

Sustainable Transportation Energy Pathways (STEPS)

STEPS Lookback Analysis

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STEPS Lookback Workshop

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Project Overview

Big body of work

Many potential entrypoints

Objectives, methods, etc. for models and lookbacks

- Scenario types "forecasts," "predictions," "projections," "storylines," "policy what-ifs," "how-to-hit-targets"
- Entrypoints outputs, scenario choice, input data (baseline data, embedded assumptions, behavioral parameters/elasticities), model structures

Institutional angle

What can we add? Seek to…

- **add clarity to communications on what {STEPS} models say**
- **derive lessons for improvement in light of real-world experience**

Develop typology

- Step 1…
  - Learn from existing retrospective analyses (**literature**, in and outside STEPS
  - Scope out and classify models (publications, in and outside STEPS)
- Step 2…
  - How can we use the past to understand and improve modelling efforts (given stated objectives)?*
  - Case studies within STEPS*
- MAVRIC research thread tie-in (modeling comparison & robustness)

Apply typology

Day Overview

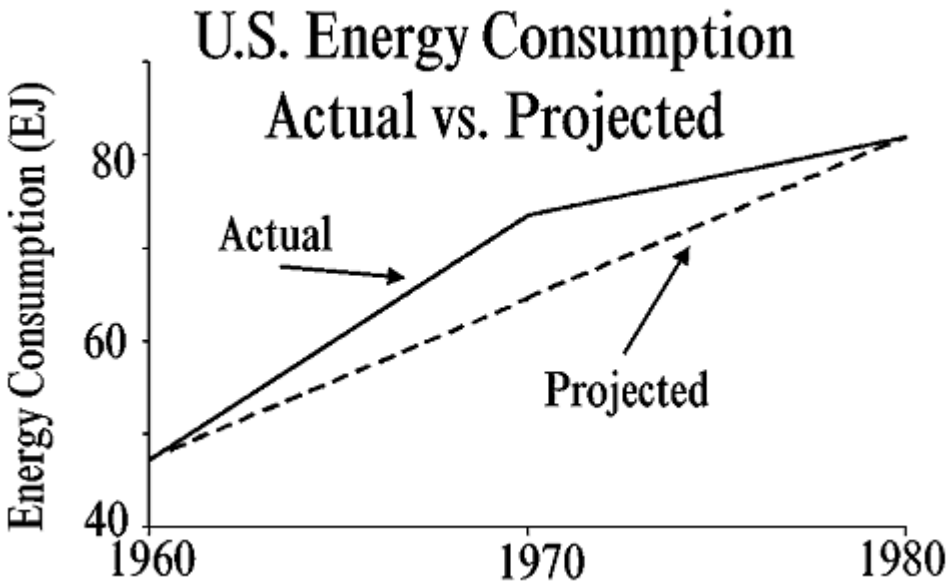
- **Can we learn from others' experiences with model evolution & retrospective analyses?**
  - **Motivation, approaches, insights** and shortcomings, usefulness and prospects
  - Different model developers, users, objectives **(academia, business, government, NGOs)**

- Modeling team examples gateway for participation, discussion
  - a.m. lightning round models, interests, concerns
  - p.m. deep dive model evolution, retrospective analysis or prospects
  - participant-focused post-its!, exchanges are priority
  - throughout & after feedback, filled-out templates

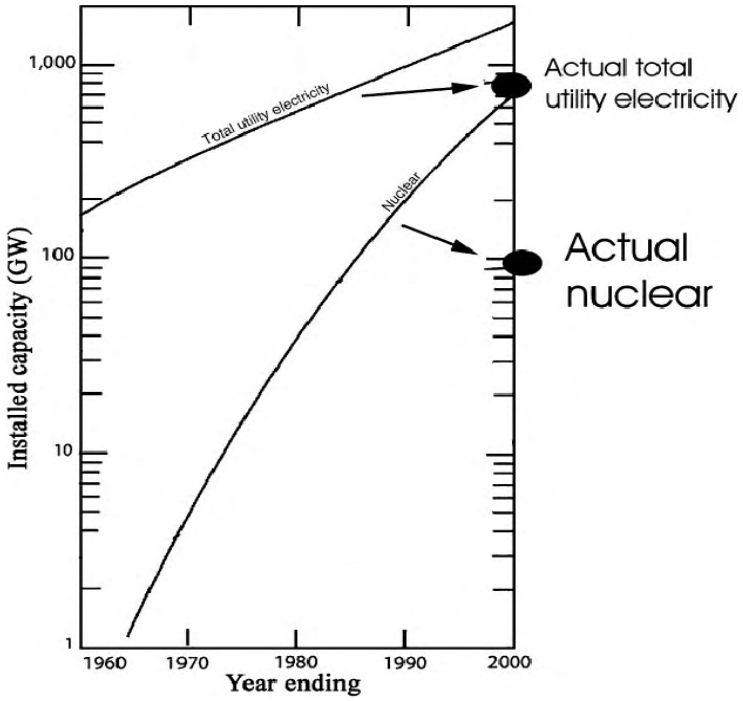
workshop report

reception

Retrospective Analysis – what is it?



Resources for the Future projection
(1960s , revisited 1980s)



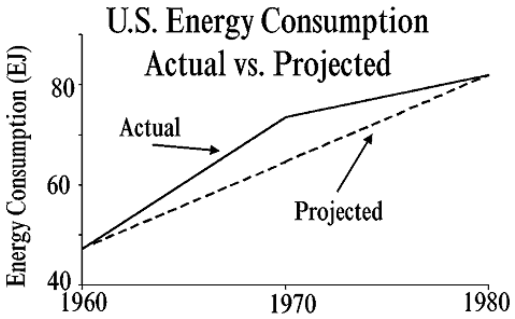
Atomic Energy Commission
(1963 report)

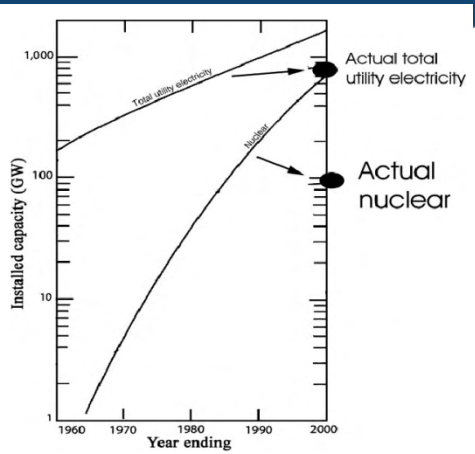
Source: *What can History Teach Us*?...
(Craig et al 2002)

Retrospective Analysis – what is it good for?

Why?

Source:
…Plea for Retrospective Analysis (Koomey et al. 2003)





- Make models more useful at functions…track info, communicate, educate, bound or limit outcomes, aid thinking and hypothesizing, sell ideas
- Reinforce modesty
- Reveal biases, embedded assumptions e.g., benevolent v. malevolent hiding hand (Flyvberg & Sunstein 2015)
  - for model developers
  - for model users (understand & constructively critique)
- Uncover, explain uncertainties

A Flavor of Retrospective Analysis

- **Magnitude of Error.** EIA retrospectives (since 1996, mean absolute percent errors for key variables, reference scenario)
  - AEO lags macro trends assumption drag
  - Energy intensity overestimated, due to GDP underestimate (pre-2000), energy consumption overestimate (post-1998)
- **Reality outside stated confidence intervals** (Shlyakhter et al. 1994)
- **Decomposing errors**
  - Visible error = baseline + trend + variability (O'Neill & Desai 2005)
  - Directional consistency in errors by sector, time horizon (Fischer et al. 2009)
- **Explaining error**
  - EIA's "asymmetric loss function" – as if cost 7 times higher to under- than overpredict energy intensity; "black box" GDP projections (Auffhammer 2007)
  - model inputs & structure by sector (Wilkerson et al. 2012)
  - backcasting runs to isolate impact of particular elements/modules (Huntington 1994)

Retrospectives - Topic Overview

- **Motivations**
- **Uses**

- Develop, evolve model
- Identify limits, domain
- Better understand, communicate
  - possible, actual, out-of-bounds
  - constructive feedback possible?*

*step-by-step improvement, blind spots**

- **Targets**

- Single component *outputs, inputs, scenarios, or structure*
- Single modeling effort *may involve multiple models*
- Single Topic *multiple modeling efforts*

- **Methods**

- "Error" analyses *define, measure error; describe or explain*

- **Insights/Drawbacks**

- Theoretical *model evaluation under ideal conditions*
- Practical *team, resources ($, time), project motivation, model*

simple ⟷ complex

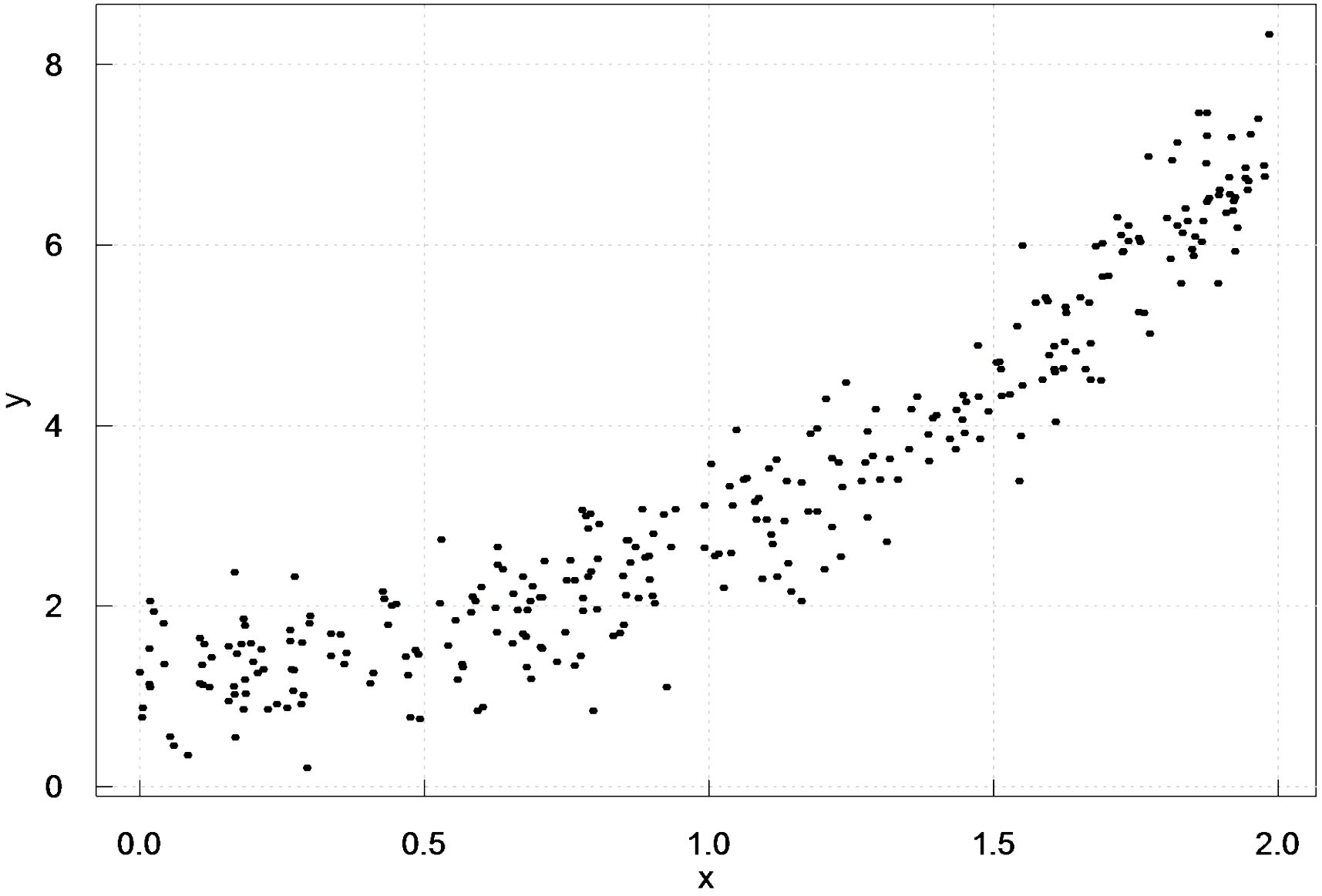
policy

Modeling overview

- **We consider three "categories" of approaches to forward-looking modeling from *What Can History Teach Us?...* (Craig, Gadgil, Koomey 2002):**
  - **Trend based models—using past data to inform the future**
  - **Systems based models—disaggregation of a system into definable sectors that can be modeled, e.g., from the bottom-up**
  - **Expert elicitation—integration of specialized knowledge in the industry/field**

Trend based models

- Incorporates any models relying on existing current/historical data to inform the future, e.g.
  - Straight line projections (bivariate)
  - Regression analysis (econometric approach, statistical predicted values)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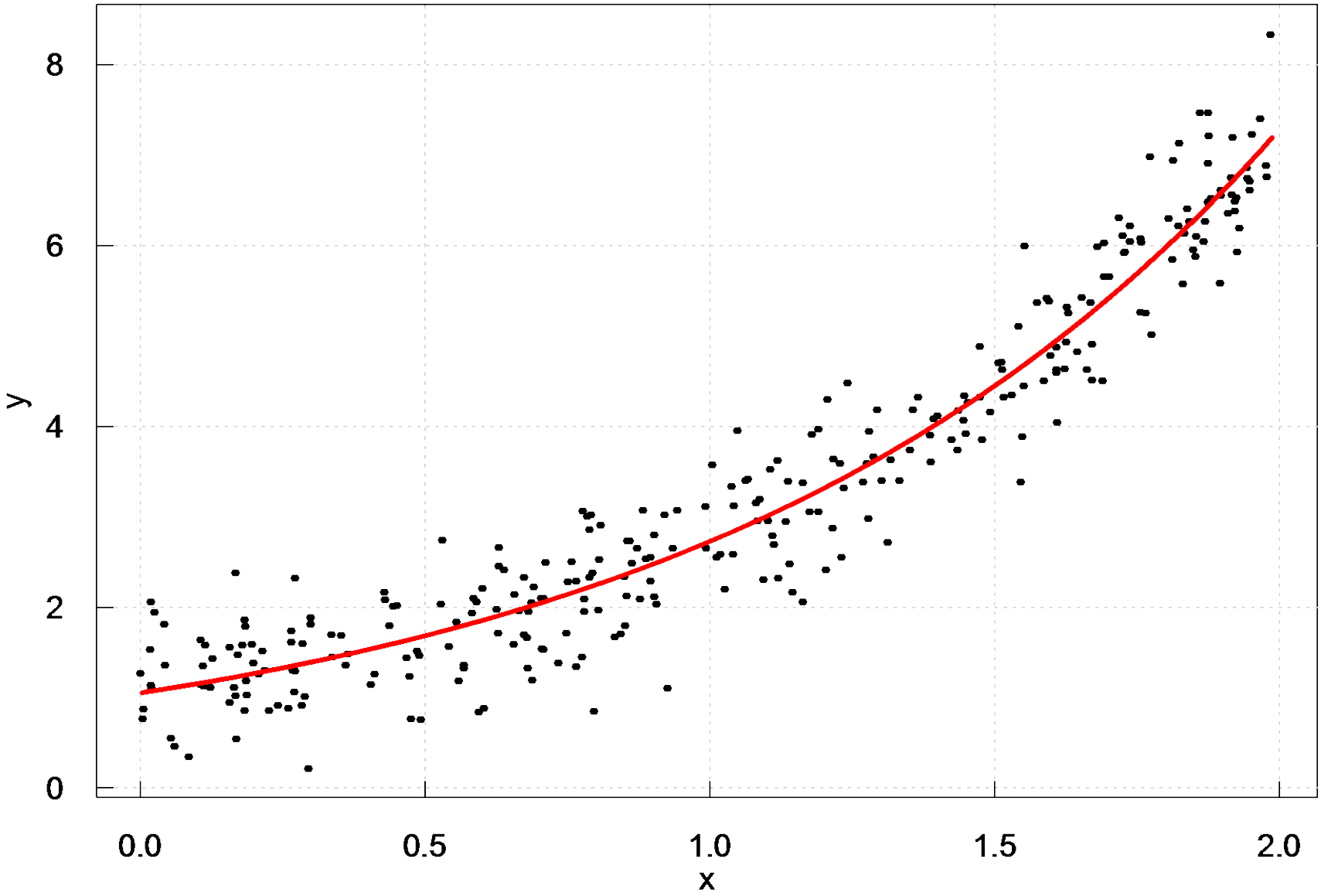
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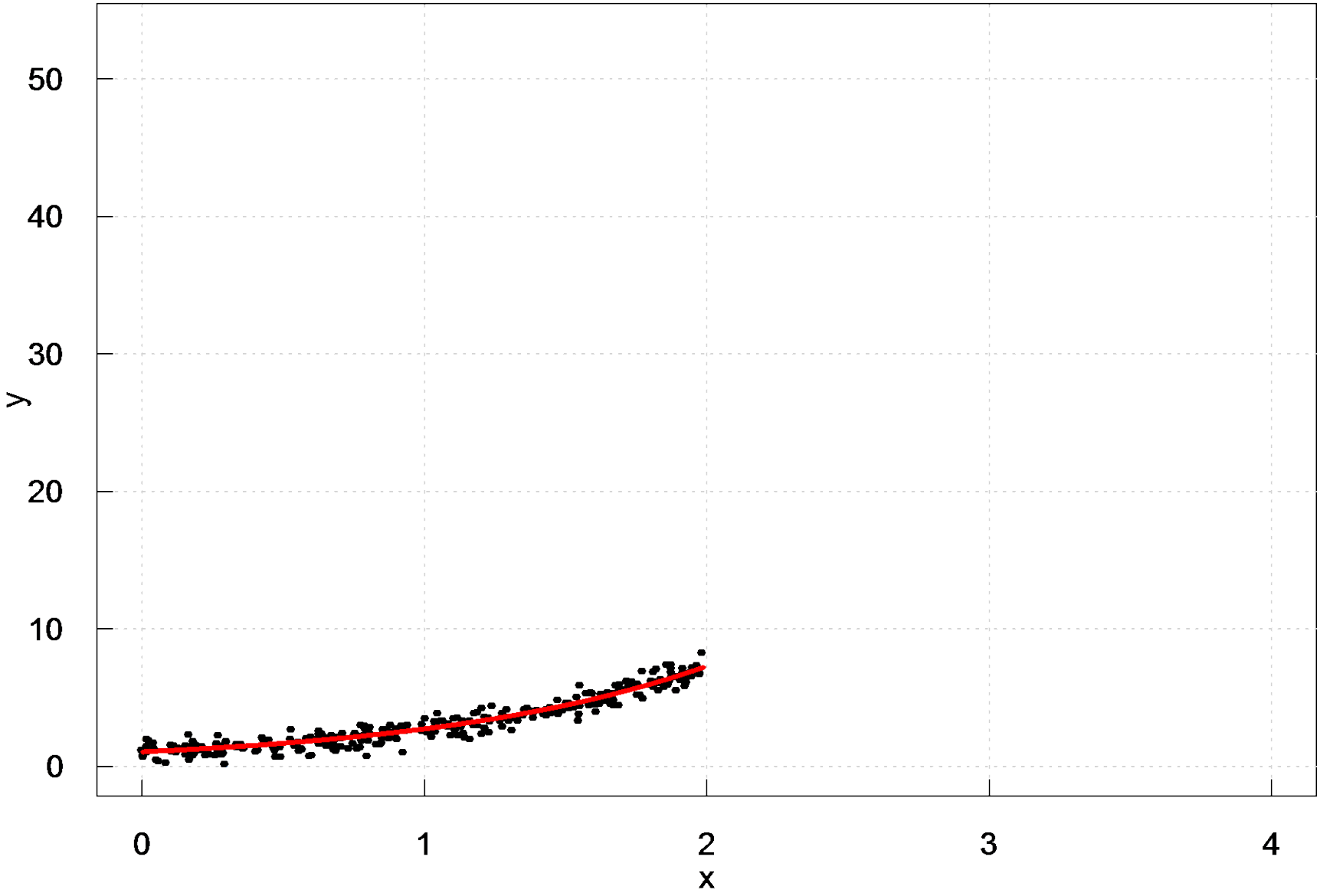
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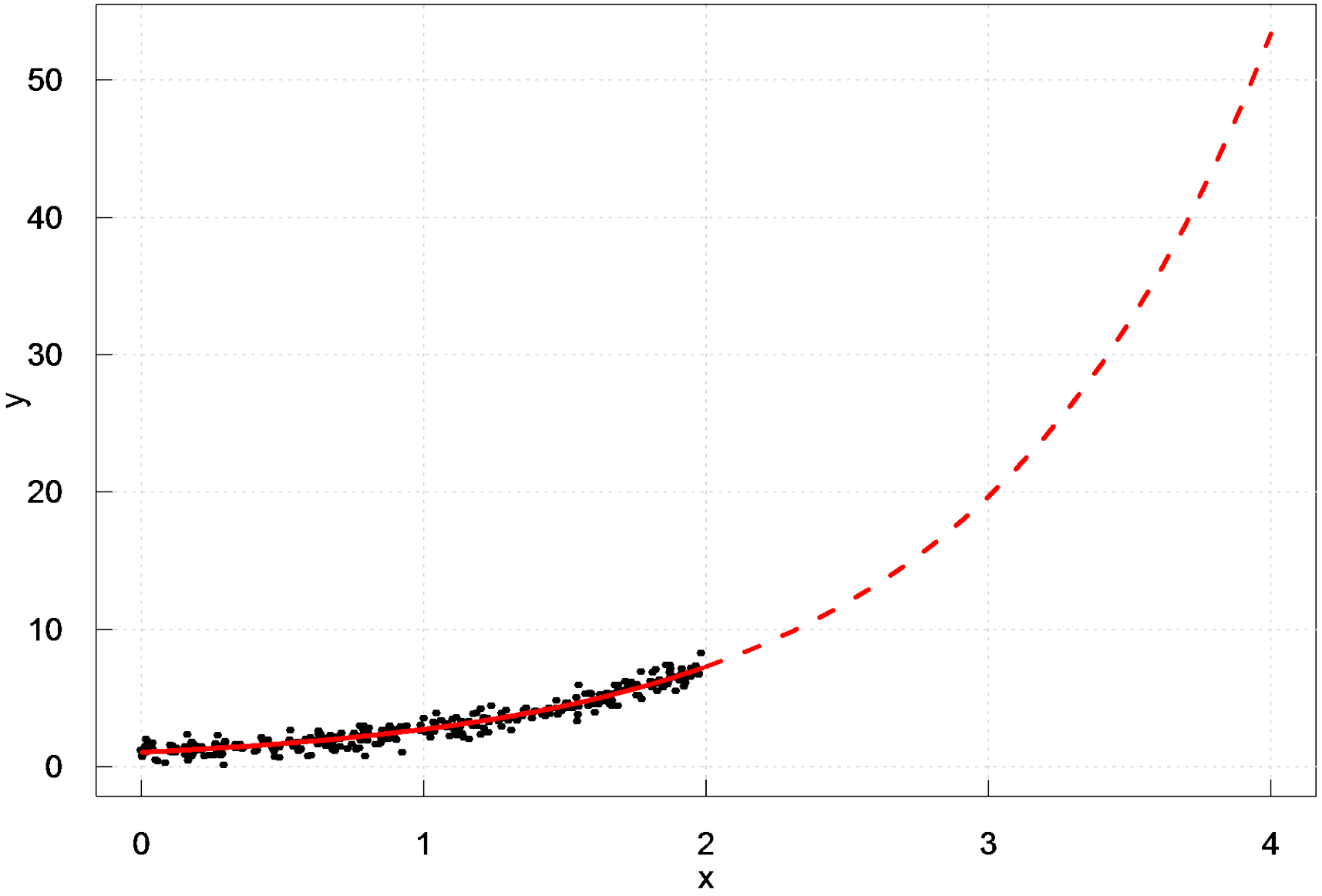
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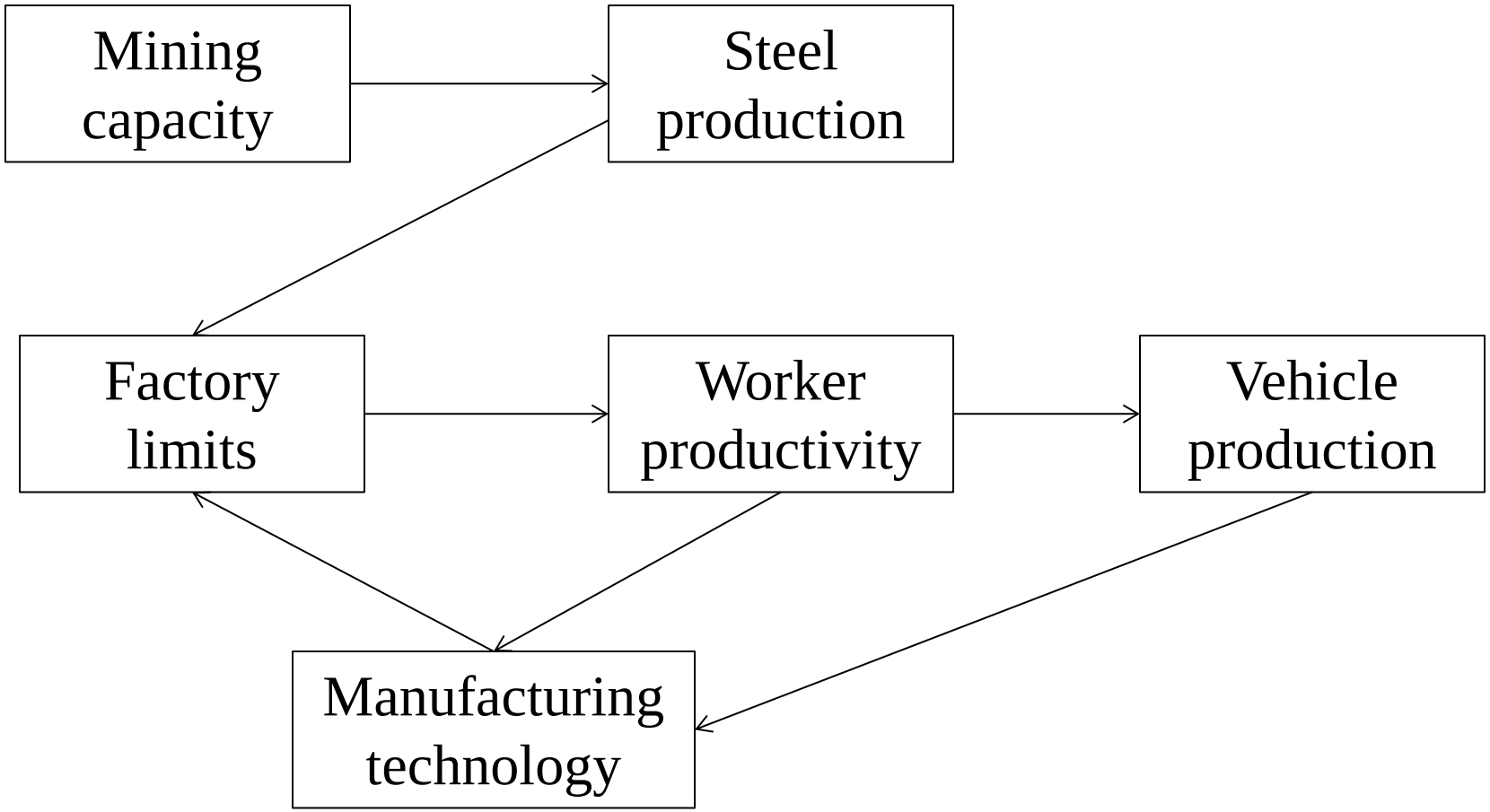
Systems based models

- "Bottom-up" approaches
  - Understanding components: how they work and how they interact
  - Often disaggregation to end-uses
  - Can incorporate actual physical limitations
- Economic models
- Engineering models
- Models with multiple modules (incorporating economic, engineering, other system dynamics)


Mining capacity
Steel production
Factory limits
Worker productivity
Vehicle production
Manufacturing technology

Expert elicitations

- **Aggregation of the opinions of authorities on specific subjects**
- **Encompasses knowledge that is not readily accessible / distillable via other methods**
- **Useful in unknown / non-existent systems**

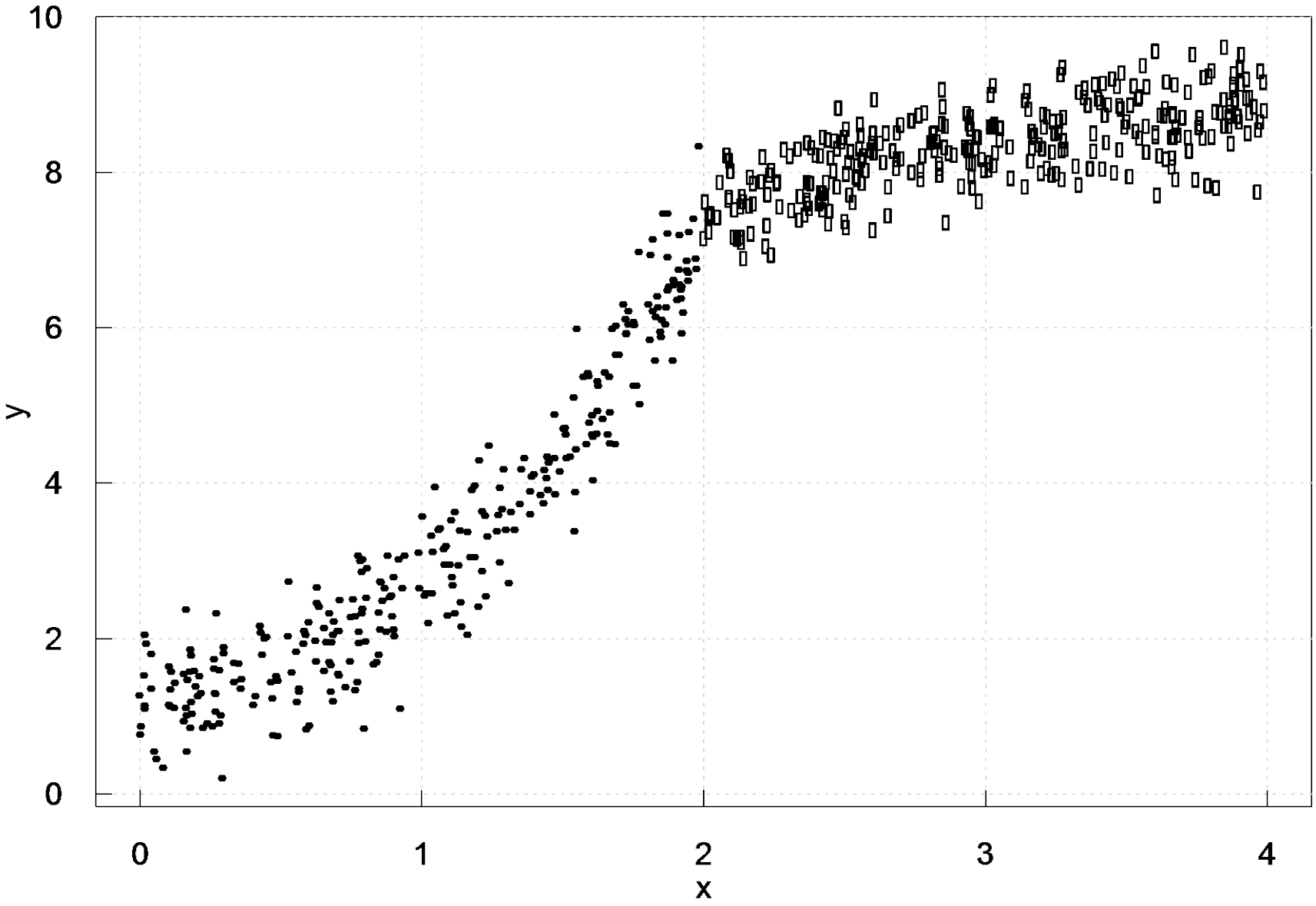
Note: three approaches are *not* mutually exclusive (combined approaches)

- **E.g., systems-based model *with* parameters from econometrics *&* expert knowledge**

Applying retrospective analysis

Retrospective techniques

- From *Long-Range Energy Modeling: A Plea for Historical Retrospectives* (Koomey et al. 2003):
  - Disentangle input data issues from modeling issues (e.g., baseline data, exogenous trends, behavioral parameters/elasticities *v.* model structure, scenario choice, model objective)
  - Use historical decomposition techniques
  - Document everything
  - Identify and assess discontinuities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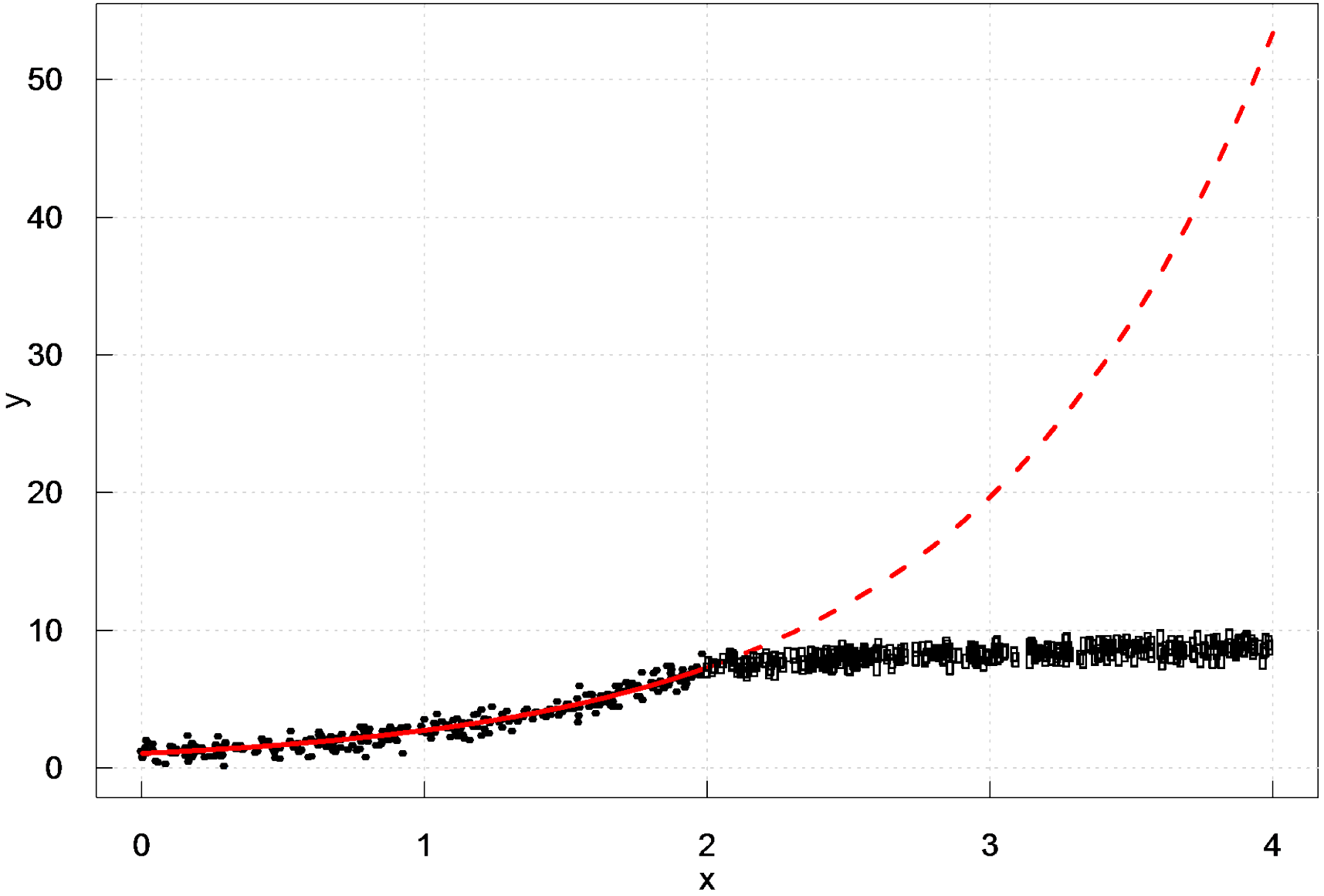
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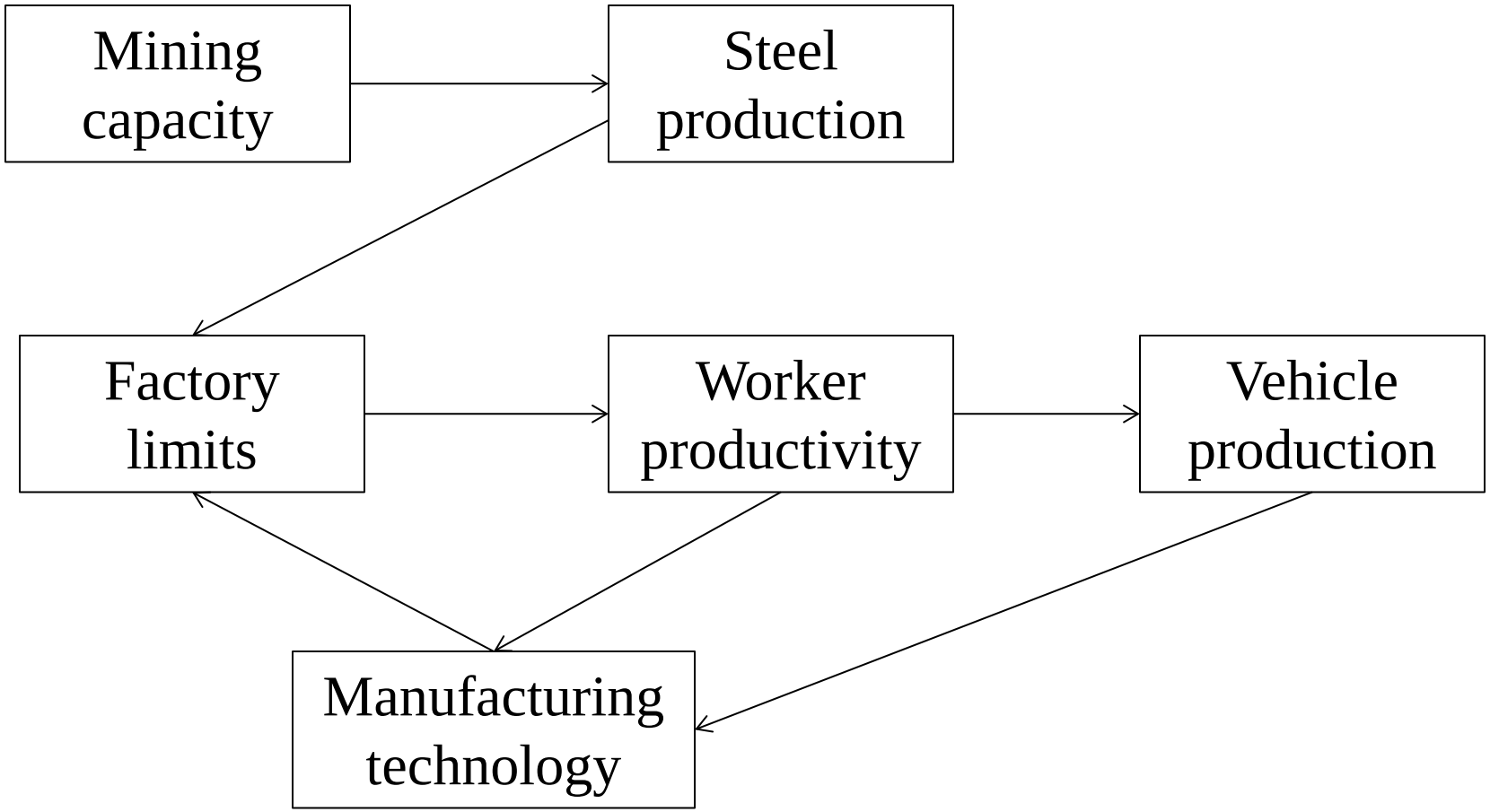
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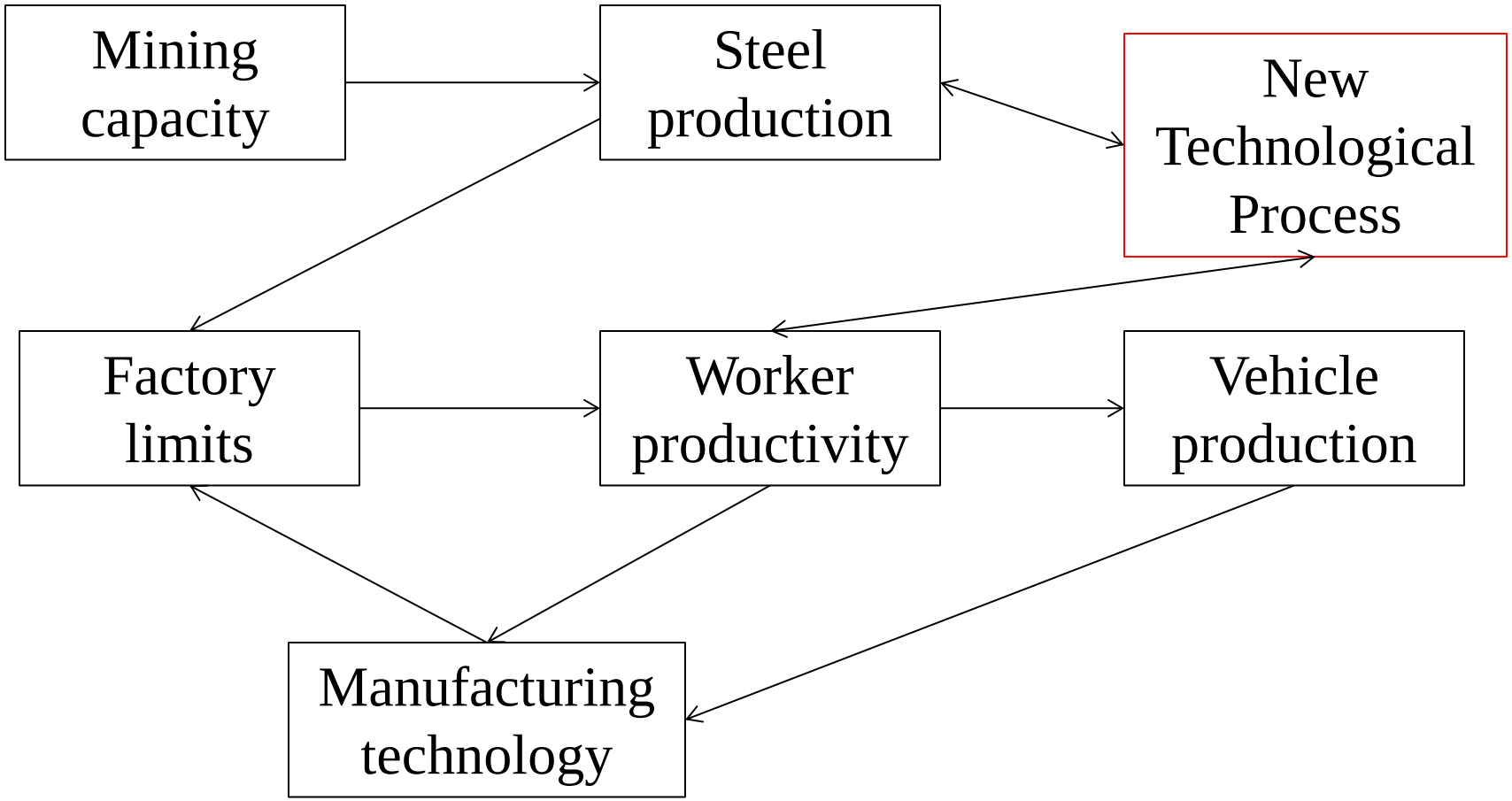
Mining capacity
Steel production
New Technological Process
Factory limits
Worker productivity
Vehicle production
Manufacturing technology

Potential Topics of Interest (entrypoints)

- Outcomes
- Inputs
- Structure
- Type (optimization, simulation, other)
- Purpose (predictive, policy analysis, etc.)
- Timeframe
- Uncertainty
- “Confidence Intervals”
- Scenario development

Lookback Analysis – Elements to consider

- Modeling system
  - simple/complex (implications for analysis, communications)
  - spatial issues
  - role in less-quantitative models
- Practicalities
  - model available or not
  - resources (team, time)
  - model longevity and 'update' frequency
- Motivations & Methods
  - Mistakes, small improvements v. blindspots
  - role for model comparisons
  - policy (for scenarios, to inform)
    - rising profile of policy lookbacks

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  - policy (in scenario development, potential use of output, rising profile of retrospective analysis of policy – including ex ante impact analysis)