What inventions are we missing?

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What inventions are we missing?

Example: Why don't we yet have a cure for Alzheimer's disease?

- Common characterization: Basic science is challenging
- Economic perspective:
  - Available scientific opportunities may reflect past research investments
  - Potential role for gov't policies – e.g. patents – to impact innovation

Motivation

- Over last five years, eight new drugs approved to treat lung cancer
- All eight were approved based on evidence of incremental survival improvements in patients with most advanced form of the disease
  - Well-known example: Genentech's Avastin (10.3 vs. 12.3 months)
- In contrast, no drug has ever been approved to prevent lung cancer, and only six drugs have ever been approved to prevent *any* cancer

This paper

- While this pattern could solely reflect market demand or scientific challenges, in this paper we investigate an alternative hypothesis: private firms may (differentially) underinvest in long-term research
  - Late-stage cancer drugs can be brought to market comparatively quickly, relative to early-stage treatments or preventatives
    - ★ Key: Time required to show a statistically significant treatment effect
  - Excess impatience or patents may under-incentivize long-term research
- We document that such underinvestment is quantitatively significant in markets for cancer drugs, and analyze potential policy responses

Cancer markets as an empirical setting

Key empirical challenge: We do not observe the (counterfactual) commercialization lags of projects that are never developed

Two useful features of cancer markets:

1. Cancer treatment is organized around organ and stage, providing a natural categorization of both observed and potential R&D
2. For each group of cancer patients, we observe a good predictor of how long it would take to develop drugs for those patients: survival time
   - Key: observed even if no drugs have ever been developed

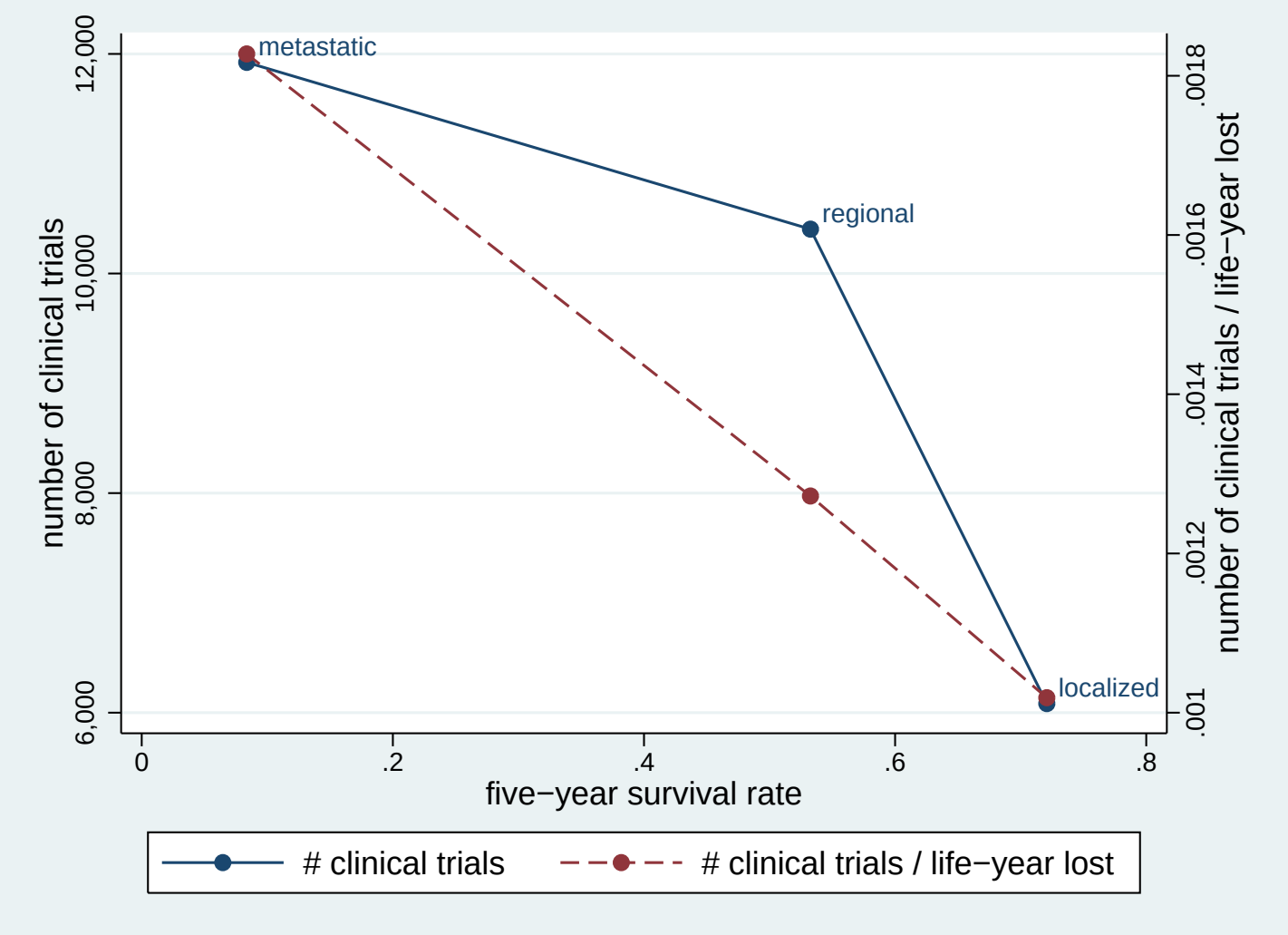
Two examples: Prostate cancer drugs

1. de Bono *et al.*: Metastatic patients (5-yr survival $\approx 20\%$)
   - Median follow-up time for measuring patient survival: 12.8 months
   - Trial length: 3 years
2. Jones *et al.*: Localized patients (5-yr survival $\approx 80\%$)
   - Median follow-up time for measuring patient survival: 9.1 years
   - Trial length: 18 years

Consistent with commercialization lags distorting private R&D incentives:

- Metastatic clinical trial funded by Cougar Biotechnology
- Localized clinical trial funded by US National Cancer Institute

Survival time and R&D investments: Stage-level data



Notes: See Figure 1(a) in paper.

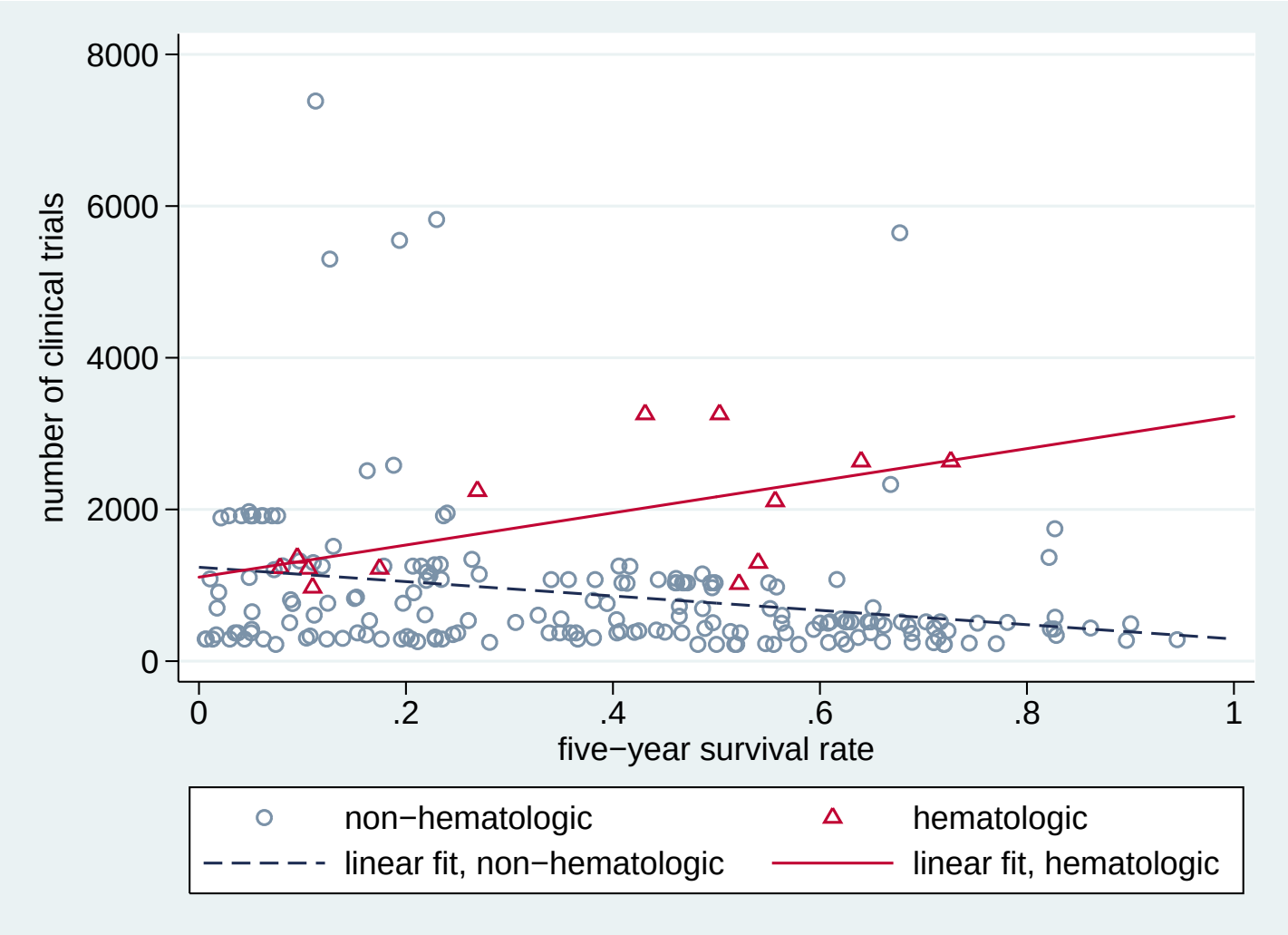
How to interpret this fact?

By itself, this fact is difficult to interpret for two reasons:

1. Correlation need not reflect a causal relationship between commercialization lags and R&D investments
2. Even if this correlation did reflect a causal relationship, it need not be evidence of a distortion because the social planner is also more likely to pursue research projects that can be completed more quickly

Surrogate endpoints and R&D investments

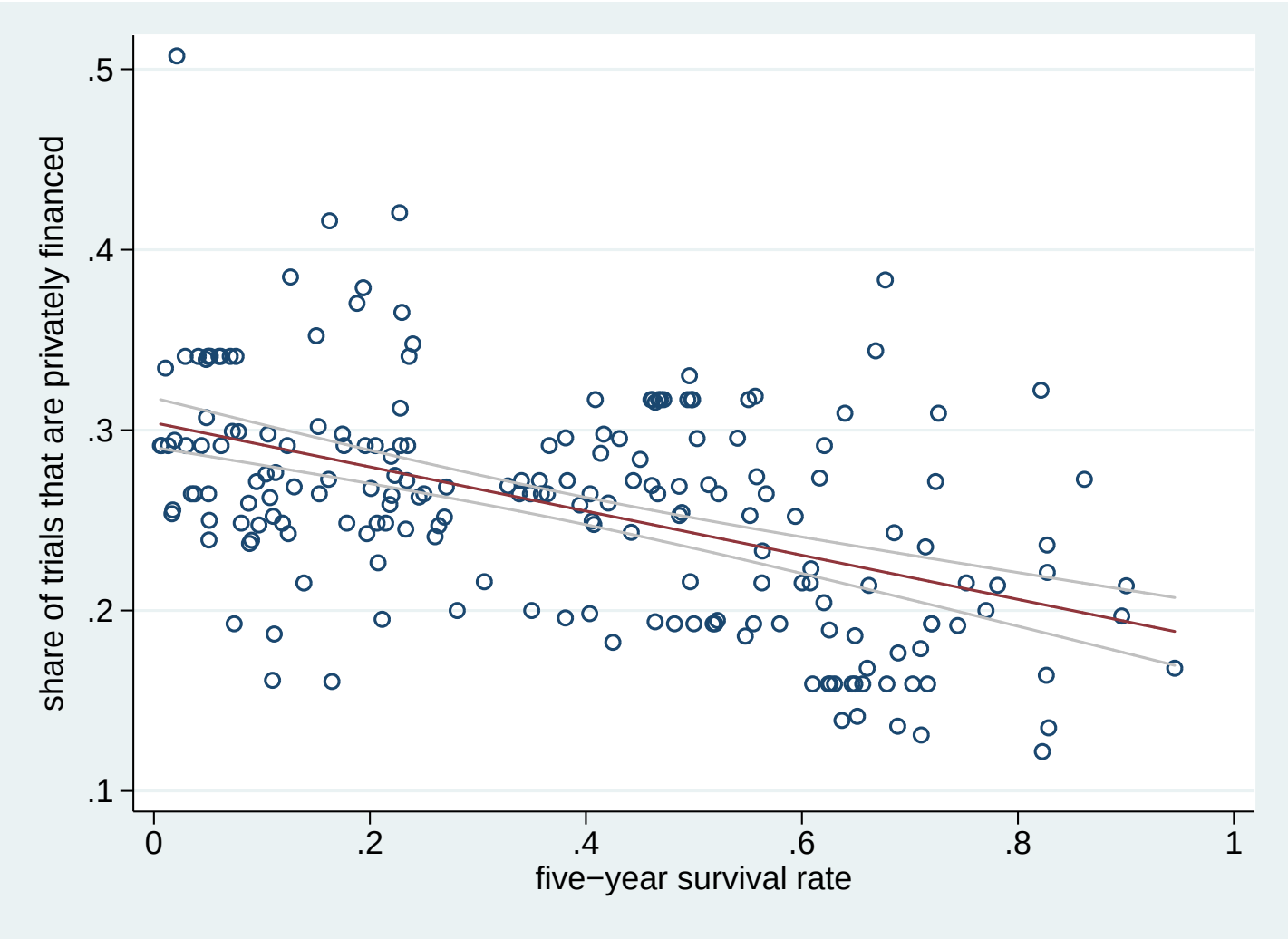
This suggests that there is a causal relationship: if commercialization lags were shortened, there are scientific opportunities available that would be pursued.



Notes: See Figure 4 in paper.

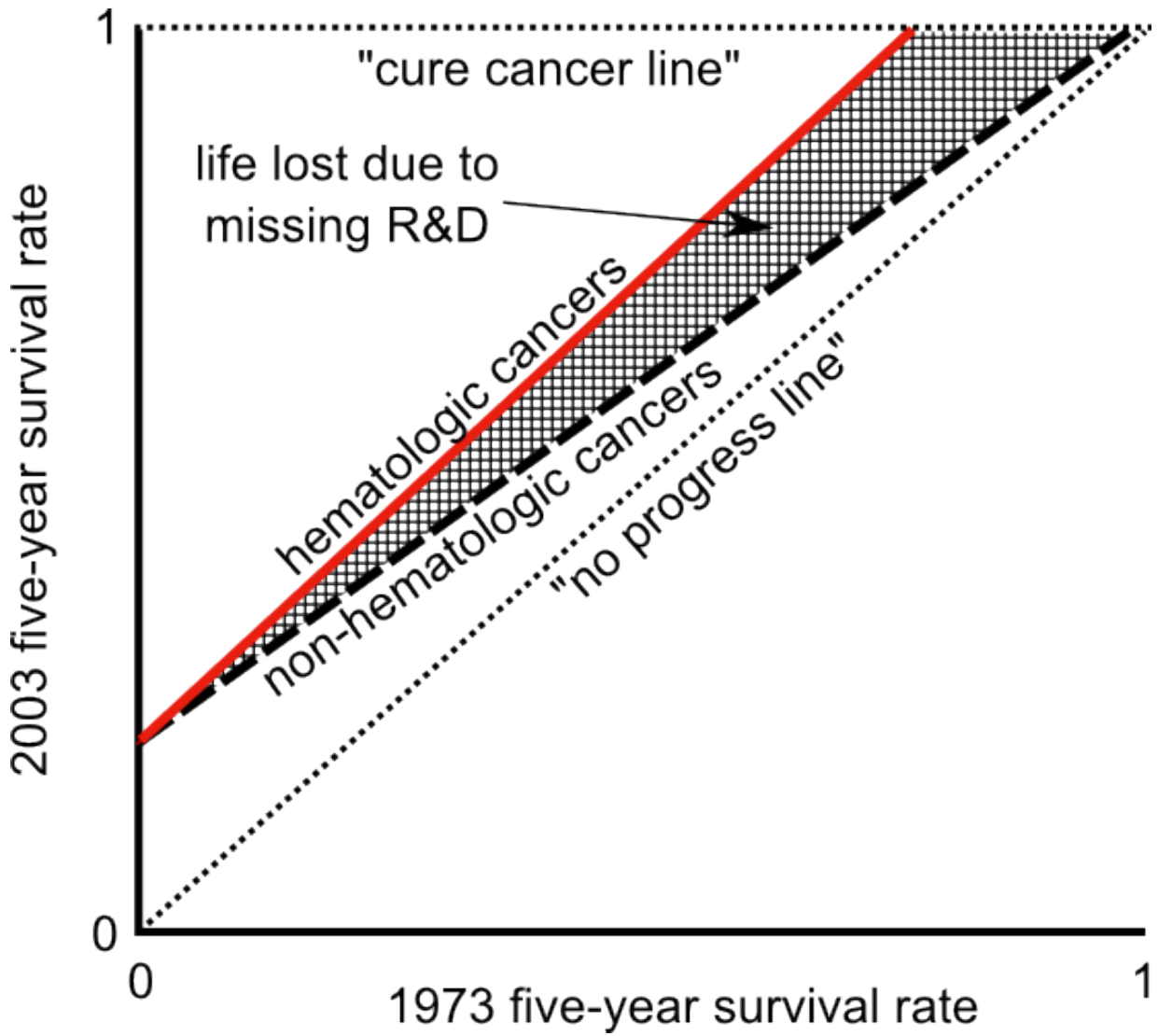
Share of clinical trials that are privately financed

Taken together, this - together with the surrogate endpoints evidence - provides support for the idea that commercialization lags distort private R&D investments.



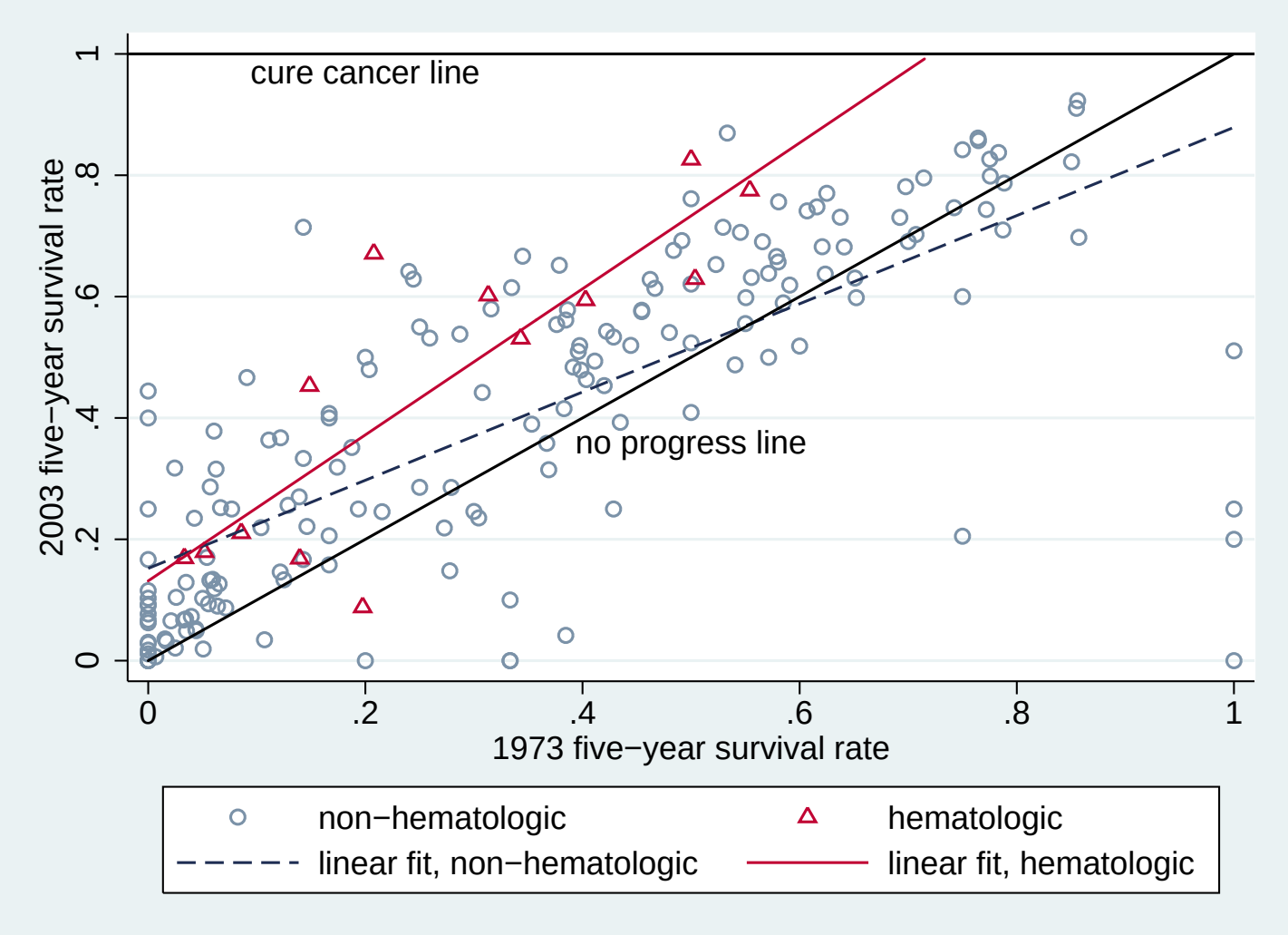
Notes: See Figure 5(b) in paper.

Counterfactual: Survival gains, 1973-2003



Notes: See Figure 6(a) in paper.

Counterfactual: Survival gains, 1973-2003



Notes: See Figure 6(b) in paper.

Rough back-of-the-envelope: Value of lost life

Value of life lost among US cancer patients diagnosed in 2003:

1. Using the cancer registry data, we translate the gap between the hematologic and non-hematologic survival curves into an estimate of life-years lost per cancer patient: 1.07 life-years per patient
2. For each cancer-stage, multiply by the number of US patients$_{cs}$ diagnosed in 2003: 890,000 life-years lost for that cohort
3. Multiplying by a standard value of a statistical life-year (Cutler 2004: \$100,000) monetizes this lost life at a value of \$89 billion

Take-aways

- Our evidence is directly relevant to two policy levers:
  1. Allowing firms to rely on valid surrogate endpoints
  2. R&D subsidies targeting long commercialization lag projects
- Estimates cannot speak directly to patents

Anecdote: Surrogate endpoints and heart disease

- Heart disease is the leading cause of death in the US, but the age-adjusted rate of death has dropped by 50% since 1968
- Decline largely attributed to beta-blockers, ACE-inhibitors, statins
- These drugs were approved based on blood pressure, LDL cholesterol
  - Surrogates first identified by decades-long Framingham Heart Study
  - Some have argued that w/o surrogate endpoints, these drugs may not have reached the market [Lathia et al. (2009); Meyskens et al. (2011)]

Both our empirical evidence for cancer and this historical case study for heart disease suggest that research investments aimed at establishing and validating surrogate endpoints may have a large social return