Input and Output Market Power with Non-neutral Productivity: Livestock & Labor in Meatpacking

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Introduction

- A firm can have market power in the product market and simultaneously in one or several input markets (monopsony power).

- To measure market power we need to asses marginal cost to compute markups, and marginal product(s) to compute markdowns.

- To do this from the production side, we typically estimate output elasticities of the inputs.

- Identification is difficult: it needs all input elasticities, elasticities are interrelated, and are affected by non-neutral productivity.

This paper proposes a method:

- To identify the parameters relevant to assessing market power in output and (possibly several) input markets of a firm.

- Robust to the type of competition: no specification of demand/behavior in the market for the product, compatible with any behavior in the input markets (but needs one to be competitive).

- Derived for an environment with labor-augmenting productivity, which separates from the effects of monopsony, and can cope with other types of biased technological change.

- Derives the profitability bound for the sum of market power contributions to gross profits together with the contribution of technology.

- Applies the model to the US meatpacking industry, assessing product and livestock market competition, and establishes the labor market as monpsonistic for the first time.

Relationship to literature

- Estimation of market power started with Bain (1951), the production approach was stimulated by De Loecker and Warzynski (2012).

- Dobbelaere and Mairesse (2013, 2018) pioneered the simultaneous measurement of market power in an input market (labor). Recent papers in this line of research are Yeh, Macaluso and Hershbein (2022) and Rubens (2023).

- A first discussion of consequences of labor augmenting productivity is Doraszelski and Jaumandreu (2019). See also Demirer(2020), Raval (2022) and Kusaka, Okazaki, Onishi and Wakamori (2024).

- One characteristic of our method is the departure from the traditional approach to measuring market power due to Hall (1988), and followed by Klette (1999) and De Loecker and Warzynski (2012).

A New Approach to Estimate the Production Function

- Assume that the production function of a population of firms is

$$Q = F(K, R, \exp(\omega_L)L, M) \exp(\omega_H) \exp(\varepsilon^*),$$

where

K =capital

R =input bought in a market possibly monopsonistic

L =labor, afected by ω_L, possibly hired under monopsony

M =materials, competitive markets.

- Two types of technological progress: Hicks-neutral ω_H, and labor-augmenting ω_L.

- Let us use $Q^* = F(\bullet) \exp(\omega_H)$, $L^* = \exp(\omega_L)L$

- FOCs for (short-run) cost minimization are

$$MC\frac{\partial Q^*}{\partial R} = (1+\rho)P_R,$$
$$MC\frac{\partial Q^*}{\partial L^*}\exp(\omega_L) = (1+\tau)W,$$
$$MC\frac{\partial Q^*}{\partial M} = P_M,$$

where $P_R,\ W,\ P_M =$ input prices; $\rho,\ \tau =$ (percentage) markdowns.

- If $\rho = \tau = 0$, sum would give

$$MC(\beta_R + \beta_L + \beta_M) = AVC,$$

or

$$MC\nu = AVC,$$

with $\nu =$short-run elasticity of scale.

• If $\rho \neq 0$ and $\tau \neq 0$, $\frac{AVC}{MC} = \nu/(1 + S_R\rho + S_L\tau) = \nu^*$, where ν^* is the (corrected) short-run elasticity of scale and S_X observable cost shares in VC.

• Take a first order approximation to the PF of each firm at each time t

$$q = \beta_0 + \beta_K k + \beta_R r + \beta_L(\omega_L + l) + \beta_M m + \omega_H + \varepsilon.$$

• Write the output elasticities of the (variable) inputs in terms of shares and parameters to estimate

$$\beta_R = \nu^*(1 + \rho)S_R,$$
$$\beta_L = \nu^*(1 + \tau)S_L,$$
$$\beta_M = \nu^* S_M,$$

and plug them. (Long-run) scale: $\lambda = \nu + \beta_K$.

• The result is the PF

$$
\begin{aligned}
q_{jt} &= \beta_0 + \lambda k_{jt} + v^*_{jt} SUM_{jt} \\
&\quad + v^*_{jt}\rho S_{Rjt}(r_{jt} - k_{jt}) + v^*_{jt}\tau S_{Ljt}(\omega_{Ljt} + l_{jt} - k_{jt}) + \omega_{Hjt} + \varepsilon_{jt},
\end{aligned}
$$

where

$$
\begin{aligned}
SUM_{jt} &= S_{Rjt}(r_{jt} - k_{jt}) + S_{Ljt}(\omega_{Ljt} + l_{jt} - k_{jt}) + S_{Mjt}(m_{jt} - k_{jt}), \\
v^* &= \frac{v}{1 + S_R\rho + S_L\tau}.
\end{aligned}
$$

• Nonlinear equation with parameters λ, v, ρ and $\tau,$ where we should control for two productivity unobservables: ω_{Hjt} and ω_{Ljt}.

• Elasticities $\beta_{Rjt}, \beta_{Ljt}, \beta_{Mjt}$ are implicitly estimated. We take scales λ and v as constant but they can be specified varying.

• Markdowns could also be made function of observables.

A bound to profitability

• Having ν^* we can compute markups $\mu = \frac{P}{MC}$ up to a mean-zero error:

$$\frac{R}{VC} = \frac{PQ}{AVCQ^*} = \frac{PQ}{\nu^* MCQ^*} = \frac{\mu}{\nu^*}\exp(\varepsilon^*).$$

• And decompose the (Bain/short-run) profitability of each firm. Contributions to profitability can be asessed as

$$\ln\frac{R}{VC} \simeq -\ln\nu + \ln\mu + S_R\rho + S_L\tau + \varepsilon^*,$$

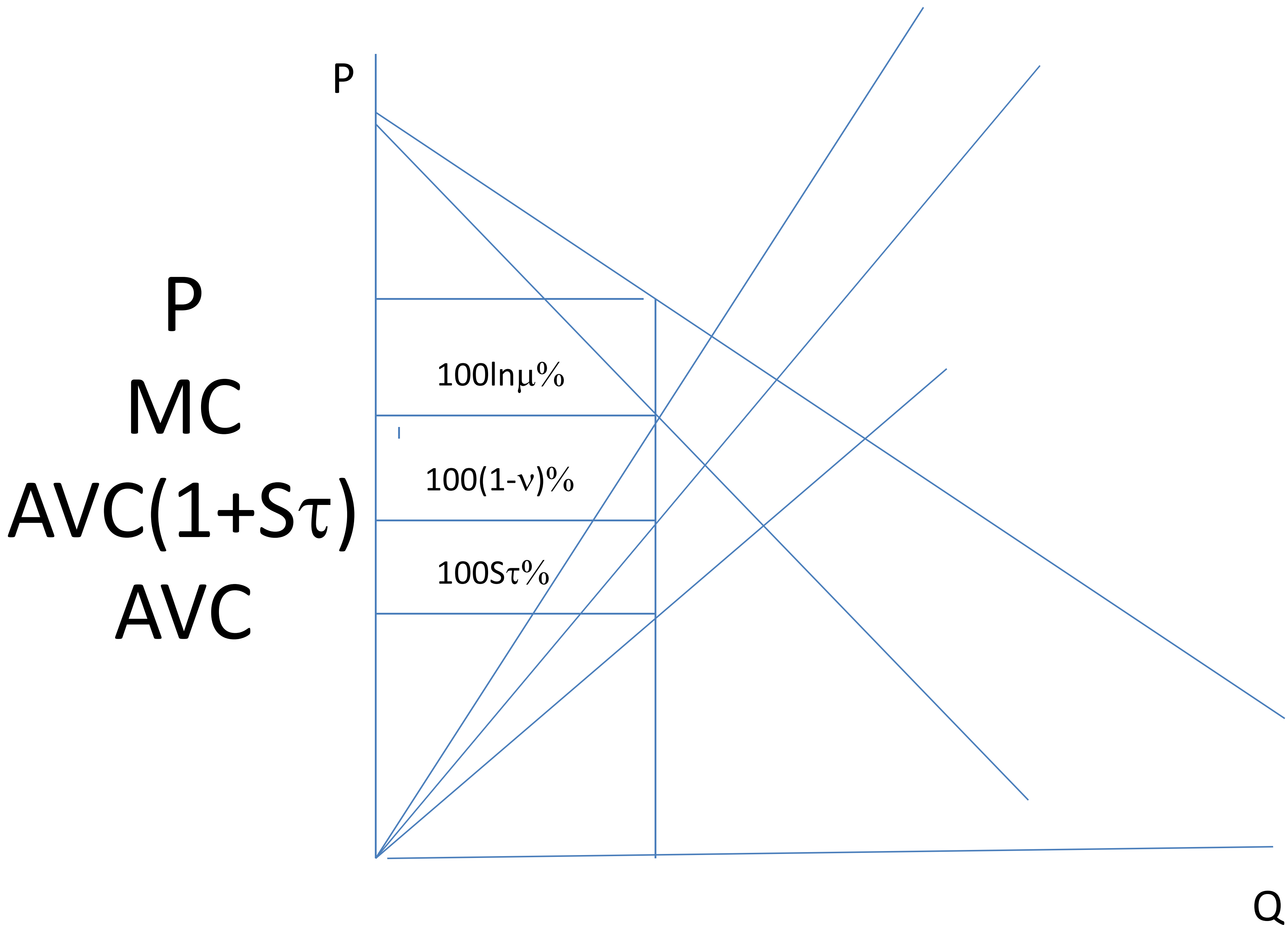
(1) (2) (3) (4)

where (1)=non constant-returns technology

(2)=market power in product market (markup)

(3)=market power in input market (markdown)

(4)=market power in the labor market (markdown)



Decomposition of profitability

Controlling for unobserved productivity

• Assuming that Hicksian productivity follows an $AR(1)$, $\omega_H = \rho_{AR}\omega_{H,-1} + \xi$, we can differentiate out the unobservable by applying "dynamic panel."

• We can replace the labor-augmenting ω_L by the (solved) approximation to the ratio of FOCs in Doraszelski and Jaumandreu (2018). For example,

$$\omega_L = cons - \frac{\sigma}{(1-\sigma)}(\tau - \rho) + r - l - \frac{\sigma}{(1-\sigma)} \ln \frac{S_L}{S_R}.$$

• Both productivities are implicitly estimated (in difference w.r.t. the mean) and can be backed up for each plant.

• Now parameters to estimate are $\rho_{AR}, \lambda, \nu, \sigma, \rho, \tau,$ and two constants (8).

Meatpacking

- Slaughtering, processing, packaging and distribution of meat from animals (150,000 workers).

- Highly concentrated industry: four big producers (Tyson Foods, Cargill, JBS USA and National Beef Packing), slaughtered 85% of cattle, 67% of hogs and 53% of sheep in 2019 (USDA).

- Concern about monopsonistic behavior in the livestock market and poor conditions in the labor market.
  - Class action antitrust lawsuit in 2019, but settlements denying wrongdoing.
  - Low wages, high injury rates and abnormal COVID19 incidence. Market power of the companies?

- Azzam (1998) and Wohlgenant (2013)'s reviews did not find however evidence of product and livestock market power. Labor market power never formally analyzed before.

- Structure 2021:

Size (number of heads)	Plants	% of production
<1,000	476	<1
1000-9,999	161	1
10,000-99,999	37	4
100,000-999,999	40	45
1,000,000+	12	50
Total	726	

Source: USDA NASS, 2022.

- 56 counties in which meatpacking accounts for more than 20% employment. They tend to be rural and poor (USDA).

- More than 50% of red meat production is concentrated in Iowa, Nebraska, Kansas and Texas (USDA).

Some aggregate descriptive statistics

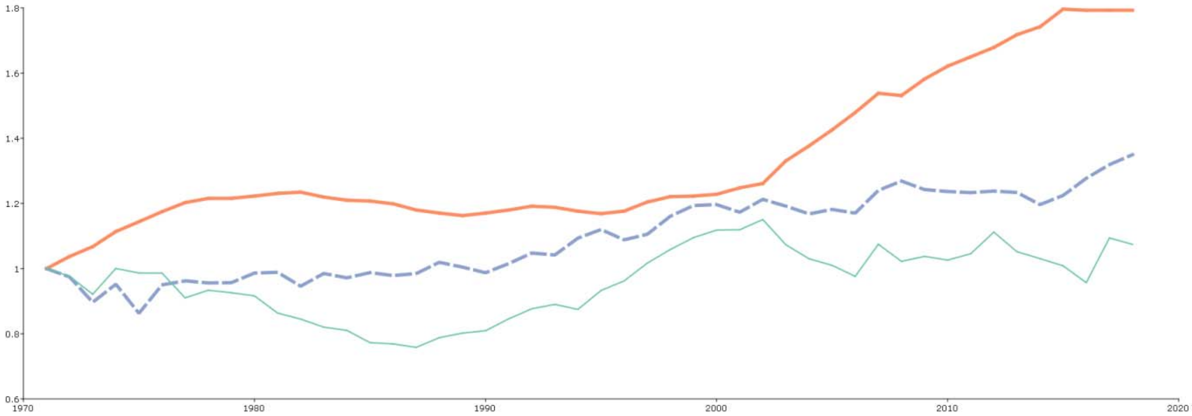
- Output grows about 40% from 1970 to 2018 (NBER-CES Database).

- Livestock matches production while capital seems to replace labor, labor stays without much change.

- Variable inputs (livestock, labor, materials) cost shares are stable.

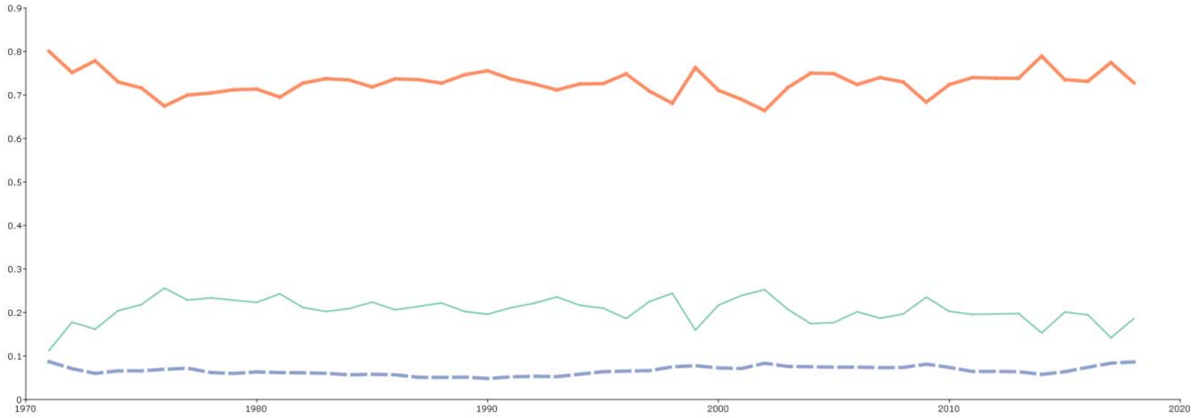
- Has labor-augmenting productivity been relevant?

Figure 1.: The evolution of three meatpacking inputs: capital, livestock and labor, 1971-2018.



Thick solid line: Capital; Dashed line: Livestock; Thin solid line: Labor. Source: NBER-CES Database, 2021

Figure 2: Livestock, labor and materials share in variable cost, 1971-2018



Thick solid line: Livestock; Dashed line: Labor; Thin solid line: Materials. Source: NBER-CES Database, 2021

• Wage per hour increases from $\$4.30$ to $\$19.70$, 30% more than the price of the other variable inputs (NBER-CES Database).

• A version of the ratio of FOCs to explain the evolution of the labor share in cost is

$$\Delta \ln \frac{S_L}{(1 - S_L)} = (1-\sigma)\Delta(w - p_M) - (1-\sigma)\Delta\omega_L,$$

where w pushes the share up and LAP down.

• A rough calculation says that, if S_L has been stable, $\Delta\omega_L$ was 30%.

Summary of aggregate results

- Earlier version of the paper: preliminary estimation with the industry NBER-CES Manufacturing Industry Database (1970-2018) and USDA data.

- We expected ω_H to be picked up by trend, but it was zero. We specified efficient labor as observed labor plus 2% productivity increase per year.

- Quantity of meat (millions of pounds) regressed on capital, livestock, hours of production and materials.

- Instruments (8 for parameters λ, ν, ρ, τ and a constant): constant, time trend, capital and livestock lagged, share of labor lagged, price of corn lagged, cattle cycle, and utilization.

- The result said:
  - Not very significant market power in the product market.
  - No monopsony power in the livestock market.
  - Monopsony in the labor market (workers receive 60% of MP).

The challenges of a sample of plants

- We are going to have an (unbalanced) panel sample of plants from CMF and ASM for 24 years (1997-2020)

- Many plants are very unequal in size. The production function should account for long-run and short-run variation in the cross-section by means of the elasticities.

- Plants have different locally (county) presence. Labor market power may be varying. Cattle market power probably less.

- The unit for production may be the plant, but behavior is likely to be coordinated at the firm level.

Specification and estimation

- We need to examine the effect of buyer concentration on ρ.

- τ is likely to be heterogeneous according to the modeling

$$\tau = \tau_0 + \tau_1 shce + \tau_2 l + \tau_3 (shce \times l),$$

$shce$ =log share of the plant in the meatpacking employment in the county,
l =log employment.

- Final specification: 11 parameters ($8+3$ constants), 21 instruments.

- Instruments: Ones, time trend, k_{jt} and k_{jt}^2; $w_{jt-1}, w_{jt-1}^2, w_{jt-1}^3$, p_{Rt-1}, p_{Rt-1}^2; S_{Rt-1}, S_{Lt-1}, S_{Mt-1} and squares; SUM_{jt-1} and square; an approximation to l_{jt-1}^*; and variables $cycle_t$, $shce_{jt}$ and $1 - RTW_{jt}$.

- GMM: Nonlinear minimization of a quadratic form with the consistent weight $(N^{-1} \sum Z_j' Z_j)^{-1}$, Z_j =matrix of instruments for plant j.

Production Function

- New production function needs to estimate the $AR(1)$ parameter for ω_H, and the σ parameter for the elasticity of substitution between the inputs used in the ratio of FOCs that replaces ω_L.

- Is the aggregate production function overstating the long-run returns to scale?

- Short-run scale is key, $-\ln v$ gives tells how marginal cost exceeds average variable cost ($\simeq 4\%$ in the aggregate).

- Is ρ nonsignificant, is τ increasing with $shce$ and l? We anticipate a problem with the identification of the "level" of labor market power.

Parameters/elasticities	PF Plants[a]		PF Aggregate[b]	
	Value	Std. error	Value	Std. error
$\rho_{AR(1)}$	+	***	-	
λ	+	***	1.185	(0.100)
ν	+	***	0.960	(0.097)
σ	+	*	-	
ρ	+		-0.012	(0.460)
τ_0	-		0.666	(0.426)
τ_1	+	***	-	
τ_2	-		-	
τ_3	-		-	
β_K	+		0.225	(0.066)
β_R	+	***	0.668	(0.026)
β_L	+	***	0.102	(0.015)
β_M	+	***	0.190	(0.027)

[a] Part of clearance request #11995 under project no. 2585 of the FSRDC (CBDRB-FY25-R11995);
[b] Estimation carried out with the NBER-CES Database.

Decomposing Productivity

- As a result of the estimation we can decompose the mean profitability 1997-2020 for each plant.
- Average decomposition can be examined for any subset of plants that we are interested in.
- We are interested in ordering the sample by labor market power and examining the sources of profitability in the 25% of firms with more market power.
- We may also be interested in the firms with more market share, but this may be non-reportable because of the degree of concentration.

Decomposition of profitability 1997-2020

Sample	Gross profit	Technology	Markup	Labor Market Power
All plants				

Relationship to other Measurements

- What would happen if we had applied De Loecker and Warzyinski (2012) and Yeh, Macaluso and Hersbein (2022) measures of market power?

- They would give exactly what we have obtained. But this is because the way we have estimated the production function. Our elasticities are unbiased, consistent and compatible among them.

- This, however, is not warranted when one estimates elasticities not theoretically restricted (e.g. without relationship with the shares in cost).

- The numbers that have been advanced for market power and labor market power in the US, are fully incompatible with the most optimistic available estimates of profitability of firms (e.g.: $-\ln 0.9 + \ln 1.61 + 0.25 \times 0.53 = 0.714 >$observed $\ln \frac{R}{VC}$).

Concluding Remarks

- We want to identify market power in output and input markets, assuming only cost minimization, under the natural complication that productivity is not neutral.

- We derive a way to estimate the production function imposing the relationships among observables and parameters implied by the FOCs.

- Estimation gives reasonable output elasticities of the inputs, sensible market power inferences, and a nice, varying assessment of the sources of profitability.

- Meatpacking firms turn out to have no market power in the livestock market, but they exercise monopsony power in the labor market combined with some product market power.

Identification

- Both the degree of labor monopsony τ and LAP ω_L increase the gap between labor marginal productivity and observed price.

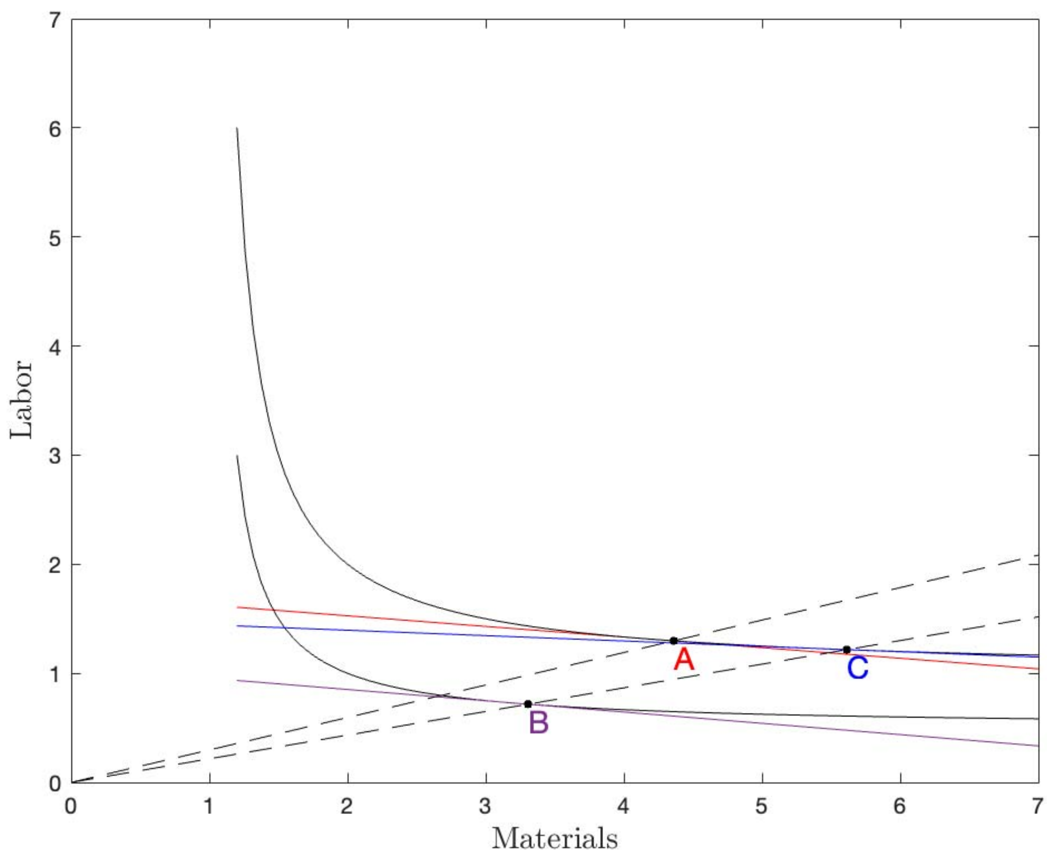
- Substitution of observables for ω_L ensures identification, but still must check that are very different effects.

- A cost minimizing firm chooses equilibrium L and M at point A. Suppose WLOG that τ and ω_L increase alternatively from a starting value of zero.

- LAP: Isoquant moves down with new slope which implies -at the same prices- the choice of a new point as B. With $\sigma < 1$ (a condition on curvature): less L, M and L/M, smaller S_L and MC.

- Monopsony power: A firm chooses less slope in the same isoquant. Let's say point C for convenience. Less L, more M, same L/M as with LAP by assumption, smaller S_L but more MC.

Figure A1: The effects of an exogenous increase of labor-augmenting productivity and labor market power



Labor-augmenting productivity (A to B): The isoquant moves closer to the Materials axis and the firm chooses an equilibrium on the new isoquant given prices.

Input market power (A to C): On the unique original isoquant, the firm chooses an equilibrium in which the slope equates the new (absolute) price ratio P_M /W'(1+τ) flattened by the increase in monopsony power.

Assessing $\ln \frac{R}{VC}$ in manufacturing

Source	2000-2018
Compustat	**0.587**
$VC = cogs$	(0.360)
NBER-CES	**0.416**
$VC = WL + P_M M$	(0.181)
Compustat	**0.134**
$VC = cogs + (xsga - rd - adv)$	(0.226)
Compustat	**0.022**
$VC = cogs - xsga$	(0.242)