized Facts

# Energy and Income per Capita 2007



# Energy and Income per Capita 2007



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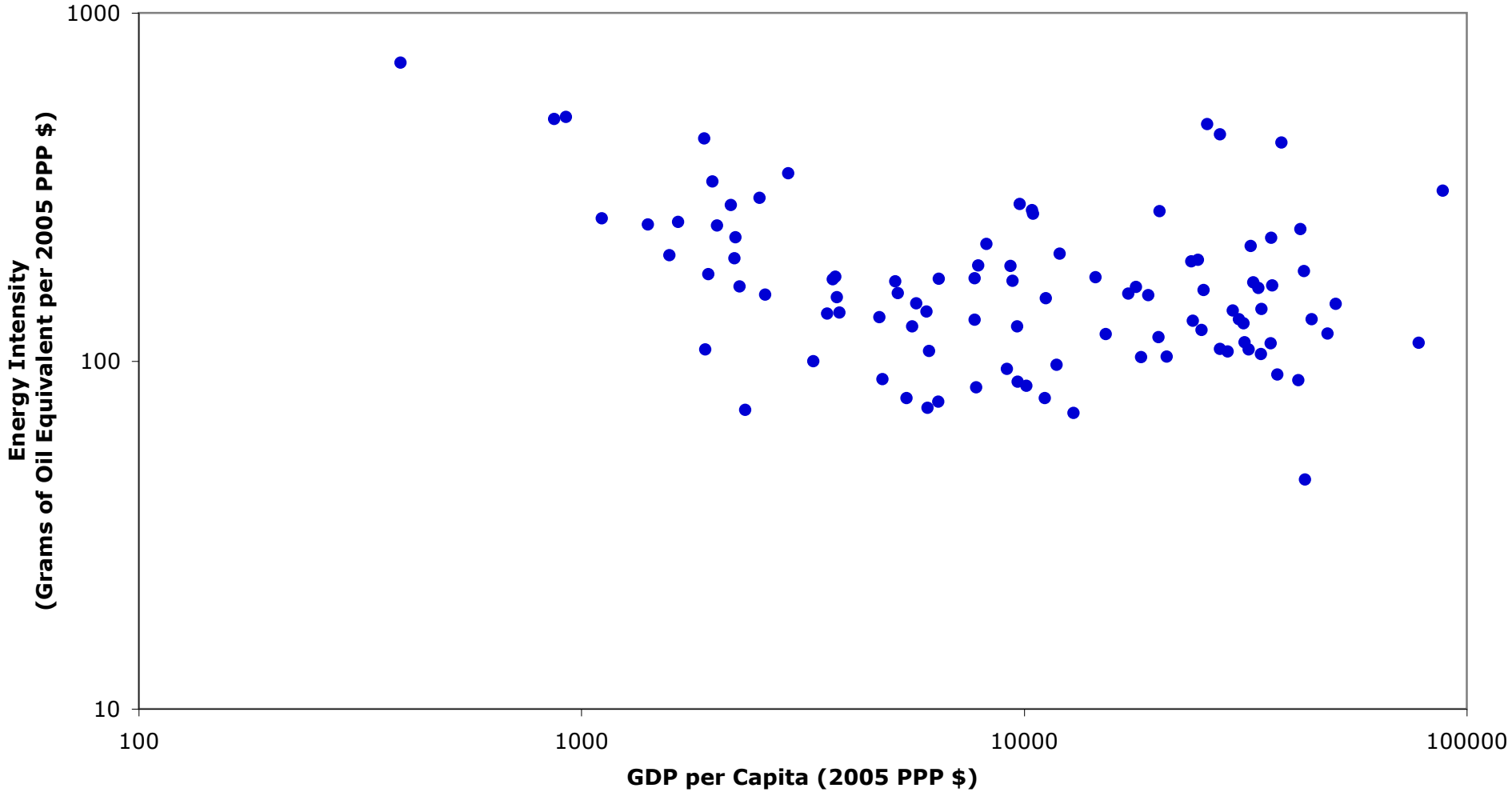
# Energy intensity is not correlated with GDP per capita

## Energy & Growth:

The Stylized Facts

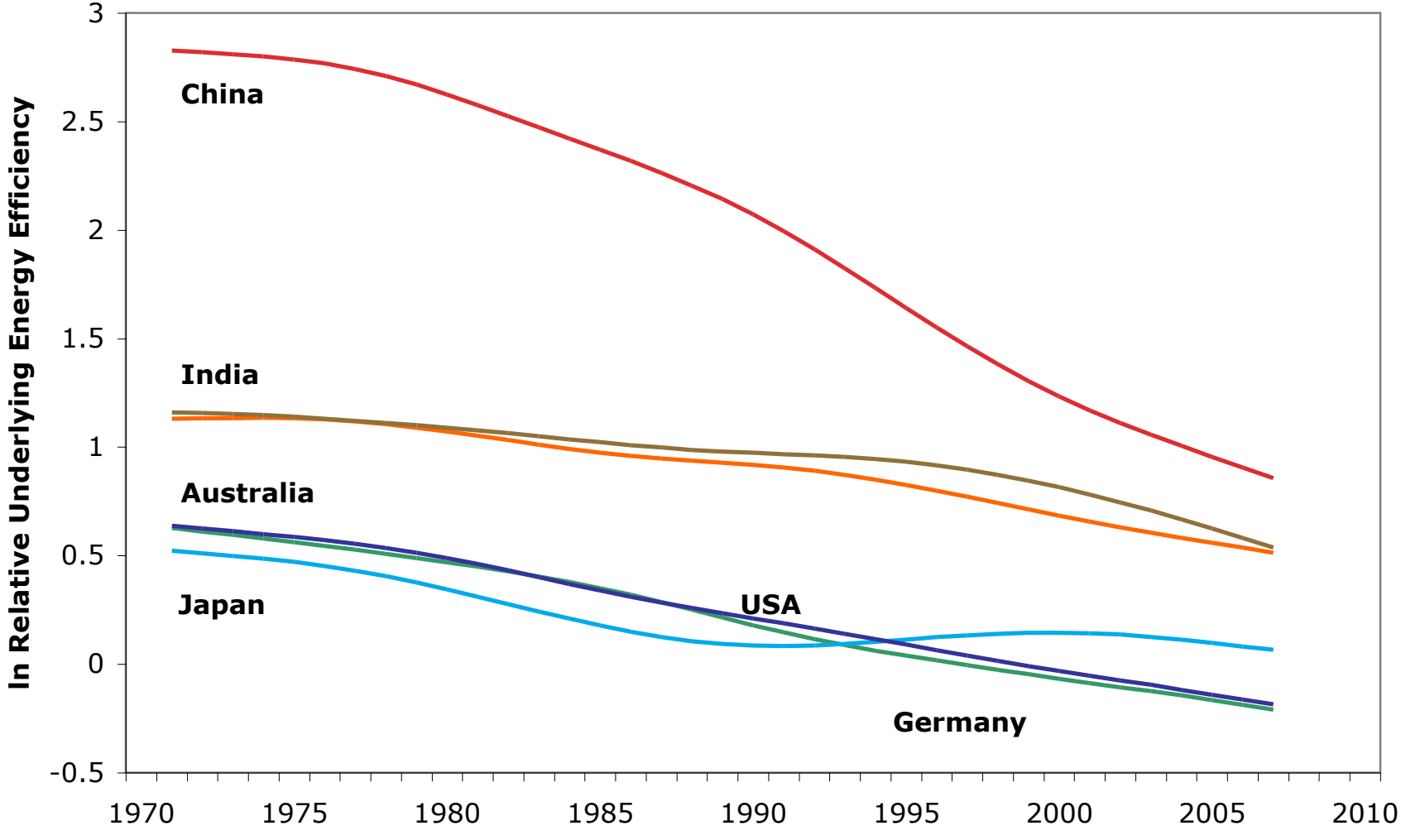
# Energy Intensity & GDP per Capita 2007



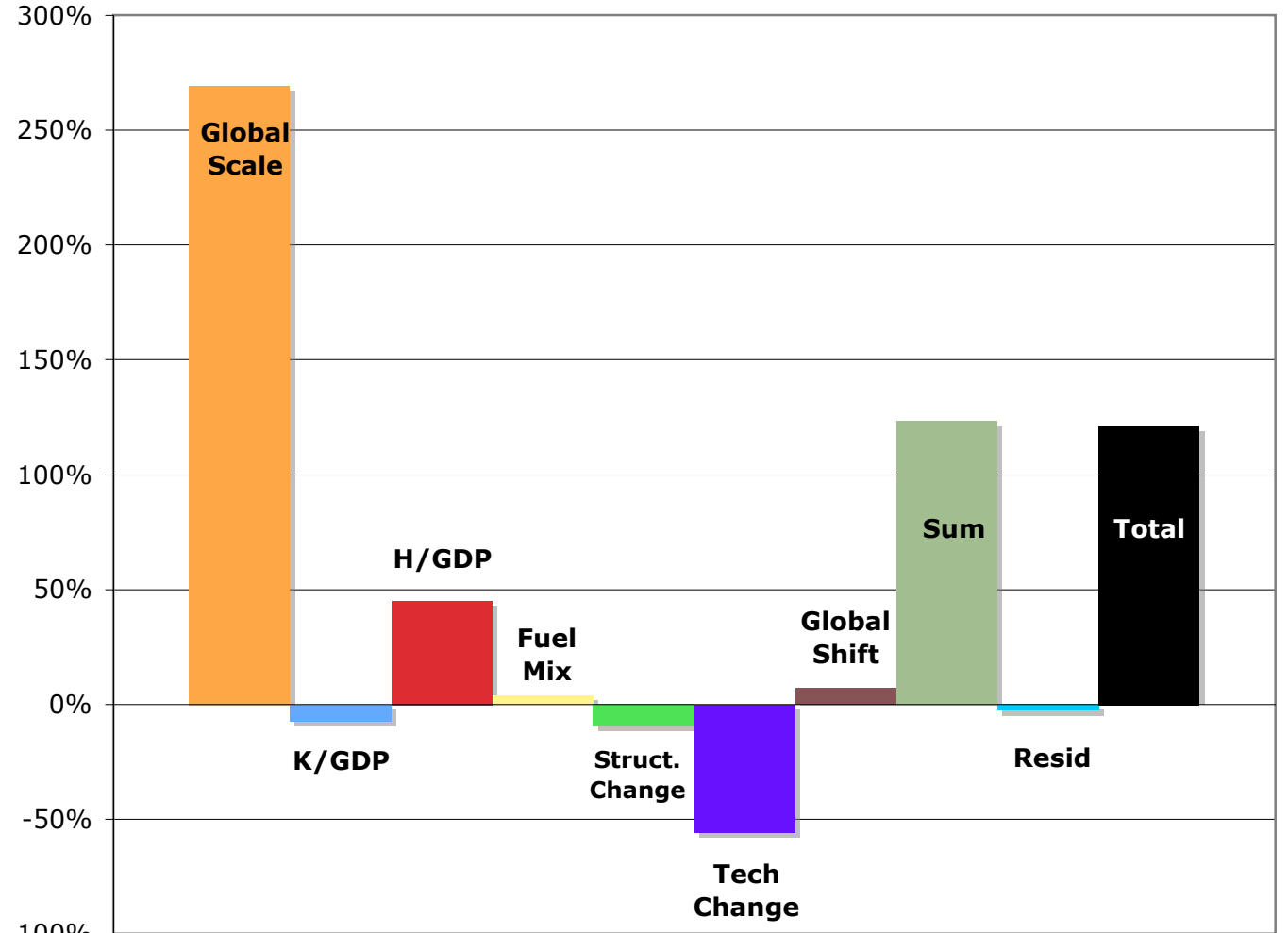
## Key Variables (2007): Australia & Other Countries

| | Winter Temp | Mining & Utilities | Coal | TFP | PPP | Fossil Reserves / GDP |
|---|---|---|---|---|---|---|
| Australia | 15.2 | 10% | 44% | 0.88 | 1.15 | 55.87 |
| Canada | -20.4 | 10% | 11% | 0.85 | 1.11 | 26.06 |
| China | -5.8 | 14% | 66% | 0.39 | 0.32 | 7.40 |
| Germany | 0.2 | 2% | 26% | 0.84 | 1.21 | 1.06 |
| India | 17.1 | 5% | 41% | 0.36 | 0.25 | 10.27 |
| Japan | 0.8 | 3% | 22% | 0.77 | 1.07 | 0.07 |
| UK | 3.4 | 4% | 18% | 0.98 | 1.33 | 0.68 |
| USA | -2.7 | 4% | 24% | 1 | 1 | 10.02 |

# Underlying Energy Efficiency: Chindia & Developed Economies



# Decomposition of Increase in Global Energy Use, 1971-2007



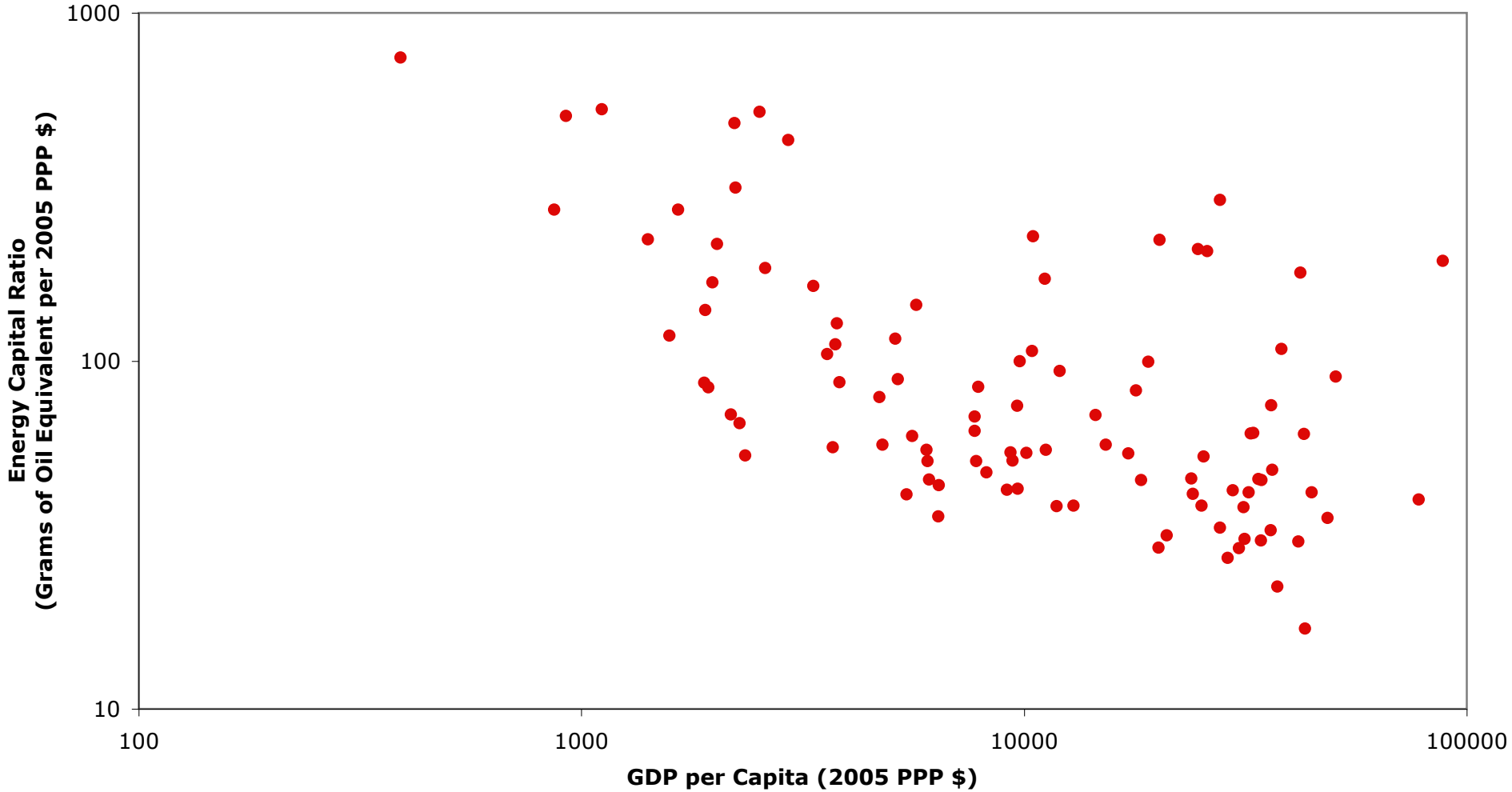
# 4

# Energy/capital is negatively correlated with GDP per capita

## Energy & Growth:

The Stylized Facts

# Energy Capital Ratio & GDP per Capita 2007



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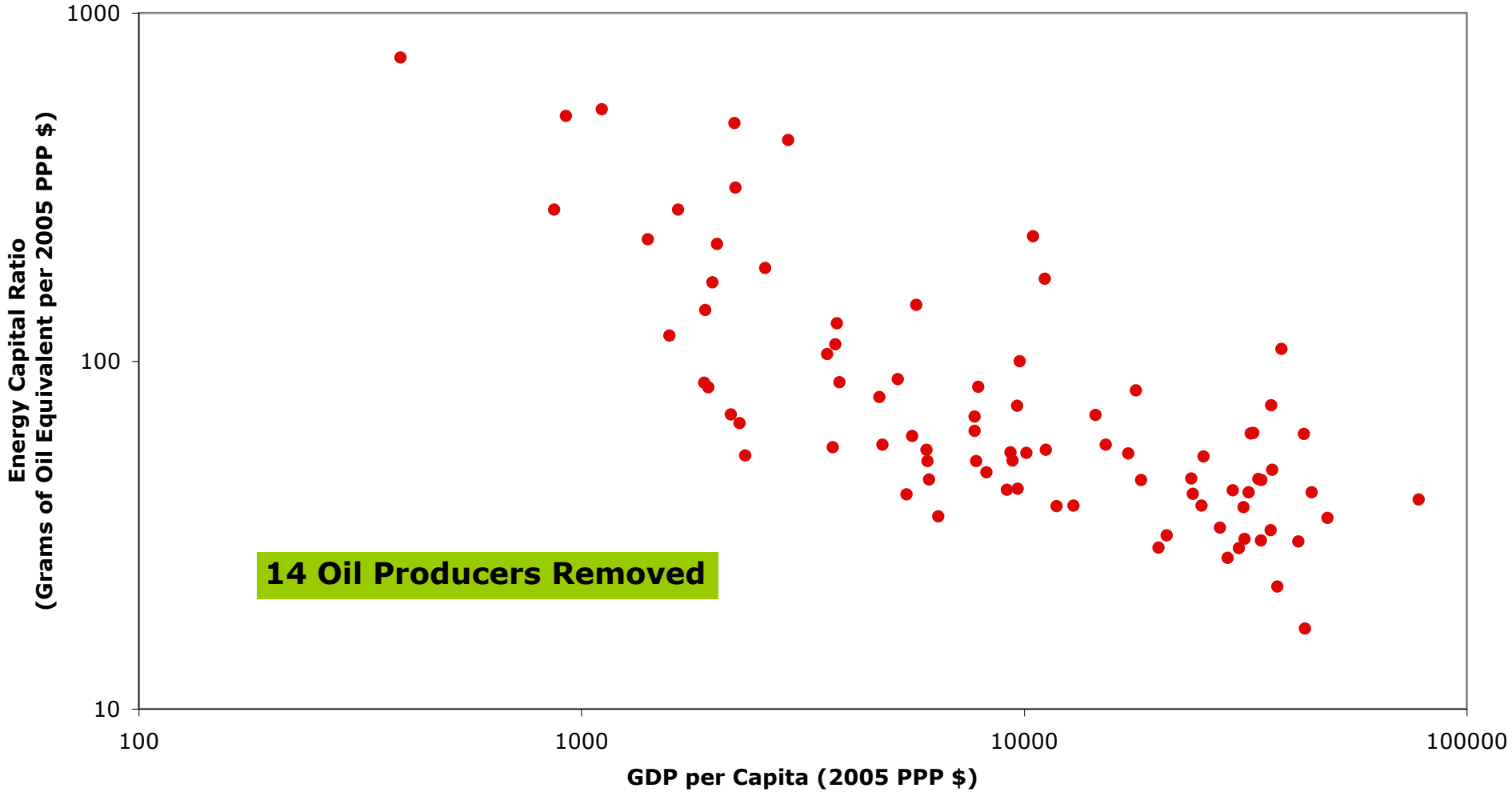
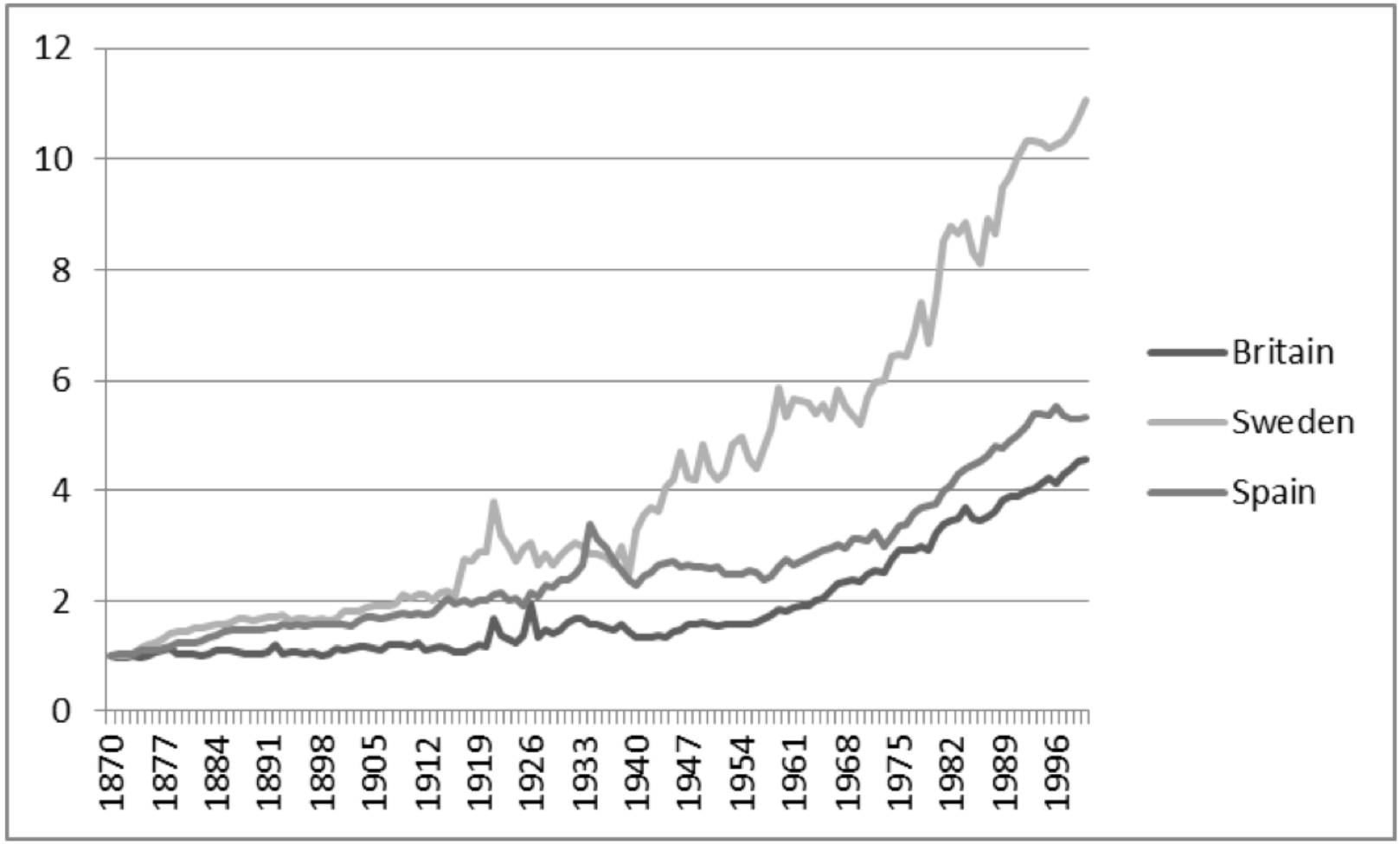


# Capital/Energy Ratio in the Long Run




Source: Kander (in press)

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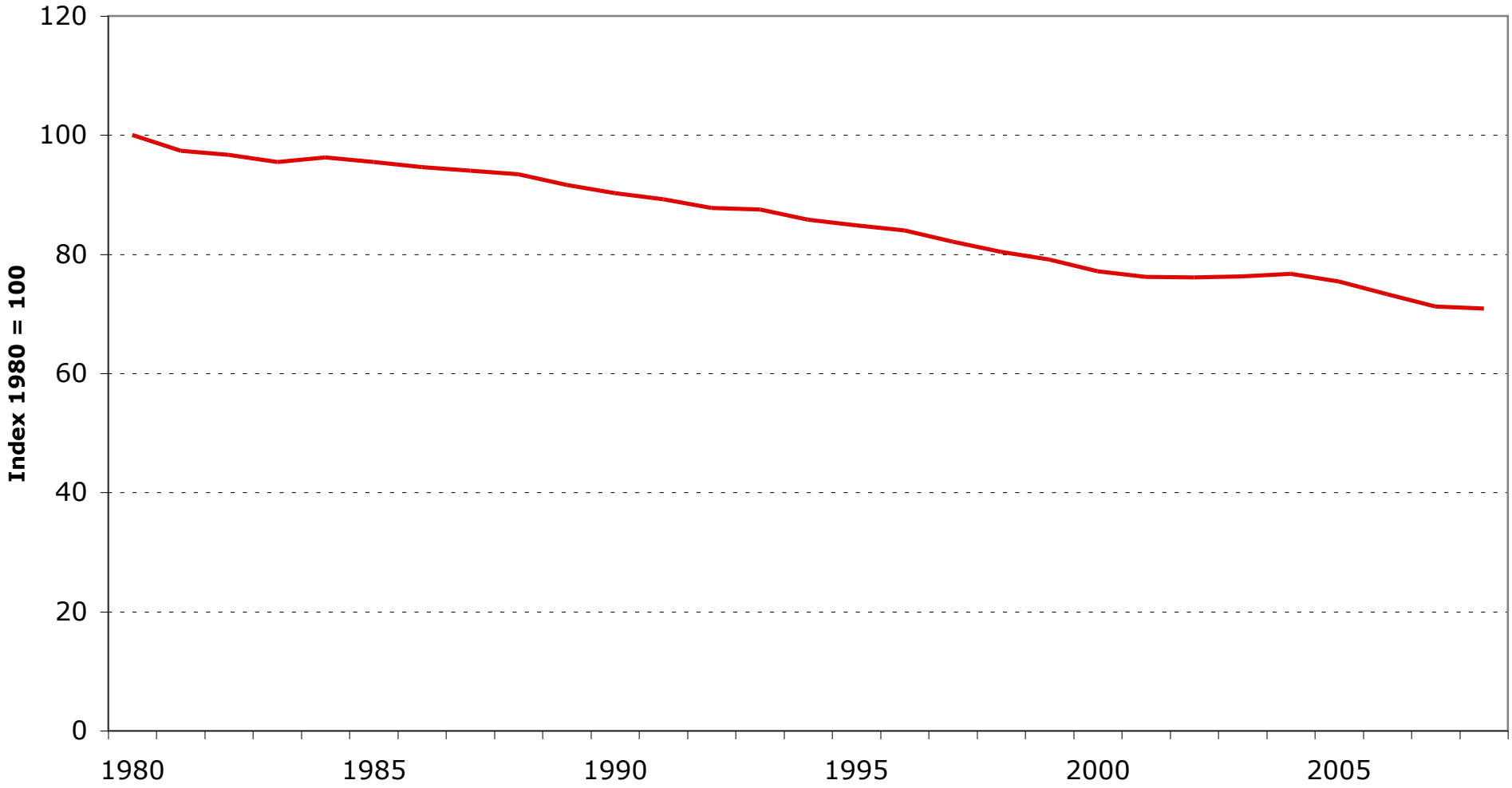
# Energy intensity declines over time

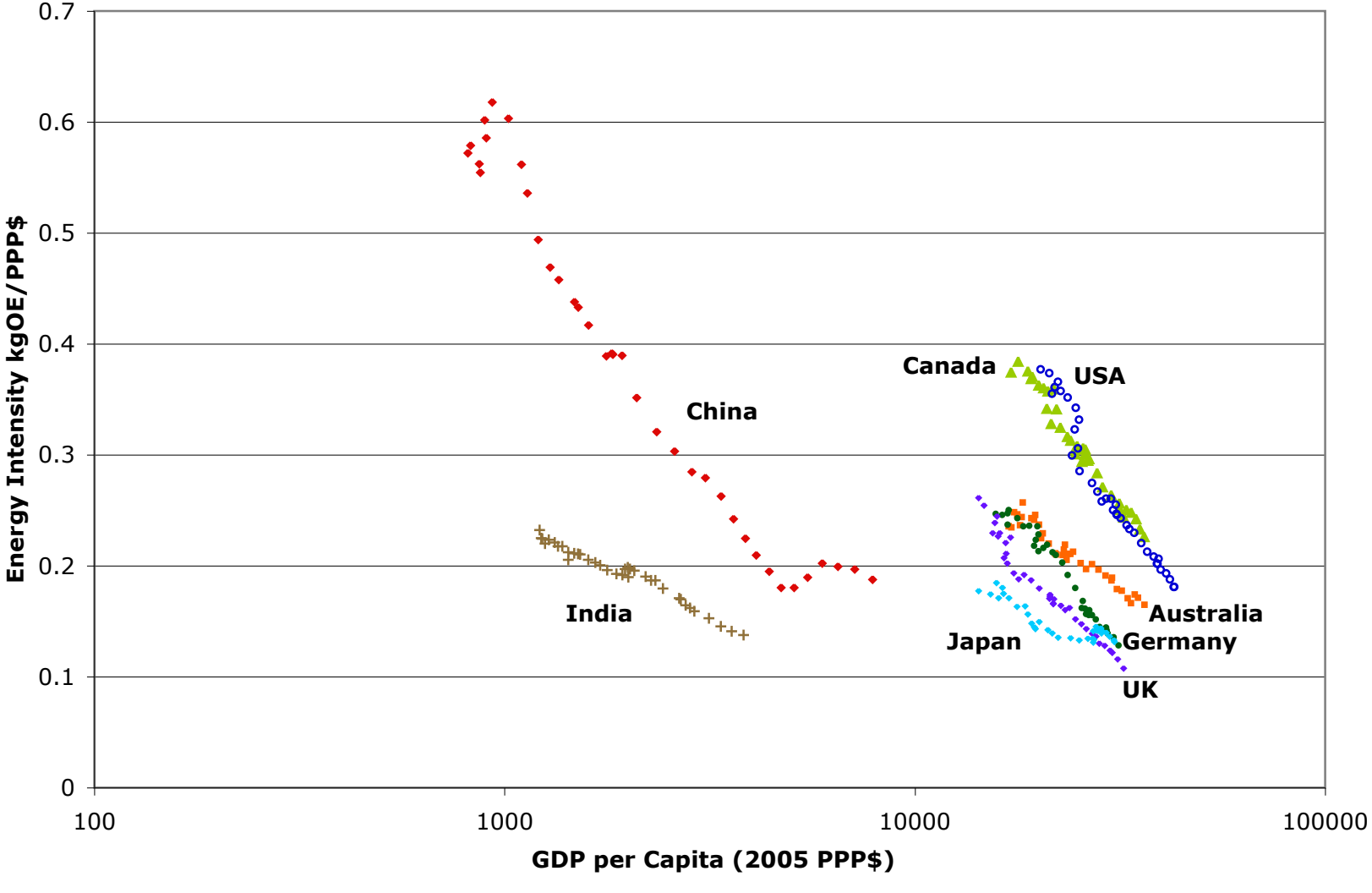
## Energy & Growth:

The Stylized Facts

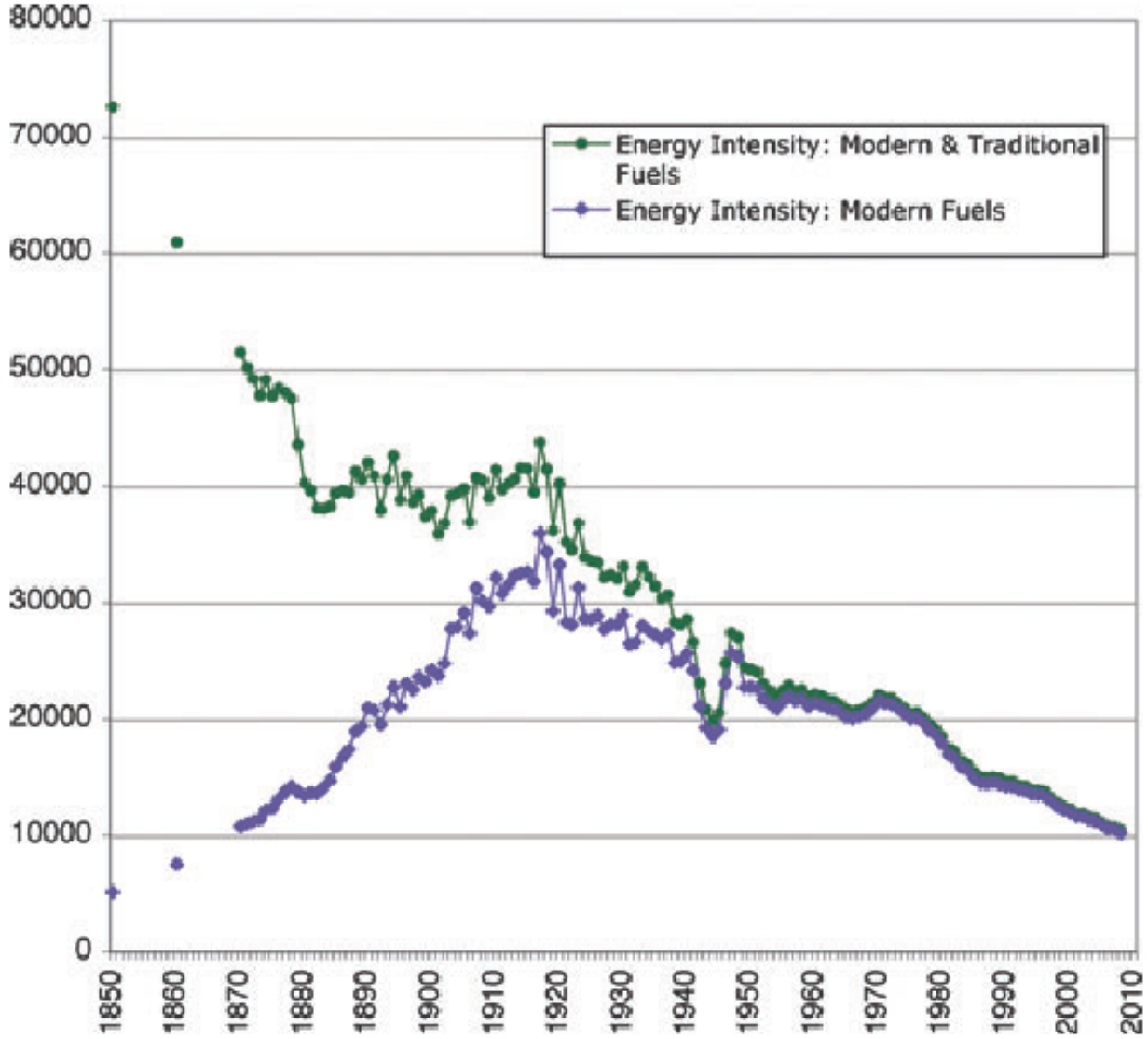
# World Energy Intensity



# Energy Intensity & GDP per Capita



# U.S. Energy Intensity 1850-2008



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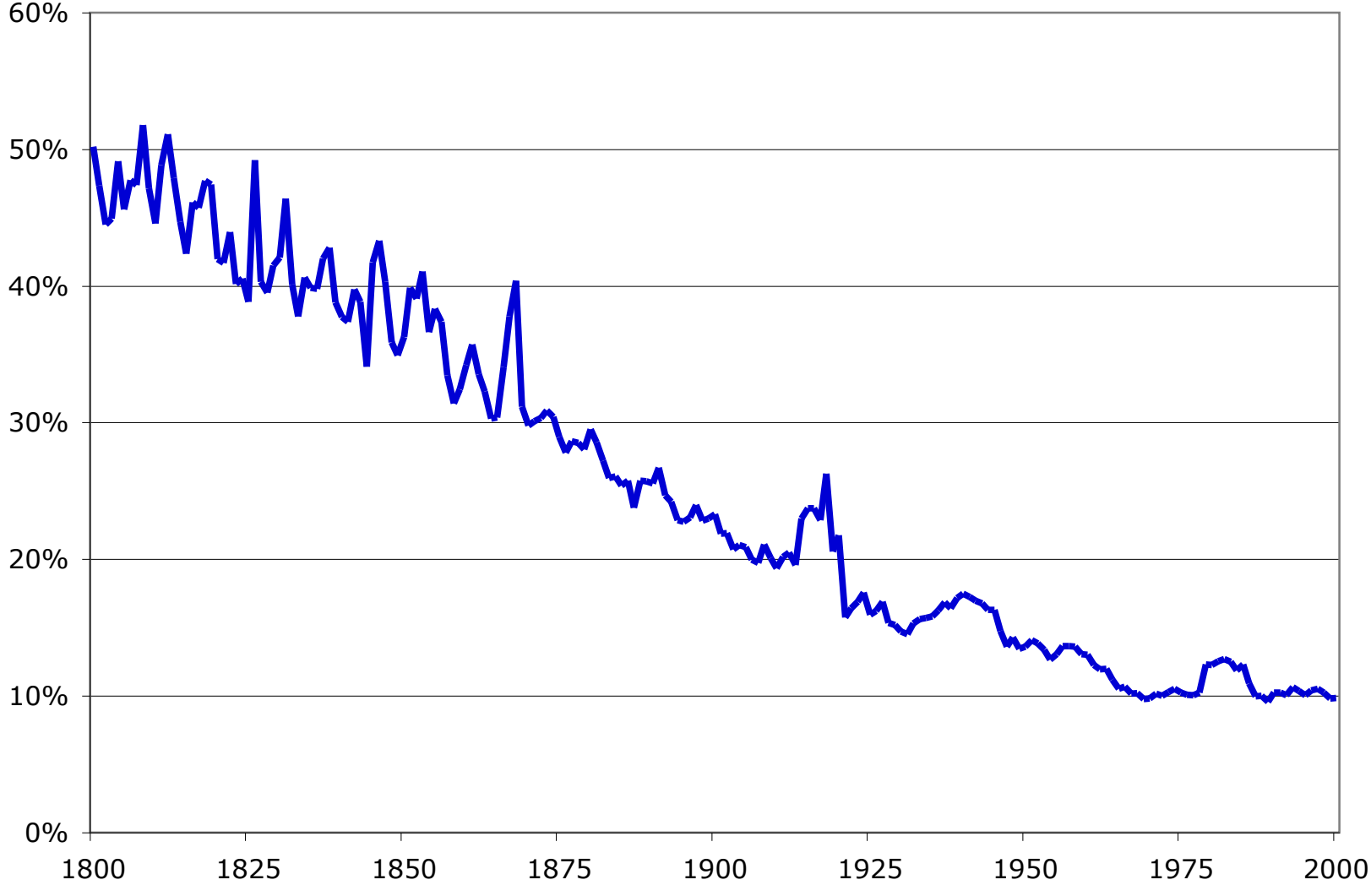
# The energy cost share declines over time

## Energy & Growth:

The Stylized Facts

# Sweden 1800-2000 Cost Share of Energy



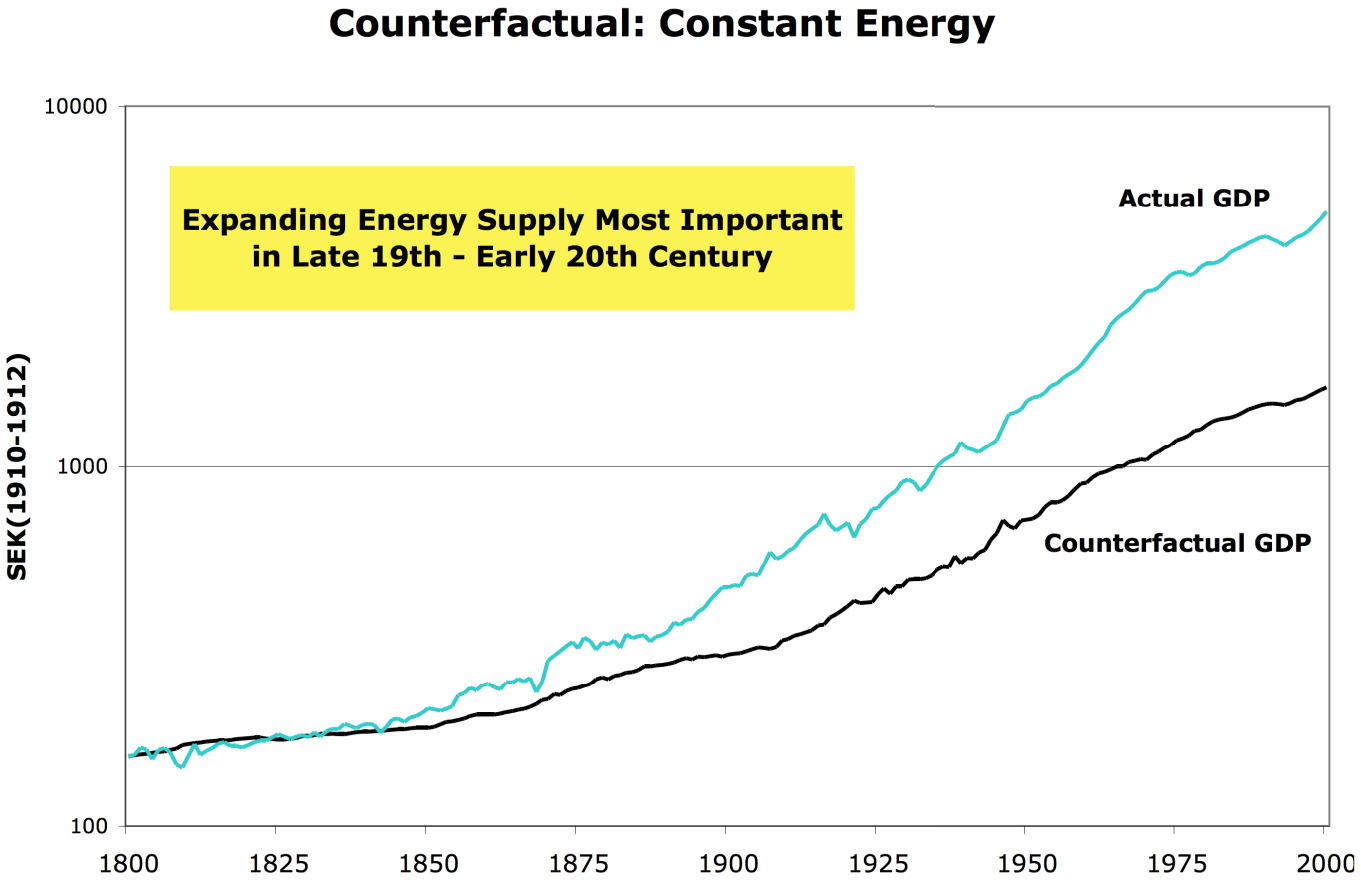
# Energy and Long-Run Economic Growth

Lund U.

Astrid Kander

Kerstin Enflo

- 200 years of Swedish energy and economic data
- Econometric economic growth model
- Counterfactual simulation and growth accounting



# Energy & Capital-Labour CES Production Function

$$Y = \left[ (1-\gamma)(A_L^{\beta} L^{\beta} K^{1-\beta})^{\frac{\sigma-1}{\sigma}} + \gamma (A_E Q E)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

$Y$ = Gross output

$L$ = Labour

$K$ = Capital

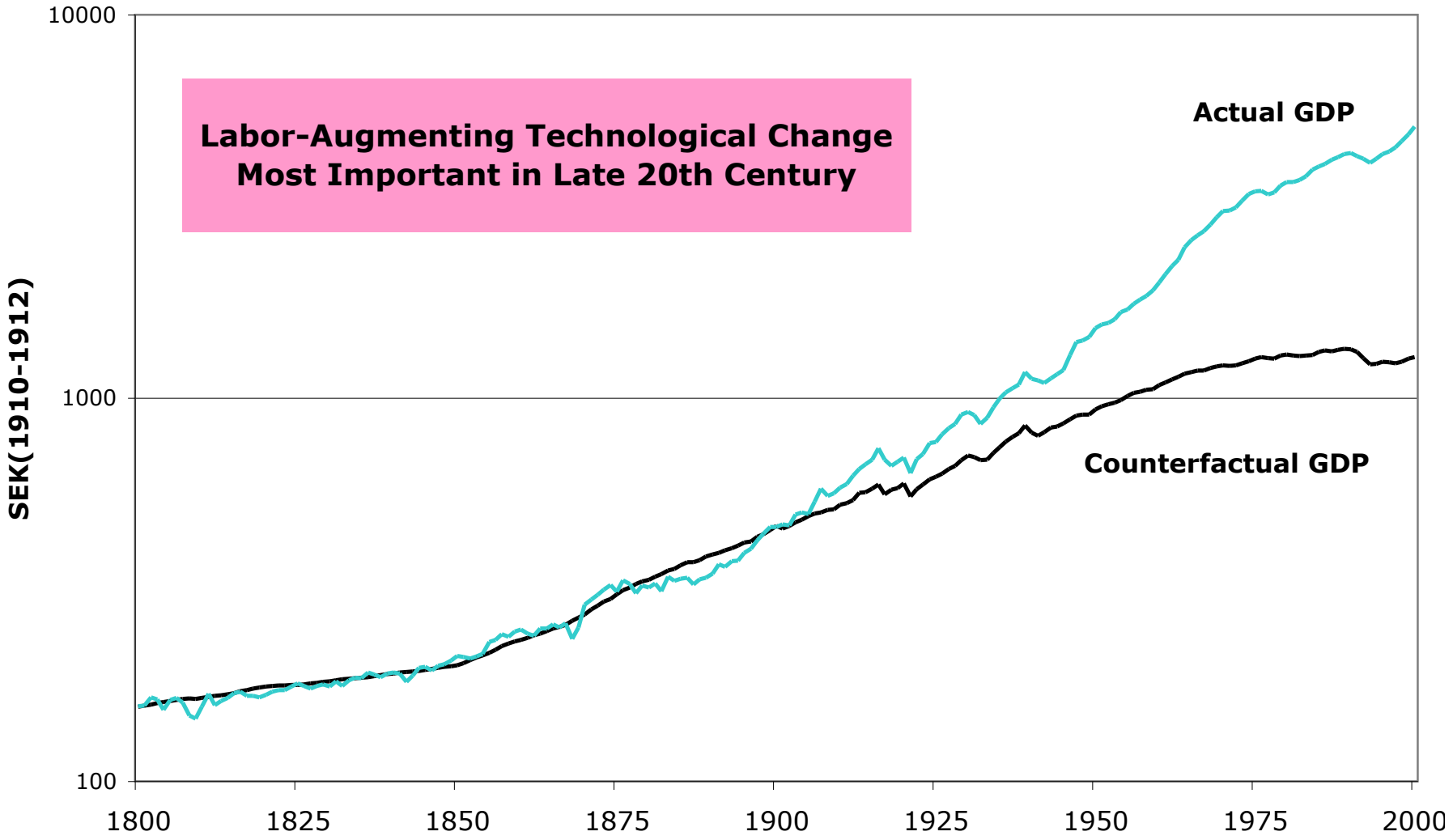
$E$ = Energy (Joules)

$Q$ = Energy quality

$A_L$ = Index of labour-augmenting technological change

$A_E$ = Index of energy-augmenting technological change

# Counterfactual: Constant Labor Technology



# Energy &Growth: The Stylized Facts

- Energy use per capita increases over time
- Energy use per capita increases with GDP per capita
- Energy intensity is not correlated with GDP per capita
- Energy/capital is negatively correlated with GDP per capita
- Energy intensity declines over time
- The energy cost share declines over time

# Kander's Stylized Facts

- Convergence to 3 in capital/GDP ratios
- Machinery increases more than capital and GDP
- Useful work/GDP follows inverted U
- Energy/capital falls over time
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- Energy quality increases over time
- **Energy intensity falls and converges**

# More information:

http://stochastictrend.blogspot.com

http://www.sterndavidi.com