Changes in Technology in the U.S. Beef Industry: Welfare Analysis and Trade Implications

Lia Nogueira, Kathleen Brooks, and David Bullock

Selected Paper prepared for presentation at the International Agricultural Trade Research Consortium's (IATRC's) 2015 Annual Meeting: Trade and Societal Well-Being, December 13-15, 2015, Clearwater Beach, FL.

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Dec. 14, 2015

Part 1: Motivation, Background, and Literature Review

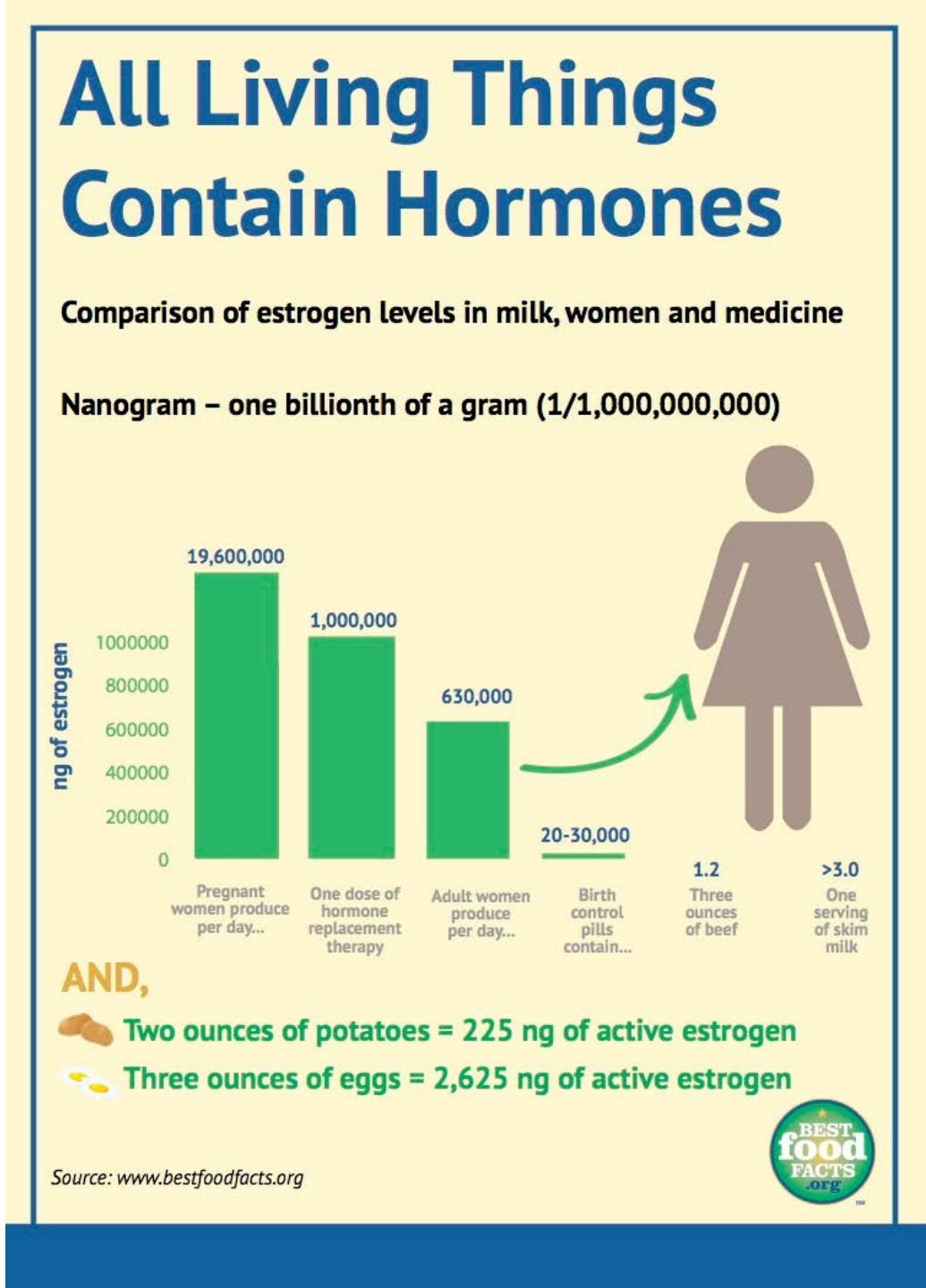
Motivation

US cattle industry declining over time

- 132 million head of cattle January 1, 1975 (peak)
- 89.8 million head of cattle as of January 1, 2015

Technology used to enhance beef production

- Hormone implants
- Beta-agonists

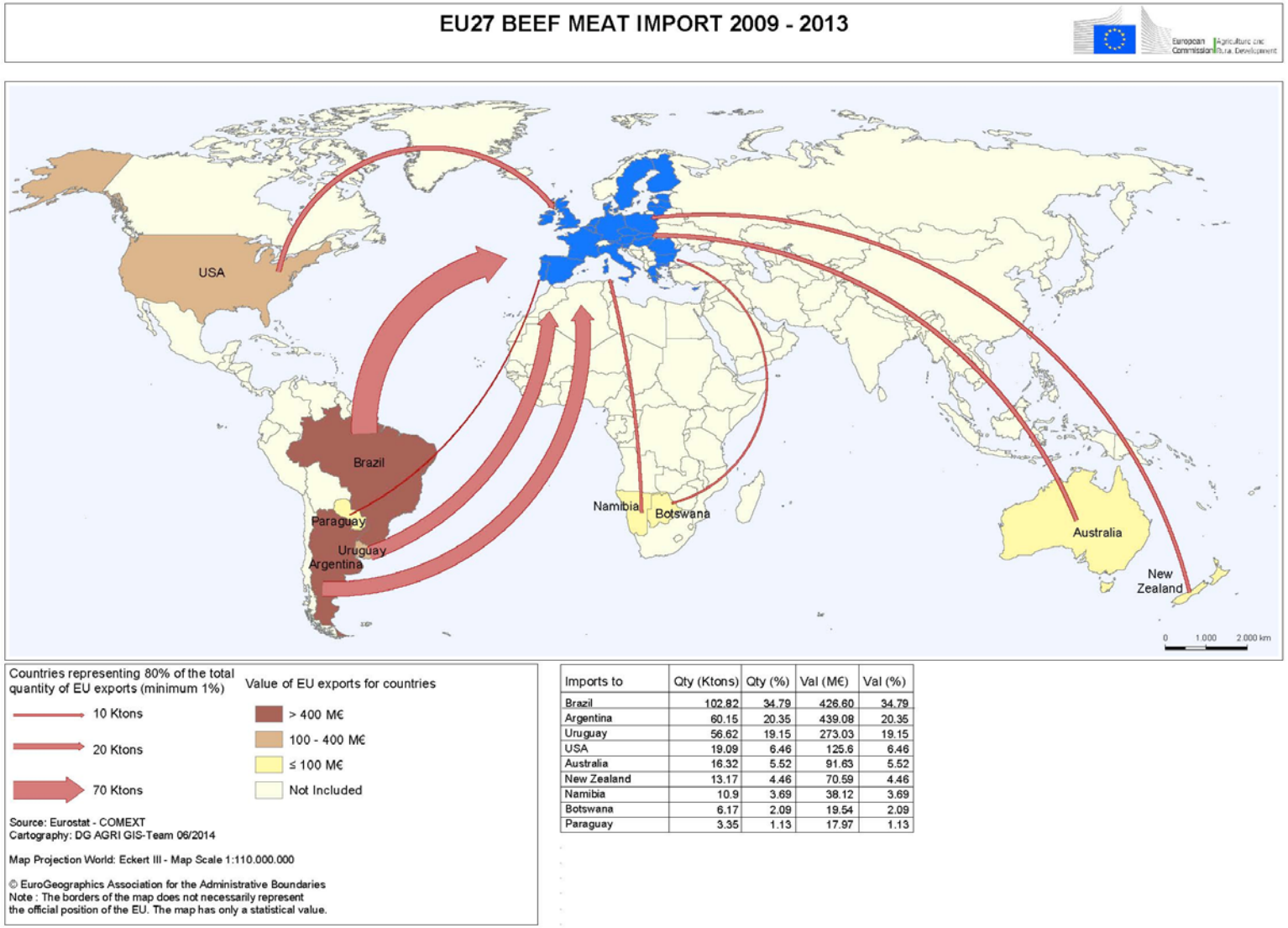


Domestic and international consumer's preferences

- Concerns about hormone and Beta-agonist use in beef production

Trade disruptions because of production practices

- Concerns about protectionist or discriminatory/retaliatory policies
- Consumer driven?



Imports to	Qty (Ktons)	Qty (%)	Val (M€)	Val (%)
Brazil	102.82	34.79	426.60	34.79
Argentina	60.15	20.35	439.08	20.35
Uruguay	56.62	19.15	273.03	19.15
USA	19.09	6.46	125.6	6.46
Australia	16.32	5.52	91.63	5.52
New Zealand	13.17	4.46	70.59	4.46
Namibia	10.9	3.69	38.12	3.69
Botswana	6.17	2.09	19.54	2.09
Paraguay	3.35	1.13	17.97	1.13

Objectives

- To build a detailed theoretical model to describe the US beef industry to analyze welfare changes due to technology use
  - Incorporating all stages from the farm to the plate
  - Including the use of hormones and Beta-agonists in production

Model to be used to:

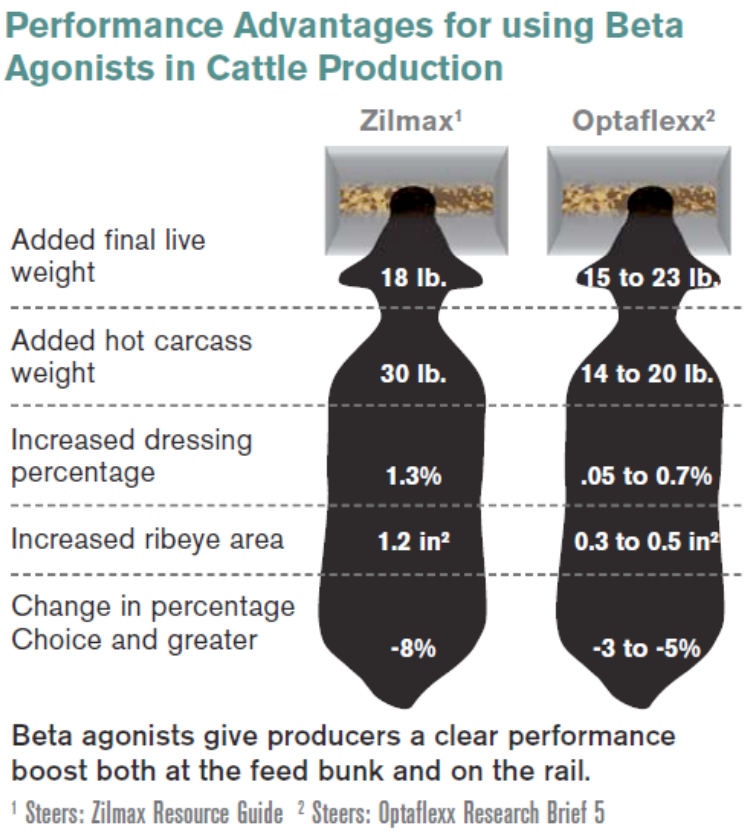
- Calculate and compare the cost of US beef production with and without the use of hormones and Beta-agonists
- Calculate welfare changes for producers and consumers if hormones and Beta-agonists were banned in US beef production
  - Determine how the supply curve would shift

Background

70-80% of US cattle produced using Beta-agonists in 2013 (Cargill)

Beta-agonists are veterinary drugs used as feed supplements to increase weight gain in cattle

- Used to improve feed conversion – more beef per animal
- Two approved in the United States
  - Ractopamine hydrochloride (Optaflexx, Elanco) approved in 2003
  - Zilpaterol hydrochloride (Zilmax, Merck) approved in 2006, released in 2007 and removed in 2013 (animal welfare concerns)
- Fed last 20 – 40 days before slaughter



Hormone implants increase growth rate and feed conversion efficiency

- FDA has approved steroid hormone drugs for beef since 1950s
- Implanted as pellets under skin in ear
- Usually at entrance into feedyard, approx. duration 100 – 120 days
  - Can be re-implanted

Consumer preferences changing

- Consumers willing to pay 17% higher prices for hormone-free beef (Lusk and Fox 2002)
- Approximately 160 countries ban or restrict the use of Beta-agonists
  - European Union, China, Russia

Current trade agreement negotiations with countries that ban the use of hormones and/or Beta-agonists

- Transatlantic Trade and Investment Partnership
- Trans-Pacific Partnership

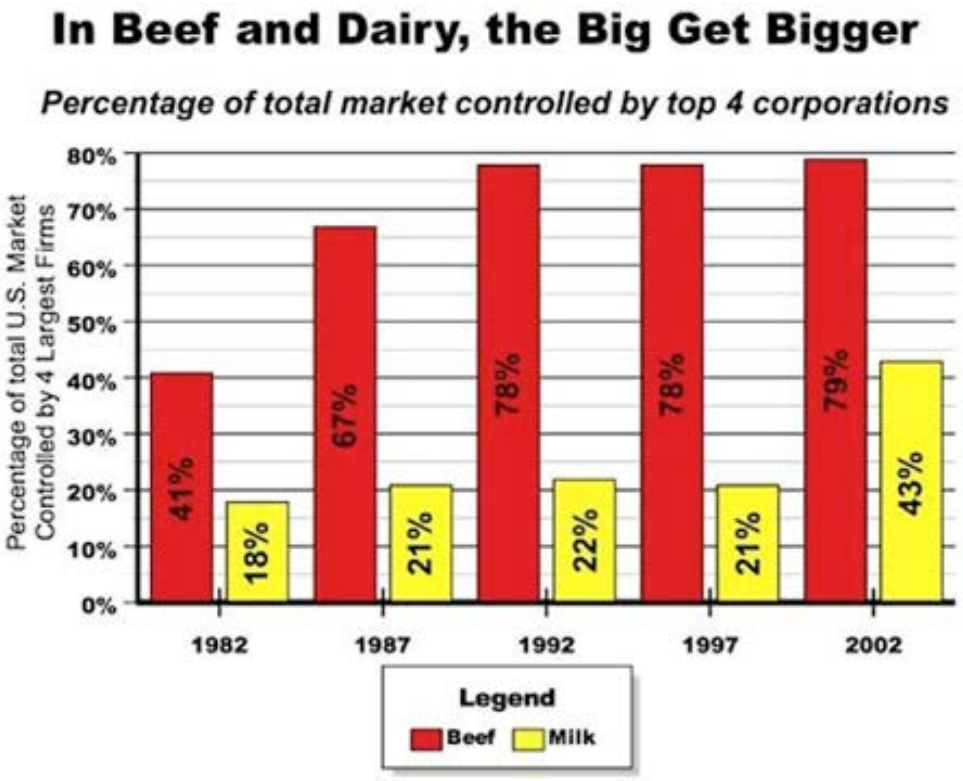
The literature on the welfare effects of technological change in the beef industry

- Most studies fail to fully characterize many stages of the cattle industry
- Ban on the use of antimicrobial feed additives in the US pork industry (Hayes, Jensen and Fabiosa 2001)
- Economic impact of Zilmax adoption in the US cattle and beef industry (Schroeder and Tonsor 2011)
- Economic impact of E. coli vaccination for feedlot cattle in the US cattle industry (Tonsor and Schroeder 2015)

Genetic testing technologies – economic impact of using the technology

- Tenderness: Weaber & Lusk 2010
- Appetite and metabolism: DeVuyst et al. 2007; Lambert 2009; Lusk 2007; Mitchell et al. 2009

Lots of work on market concentration in the US cattle industry



Part 2: Model and Welfare Measures

Long-time Challenge in ag econ: to measure the effects of technological change on producer welfare

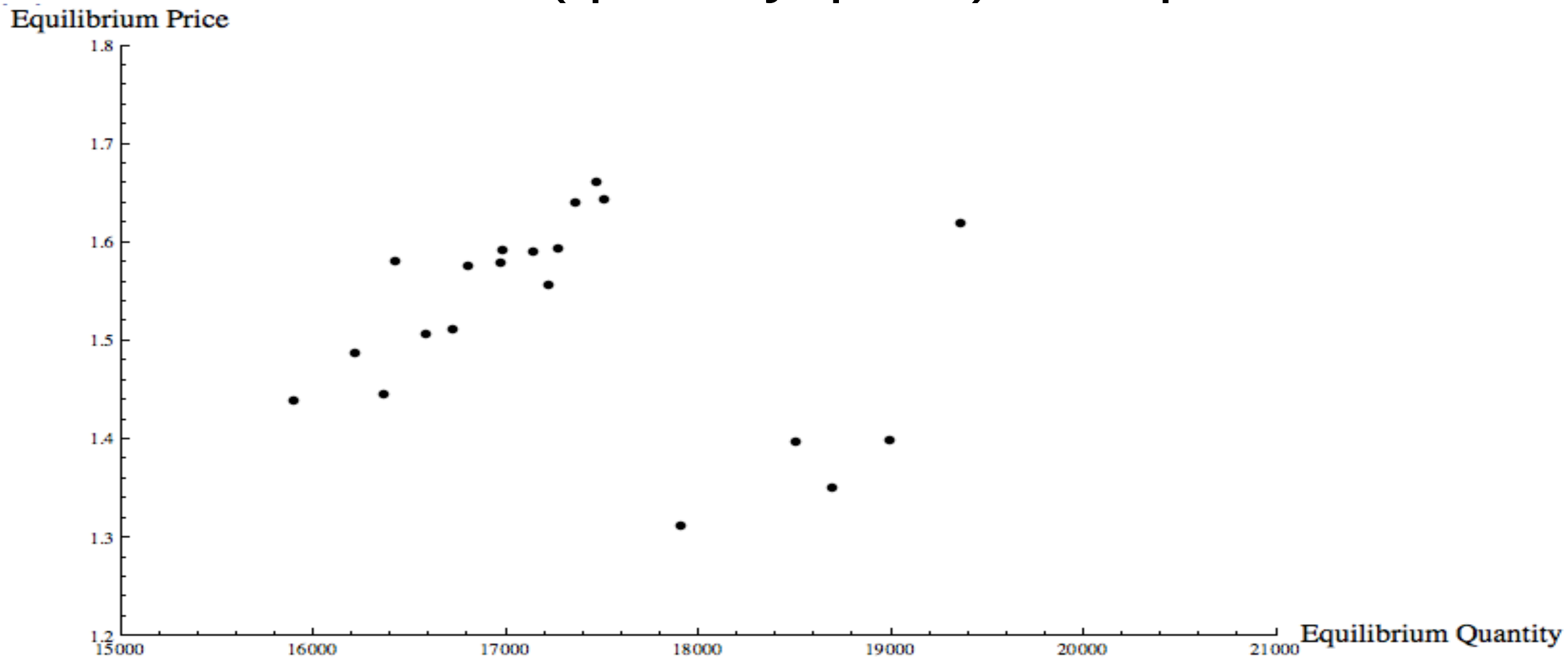
- Hybrid corn
- Green Revolution
- Genetically modified crops
- Precision agriculture

Traditional Method:

- Estimate where the supply curve was under the old technology
- Estimate where the supply curve is under the new technology
- (Possibly) Estimate a demand curve
- Figure out the effect of tech Δ on price
- Measure a producer surplus area behind the supply curve, for both the old and the new technology

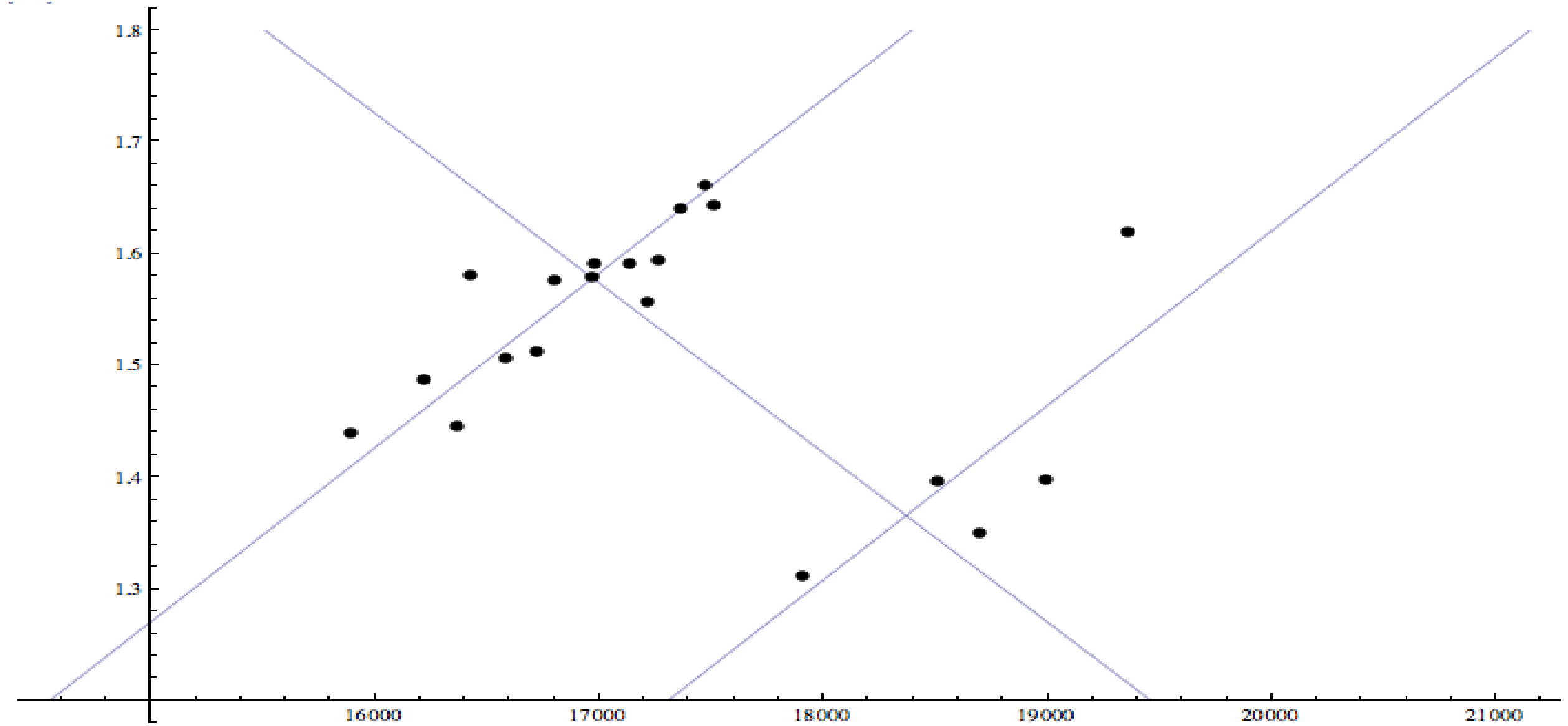
Long-time Challenge

Get some (quantity, price) data points:



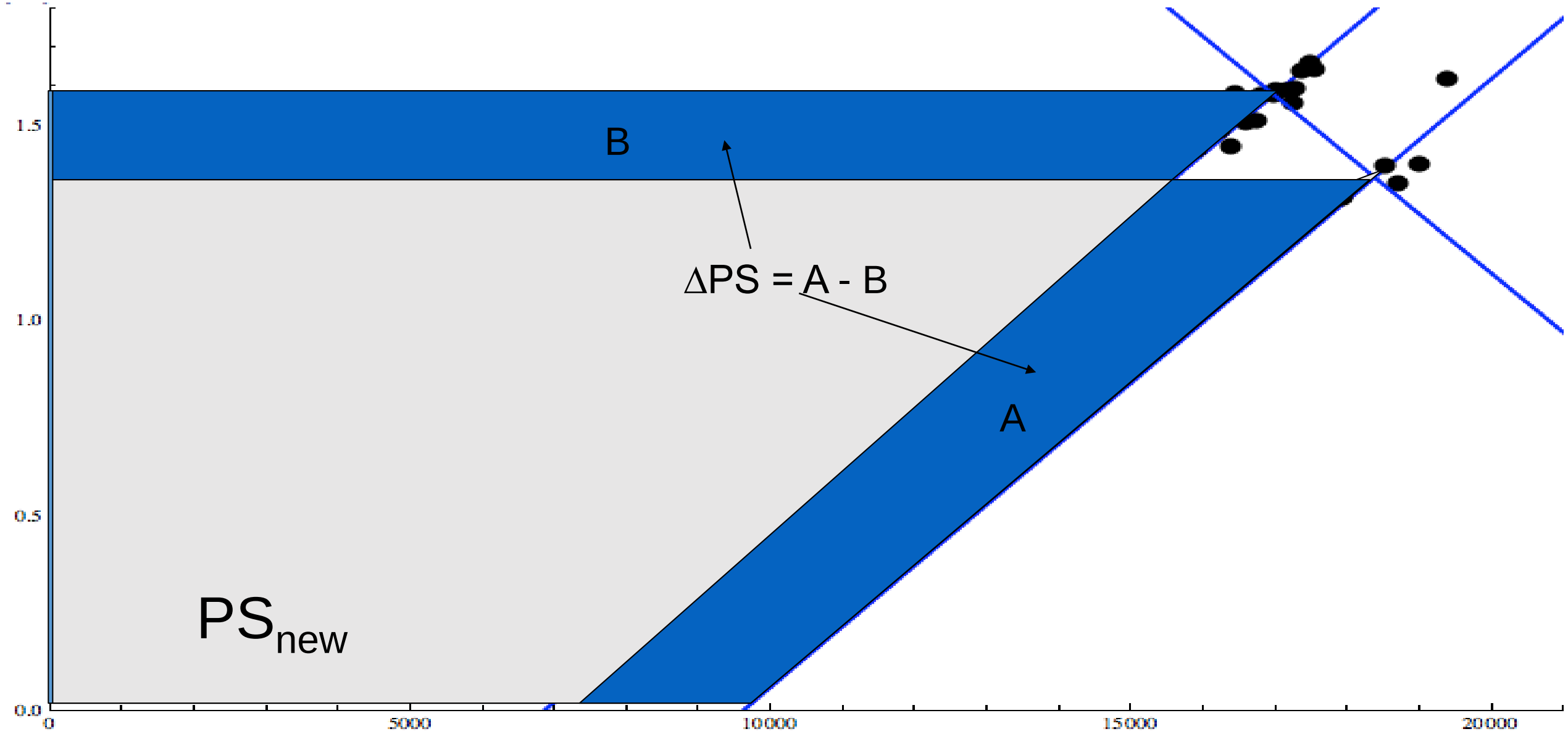
Long-time Challenge

Estimate supply and demand curves:



Long-time Challenge

Use estimated curves to get producer surplus measurements:

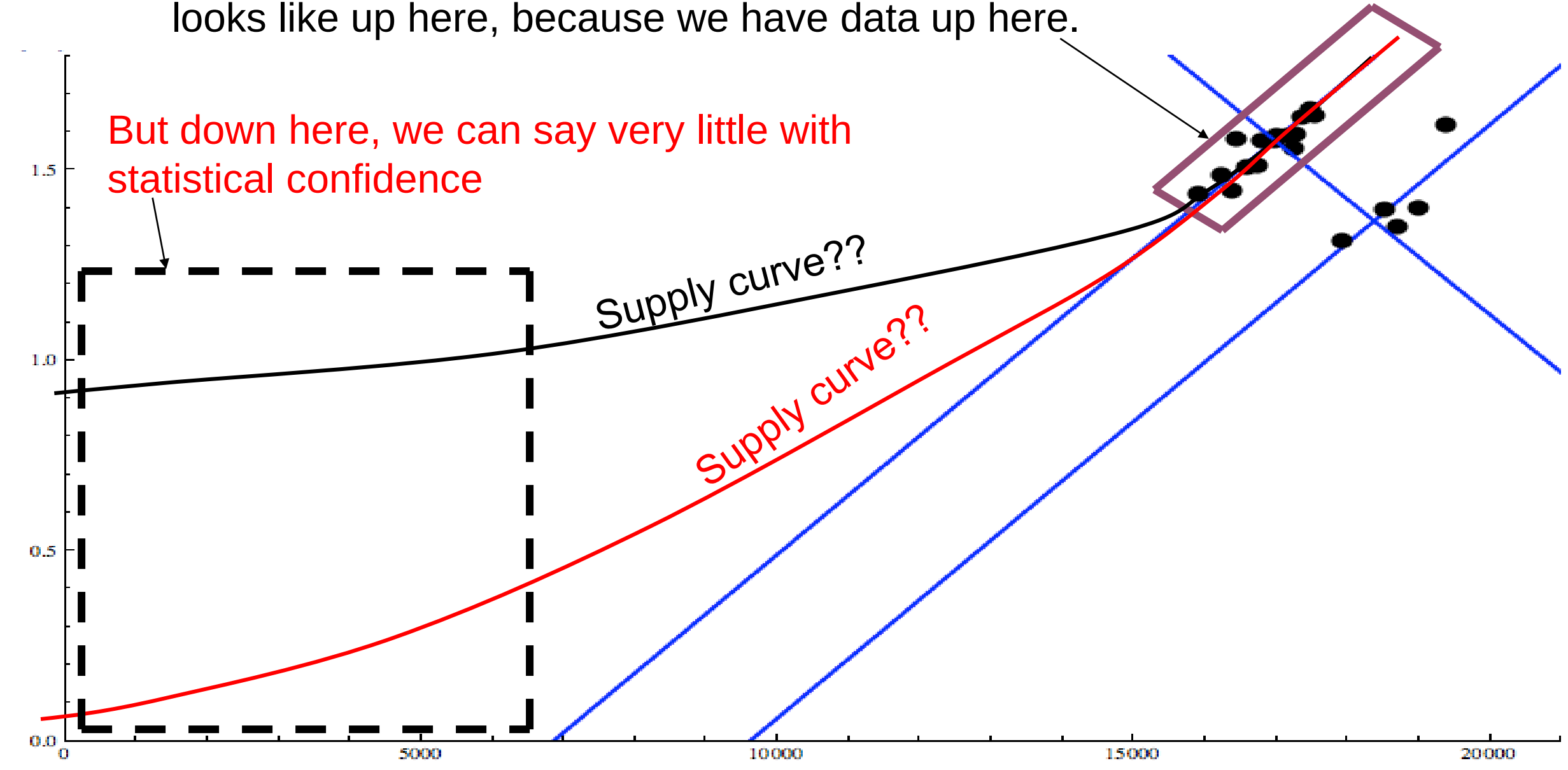


But there are well-known problems of statistical reliability:

- The observed (quantity, price) points take up a small part of the diagram
- But the ΔPS measure requires measurement of the entire length of supply curves
- "Extrapolation" beyond the observed range of the data

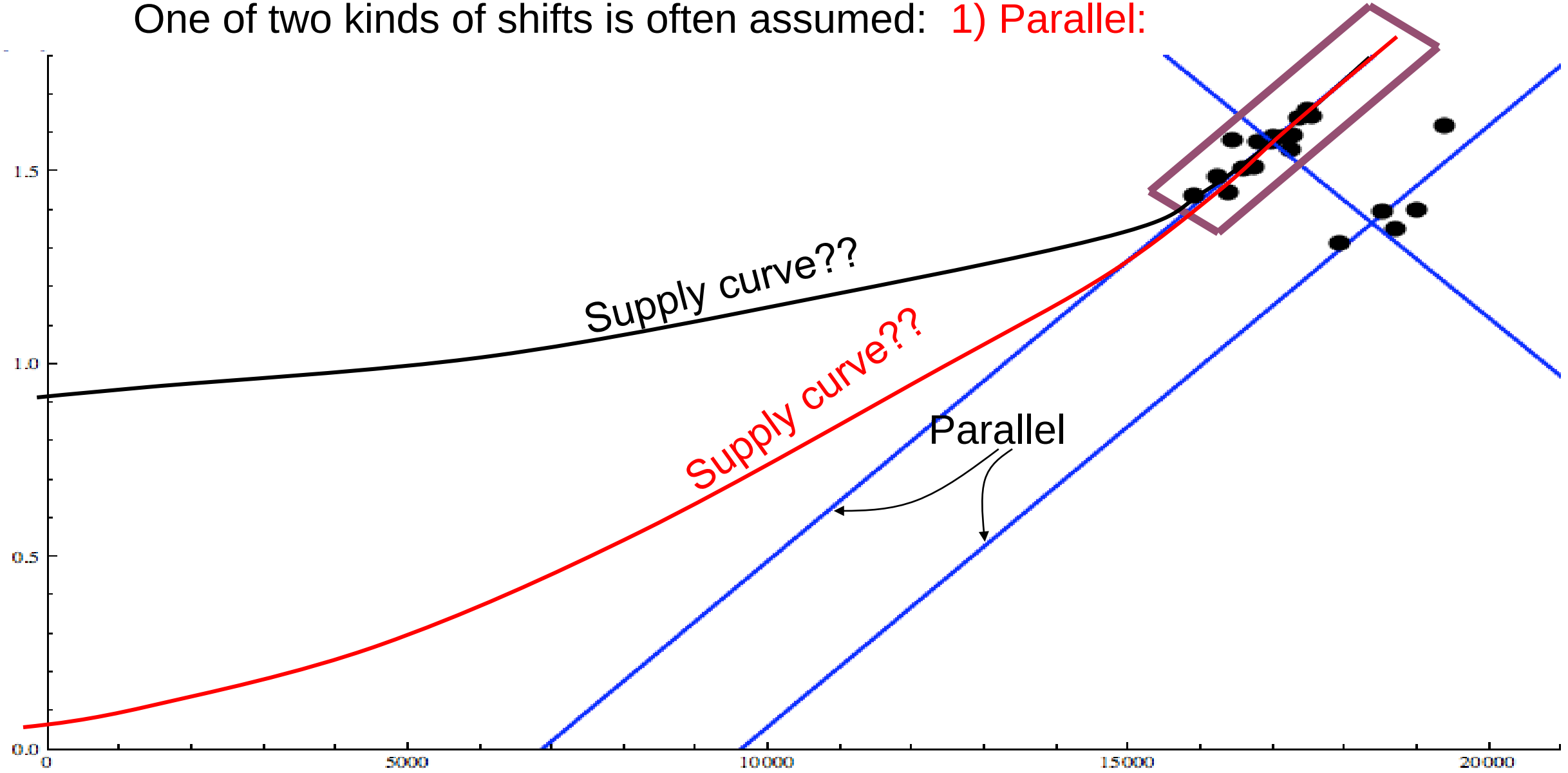
Long-time Challenge

Have a pretty good idea about what the supply curve looks like up here, because we have data up here.



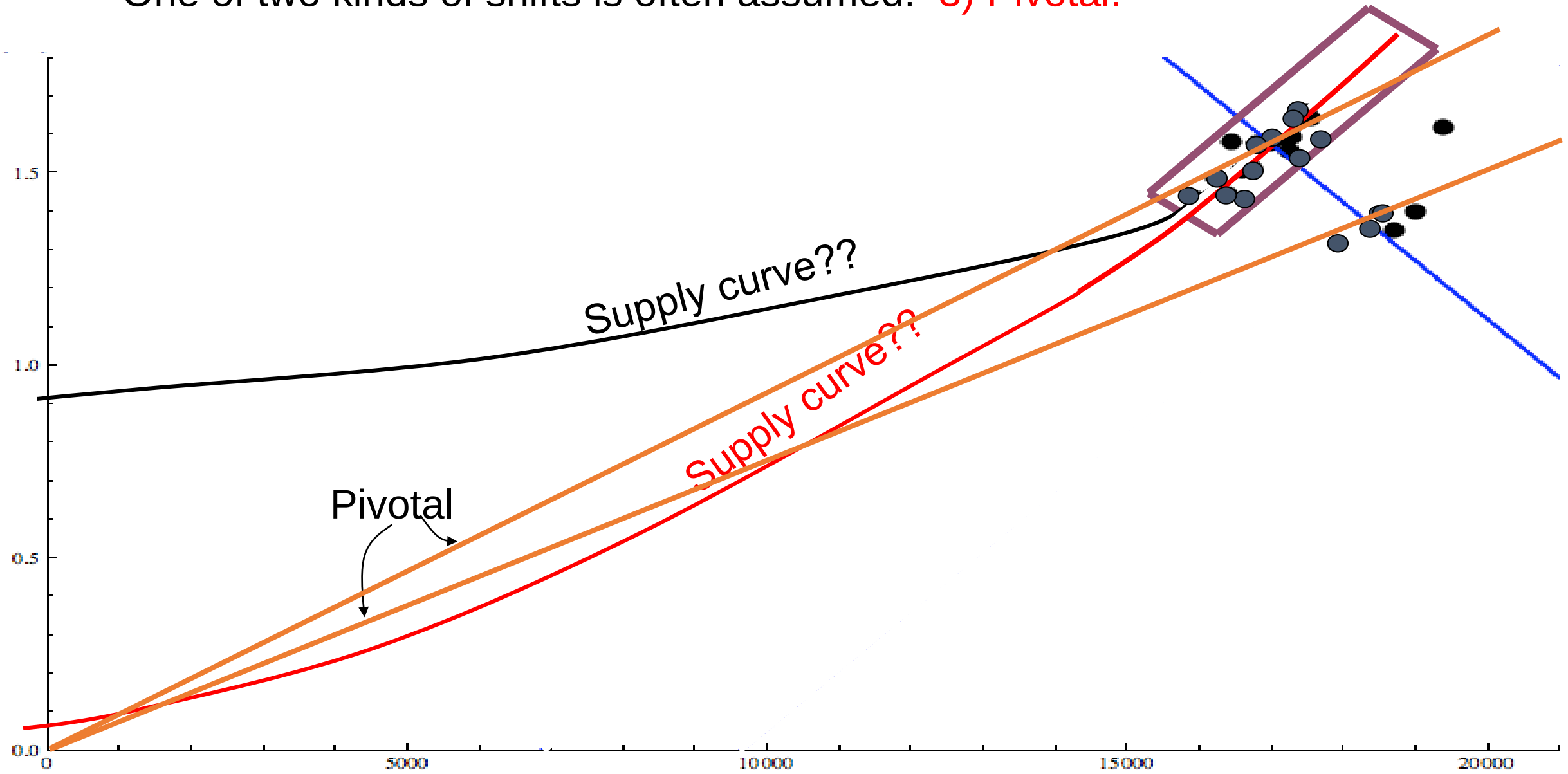
Long-time Challenge

One of two kinds of shifts is often assumed: 1) Parallel:

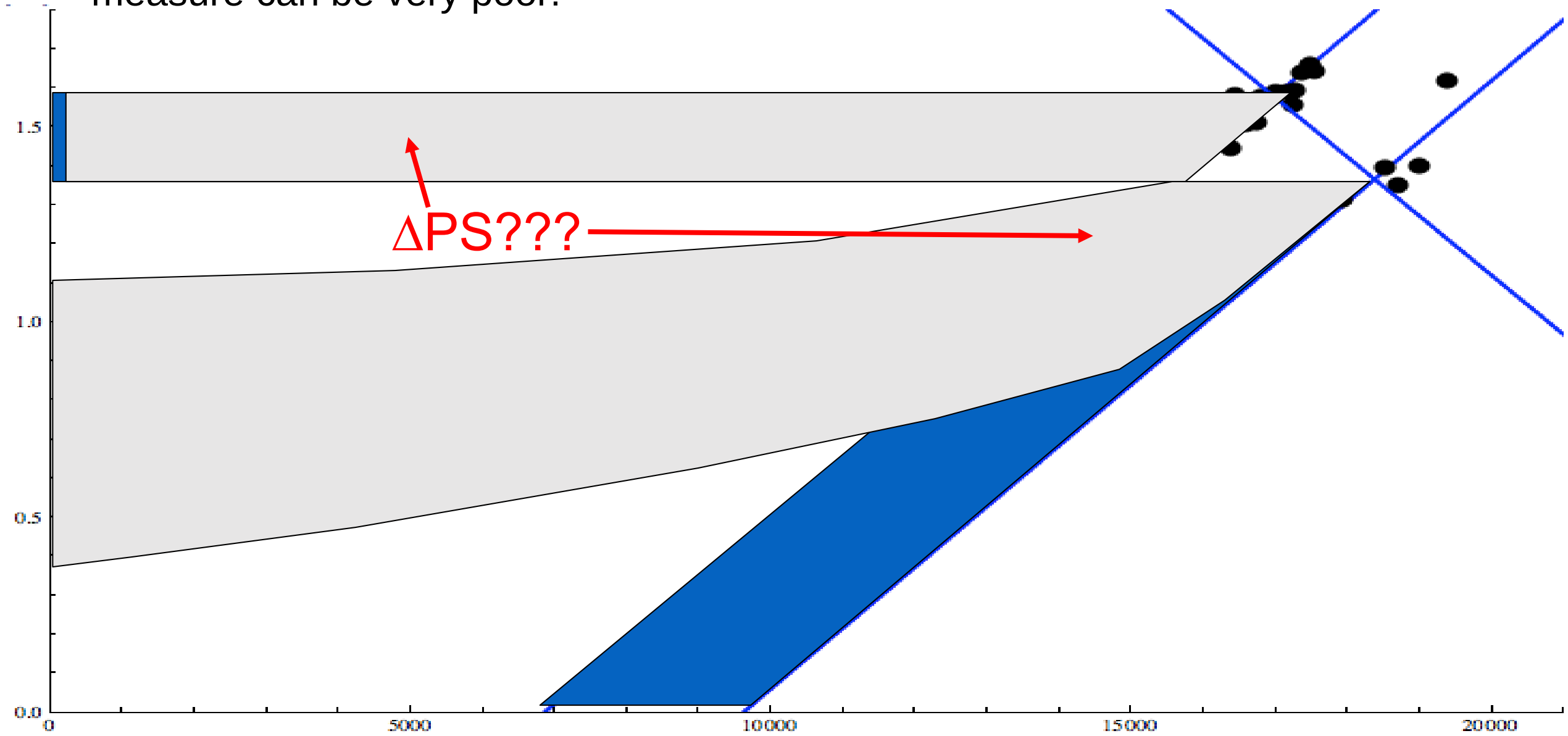


Long-time Challenge

One of two kinds of shifts is often assumed: 3) Pivotal:



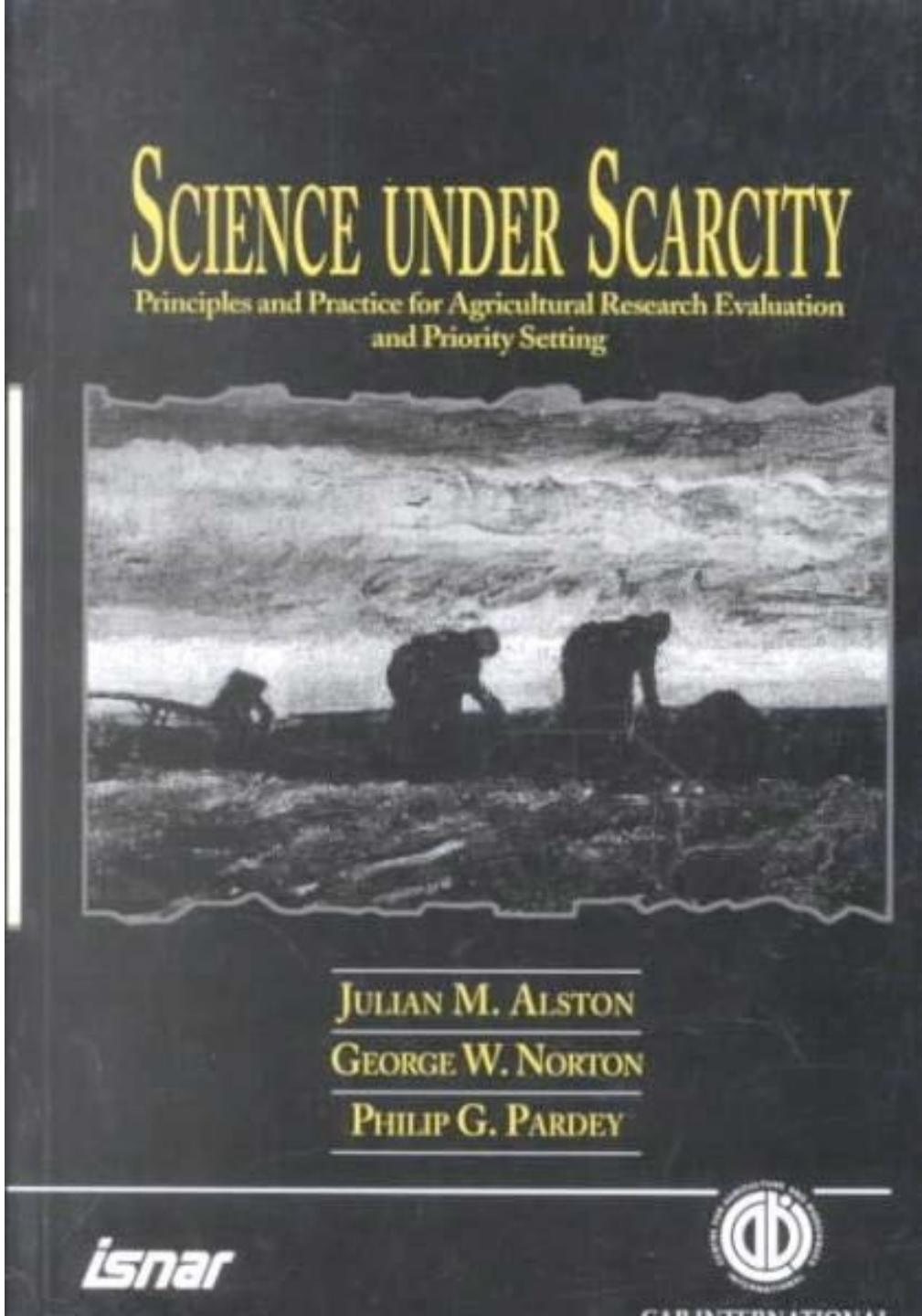
Which means that the statistical accuracy of the change-in-welfare measure can be very poor:



Long-time Challenge

Alston, Norton, and Pardey published an excellent book detailing this methodology, but also recognizing its shortcomings:

(It's been cited about a million times.)



Despite the traditional methodology’s frequent use, the concerns about statistical inaccuracy remain:

Beattie (1995, p. 1065) in general was complimentary in his review of Alston, Norton, and Pardey (1994), but he also wrote,

If total benefits from a research-induced supply shift are halved when that shift is deemed to be pivotal rather than parallel, and if producer benefits disappear when the supply shift is pivotal against an inelastic demand, then it seems to me that we have a rather big problem here.

Our Objectives

Build detailed theoretical model of US beef industry to analyze welfare effects of technology change

- Model from farm to plate
- Model use of hormones and Beta-agonists

New ideas for measuring the change in producer welfare due to technology change (Bullock)

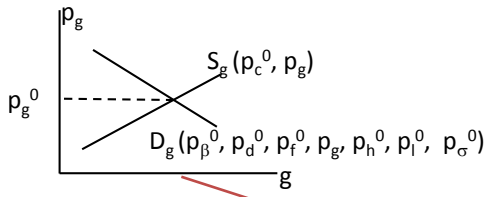
- Trying to avoid estimation far **beyond the range of the data**
- So that increased statistical confidence can be placed on the estimation of the change in producer welfare

The Model

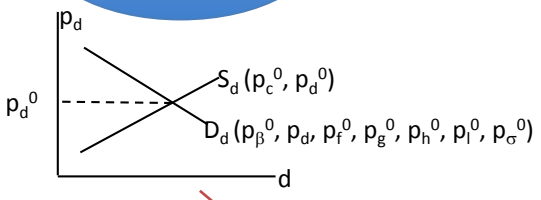
Key idea: **use data from input markets to measure producer welfare change**

The U.S. beef complex in initial equilibrium

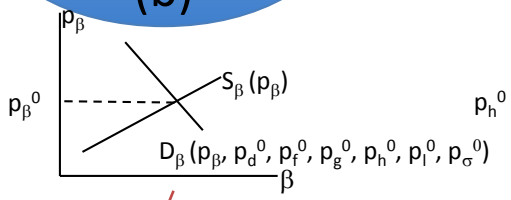
Handled Feed Grain (g)



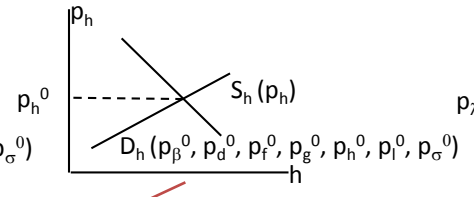
DDGs (d)



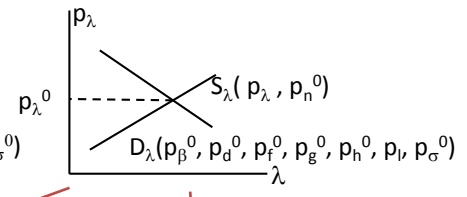
b-agonists (b)



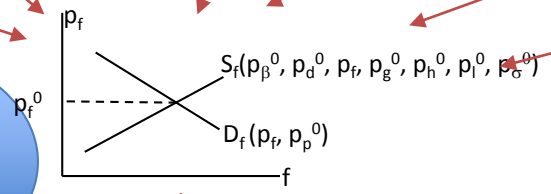
Hormones (h)

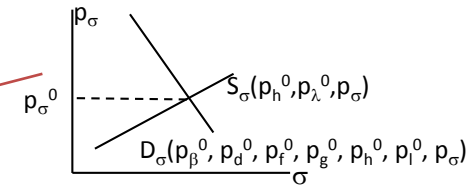


Light Weight Calves (l)

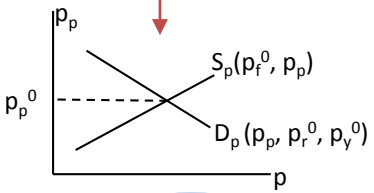


Fed Cattle (f)

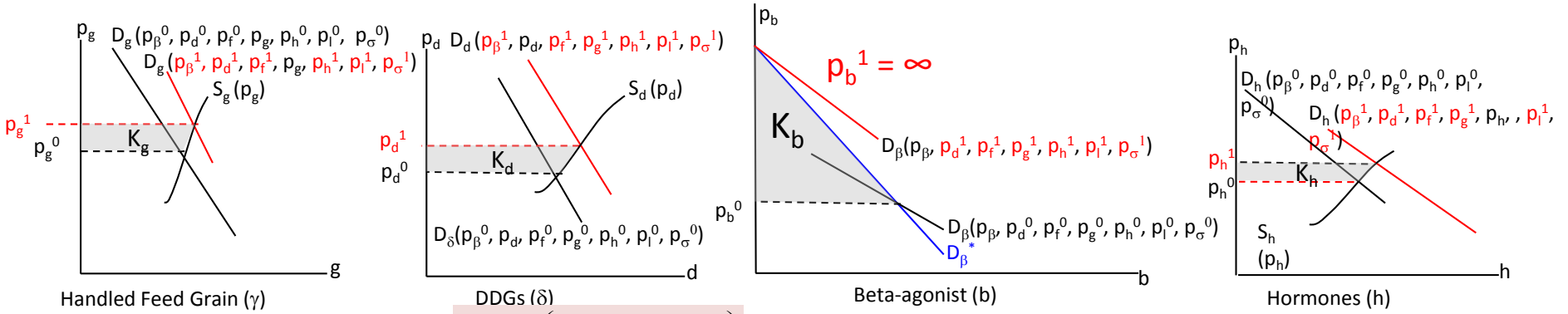




Feeder Steer from Backgrounders (s)



Processed Beef (Packed Beef) (p)

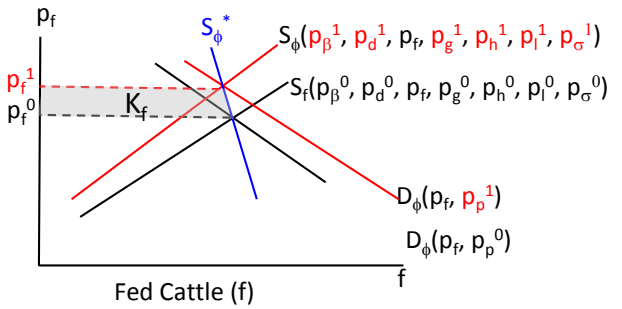


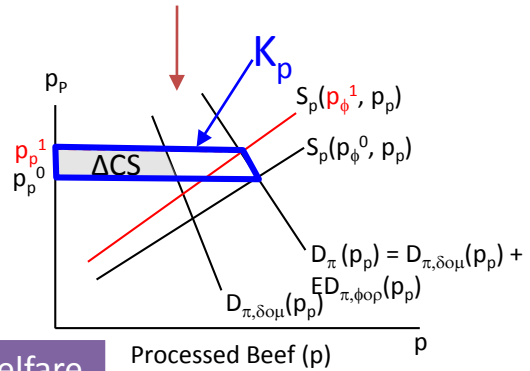
Calves Markets: See next slide

$$\Delta\Pi_g = \underbrace{\left(\int_{p_g^0}^{p_g^1} S_g\left(p_g\right) dp_g\right)}_{K_g}$$

$$\Delta\Pi_d = \underbrace{\left(\int_{p_d^0}^{p_d^1} S_d\left(p_d\right) dp_d\right)}_{K_d}$$

$$\Delta\Pi_h = \underbrace{\left(\int_{p_h^0}^{p_h^1} S_h\left(p_h\right) dp_h\right)}_{K_h}$$



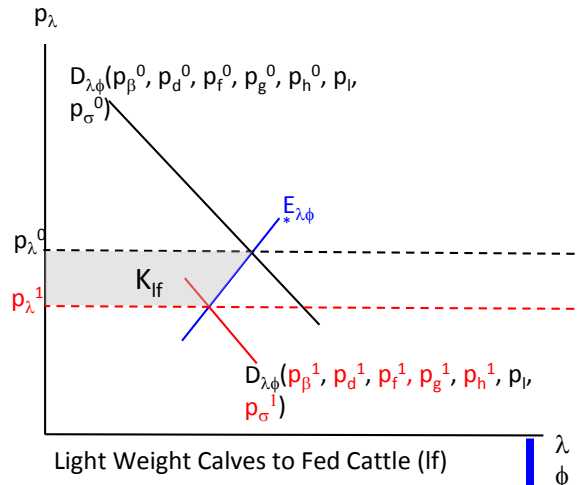


$$\Delta CS = -\int_{p_p^0}^{p_p^1} D_{p,dom}\left(p_p\right) dp_p$$

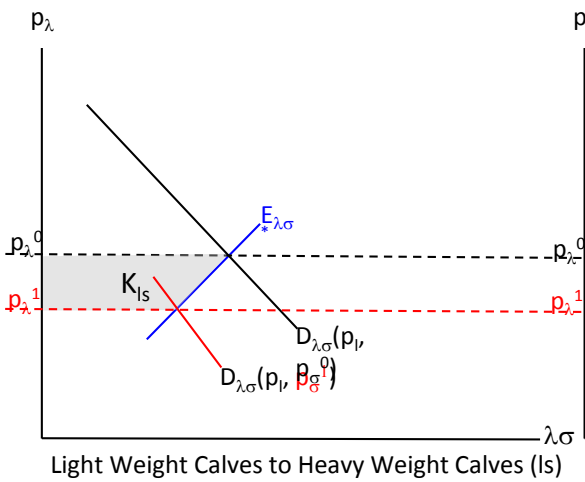
$$\Delta\Pi_p = \underbrace{\int_M S_p\left(\phi\right) dp_p}_{K_p} + \underbrace{\left(-\int_M D_f\left(\phi\right) dp_f\right)}_{-K_f}$$

Figure. Effect of βετα-agonist ban ($p_b^1 = \infty$) on feedlot welfare

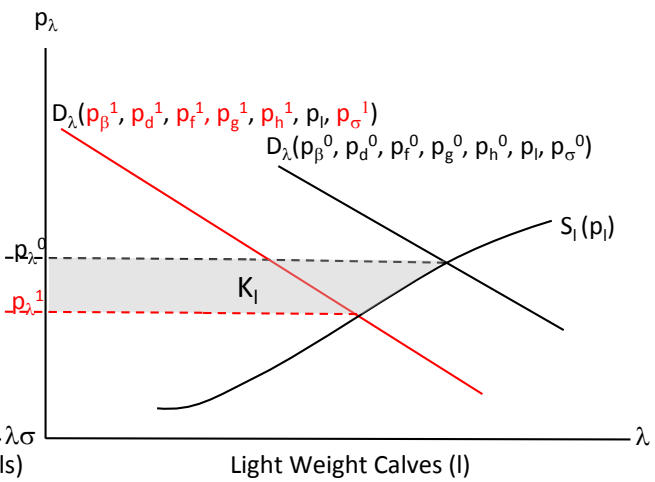
Changes in Profits in the Calves and Cattle Industries



Light Weight Calves to Fed Cattle (lf)



Light Weight Calves to Heavy Weight Calves (ls)



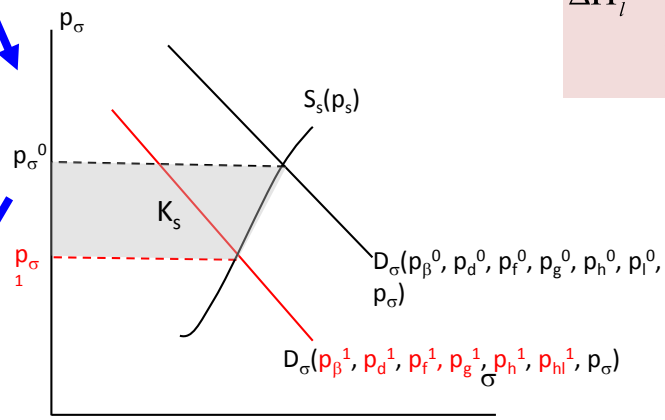
Light Weight Calves (l)

$$\Delta\Pi_f = \Pi_f\left(\phi\left(t^{hi}\right)\right) - \Pi_f\left(\phi(0)\right)$$

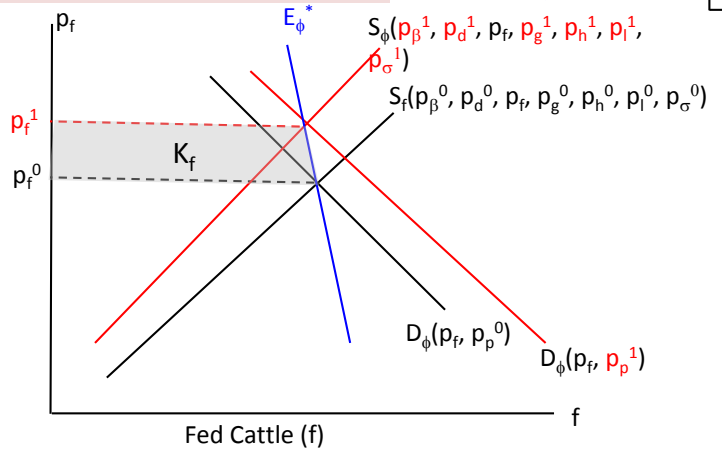
$$= \int_V \left(\frac{\partial \Pi_f(\phi)}{\partial p_b} dp_b + \frac{\partial \Pi_f(\phi)}{\partial p_d} dp_d + \frac{\partial \Pi_f(\phi)}{\partial p_f} dp_f + \frac{\partial \Pi_f(\phi)}{\partial p_g} dp_g + \frac{\partial \Pi_f(\phi)}{\partial p_h} dp_h + \frac{\partial \Pi_f(\phi)}{\partial p_l} dp_l + \frac{\partial \Pi_f(\phi)}{\partial p_s} dp_s \right)$$

$$= -\underbrace{\int_M D_b(\phi) dp_b}_{K_b} - \underbrace{\int_M D_d(\phi) dp_d}_{K_d} + \underbrace{\int_M S_f(\phi) dp_f}_{K_f} - \underbrace{\int_M D_g(\phi) dp_g}_{K_g} - \underbrace{\int_M D_h(\phi) dp_h}_{K_h} - \underbrace{\int_M D_{lf}(\phi) dp_l}_{-K_{lf}} - \underbrace{\int_M D_s(\phi) dp_s}_{-K_s}.$$

$$\Delta\Pi_l = \underbrace{\int_M S_l(\phi) dp_l}_{-K_l}$$



Heavy Weight Calves (Feeder Steer) (s)



Fed Cattle (f)

$$\Delta\Pi_s = \underbrace{\int_M S_s(\phi) dp_s}_{-K_s} + \underbrace{\left(-\int_M D_{ls}(\phi) dp_l \right)}_{K_{ls}}$$

Why we want to focus on the welfare measure in the beta-agonist market instead of the fed cattle market or the final beef market:

Beta agonist expenditures take a share of about 0.005 of fed beef revenues:

- Size of fed steer market: ($1.55/pound)x(34 billion pounds) = = $53 billion per year

- Size of beta-agonist market: ($15.4/head)x(16.6 million head per year in U.S.) = $256 million per year.

Beef producers' DDG expenditures take a share of about 0.04 of fed beef revenues:

- Size of DDGs-to-beef market: ($120/short ton)x(18 million short tons per year in U.S.) = $2.16 billion per year.

So size-wise, the diagram looks more like this:

The difficult "K_b" area can only be so big, so maybe it doesn't make sense to look at its effect in the much bigger fed cattle market.

A and B are much *skinnier* than shown here:

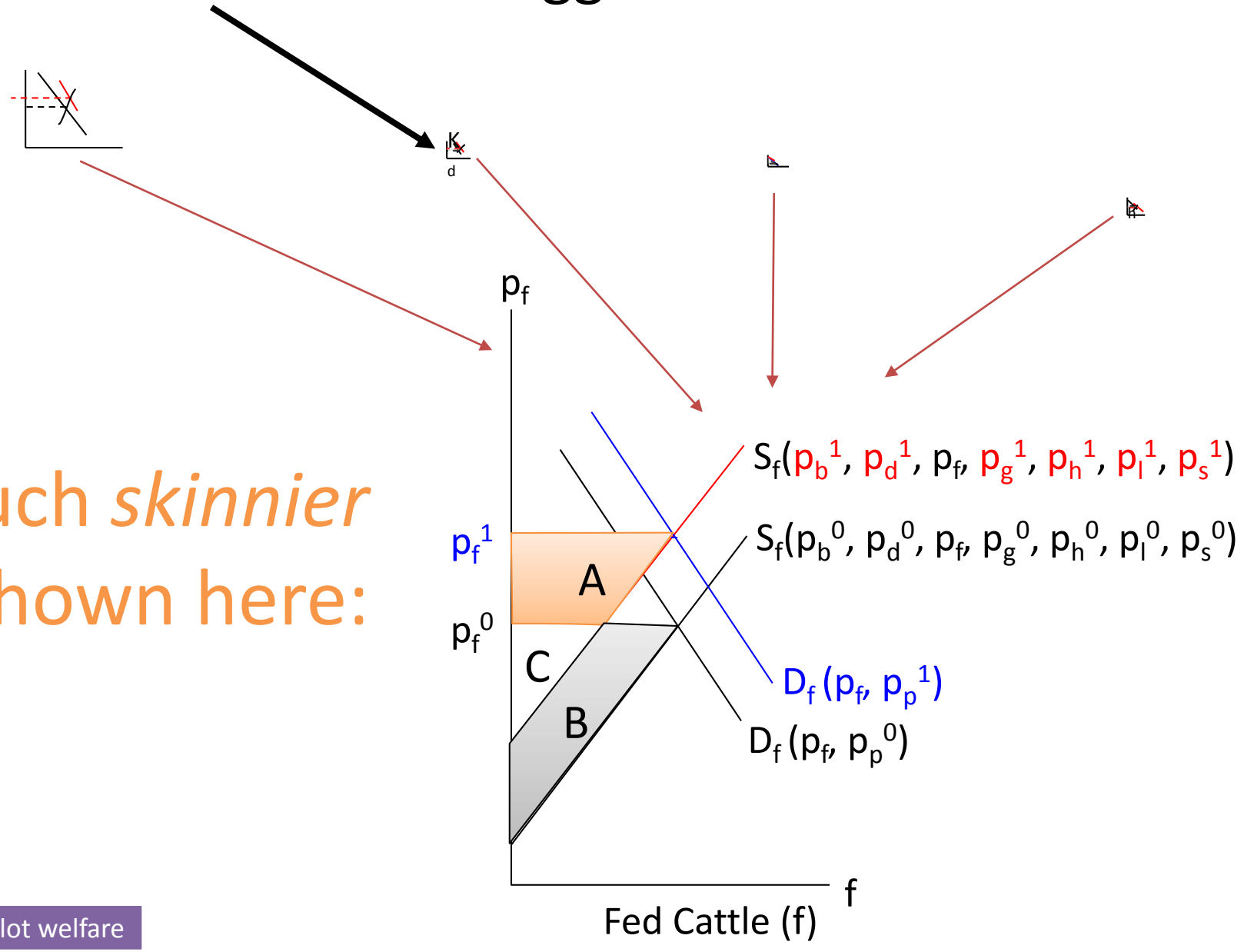
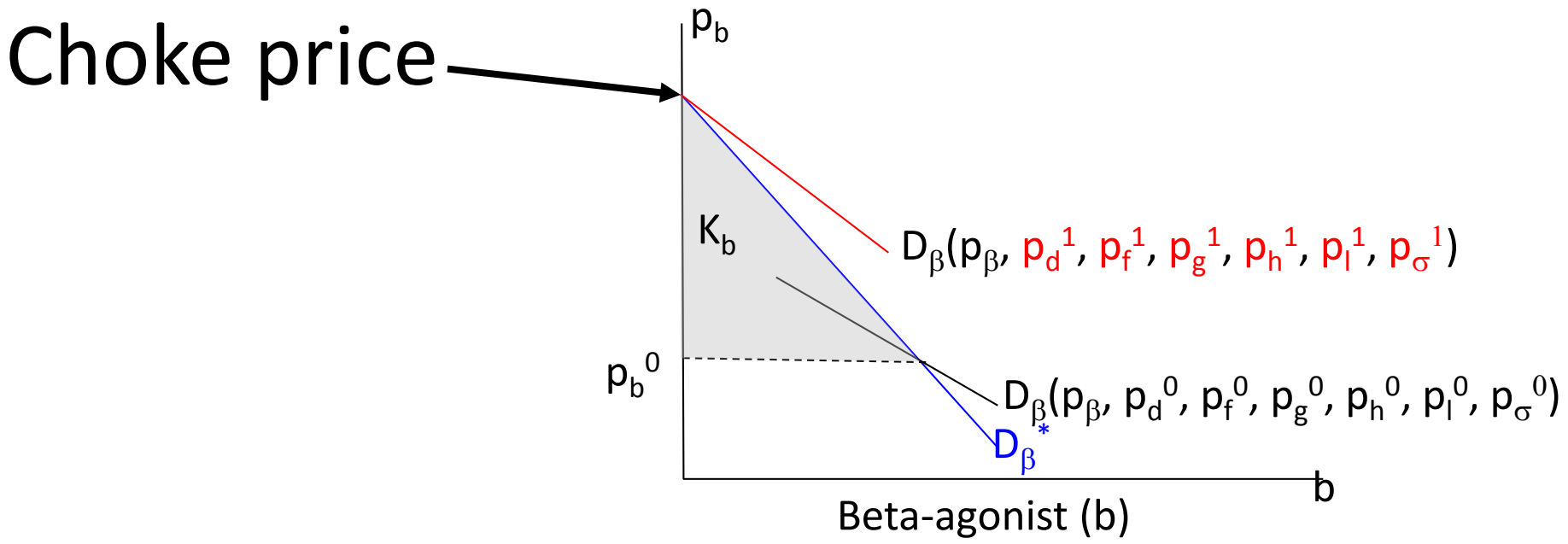


Figure. Effect of βετα-agonist ban ($p_b^1 = \infty$) on feedlot welfare

And because of close substitution between beta-agonist and feed grain market, we might have a pretty good idea about the beta-agonist choke price, and so size of triangle K_b:



Part 3. Next steps...

1. Calculate and compare the cost of US beef production with and without the use of hormones and Beta-agonists
2. Determine how the supply and demand curves would shift if hormones and Beta-agonists were banned in US beef production
3. Quantify consumer and producer welfare changes with and without the use of Beta-agonists and hormones

Implications

- Trade restrictions have caused major disruptions to the US beef industry
  - Accurate estimates of welfare effects are scant
- Disease issues and controversial production practices have the potential to abruptly disrupt trade for an indefinite time
- Importance of understanding the consequences of changing US beef producing practices to address international concerns
- Importance of having accurate estimates of the welfare changes for producers and consumers if US beef practices are to be changed
  - TTIP and TPP

Thank you!

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