A New Measure of the Producer Welfare Effects of Technological Change

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A Challenge: to measure the affect of technological change on producer welfare

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

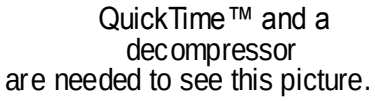
Long literature:

- Grilliches (1952)
- Lindner and Jarret (1978, 1980)
- Rose (1980)
- Wise and Fell (1980)
- Norton and Davis (1981)
- Edwards and Voon (1991, 1997)
- Alston, Norton, and Pardey (1994)
- Huang and Sexton (1996)
- Wohlgenant (1997) …

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

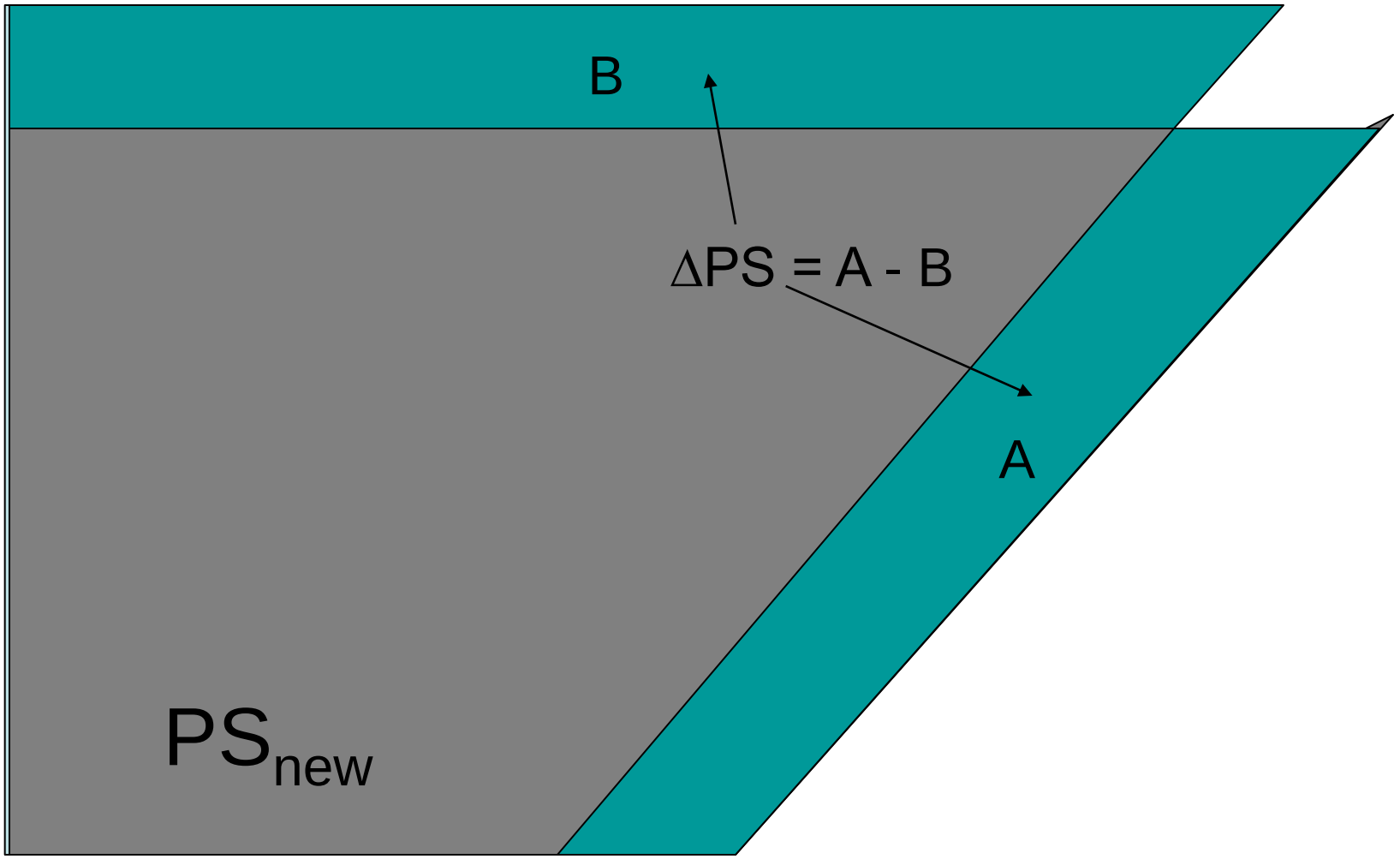
Get some (quantity, price) data points:



Estimate supply and demand curves:

QuickTime™ and a
decompressor
are needed to see this picture.

Use estimated curves to get producer surplus measurements:

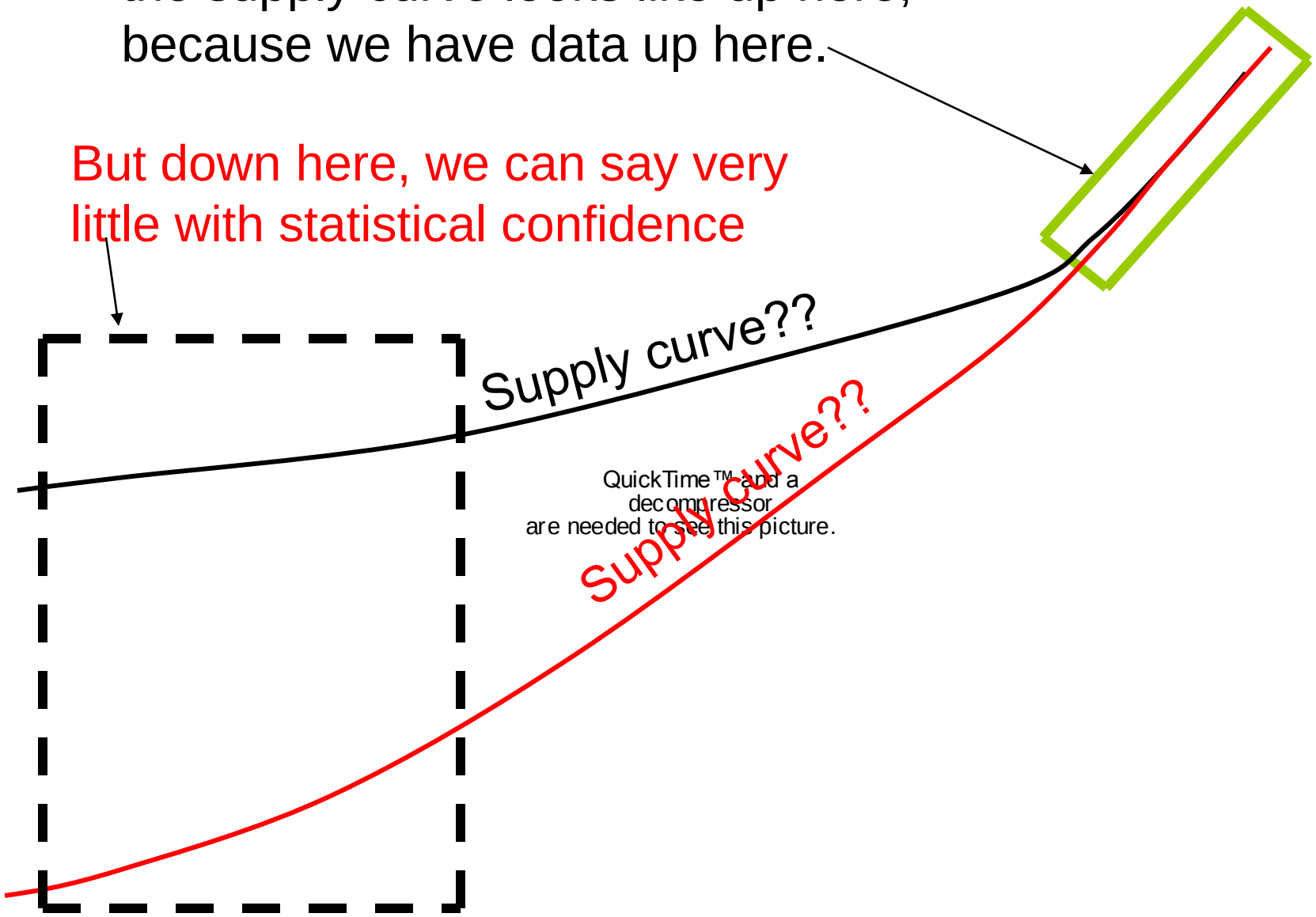


But there are well-known problems of statistical reliability:

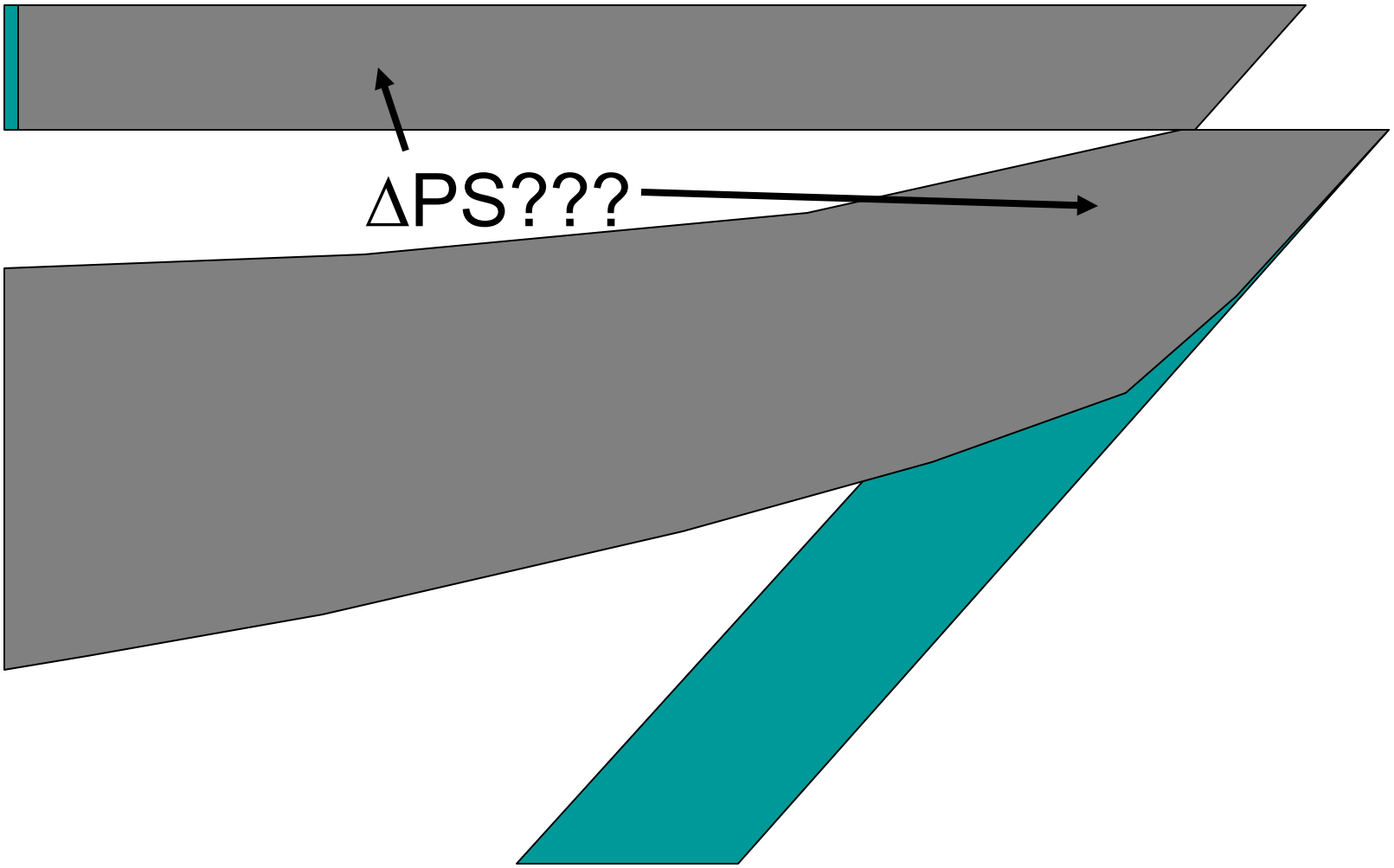
- The observed (quantity,price) points take up a small part of the diagram
- But the ΔPS measure requires measurement of the entire length of supply curves
- “Extrapolation” beyond the observed range of the data

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

But down here, we can say very little with statistical confidence



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



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

Science under Scarcity

(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.

Purpose of my paper:

to introduce an alternative measure of the effects of technology change on producer welfare

The new measure has the potential to be much more statistically reliable than the traditional measure:

- Doesn’t rely on (quantity, price) observations out of the range of the data.
- Relies instead on observable data on the change in input use after the technology change.

I figured out this new measure in my Applied Welfare Economics class, prompted by student questions.

Use line integral theory to develop the new measure.

(Are you sitting down???…..)

QuickTime™ and a decompressor are needed to see this picture.

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$$\Pi = p^0\left[S\left(p^0,\mathbf{w}^0,T^1\right)-S\left(p^0,\mathbf{w}^0,T^0\right)\right]-$$

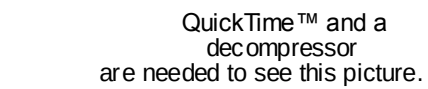
$$\sum_{i=1}^{n} w_i^0\left[v_i\left(p^0,\mathbf{w}^0,T^1\right)-v_i\left(p^0,\mathbf{w}^0,T^0\right)\right]+\int_{p^0}^{p^1} S\left(p,\mathbf{w}^0,T^1\right)dp.$$

I won’t go into the math here. But I’ll give a demonstration of how this works.

Simulation:

- Start out with 100 farms, each with its own quadratic production function:

Farm *i*'s production parameters



Input 1

Input 2

Technology variable

Production parameters α_i are drawn at random from a joint normal distribution for each farm $i = 1, \ldots, 100$.

So each farm gets its own production function.

Each farm has its own supply function and input demand function implied by its production function:

$$s_i\left(p, w_1, w_2, T\right)$$

$$x_{1i}\left(p, w_1, w_2, T\right)$$

$$x_{2i}\left(p, w_1, w_2, T\right)$$

Get market supply and input demands by summing over the farms:

$$S\left(p, w_1, w_2, T\right) = \sum_{i=1}^{100} s_i\left(p, w_1, w_2, T\right)$$

$$X_1\left(p, w_1, w_2, T\right) = \sum_{i=1}^{100} x_{1i}\left(p, w_1, w_2, T\right)$$

$$X_2\left(p, w_1, w_2, T\right) = \sum_{i=1}^{100} x_{2i}\left(p, w_1, w_2, T\right)$$

For the simplicity of the simulation, I don't allow input prices to change

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$$X_1\left(p, w_1^0, w_2^0, T\right) = \sum_{i=1}^{100} x_{1i}\left(p, w_1^0, w_2^0, T\right)$$

$$X_2\left(p, w_1^0, w_2^0, T\right) = \sum_{i=1}^{100} x_{2i}\left(p, w_1^0, w_2^0, T\right)$$

Assume an aggregate supply function: $D(p, Y)$.

Created a 20-year data set, with the technology at one level for the first 15 years, then at another level for the last 5 years:

$$T_{year} = 4, \text{ year} = 1,\ldots,15$$

$$T_{year} = 6, \text{ year} = 16,\ldots,20$$

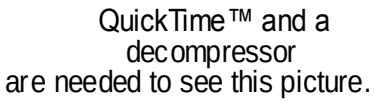
Income varied randomly over the twenty years

(for the purposes of econometric identification of the supply and demand curves):

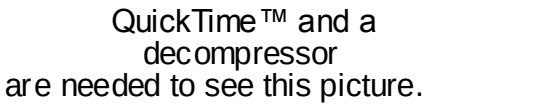
$$Y_{year} = Y_{base} + \Delta Y_{year}, \text{ year} = 1,\ldots,20$$

Then by introducing at random aggregate supply and demand disturbances, I use market clearing to solve for twenty years of equilibrium (quantity, price) data:

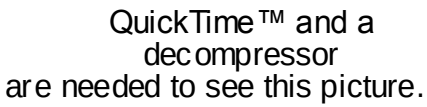
Simulated equilibrium (quantity, price) points:



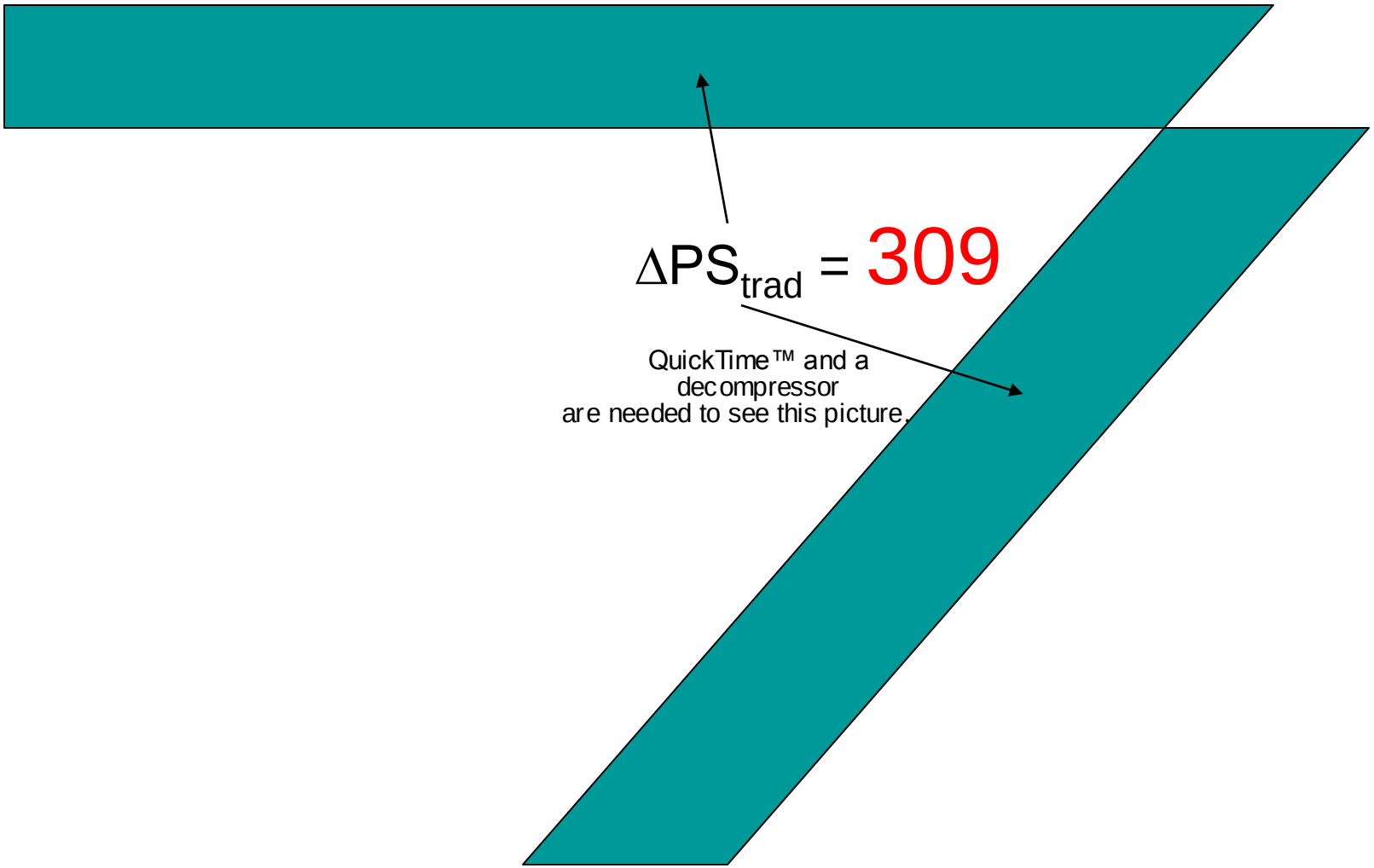
Used instrumental variables technique to estimate linear supply and demand curves:



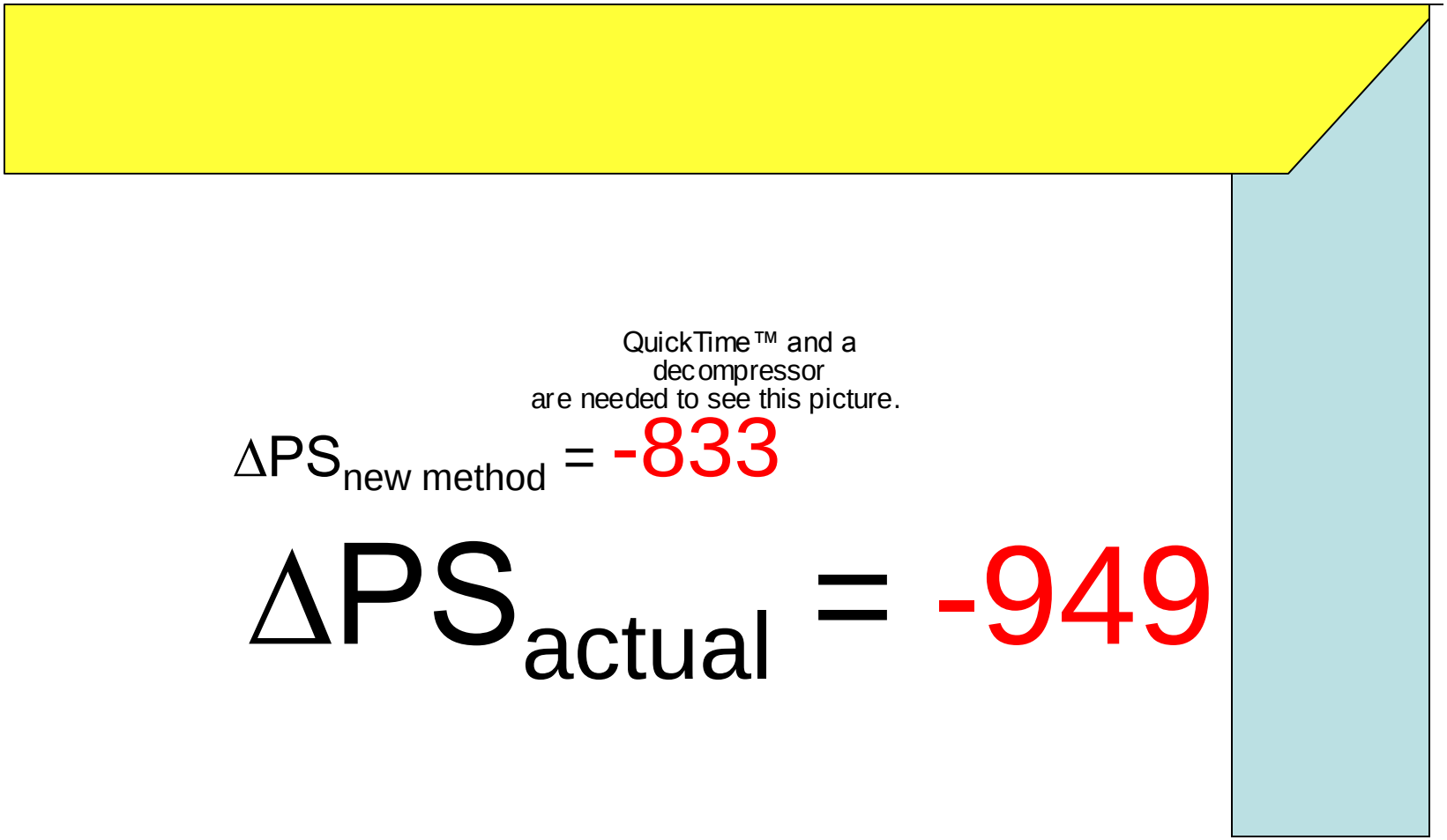
Though a researcher couldn't do this, because I know the underlying production functions, I can generate the "true" supply and demand curves, and input demand quantities:



Then I can calculate the measures of welfare change under the traditional method and the new method:



I can also use my method (input cost changes not shown):



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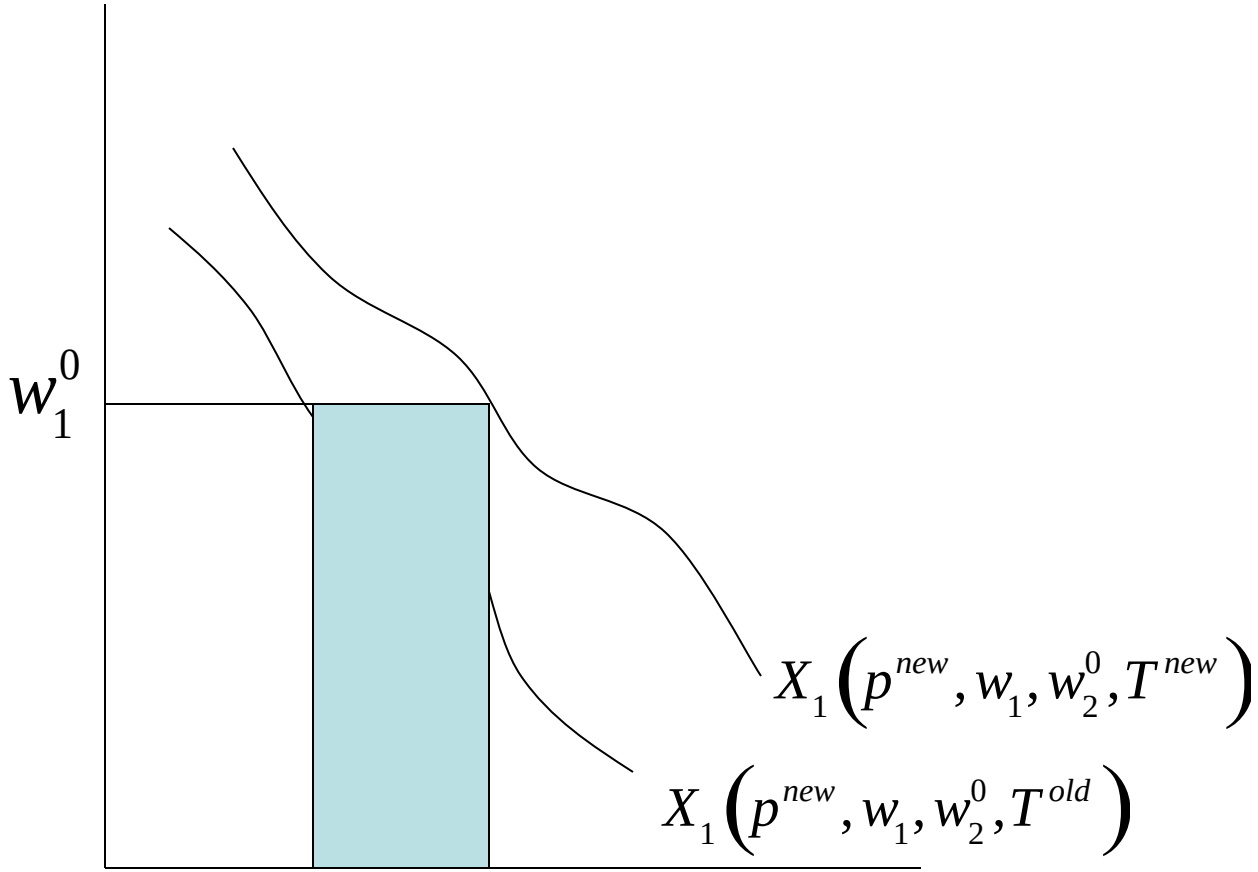
$\Delta PS_{new\ method} = -833$

$\Delta PS_{actual} = -949$

Use the input demand markets:



- Actual change in producer welfare: -949
- New and improved method: -833
- Brand X: +309

Of course, this is just one "draw" from the distribution.

Next: Monte Carlo analysis.