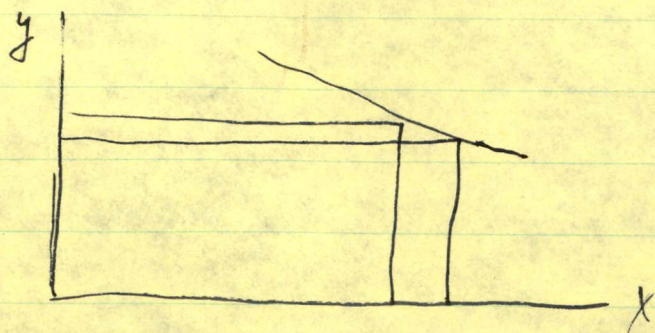


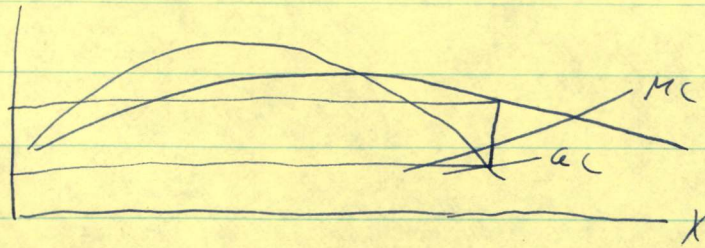
Ec. 162, Prodn. Ecs.



$$\epsilon \text{ of demand} \equiv \frac{\Delta(xy) / \cancel{\Delta x} y}{\Delta y / y} = \frac{\Delta(xy) / x}{\Delta y} = \frac{\Delta(xy)}{x \Delta y}$$

$$\epsilon \text{ of profit} \equiv \frac{\Delta(xy) / \cancel{\Delta x} y}{\Delta x / x} = \frac{\cancel{\Delta x} \Delta(xy)}{y \Delta x}$$

"Efficiency". Give as problem.



$$TP = AP \cdot x$$

Grand Total: $GT C = AC \cdot x + (\bar{AP} - \bar{AC}) \cdot \bar{x}$

$$\frac{TP}{GT C} = \frac{AP \cdot x}{AC \cdot x + (\bar{AP} - \bar{AC}) \cdot \bar{x}}$$

When $x = \bar{x}$, $\frac{TP}{TC} = 1$

But any move from eq. will $\Delta TC > \Delta TP$
or $-\Delta TC < \Delta TP$

but at eq. $MP = MC$

Fri, Nov. 13, 1981, E1.162

Cost Anal.

1. $ac = \frac{\text{Input}}{\text{Output}} = \frac{1}{AP}$

Provided AP is AP of "\$1 of input." - i.e., all inputs.

AP may also refer to just one variable input.

ANP covers all inputs, but differently:

$$ANP = \frac{NP}{I_x} = \frac{P - CC_y}{I_x} = \frac{P}{I_x} - \frac{CC_y}{I_x}$$

$$ac = \frac{I_x + CC_y}{P} = \frac{1}{AP_x} + \frac{1}{\frac{P}{CC_y}}$$

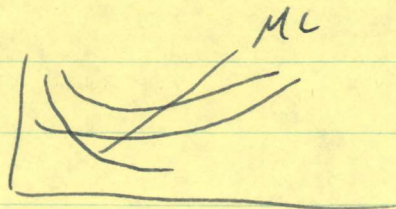
2. Purpose of inverting?

a. Δ mental agility, translating, understanding facts as presented -- but, some people are bound to present them both ways.

b. To relate to demand.

c. To relate to Efficiency

3. 4 curves



Q.S. 162
 Jan. 24, 1978
 and
 Jan. 26, 1978

1. Quiz re MP

Planning spacing of trees. ~~Learn ff.~~

(1) No. of trees/acre	(2) Expected yield of per tree marginal tree	(3) TP	(4) MP
50	300 lbs	15000	
55	280		60
60	260	15600	-20
70	220	15400	-150
80	180	14400	
50	300 lbs	15,000	180
60	280	16800	
70			140
70	260	18200	100 80
80	240	19200	

Given (1) & (2), find (4).

2 minutes

2. Free entry e.g. — mining law,
Alaska o & g.

Pt. #13. Max. AP of land when MP labor = 0.

And v.v. (B & P, p. 175)

Move to left of max. AP labor, reduce output/mon.
If move left while holdg no. of men fixed, this
reduces output.

This is adequate proof for now. See Fug. for
formal proof.

Moral: one-factor productivity is max. by wasting
others. No basis for efficient combo.

Jan. 26

#20 ~~Jan~~

When opt. to max AP.

a. Free labor, max. AP land. ~~There~~

b. W.r. = AP. Then land is free,
and adding it to MP = 0
Even tho is free, you can do no better.

21

~~the~~ ~~by~~ ~~the~~

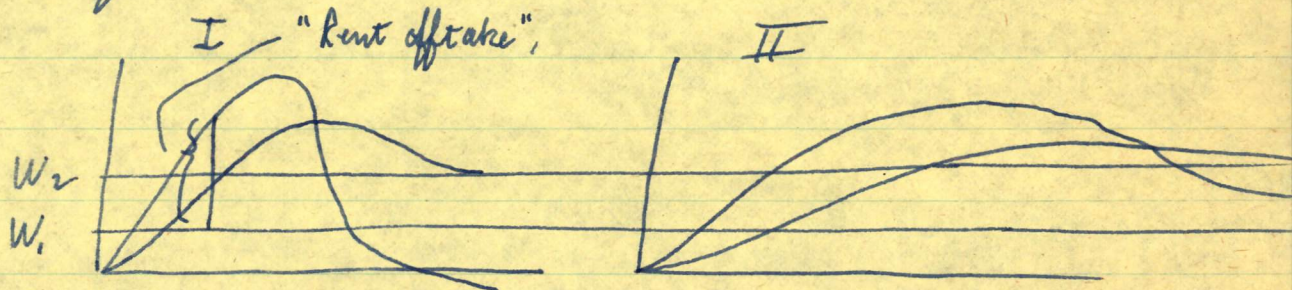
~~Complete list is MP~~

Effect of higher wage ^{cost} ~~rate~~ on ^{choice of} land uses

a) Shift land to uses of low capacity, (& hi surplus $\frac{1}{2}$ = hi AP)

~~Payroll~~

Understatement of effects, to say that they are merely marginal, cut off unqual. workers. E.g. of payroll tax, seems to have no unqual. effect. ~~But~~ on individual, But will tip some land from use II to use I.



To solve basic ec. problem of resource limits, go to uses like II. (Good ec. policy fosters this.) This is substit. labor for land.

are Two ways of underusing land, both reflected in hi AP of labor. i) Use little work/acre for given crop ii) Use cheap crop on clear land of hi capacity.

Leave room on the right!

21

~~Att, B~~

WB = wage bill

G = gross revs.

R = Rent

$$I. \frac{WB}{G} = .90$$

;

$$\begin{aligned} \text{G} - \text{WB} &= \$1,000 \\ 10,000 - 9,000 &= 1,000 \end{aligned}$$

$$II. \frac{WB}{G} = .40$$

$$G - WB = 1,000$$

$$.6G = 1,000$$

$$G = \frac{1,000}{.6} = 1,666 \frac{2}{3}$$

$$1667 - 667 = 1,000$$

Δ WB by 11%, wipe out I, land goes to II.

Different land uses have very diff. mixes.

Thurs., Jan. 26, 1978

#22. ~~Elas.~~ Elast. of produ.

a) A concept much used in ec. analysis and managerial planning & control, elast.

$$\frac{\% \Delta P}{\% \Delta W}$$

b) We already have this: $= MP/AP$

$$\frac{\frac{\Delta P / \Delta W}{P / W}}{\frac{\Delta P / P}{\Delta W / W}} = \frac{\Delta P / P}{\Delta W / W}$$

c) This tells us how cutbacks in inputs affect total output.

If $MP = 0$, no effect
 If $MP = AP$, full effect --- (and more, drive out of business, too.)

d) Shows unfairness & ineff. of prorate.

c) Shows differential effect of higher wage costs (i) large & small firms;

(ii) Different land uses

Where $\frac{MP}{AP} = .25$, can lose 10% of labor & lose only $2\frac{1}{2}\%$ of P.

But if $MP/AP = .90$, lose 9% of P

So, are wage Δ s passed thru in higher price?
Not really. If $\frac{MP}{AP}$ is low, there is little

reduction of supply, $\therefore$ little ~~reduction~~ rise of price.

1. Perfect substitutes

oil + nat. gas for heating + generating.
Not really — oil is more polluting.
(as for coal, it leaves an ash)

2. Partial subs.

Water & wtr. cons., a) K b) work

Bldg. ut. & land size.

Farm workers & tractors.

✓ If land Δ s w. tractors, then tractors complement workers. So, much depends on what else is fixed, until we specify this, haven't said much.

Thus, indiff. gimmick diverts us from specifying key fact.

✓ If land is fixed, then some K still complements labor. But it must then sub. for land: eg. ut. of bldg; fertilizer (by Δ s crop); row intvl. for mfg.

Or dev. new land: exptn. tapping new land, or intensifying old land (but this is off/site); paving r.o.w., allowing more traffic;

Line capacity & storage

Line pressure & line capacity.

Class exercise: think of ways to substitute.

3. Perfect complements? Beware! Fixed valence. There are no such things!

Wheels + tires

Cd. modify wheel to use less tire. Cd. drive less, in rubber Mortgage.
Boards + bond counsel
Or change air pressure

Cars + gas

Obviously Mangleable

Oxygen + hydrogen

But who makes water

Energy + N.I.

B.S.

Who can draw an indiff. curve showing what big price changes wd. do? It is unexplored territory. All we know is Scarcity breeds substitutes and routinized conventional minds underest. it.

Take wheels + bike frames. If wheels tripled in price, mutae. wd. focus on wheels. Recycle old ones. Check spokes. Stop curb-jumping. Use bigger tires to save wheels.

But a wheel is not a wheel. Cd. produce a cheaper

2
wheel, in order to have more.

Make wheels more rugged, less rideable, so they last longer. Change nature of wheel. Cut out super light racing wheels that damage easily.

You can stop space wheels, as I do for my car. You can use wobbly wheels longer.

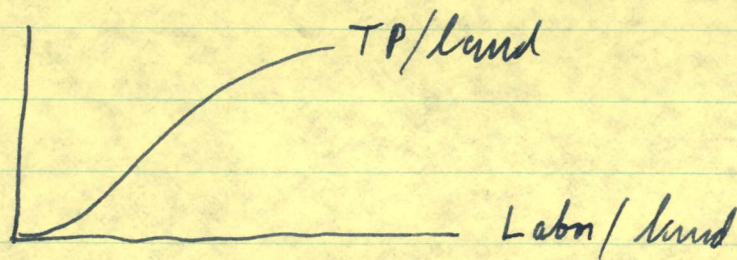
Stop making wheels w/o adj. spokes, that can't be trued up.

With isoquants, output is const, so labor & land become substitutes. p. 220 n. 10.

Beware, cd. lead to weird results. But p. 223 is ok.

In dim. rets., hold one ^{or more} inputs const. In isog., hold output const., thus abstract from scale.

Cd. also abstract from scale by using ratio of inputs as indep. vble. on dim. rets.



Points re cost

1. FC are int + deprec.
rent + prop. taxes. (Note implication for s.s. econ.)
- apprec. (you pay extra int. for this)

2. S curve, ΣMC

3. ~~Deprec.~~ includes obsolescence.

4. Daily + seasonal changes in demand

Value of flexible p

Renting pipe for PUB ... they give good price when shops empty.

5. Change in input mix

a. $\downarrow$ demand, higher ~~the~~ variable component

b. Change relative costs,

6. ~~ATC are not fixed over life of K .~~

~~They fall, as it loses value.~~

$$= \frac{a}{(1+d)^t}$$

~~E.g. old appts.~~

7. How adapt to K scarcity?

All these in WWII

Extended closures

Put less life in new cap.

Longer hours

More labor - fuller utilization

More land/ K .

7. a. To use more labor, need more working K .
Taken K to consume K . Be sure you have it.
To complete K under constr., need more K .

8. o.c.

9. Acct'g cost ... unless for current eff'ic.
bygone are bygone
Don't hold invy. for hist. cost, if demand falls.
Always look fwd. (R.E. mkt. don't.)
Uncle Munk's house. Free gifts - no cost?
Implicit cost.

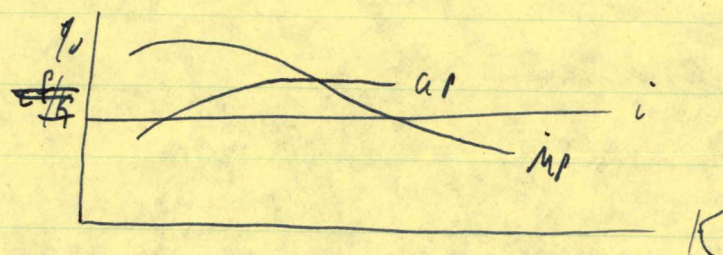
10. ~~Deprec.~~ Depends on asset. Rarely S.L.
~~Russian rug~~
~~House~~
~~Cars~~
~~Fruit trees.~~

Ec. 162 11-1-84

Prodn. Ec.

1. Now integrate IOVA prodn. ec. with DCF analysis.

a. Use IRR, with K as variable.



- 1, common business practice.

- 1, a "marginal net product" analysis. 1, bottom line after following ~~several~~ several steps correctly. It is pure return to K , to cf. w. pure cost of K .

1. C.F.

a. Design or select the K , tentatively.

b. Select size, + time to begin

c. Forecast sales + expenses. (expenses are an expense)

d. Search + select opt. ^{opt} output, to max $S - E$

e. Cost the K

f. Add L_n as ~~out~~ to Sales, + L_o to K .

2. ~~Search + select opt. K_o~~

That is what the graph does, explicitly

2. Calc. IRR - over whole life.

Avoid identifying IRR as $\frac{CF_o}{K}$

3. Search for opt K

That is what graph does explicitly.
Try different intensities.

~~As~~ separate into increments. Find
mgul I.R.

4. ~~Adjust~~ ^{Adjust} other details, ^{as K varies} ~~constantly~~; opt intensity;
life; ~~metric~~ metric; starting date.

5. Select hurdle rate

~~As~~ Usually above your borrowing rate, bcs. it
affects your credit to borrow. E.g. periods of pay
self, T & S devmt.

~~But usually is below nominal i~~

Use real i.r. w. const \$ c.f.; +
nominal i.r. w. current \$ c.f.

Real data are purer. But most people
use nominal, bcs. taxes are calc. on nominal
basis. Like metric system, the more convenient
method cannot overcome inertia + custom.

As some forecasting to choose hurdle
rate. Your money ~~will~~ ^{may} be frozen up many years.
On borrowed funds you may use the mkt. rate.

which rep. the forecasts of others. On your
own K , you forecast.

E.g. Cal. bonds, 1960, 3%

Complex - yes!

If viewed as abstract academic problem
 you'd say is irrelevant. Who needs "pure"
 return to K ?

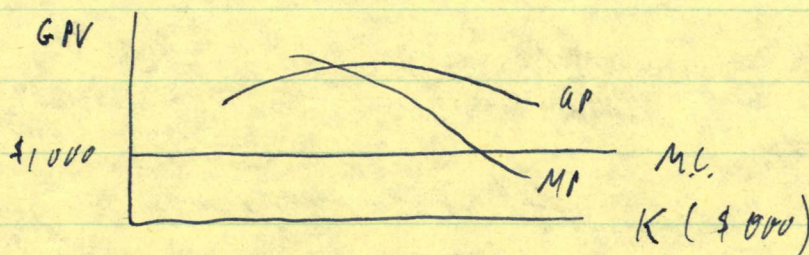
But in bus. you do. To make decisions.
 I.e. is price for pure K .

Commensurability is key. Mstrnt. is Science.
 Mstrnt. is also necessary basis for ec. decisions —
 wise bus. decisions. Wise inv. decisions of all kinds.

Complex? Again, yes. I never promised you
 a rose garden. That is why some succeed, &
 some fail, & most are mediocre. If you
 want to succeed, master these complexities.

"The heights by great men --"

- b. Use max DCF , fixed i , r
 K is variable.



Same set of procedures

1. CF
2. Discount to $t=0$, Calc GPV (include $L_n I^{-n}$) (over)
3. Search for opt I
4. Adjust other details as K varies
5. Select i
6. Choose among conflicting alts.
7. Don't be surprised or appalled if best you can do is $DCF = 0$. This is natural result of including all costs.

c. Omit land cost + land salvage, max return to land.

Is the traditional way.

Has the disadvantage of max'g return to G only. Correct for this by d.v. mult. $\frac{G_{t-1}}{1-i} \cdot i$.

Discounting is subtracting interest.

$$P = \frac{F}{1+i}$$

$$P = F - Pi$$

It completes the process of subtracting costs that we began by going from Sales to Cash Flow.

Thus, DCF is a net, pure number, clean, unencumbered. Commensurable w. K you began with.

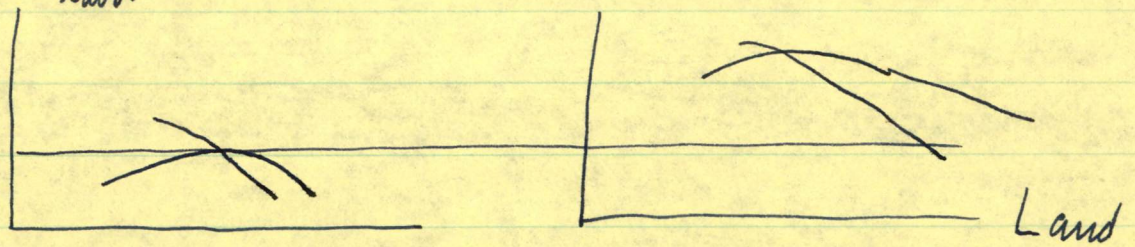
Reqs. a complete analysis. Hence a basis for decision.

also has disadvantage of assuming land is fixed.
 Correct for this by recalculation, for diff. areas of
 land. This ~~§~~ gets us into ess. of scale.
 Later, Now. vble. proper.

Has advantage of emphasizing that ~~inv.~~ ~~are~~ on
~~same~~ ~~to~~ many invs. are mutually exclusive.
 "2 objects cannot occupy same place at same
 time."

Overpriced mqr &
labor

~~Overpriced~~ Low-priced



A.S. 162

Tues. Feb. 14, 1978

Social Synergy, (exemplified by city.)

W/o Synergy, w. static ~~pop.~~ ideas, ~~but~~ when pop. grows
we a) Drive people away.

b) Divide into small parcels

c) Fragment parcels, so everyone has self-contained
unit.

Code Napoleon. (vs. Primogeniture.)

Better way: specialize, trade, intensify.

Land specializes, & power. Match land & product better.
People specialize.

Syn. City. — from p. 3 of prior notes.

3. E.g.s. of substitution — give many!

Inputs. 4 elements, ^{at least} one is held constant.
3 are inputs: land, K, labor.
1 is output.

Most natural is hold land constant.

E.g.

Sheep for plowland. The 16th cent. enclosure ^{effect}
(Cattle, timber)

Horses for men. 18th cent., horses for
traction used w. "corn", displaced villagers w. garden
cows, meat animals. i.e., the small grain use of land
is land-using.

Farm tractors & machines later do same in U.S.

Mgrl.

30

24 GPM
18
12
6

30 50 70 90 100

1" pipe, plastic heads

1" pipe, brass heads

3/4" pipe, plastic heads

3/4" pipe, brass heads

Note: Dim. rets. to pressure
Δ rets to diameter

TABLE 3B: SPRAY SPRINKLERS GPM DISCHARGE

TABLE 3A: IMPULSE SPRINKLERS GPM DISCHARGE

MODEL	TYPE	DISCHARGE
25 Series	Brass	4.6 gpm
20 ADJ	Brass	4.6 gpm
15111A	Brass Pop-A-Way	4.6 gpm
P5-PJ	Plastic	4.4 gpm
P3-PJ*	Plastic	1.7 gpm
15103*	Plastic Pop-A-Way	1.7 gpm

*Recommended for low pressure/low gallonage installations.

TABLE 3B: SPRAY SPRINKLERS GPM DISCHARGE

Pattern	Pop-Up		Surface		Shrubby	Bubbler	
	2800	1800	2600	1600	2400	2200	1300
Full Circle	3.2gpm	2.7gpm	3.2gpm	2.4gpm	3.2gpm	1.3gpm	1.3gpm
Half Circle	1.9	2.1	1.9	1.6	1.9	1.1	—
Quarter Circle	1.2	1.3	1.2	1.2	1.2	0.6	—
Square	3.2	2.8	3.2	2.5	3.2	—	—
Center Strip	1.1	1.4	—	1.2	—	0.6	—
End Strip	0.5	0.8	—	0.8	—	—	—
Third Circle	1.6	1.6	—	—	—	—	—
3/4 Circle	2.6	2.9	—	—	—	—	—

IMPORTANT — Maximum GPM flow rate may vary significantly because of pressure losses resulting from size and type of pipe used as well as the total length of pipe in an installation. Another important factor is elevation. Therefore, before digging any trenches, hook up each circuit and test for sufficient pressure.

TABLE 2: MAXIMUM GPM FLOW PER CIRCUIT*

TYPE OF SPRINKLER*	SERVICE LINE SIZE	STATIC WATER PRESSURE (PSI)							
		30	40	50	60	70	80	90	100
Spray heads & 1/2" plastic impulse heads	3/4"	6gpm	9gpm	12gpm	14gpm	15gpm	17gpm	18gpm	18gpm
	1"	10	14	18	25	28	28	28	28
1/2" brass impulse heads	3/4"	**	5	8	11	13	15	17	18
	1"	**	6	12	16	24	26	28	28

**Insufficient pressure to operate a brass impulse head.

*Based on full flow through water meter, 75' service line, circuit manifold, and 50' of 3/4" sprinkler pipe.

Next, group the sprinklers on your drawing into separate circuits, making sure that different types of sprinklers (impulse, spray and bubbler) are not mixed on the same circuit.

From Tables 3A and 3B determine the GPM discharge rate of each sprinkler head. Then add the rates to determine the total GPM discharge of the circuit. To insure proper operation, it must not exceed the maximum GPM rate determined from Table 2.

Now, draw the piping for each circuit, starting at the control valve location, and connect all sprinklers in the circuit. (Avoid running pipe under sidewalks or driveways if possible.)

NOTE: DO NOT MIX DIFFERENT TYPES OF SPRINKLERS (IMPULSE, SPRAY, AND BUBBLER) ON THE SAME CIRCUIT.

Determine the size of control valves and pipe. Table 4 shows the maximum GPM flow that can flow through the given size valve or pipe.

TABLE 4: MAXIMUM GPM FLOW

VALVE OR PIPE SIZE	MAXIMUM GPM
3/4"	18
1"	28

Circuits that require more than 18 GPM should use a 1" control valve and 1" pipe. Should the circuit divide into branches, pipe size can be reduced on the branch 3/4" for any branch requiring less than 18 GPM. (See circuit 3 in the example.)

Determine connecting pipe size from the service line to the control valves. Here is an easy rule to follow: the size of the connecting pipe from the service line to the group of control valves must be the same size as the largest valve in the group. If the distance to the control valves is over 100', the pipe should be one size larger. Note that this could result in the connecting pipe being larger than the service line. Draw the connecting pipe on your plan.

PVC Schedule 40 plastic pipe (semi-rigid, straight lengths), can be used as a connecting pipe but poly plastic pipe (flexible, coiled lengths) is not recommended for this purpose because of surge pressure. (Copper or galvanized pipe can be used if desired but if you use galvanized the pipe must be increased one size.)

Appl.

Alienation is #1 human problem.

Riots, looting, Redneck of South, local comm.,
family, small bus, small property. Hi mobility.

Note farmer Kassner, Antler, Mont. — gave
out small land parcels to keep local school open.

Note Udell on mergers.

✓ As, there is a social externality, alienation,
as a diseq. of scale. A reason for society to
follow Jefferson + encourage small business.

For a personal ex. of alienation. of your
own attitude as a tenant vs. as a
home-owner.

Fri. ~~Topic~~ Ec. 162

Nov. 20, '81

Refer mid term to Wed.

1. Empirical prodn. + cost analysis. ch. 11

2 disappointing chap. What can we learn from disappointment?

(a) Generally, a wasteland of inconclusive, badly conceived studies. I blush for my colleagues.

(b) There are some better studies, not cited. E.g. Reinsel on agric.

M + M are like Adlai Stevenson's def. of editor.

So is the whole profession. Call out some mediocre chapter that leads nowhere, call it "state of the art", dwell on it. Obsessed w. techniques more than substance.

(c) So, why should you know this?

To understand data in the form it is likely to come to you.

Relationship of exponents to elasticity.

$$y = x^a$$

$$dy/dx = a x^{a-1} = \frac{a x^a}{x}$$

$$\frac{dy/dx}{y} = \frac{a}{x}$$

$$\frac{dx/dx}{x} = \frac{1}{x}$$

$$\text{or } MP = \frac{a x^a}{x}$$

$$AP = \frac{x^a}{x}$$

$$MP/AP = a$$

$$E = \frac{a/x}{1/x} = a$$

(d.) Cobb-Douglas prodn. fn.

$$Q = \alpha L^{\beta} C^{1-\beta}$$

a common procedure in studies of prodn. fns. is the ff.

1. Get x-section or time-series data on inputs and ~~the~~ outputs
2. Plot points, fit a curve described by exponents
3. Note ~~that~~ how output changes w. inputs
4. ~~the~~ Note that exponents are ϵ ,
thus note
 - a) Effect of changing propns.
 - b) " " " " " scale.

e. I do not care for this procedure.
~~Skilled.~~

1. Skilled, contrived. Reflects compulsion to write an eqn. The eqn. is pessimal:
 - too abstract to be readily understood by most people.
 - too simple to describe whole situation

But what is pessimal to me is optimal to many others. The eqn. form is simple enough so as to attract large nos. of half-baked theorists looking for a cheap ~~savvy~~ magic trick for their dog- & -pony show.

2. Assume complementarity.

One of first to be bamboozled was Douglas. Scent of a man, twisted by Wicksteed, who invented this thing.

$$\frac{dQ}{dL} = L C^{1-B} [B L^{B-1}]$$

No room for ~~substit~~ displacement.

Labo- saving machines

Cattle

Trees

3. Not necy.

a. To of. large + small firms, just of. some reasonable msre. of a bottom line

E.g. GNP

E.g. return on capt.

b. To ~~of~~ observe up of an input,
just find, ~~1 input, less ACC,~~
 $\Delta \text{ output, less ACC, } \div \Delta \text{ input.}$

c. There are many common ways to find MB. E.g., water in Kuwait.

(c) "Survivor technique."

Whatever firms survive, are most fit.

Pure e.g. of circular thinking. The qn. is, are firms surviving bcs. of ec. reasons, or instl. bias? The answer: the survivors are defined as the ec. ones.

This is rationalizing the status quo, carried to an absurd length.

It has a value. It is worth knowing what size firms are dying, what are surviving. But doesn't tell us why. $\therefore$ doesn't help env. mgt., or help make any public policy — e.g. saving the family farm, or promoting exports.

Ec. 162 Wed., Nov. 11 '81

Cost Analysis.

1. S.r.

~~Influence of MP etc.~~

~~4 curves~~

Imputed + competed

Price of pig

Price - determined

Always at min. cost.

Social fr. of rent, if price-det.

2/2

$$120 \text{ V}, 50 \text{ W}$$

$$I = .42$$

$$= 35 \text{ W}, 32 \text{ V}$$

$$I = 1.09$$

$$VI = W$$

$$I = \frac{W}{V}$$

$$\% \Delta I \text{ by } \frac{1.09 - .42}{.42} = 2.6 - 1 = 1.6 = 160\%$$

$$\text{Then reduce needed } W \text{ by } \frac{50 - 35}{50} = 30\%, \text{ for const. output}$$

$$\text{Voltage Drop or Line Losses} = I^2 R$$

To reduce line losses we go to hi voltage, reduce $I + I^2 R$.

But hi v is bad in and uses. Even 120 v is perhaps too hi. Light bulbs ~~and~~ ~~use~~ ~~efficiency~~ increases w. I. - p.l., hard to follow.

a. Use one big bulb rather than banks of small ones.

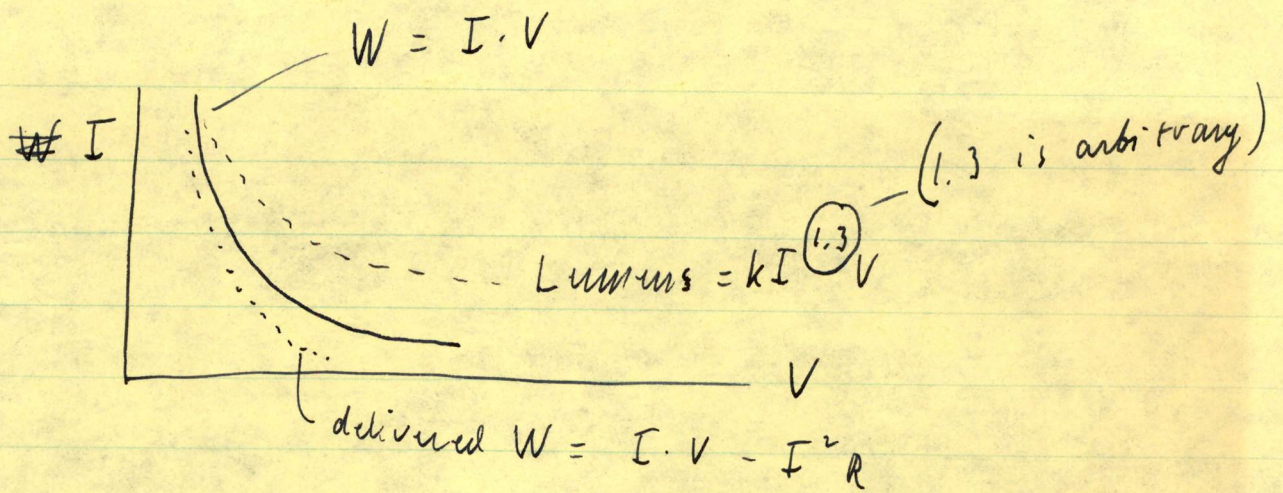
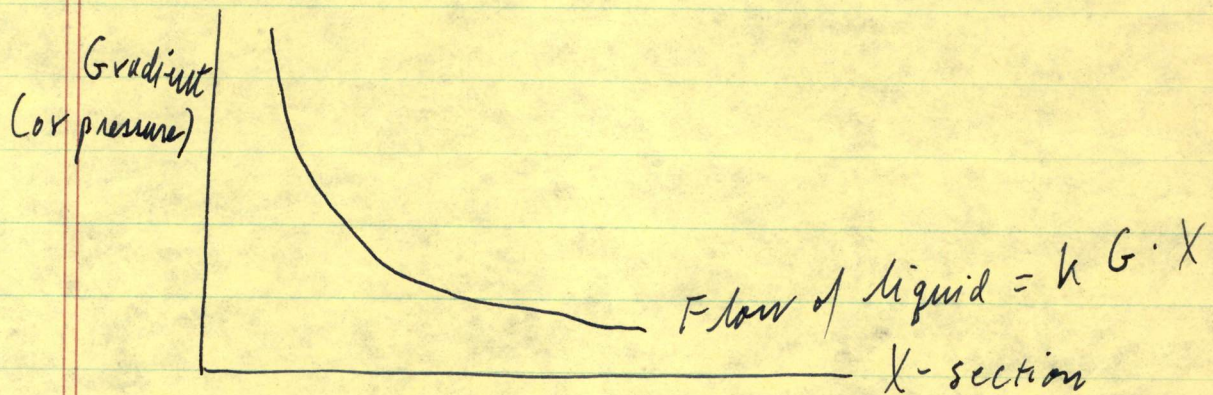
b. Step down v

To get hi I at low V, must lower R:

a. Shorten lines

b. Widen " or upsize

Good ways to illustrate + use indiff. curves.



Remote power sources require hi-V generation. Thus, they cannot use low windspeeds; low heads; etc.

Hi-V is necessitated by spread!

At lower V, many new energy sources wd. become ec!

(Can xformer step low V up?) (Yes, there are step-up xformers)

Is it prohibitively costly to gather & step-up low-V sources?

Low-V is easier to store. Hi-V batteries are heavy. (electric cars $\therefore$ require low-V)

(N.B. the explosion of battery-op. appliances)

Why AC? Bcs. it can be xformed, to hi V for xmission, & down again.

Inverse relation of productivities. How to expound?

1. Use land & K & workers, not abstract inputs.

2. Begin w. land as variable input.

3. Go to $MP = 0$

$$P/w = \max.$$

4. Change label of axis from acres, to acres per man, L/w

a. If fixed factor was one man, all is same.

b. If there are no scale effects, it doesn't matter.

So, assume no scale effects

Now, we can move either way, left or right

Can move left by $\Delta g W$ as well as $-\Delta g L$.

5. Move left by ΔW .

$$\text{Since } AP_w = \max, MP_w = AP_w$$

6. In 4, changing scale to L/w means that TP now means P/w . Is AP of labor, throughout.

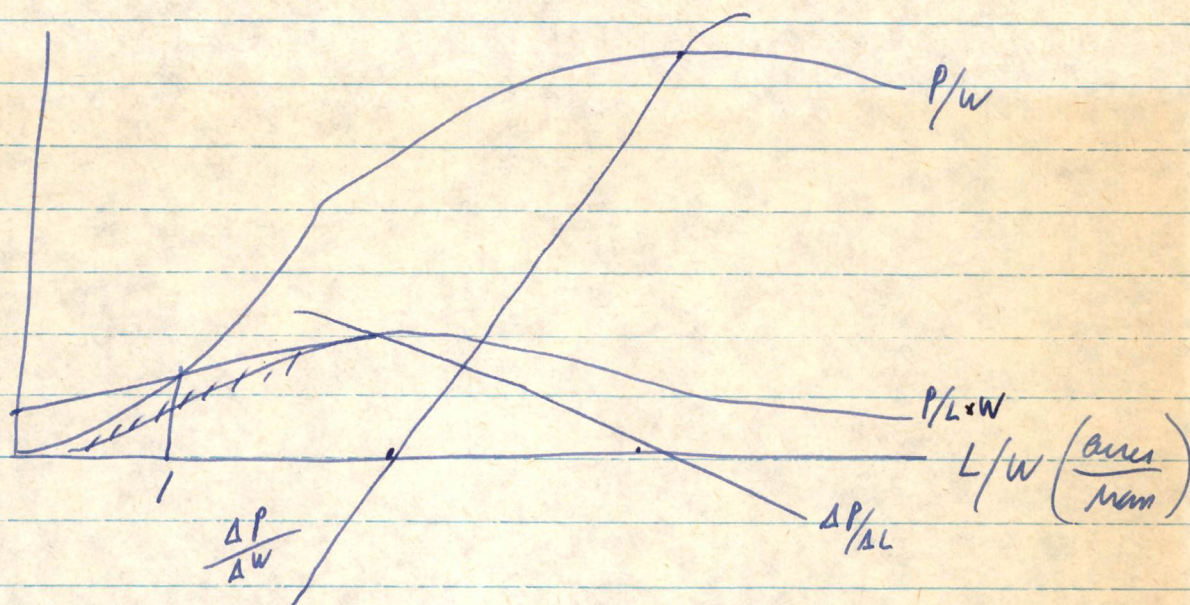
i.e. the TP of land is the AP of labor.

(And AP is now $\frac{P/w}{L_{land}}$, or P per man per acre. But skip this.)

7. Knowing AP of labor, we know TP & MP .

We can graph them.

8.



9. Where $L = W$, $L/W = 1$.

Then, $P/W = P/L$

Left of that, $P/W < P/L$, so ΔP curve begins above TP curve. This won't change anything else, and could occur anywhere.

Is not a critical point. (Could be way over on right).

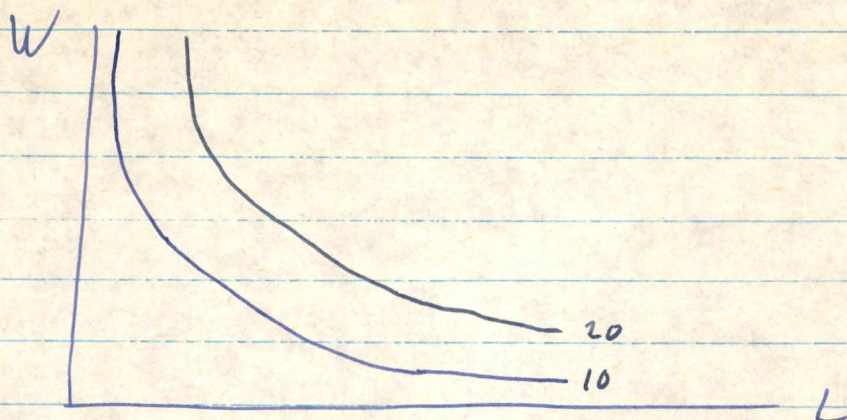
→ 10. Moral for fisheries, when overfished, & dams & oil spills threaten res. base.

11. ~~This method is only valid only in middle of graph, where changes in side within limited ranges.~~ assumes const. returns to scale.

It could also assume const. output, and there are different mixes of L & W yielding this same output. ~~At the~~ ~~then~~ Then, as you $\Delta L/W$, you are reducing W as you ΔL , in some way not shown.

~~Ship~~

11. To show const. output, and changing MRS:



a. Vert. Const Output curve says that:
 when W/L high, can lay off W and keep
 const output, w/o ΔL

b. The MP of W here is measured not in output directly, but
 in land required to replace them.

There is no direct measure of MP in output.
 Even when we add "price lines", they only trade off
 L & W . (But we can have const. ΔP betw. contours)

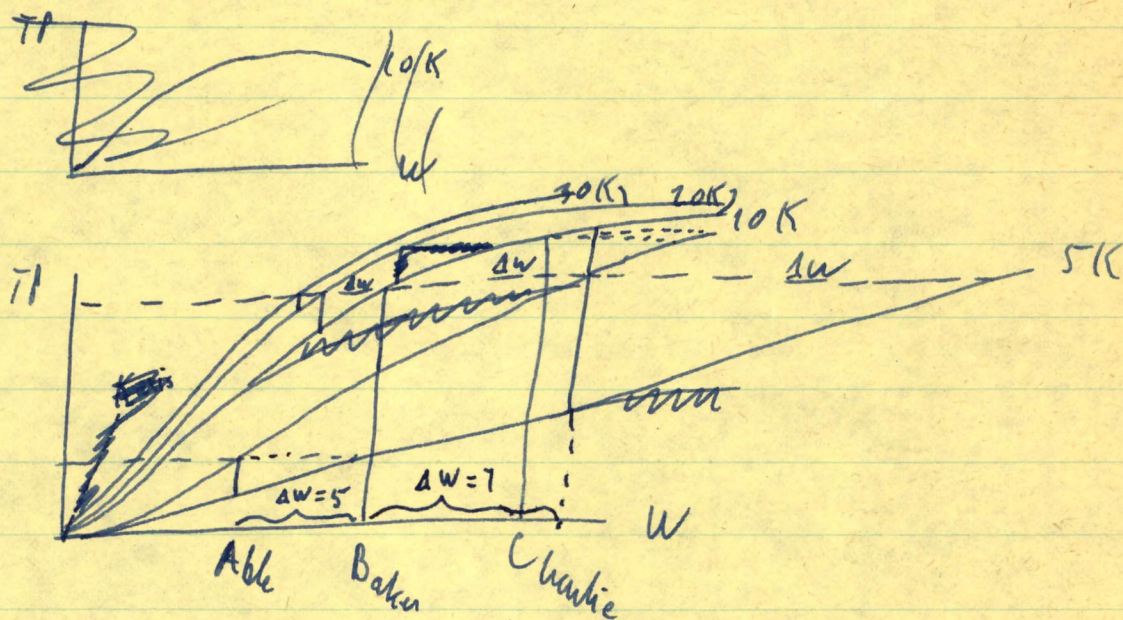
On other hand, MP graph not only measures MP,
 it also gives substitution, bcs. MP_W / MP_L is there.

Tues. Jan. 31, '78 - 1 -

A.S. 162

Sequence

0. Idea is to add a 3d input, K , but stay in 2D; then go to one D.
1. Add a 3d factor, K . $K \equiv \$1000$ worth of capl.
Rent it, at first -- rent covers int. plus K consumption (KC)



2.

$\Delta W = 10K$, $\equiv MRS$.

- i) To keep TP const.
- ii) To ΔTP by amt of vert. distance between lines.

If w is cheap, you'll put out a big Δw to save $10K$ ~~per unit~~ (if K is dear.) And v.v.

3.

As you add w , MRS changes

Begin w . $5K$, add w

at checkpoint A , $5K = 5w$ is MRS

$$K = w$$

So now we look at price.

K is already a price: \$1000 worth of capital.

$r =$ ~~the~~ rate of wage

So when $w \cdot r > 1000$, jump up to next curve, 10K.

Say $w \cdot r = 1000^+$

at checkpoint B, repeat.

MRS is $10K = 7w$

$$K = .7w$$

$$1000 > 700$$

~~$$10,000 > 7,000$$~~

It takes .7 worker to replace K

So stay on curve 10K, to



Checkpt. C.

MRS is $10K = 4w$

$$K = .4w$$

$$1000 \text{ vs. } 400$$

Stay on 10K curve.

4

If ~~the~~ ^{double} r , ~~in half~~ would, at Checkpt. B,
go instead to 20K

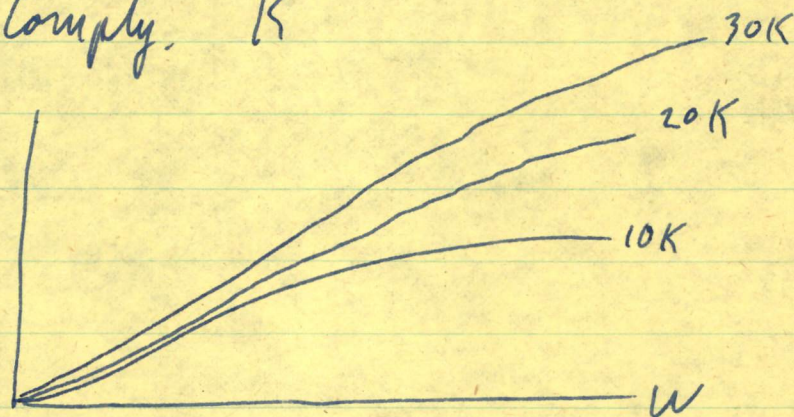
5. Thus, zigzag your way up the hill, adding both K & W in opt. combo.

Stop when $MP \leq MC$

6. ~~Now, place all in one Dim.~~
Compare K vs. Subst. K

a. Comply. K

Curves fan out. MP_w
~~MP~~ rises.



b. Subst. K

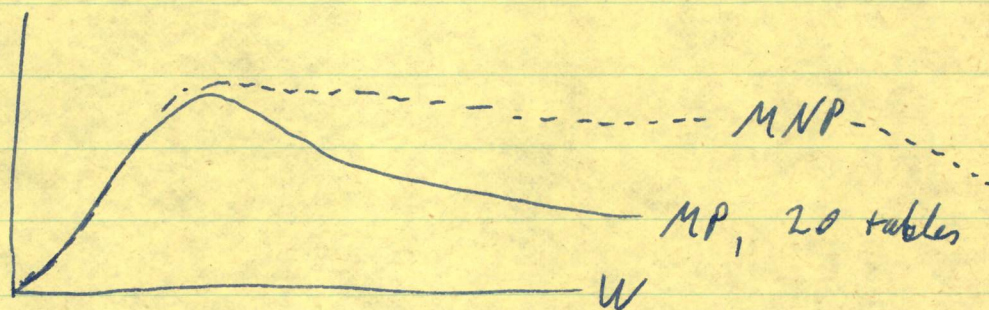
Curves converge
 MP_w falls.



7. Go to one curve: MNP

Add w , also add opt. compl. of K , and subtract its cost.

E.g., add a waitress, also add more tables, more kitchen equipment, etc.



8. Next step -- show how to ~~add~~ subtract the cost of comply capt. by discounting

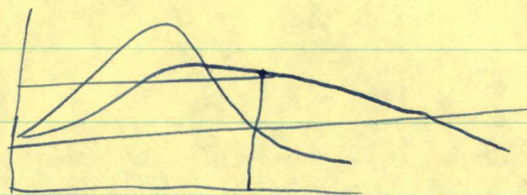
i.e., build your own K , P is deferred, and K cost is int. cost of carrying K into future.

Ideas. 10/5

1. Appraisal by computer -- proper count.
Moral of chem. rets - keep things in proper.

2. X - subsidy. Intra or supra input, carries extra or sub input.

3. 2 ways show rent:
" " TP
~~TP~~



4. Eg. pts. $MP = MC$
 $AP = MC$

5. A "input" adjustment is not minor - it changes ~~the~~ mix ratios throughout.
Or it should. A good mgr. is one who sees this.

6. Each change of price or cost changes opt. mix.
Mgr. must be flexible

7. Give list of key words.

8. M & M weakness: Too much CFA.

✓ 9. M + M ~~to~~ develop only ^{variable} ₁ input, one output. (p. 212, they forget the mine) (+ one fixed, the ore)
 1 go to 3 by MNP
 4 by DMNP

10. Input factor, resource, all same to M + M
 To me, "resource" means natural.

9. Use numbered mines instead of 3-D

11. a. When is land input, $AP = AC$
 b. Intensive + extensive input.

12. M + M, bad ex. of overtime causing dim. ret. in mine.
 Actually, overtime (in a mine) means Δ labor cost, not dim. rets.

More workers per shift, (using same shifts + equipment) wd. be right ex.
 (A mine is a poor ex. anyway.)

13. Tendency of text books to forget resource base,
 ex. M + M p. 212.

Tendency of some corps. to do same thing -
 ex. recent Harvard study.
 Reflects "cowboy ex." outlook - sawdust saws,

beef barbarian, pit-urnie pirates, handrock hums,

M + M haven't caught up w. age of limits.
But we will.

14. Let $g = x^a$

$$\frac{dg}{dx} = a x^{a-1} = \frac{a x^a}{x} = a \frac{g}{x}$$

$$a = \frac{dg/dx}{g/x} = \frac{MP}{AP}$$

This comes in
ch. 11.

15. Continuous vs. discrete variables.

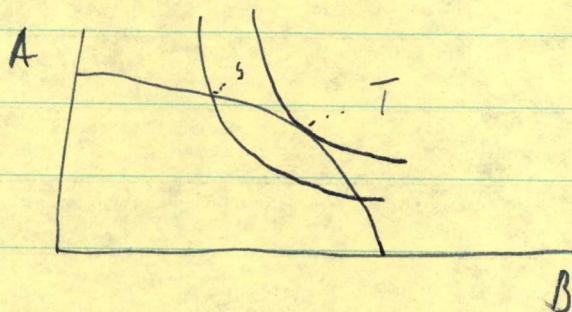
Trade-off exercises.

1. ~~How~~ Storing gas in cylinder.
Strength wall to Δ pressure, store more gas.
2. Flow thru duct
Pressure vs. X-section
Drop vs. " " , canal

f.) Models force you to acct. for all inputs.
 Good bookkeeping. (Bookkeeping, in turn, is like Law of
 Conservation of Energy. Everything must be acctd. for.)

g.) Models are good for cheap experimenting.
 E.g. models of nuclear war.

4



At T, The cost of one A is $1.5 B$ (MRT, transformation)
 The Value $1.5 B$ (MRS, substitution)

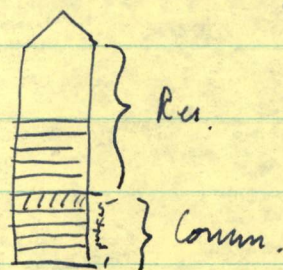
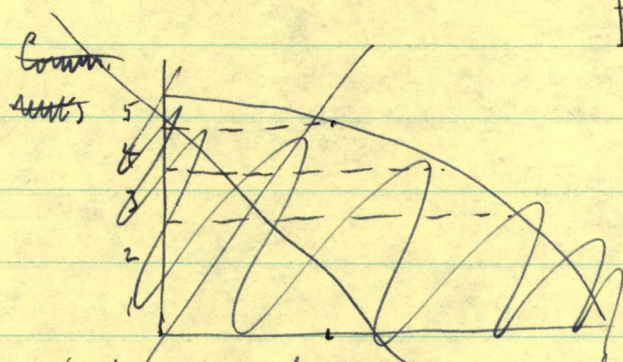
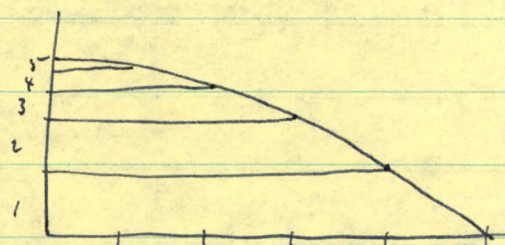
At S, The cost $3 B$
 The value $\frac{1}{2} B$

The prodn. possibilities curve is concave —
 meaning to the origin — bec. of ~~de~~ incl. cost of
 A (in terms of B) as we produce more A + less B.
 (The indiff. curves, ~~curve~~, show the reverse re value of A.
 Shows declining incl. value of A (in terms of B))

as we consume more A.)

This leaves in doubt as to whether the change is inherent in A, or B, or their relation. This model ~~is~~ is approp. when it is their relation.

a) E.g., p. 26, a hi-rise bldg, allocating floor space between resid. & comm. uses, measuring ea. in the rents it brings



(Model refers to 1st & 5th floors only; may $\therefore$ speak of 20s.)
 Start w. 5th floor, give up 7% of ~~rent~~ comm. rent, get same $\Delta_{\text{resid.}}$ of resid. floor (+ rent) as from 1st floor, which is much costlier, w. 40% of comm. rent. Thus here, the change is inherent in A, the comm. rent.

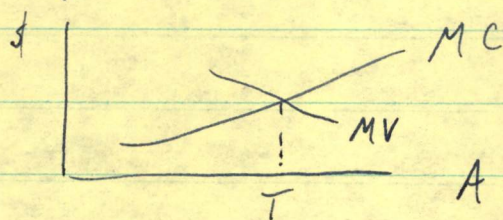
(In the particular case, make same decision by noting higher resid. rent than commercial, ^{on 5th floor}. The purpose here is to introduce the type of modeling, which is used in LP, etc.)

b) Dam, trading of wtr. supply + power.
 (Today, wtr. cum power v. retn. is the livelin issue. S + J model assumes dam already built.
 Is a generic weakness of this approach -- assumes fixed resources.)

But you add 3d vble by pushing out the frontier. But how far do you push it? This requires another model. So all this model is doing is reminding you to equilibrate $A + B$ so the marg. cost of A in terms of $B =$ marg. value of A in terms of B .

c) Try log / log? Sometime.

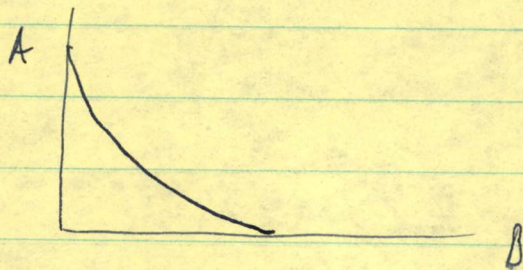
d) Instead of output B , cd. put \$ on abscissa, then you have ∞ marg. cost + marg. value of A in \$. At T they are =.



Here, MC of A is sum of $\Delta \$ + -\Delta B$ (in \$). The choice between $\Delta \$ + -\Delta B$ is behind the scenes, or "off the sheet", but assumed as "marg. marg.", or "implicit".

Thus, the 2 models say same thing, but differ as to what is implicit, what is explicit.

e) You can have "convexity" of possibilities. Marg. cost of A falls as you get more.



This leads to "corner solutions" i.e. $B=0$

Ec. 162

In a vert. int. opn. if a union ~~contract~~
contract makes labor cost too high in stage B,
you sub. machinery made in stage A.

"Oversizing"

Simple energy cons. idea is, \$ more K needed to save energy. But depends on what one does w. K. To date, a major use is oversizing.

Current in electro. motor does 2 things:

1. Real current does work.
2. Reactive -- makes mag. field in motor.

$$\text{Power factor} = \frac{\#1}{\#2}$$

#2 includes friction, windage & losses from magnet.

So an oversized motor wastes energy (altho not in prop. to size.)

There are also friction losses in the drive line, & size. Driveline includes gears for speed change, usually reduction.

On other side, "larger" motors at full load may be more effie. -- (altho "larger" may refer to no. of pole pairs.)

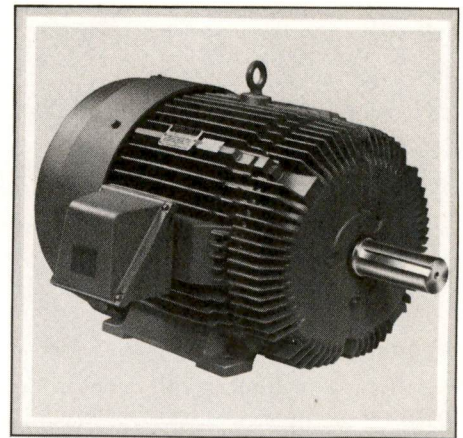
Pump, centrifugal:

$$H_p = V^3$$

(Ecs. of designing pumps wd. make good mpt. study, if
so. Widen canal ~~to~~ or 4 radius of well, & lower V ,
seems highly desirable! But I need basic idea of
centrif. pump, first.)

Sipping Juice

✓ For every person in the United States, there are several electric motors in service. Of all the electricity sent out from US powerplants, two-thirds winds up in a motor winding. Even small changes in electric motor use and efficiency can have a major effect on electricity use. Yet most people, including many engineers, believe this national armada is nearly 100 percent efficient: no significant energy savings can be found in its operation.



IN FACT, ELECTRIC MOTORS probably represent the single largest source of electrical energy savings yet to be tapped in the whole economy. Significant technological developments are underway in electric motor technology that will shake the dust off equipment designed long ago and since forgotten.

Electric motors provide useful energy in the form of drive: to lift, stir, pump, compress, turn, or move something at high, low, or varying speed. Motor applications can:

- provide relative motion between a solid workpiece and a tool (lathes, metal-forming tools, mills, saws, grinders, etc., or simply machine tool applications);
- move material or people by means of stationary or mobile transport equipment (elevators, escalators, cranes, conveyors, feeders, winches, electric cars, trains); and,
- impart motion to a fluid (blowers, pumps, fans, compressors, mixers, etc.).

In most applications, the required horsepower to do these tasks varies because the load on the equipment or the speed of the drive can vary: elevators, for example, run empty much of the time. The speed of machine tools, saws, and similar equipment, must be adjusted to the size of the material being worked. In processes, a variable rate of pumping or feeding is frequently necessary to accommodate temperature changes.

If only the most efficient electric motors were used, and if these motors were adjusted to varying loads and speeds without substantial losses, there would be little reason to expect substantial opportunities for energy savings. But cost considerations and technical limitations have left a huge gap in this ideal state of affairs. In-depth studies suggest that more than 50 percent of the electricity supplied to industrial rotating machinery is wasted in producing the final mechanical drive. New technologies now entering the electric power market promise substantial improvements via high-efficiency motors, power factor controllers (PFC), and, most importantly, solid-state power inverters for ac variable speed drive (VSD). Before looking at these, it is helpful to understand why electric drives are currently so wasteful.

Wasted power

There are four leaks in current electric drive technology: inefficient motors, part-load losses, low power factors, and wasteful means of adjusting output speeds.

A fifth reason, not technical but institutional, concerns the way electric motors are purchased. Typically, capital purchases in industry need to be justified to a higher management level, while operating expenses are not. Thus, first-cost criteria predominate in motor drive purchases. In about half the cases, the motor is an integral part of the equipment, so that original equipment manufacturers choose the motor. This choice, too, is based on first cost and reliability, not on life-cycle cost.

Motor losses

The centerpiece of electric drives can be an alternating current (ac) or direct current (dc) motor. Dc motors are many times as expensive as ac motors, but they were, until recently, the only reliable and affordable means of providing a wide range (20:1 or more) of speed variation (e.g., in paper, textile or steel rolling mills).

Collectively, dc motors account for about three percent of all motors, ten percent of total installed motor capacity, and five percent of total electricity consumption in motors. They are somewhat less efficient than equivalent ac induction motors, but represent only a minor opportunity for efficiency gains.

Standard ac motors, on the other hand, are brushless induction devices. They are fixed in their running speed by the number of pole pairs physically built into them and by the frequency of the power supply. To keep the motor compact and cheap, manufacturers commonly offer only motors with one, two, or three pole pairs. Driven with the 60-hz ac power of the utility grid, these motors will deliver shaft speeds of 3,600, 1,800, or 1,200 rpm. Standard ac-induction motors show full load efficiencies from the 50 percent range for smaller motors to the 80 percent range for large models, a far cry from "close to 100 percent."

Soft Energy Notes

Access to Tools for Soft Energy Path Studies

Volume 5, Number 3

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But uses energy & full capacity!

Part-load losses

In most applications, the full rated power of the motor is used only intermittently or never at all. Furthermore, motors are routinely sized 20 to 40 percent over maximum load requirements. This is done as a precaution against overload. For example, a saw used to cut boards may encounter logs of various diameters, or an elevator may experience an occasional overcapacity load. In other instances, oversizing of motors occurs because plant managers simply guess rather than measure the requirements of their equipment.

Whatever the cause, the effect of operating induction motors at partial capacity is reduced efficiency. The current flowing through an induction motor consists of two components: real and reactive. Real current produces output power and does the work, whereas reactive current establishes the necessary magnetic field in the motor. Under part-load operation, the fraction of the total current that does the work (*i.e.*, the power factor) decreases (see Figure 1). At the same time, friction, windage, and losses from the 60-hz core magnetization remain the same. Therefore, at less than about 50 percent rated motor power, efficiency begins to drop off steeply (Figure 1).

Utility headaches

The wattage used by the motor and paid for by the customer is essentially proportional to the real current component. However, the utility must size its generating, transmission line, and transformation equipment to supply the reactive component as well. The reactive current flows through the entire grid, creating heating losses and voltage drops. Utility losses in electricity distribution are typically seven to nine percent. Of these losses, an estimated ten to 20 percent are caused by reactive current.

Under part-load or idling conditions, things get worse for the utility: as the real current becomes smaller, the reactive component's share of the total supplied current becomes larger. Some plants with oversized motors or mostly idling machinery have such a low power factor that they pay

penalty charges to the power company.

This is not all of it. Everybody has seen the lights go dim when the refrigerator kicks in. During motor starting, an inrush of current to the motor windings occurs. This "locked rotor" current can be five to six times as large as the normal operating current and it causes sudden voltage drops in the power lines. To avoid these, utilities are billing their customers with peak demand charges or are encouraging the use of solid-state starters that limit inrush current to a 200-300 percent surge. These "soft-start" features play an important role in new power-saving technology.

Drive losses

Ac induction motors are the universal electric work-horses of industry, due to their ruggedness, reliability and low cost. However, most applications require drive speeds of a factor of ten or 100 lower than that of the motor output shaft. This calls for speed reduction equipment such as gear boxes, worm gears, and pulleys. These devices can dissipate as much as 20 percent of the motor output at full load—and more under part-load conditions. In fact, the load/efficiency curve in Figure 1 is deceiving. Frictional losses in the driveline add to motor friction and core losses, which are all independent of the load. Figure 2 shows load/efficiency curves for the whole machine (i.e., for the motor and the drive combined). Three types of speed reduction efficiencies can be distinguished: gear boxes and pulleys, worm gears, and throttles.

Unfortunately, some of the largest consumers of electric drive are also the machines with the worst part-load curve: pumps, fans, and blowers. These consume more than 30 percent of all the electricity used for drives. Because the required horsepower in centrifugal equipment varies with the cube of the load (i.e., flow speed of the fluid), throttling the flow rather than slowing the pump drive incurs a particularly heavy efficiency penalty. Conversely, these machines constitute the statistically largest and most promising target for efficiency investments today.

Figure 1: Typical performance curve for a standard 10-hp ac induction motor (Design B, 1,800 rpm, 220V 3-phase)

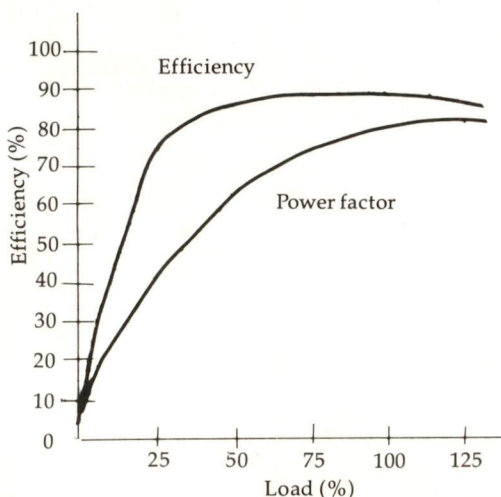
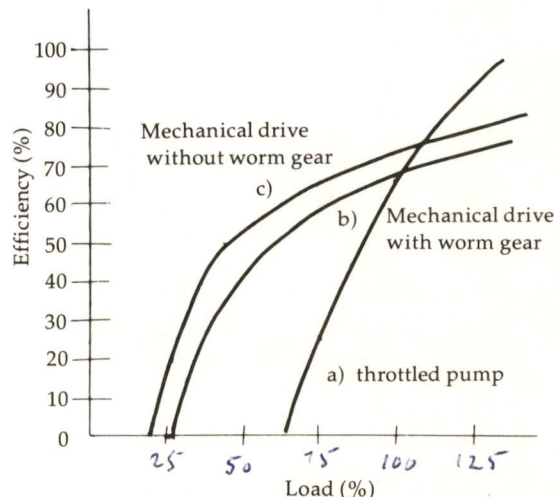


Figure 2: Typical performance curves for electric drives (motor plus speed reduction device).



Source: Murgatroyd and Wilkins, 1976

Remedial technologies

The three principal technologies which promise substantial electric power savings in motor drives are better motors, power-factor controllers (PFC), and ac variable speed drives (VSD). These have been described in an earlier issue of *Soft Energy Notes* (see Notes 3:2:27, 1980).

A high-efficiency line of electric motors is now offered by most manufacturers. The improvements are confined to conventional means of reducing losses with better materials and tighter construction. In effect, the trend is to return to those manufacturing practices that were simply a necessity three decades ago when good heat-resistant insulating materials were not available and internal motor losses had to be kept to a minimum. At the present time, high-efficiency models do not yet constitute a major market. They used to cost 50 to 100 percent more than standard designs; for this reason equipment manufacturers have not yet made them a standard feature of their products. Now some manufacturers are offering models that achieve two to four percentage points higher efficiency at no extra cost. If large numbers of such motors are sold, the price might come down somewhat.

Clearly, such motors are an irresistible bargain. But whether high-efficiency motors are generally perceived as cost effective depends on the investor and on the usage of the drive. Against the national average electricity cost of 7¢/kWh and with average industrial motor usage (3,500 h), simple pay-back times range from two to five years, based on premiums for efficiency. But electricity is paid for with before-tax dollars and motors are bought with after-tax dollars, so the pay-back time seen by the industrial or commercial user is longer. The manager who looks for that less-than-one-year pay-back time doesn't always find it here. Nevertheless, even efficient motors bought at a premium can save electricity at a cost of 2¢/kWh or less when evaluated over a ten-year lifetime. Compared to the marginal costs of new coal or nuclear power plants, these premiums are a bargain: \$1,500 to \$3,000 per year-round kW capacity versus \$4,000 or more for plant, reserve capacity, and distribution lines.

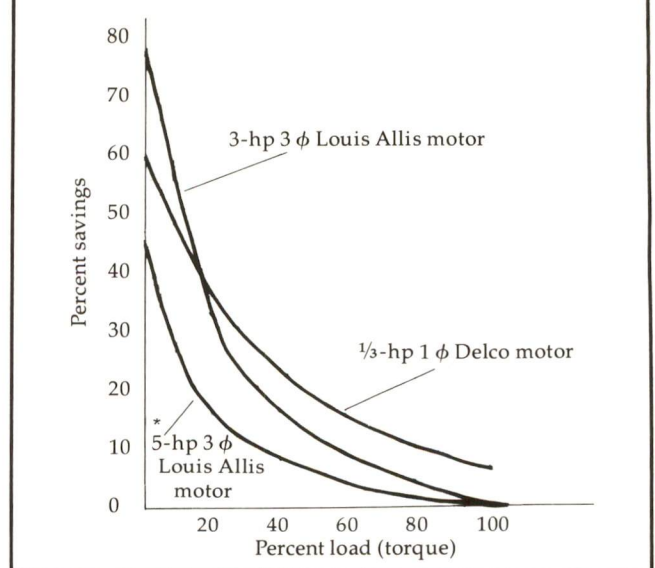
Wanlass motors are an alternate version of high-efficiency motors. These were first introduced in 1975 and have since entered the rewinding market throughout the western United States. A second winding and a capacitor improve both the power factor and the efficiency of the motor by moderating reactive current. The rewind motors outperform conventional high-efficiency motors in terms of power factors and are superior in some cases even in terms of efficiency. Above all, they are much cheaper than any new motors, which explains their apparent steady success in a highly competitive market.

The current population of US motors has an estimated average efficiency of 84 percent or less. If high-efficiency models were to become the standard, this figure could be raised to 90 percent. This would save 84 billion kWh, or the output of some sixteen 1,000 MW powerplants.

Power factor controllers

Power factor controllers (PFC) were invented in 1975 by Frank Nola, a NASA engineer. They are solid state power converters, hooked up between the motor and the line voltage. The unit senses the load on the motor and reduces the line voltage to the lowest value that will still operate the equipment. By dropping the voltage, the unit decreases both the reactive and the real current in the motor, keeping the power factor constant and saving energy. At idle, PFCs

Figure 3: Power factor controller percent savings vs. torque for various motors



can save as much as 80 percent of power consumption; in applications with frequent idling or part-load conditions, average savings may reach 35 percent (Figure 3).

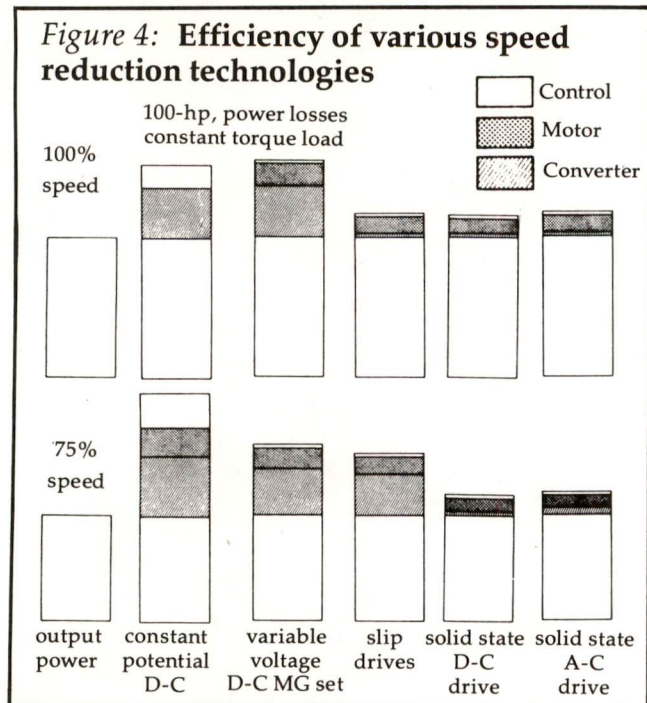
In a massive retrofit effort in a New York City public housing project, 15,000 apartments received PFCs last year for their refrigerators and for the ventilation fans of their room heaters/chillers. The energy savings were 20 and 22 percent, respectively, not a negligible matter at 10.4¢/kWh rates. Commercial refrigeration equipment and new energy-efficient refrigerators are often more carefully designed. Here savings may be only ten to twelve percent or less. In case of doubt, a quick measurement with a power meter can indicate whether installation is worthwhile.

By now, three-phase PFCs are manufactured by some 30 firms and small single-phase household units can be bought in the local hardware store. Nevertheless, sales so far have hardly scratched the surface of the PFC potential. Again, initial cost has been an inhibiting factor. Unit prices are still comparable to the cost of motors (\$30 to \$80/hp) and vary by a factor of two among manufacturers. There have also been some product failures where insufficient heat sinks were provided or internal resistances caused efficiency losses at near full-load operation. But the future looks very bright for PFCs.

Primarily, PFCs offer the sought-after soft-start feature and energy savings at the same time for little more in cost than a conventional solid-state starter. In fact, PFCs got the solid-state starter market going. Furthermore, a substantial cost-reduction is in the offing: the power switching control circuitry of the PFCs will soon be put onto microprocessor chips, eliminating most of the assembly labor costs. With typical reported energy savings of twenty percent in industrial and commercial firms, payback times of two years are common. Avoided power factor charges are another benefit. An unsuspected synergism occurs when building energy management practices cause frequent starts of the blower equipment that previously ran continuously. Without a soft-start device, belts and machinery would wear out prematurely. In addition, motors, themselves, which often fail due to overvoltage, are protected from line power variations when operated with PFCs.

Variable speed drives

The most volatile and important area of electric drive technology today is ac solid state inverters for variable speed drives (ac VSD). These power inverters also reduce part-load electricity waste. Before the 1960s, speed control was mostly achieved with dissipative systems: a throttling valve, a magnetic or hydraulic slip device, or a dc motor regulated with an armature resistor. The concept of regulating dc power with a low power control circuit was



introduced in the 1930s but did not displace the other systems. Dc solid-state VSDs appeared in the early 1960s, when solid state switching circuitry (thyristors) became available, but again did not find widespread use. Ac VSD systems had the advantage of substantially cheaper motors, but the high cost of varying both voltage and power frequency with thyristors made them uncompetitive against dc systems unless explosion-proof drives were required. Both dc and ac versions were only about 85 percent efficient (see Figure 4) and cost several times more per hp than ac induction motors alone.

In the late 1970s, advances in power transistor technology—and in utility rates—triggered renewed

interest in ac VSDs. Exxon engineers developed a prototype unit that was to be fully transistorized and use micro-processor chips for the control circuitry. This design promised to reduce the cost of ac inverters (at that time \$150 to \$1,000/hp depending on motor size) by a factor of two to five. The Exxon inverter, however, proved unreliable and more expensive to produce than anticipated. Nevertheless, some thirty manufacturers, including several electric motor firms, are currently manufacturing ac VSDs: several of them are just now in the process of introducing fully transistorized units for up to 60-hp motors. The cost reduction compared to the conventional thyristor-based models, has been as much as 75 percent since 1978; between 1980 and 1982, alone, prices for a 15-hp unit were typically cut from \$10,000 to \$5,000; chip control circuits could further reduce costs 25-40 percent. With these developments, ac VSDs are rapidly becoming cost effective against dc versions and attractive in most applications where part-load conditions are frequent and no speed variation had previously been used. VSD power losses have also been substantially reduced: efficiencies of 93 to 96 percent are now realized. At the same time, the units offer the same features as power factor controllers, including soft-start capability.

The most promising area of application is the nation's integral hp centrifugal pumps, fans, and blowers. These applications alone account for more than 20 percent of all electricity consumption in the US. Table 1 compares a solid-state VSD with throttling valves and slip devices for a pump: a 30 percent flow reduction decreases required horsepower to 43 percent of full flow operation. But, whereas VSDs show a near-proportional decrease in energy input, savings with the other systems are much smaller. In field tests, VSDs have saved as much as 50 percent in pump applications. Against electricity costs of 7¢/kWh, simple pay-back times of one year can be achieved with the pump running only 4,000 hours per year; indeed, many industrial users report benefits of that order of magnitude.

Another "hot" application is commercial air conditioning systems. Traditionally, the blower in the air circulation system—or the pump in the water chiller—is running continuously though not really needed at full output much of the time. Regulation is achieved with dampers and throttles. "Tying" the blower or pump to a temperature sensing device and using a VSD promises energy savings of 20 percent or more. Currently, air conditioning firms are planning to introduce VSDs as an OEM (original equipment manufacturer) feature. Machine tool firms are also

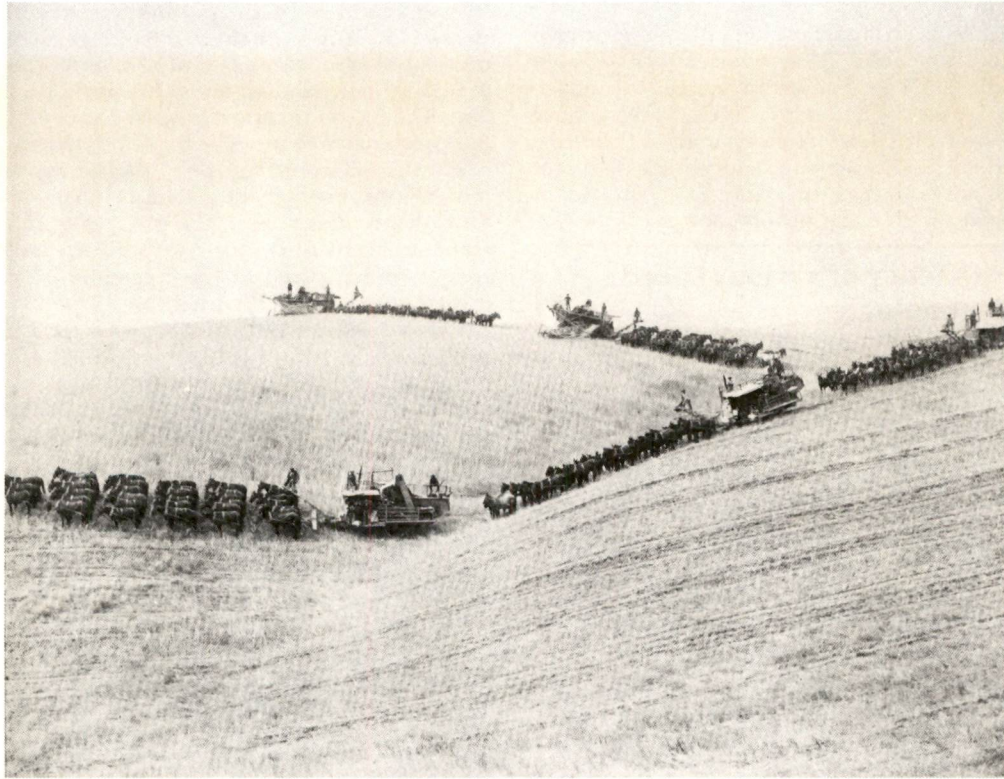
continued on page 86

Table 1: How variable speed drives save energy

Example: Centrifugal pump driven by 100-hp motor

	100% Flow	Valve control	70% Flow Slip control	Solid state VSD
Required pump output power (hp)	65.7	28.3	28.3	28.3
System losses (hp)				
Valve	—	24.7	—	—
Pump	16.9	21.6	8.9	8.9
Motor	7.9	7.0	5.1	5.1
Starter/controller	0.2	0.2	19.9	1.8
Required motor input power (hp)	90.7	81.8	62.2	44.1
Efficiency (%)	72	35	45	64

Source: Reliance Electric Co.



Combines at work in Washington wheat fields, c. 1900. Washington State Historical Society, Tacoma.

Horses or Horsepower?

It might seem that American farmers, at least in the early stages of a declining energy future, wouldn't have to worry about ample supplies of energy. Farms consume only three percent of all US energy today and since food is top priority, one would think that government policy will guarantee every farmer a necessary allotment. This assumes such virtues as wisdom, common sense, goodness, and efficiency will be exercised by bureaucrats to treat all farmers equitably.

A MORE PESSIMISTIC point of view, however, might be more realistic. There are many uncertainties in our energy economy now; the future will probably be even less predictable.

The problem the future farmer will have is age-old: passing on the costs of production. As the price of energy increases, the farmer will be even more pressed than he has been; if he is a small producer, he may be squeezed right off the farm before the palsied hand of bureaucracy can act. It seems prudent to meet future agricultural energy requirements by growing all farm traction energy. We can grow crops that can be converted into alcohol to be burned in today's tractors (with a few modifications). Or, we can grow crops which can be fed directly to draft animals as we did on a broad scale less than fifty years ago.

When we begin to "grow" this traction energy, two limits will quickly emphasize the importance of overall energy efficiency. The most obvious, perhaps, is that traction

equipment will be in competition with people and livestock for food. An equally serious limit is how little energy an acre produces, given the context of our present fossil fuel economy. Once these earthly limits become conventional wisdom, many agronomic practices that seem impractical or humorous today will suddenly become serious considerations for the farmer.

A pair of farms

There are numerous comparisons one can make, but in the end the questions we regard as pertinent stem from the values we hold.¹ Our underlying supposition is that agriculture should be a part and parcel of culture, as author Wendell Berry emphasizes.

What if we were to take a pair of identical Iowa farms—each 150 acres of tilled land with the standard crop mix characteristic in Iowa in 1940—and farm one with draft animals and the other with tractors, keeping everything else constant, how would the energy requirements compare? The old Iowa standard farm was a diversified grain and hay farm, usually consisting of 60 acres of corn, 30 acres of oats, 30 acres of soybeans, and 30 acres of alfalfa hay. Six acres were allotted to pasture, four for buildings and roads.

¹This is a critical matter needing emphasis, for our culture is rooted in agriculture, a fact that an increasing number of our citizens has either forgotten or never knew. The consequence is devastating, for culture becomes something to be consumed like an item off the shelf in a supermarket. For example, we could estimate the output per acre for a one person horse-powered farm compared with a one person tractor-powered farm where both farms are operated to be self-sufficient in motive power energy. Here the emphasis is upon reducing the number of human hours in the field—not an economic good if a teenager is denied the opportunity to learn farming skills and takes, as an alternative, a job at a drive-in theater or a fast-food place in a nearby town.

Table 2: Motor efficiency in the US

Motor type	Electricity consumption (%) (1972)	Efficiency (%)	
		Current	Best ¹
Polyphase integral hp ac induction motors	68.3	88.7	93.7
Fractional 1/6 hp ac induction motors	15.5	65	75
Synchronous ac motors	7.3	97	97
Single phase integral ac induction and other polyphase ac motors	3.1	70	80
DC motors (excluding generators)	5.8	85	90
All motors	100% ²	84.1	90.0

Source: A. D. Little (1976).

¹estimates based on manufacturers' date.

²1081 billion kWh or 64% of US electricity consumption in 1972.

MOTORS—from page 69

showing interest. Conveyors, elevators, feeders, and many other machines, which are now run at constant speeds, are promising candidates as well. While the total business volume in 1981 was only about \$100 million, growth rates reported by some firms are now 25 to 30 percent per year and projections of sales by 1990 reach billion dollar figures.

Table 3: Total US electrical consumption (1972) (billions kWh)

By Sector	Billions of kWh 10 ⁹	Electricity consump. %
Motor drive (excluding HVAC)		32.6
Industrial, integral HP	438	
Industrial, fractional HP	20	
Commercial, integral HP	74	
Commercial, fractional HP	16	
Motor drive (HVAC)		7.2
Industrial	12	
Commercial	110	
Motor drive (other sectors)		24.4
Municipal water works	116	
Electric utilities	147	
Mining and construction	28	
Residential	120	
All other electrical consumption	602	35.8
TOTAL U.S.	1,683	100
TOTAL motor drive	1,081	64.2

Motor application by equipment type

Centifugal pumps	216	20.0
Blowers and fans	156	14.4
Other pumps	111	10.2
Compressors and vacuum pumps (industry)	84	7.8
Refrigeration compressors (commercial)	70	6.5
Metal-cutting and metal forming tools	40	3.7
DC motors and drives	63	5.8
Identified equipment, subtotal	740	68.4
Other equipment	341	31.6
All equipment	1,081	100

Source: A. D. Little (1976).

Small savings, big effects

What aggregate savings might be realized with more efficient electric drives? Table 2 shows drive electricity distributed over the various kinds of motors in 1972. The average motor efficiency of the current stock is an estimated 84 percent. If all motors were of the high-efficiency kind, this value would climb to 90 percent, saving some 7.9 percent of total motor drive electricity. At current consumption of about 1,400 billion kWh, this might be 110 billion kWh—equivalent to the output of more than twenty large powerplants.

Table 3 gives a breakdown of electricity for drives by function and sector, based on 1972 data. Centrifugal pumps, blowers, and fans can be considered available for applying VSD technology. Conservative estimates place energy savings at typically 30 percent in pumps and 20 percent in air handling equipment. Power factor controllers or VSDs could be applied to most other equipment with average savings of maybe 15 percent. When weighted with the fractions in Table 3, an average improvement of 20 percent might be expected.

With more efficient motors, the total technical potential could be as high as 25 percent (even though better motors reduce part-load losses themselves and these savings are not necessarily additive with savings from VSDs or PFCs). This corresponds to about 370 billion kWh, or more than 70 large powerplants. If evaluated against newly constructed 1,000 GW central stations, the whole potential should be easily cost effective, but whether this economic (and environmental) benefit will ever be realized depends strongly on informed and effective public control of energy policy.

—Florentin Krause

References:

Little, A. D., Inc.

1976 *Energy Efficiency and Electric Motors*. Available from National Technical Information Service, Report #FEA/D-76/381.

Murgatroyd, W. and B. C. Wilkins

1976 "The Efficiency of Electric Motive Power in Industry." *Energy*, Vol. 1, pp. 337-345.

NASA Marshall Space Flight Center

1979 *Power Factor Controller*. Brief No. MFS-23280, Alabama 35812.

Reliance Electric Co.

1981 and 1982 *Electrical Drives Group*. Doc. #D-7100-1 and D-7106, Cleveland, Ohio 44117.

building contractor, Continental Heller, and eleven subcontractors on behalf of all the workers in the building. Molina asserts that these contractors were negligent in allowing emissions to harm workers.

In response to these various complaints, Cal-OSHA (California Occupational Safety & Health Administration) inspections have been carried out, but have not found excessive levels of air contaminants. Tests revealing slightly higher than normal levels of formaldehyde, carbon dioxide, and polynuclear aromatic hydrocarbons suggest the building's ventilation system is inadequate. According to the inspector, John Seabury, however, these gases pose no serious threat to human health. Small amounts of glass fiber, inorganic soil, concrete dust, and carbon particles were found in an analysis of collected dust. No spores, pollens, heavy metals or asbestos were found. The study also correlated partition placement with stale air pockets where these contaminants accumulated.

The levels of formaldehyde, although low (less than two percent of the permissible exposure limit of 3 mg/M³), could have caused some initial eye and throat discomfort while not posing a serious threat to health. Room dividers and cigaret smoke could have contributed to the level of formaldehyde. The report found no problems with the levels of oxygen, carbon monoxide, and hydrocarbons, although the level of carbon dioxide was slightly high. Because this level increased as the day went on, it seems probable that the carbon dioxide build-up was from human respiration and poor ventilation. Total dust measurements were far below the minimum detectable level of 0.2 mg/M³, which is only two percent of the allowable 10 mg/M³ level. The content of the dust could have caused some eye and throat irritation without posing health hazards. Most of the complaints came from the second and

fourth floors where, indeed, there were high levels of polynuclear hydrocarbons. The inspector correlated these levels with the increased number of cigaret smokers on these floors.

Because there were no excessively high levels of contaminants, Cal-OSHA found the Bateson Building's ventilation system capable of sustaining an acceptable air quality level. Most of the problems encountered stemmed from early occupancy in an incomplete building. VAV boxes, which control air proportions, were defective, some of the main supply fans had defective controller cables, and many supply registers that feed into the office area remained closed, preventing air from flowing into the room. The Cal-OSHA inspector also found that a negative pressure condition in some areas of the building were causing the fresh air supply to fall far below the ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers) minimum.

Part of the air quality problem can be attributed to a tenant switch. Though the building was originally designed for a single tenant, the General Services Administration, the state decided midway through the project to move in several agencies instead of one. A modification of the building's interior increased the concentration of private offices and closed off the open spaces, reducing air flow. Although a seemingly minor change, the air system had been designed for a large spacious building and now had to handle more numerous, smaller work spaces.

Except for rebalancing the fresh air system, which is now being completed, all of the problems were solved by April of this year. Cal-OSHA does, however note an excessive number of room partitions. It is feared that comfortable levels of air circulation cannot be reached while the air is being pocketed by these dividers. A

new partition design, leaving a six-inch space at floor level, has been recommended to correct this problem.

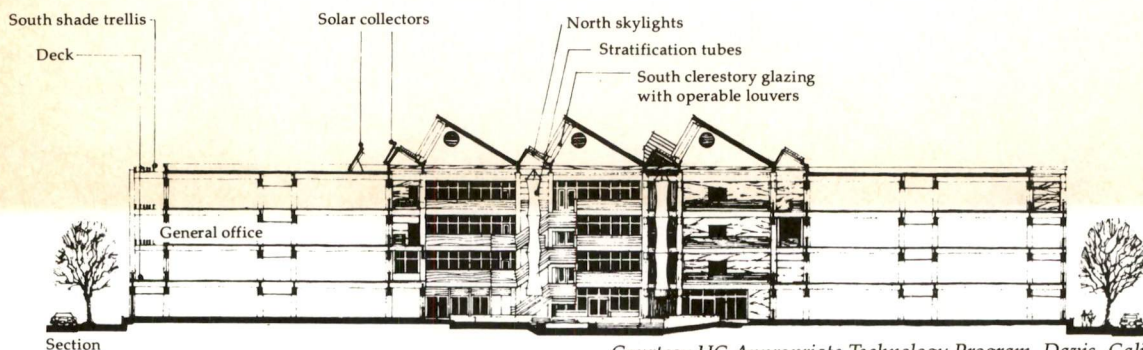
Occupants have also complained about lighting levels. Although the original design included indirect, ambient light combined with task lighting, the architect did not specify in the contract the type of task lighting to be used. When it was time to choose a particular lighting system, the architect thought that indirect lighting could provide for all lighting needs. However, when the offices moved in, task requirements were not met and task lighting was, indeed, needed. Eventually, indirect lighting will provide light for 30 percent of the tasks and task lighting will serve the rest.

Although the design of the building is actually fairly simple, the implementation is somewhat more complicated. Glenn Hezmalhalch, of the State Architect's office, states that he is "100 percent sure that the generic design of the building is sound." Initial problems were caused by a combination of normal bugs and failures. At first, neither the designer nor the occupants took responsibility for running the building. Still, the building is complicated to run.

Some of the poor air circulation in the building can be attributed to a janitor who was turning the ventilation system off at night: this system was designed to run around-the-clock. Gigi Coe, of the Office of Appropriate Technology, recommends that a training session be offered to those who run the building to avoid these problems.

By the end of this summer, the building is expected to be in working order. Only then can the effectiveness of the solar features be measured. The Bateson Building has been likened to a new car in which many good ideas are not yet in working condition—until they are all repaired, it is impossible to comment on the gas mileage.

—Ruth Simon



Courtesy UC Appropriate Technology Program, Davis, California.

Ec. 162, 10-25-85

End of prodn, ecs.

1. Extensive margin.

Quantum changes, where hi cost rather than low yields makes land marginal.

2. Wage rates indep. of AP.

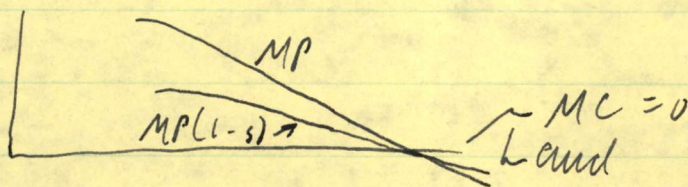
Labor share of TP not same

" " highest on best land.

But land which is above mgn. for lower use is often near margin for higher use. Like a minor league ball club, losing best players to Majors.

3. More cropper incentives.

Add land. $MC = 0$



~~Simple case.~~

Taxes have similar effect ~~Renter~~

2. MP as systems concept.

1. Add 11th acre

MP/AP is same idea as MR/AR

2. Pack trees in tighter

3. Fishing boat

Tragedy of commons
Control of access

3. MP as basis of allocation
= equl. principle.

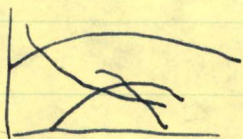
4. MNP

a. Add 11th acre, also add labor

b. Add capital, to fixed land, also add opy. expense
2 basic concepts here.

i. Cash flow = NP

ii. $\text{C.F.}/K = \text{ROR}$



41.

5.

Mon: Ecs. of Scale.

Wed: Chap. 7. Cost

Residual topics omitted from Notes on Prod. Ecs. p. 1

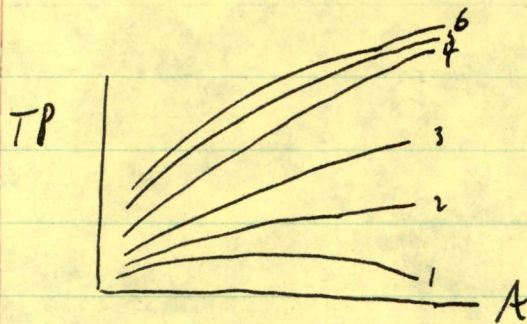
1. AC pricing as means of X-subsidy. #19.
2. CWP as struggle over rent-sharing.
Gas price - control the same. AC pricing. Rent control.
3. Inside firm, rent-sharing.
E.g. Econ, ~~the~~ has hi demand, low-cost.
So we cany other Depts.
How should this be handled?
Hire more costs?

4. Substitu.

Case where ΔA displaces ΔB , lowers its MP.
Distinguish from trade-off between complements,
where a cheapening of A displaces some B, but raises
MP of B. "Competitive substitu" vs. "Comply. Substitu".

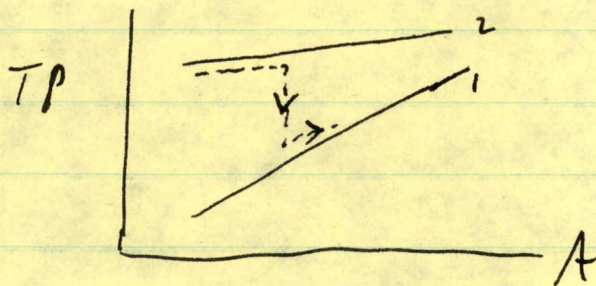
Interpret this in indiff. curves. See Sec, p. 314,
and p. 2

Firm this topic up by saying "The Fallacy of
Universal Complementarity"



as add A, reduce MP of B, after ~~add~~ B = 4

Need to show when adding A reduces TP by displacing B.



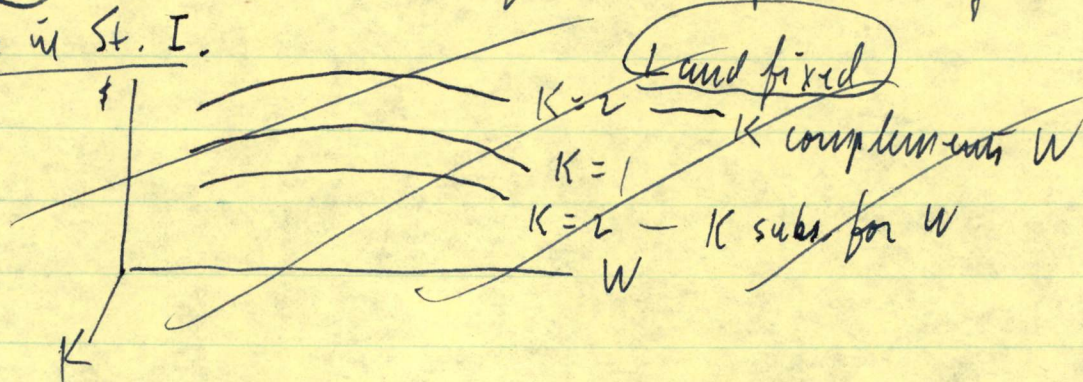
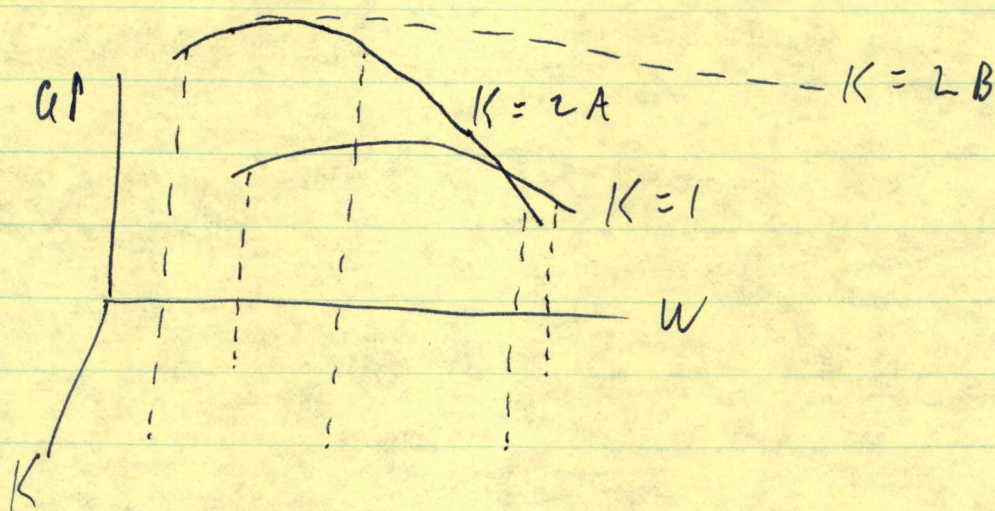
Convergence of curves means MP of B is lowered.
So produ. follows dash line.

Do isoquants allow for this? They must, but how do they look?

Handling more variables

→ (22.) Substn. Given 2 factors, adding one always raises MP of the other - unless in St. I.

Thus, w substn.



ΔK will always raise AP of W. But may lower MP. (May also lower AP_W , in ~~stage~~ St. III.)
 $K=2A$ shows substn. $K=2B$ shows compln.

Substn. must involve at least 3 inputs. If there were just land & K. Or, 2 inputs w. fixed output -- which leaves unexplained the fate of the displaced factors, and also implies that the one displaced (A) was previously in stage I -- else, adding B wd. call for more

E.g. you sub. land for K by reducing h , spreading out.
But why sub. you? This assumes problem is how to provide X cu ft. of space. Usually, it is how best to develop a site.

Handling
more
variables.

→ (23) Moving to MNP in 2 steps

a. As add workers, add tools for each, subtract cost of tools.

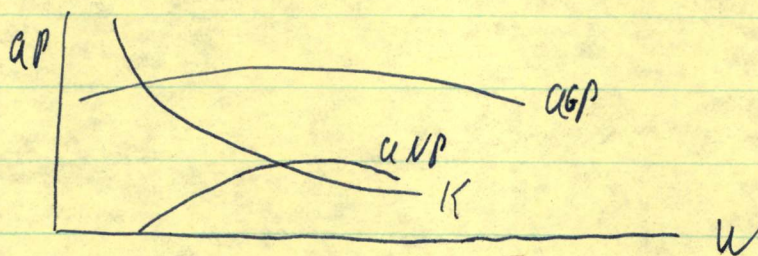
The tools complement the workers. If they shared one tool, MP_w wd. drop fast.

b. Show discounting at all levels by deducting int. on wkgs. K .

c. But then, workers can't run out of space. Add space. No limit, now.

"L.R." means adding more variables.

(22) Rather than 3D, enter K as a cost on 2D graph.



Land Still Fixed

(23) (22) shows indiv. of K .
Not same as discontinuity.

(22) Comply. of land + labor.
Frontier. Soil bank.

5. #16, automatic pass-through.

There is a cushion of rent not needed to keep land "in the field". Land is the field.

Rent-collectors generate publicity, + finance univs. + think-tanks, to picture selves as ungen. producers. Widow's skirts. Old Prospecting Miner. Use in #20.

6. Fallacy of Rep. Firm. (Old Prospecting Miner)

This got incorp. into #11, p. 12

Should be elevated to a heading.

also cited in Fallacy of Privatizing: Fallacy of Automatic Pass-through -- which is same as Fallacy that all Prodn. is Marginal.

7. Fallacy of Reifying "The Firm".

Put this in ~~Intro~~ #1, The Basic Model.

Relate to rejection of "Profit" + "income".

a mgr. ~~she~~ needs to focus on many specific decisions w.r.t. many specific, material res. "Net Proceeds" is the idea, + a good word to use.

Relate this to In Rem + In Personam

Another fault of "Profit" is that it mudds too much.

8. Why sharecroppers get to MP of land = 0.

... lessees paying in royalties do same.

Use in #7, 3 stages, as e.g. of (nearly) learning Stage II.

9. #7, Introduce stages IIA and IIB.

* Max. Net Proceeds is a Performance Standard to seek, (quest for, cultivate, pursue, aim for, shoot for, steer for, practice, follow, cherish, make one's own, study)

"Submarginal" begins with IIB, not III.

In IIB, -- e.g. "Close U" -- IIA is carrying IIB.

Go To #14, NP varies w. scale. Introduce here.

Refer ahead to "AC pricing", -- same ~~to~~ effect as taking AP as MP.

10. Realism of taking land as fixed

a. Land usually comes in standard chunks. Hard to vary, esp. in s.r., for physical, instl. & ~~market~~ bilateral mktg reasons.

b. Land is fixed; Capital is Protean, & constantly turning over. Land is ^{do the minimal one payment} retains unique differentiation. Immobile in space.

c. Land ~~is~~ is unproduced -- no cost of supply, only value.

i. Sometimes hard to find its cost -- must be found internally, as max. residual, G^* .

ii. Is a free input, supply, extensive margin.

iii. Rent can be dissipated, unnoticed, bcs. no cost, and

peculiar social claims to share in distribution.

d. Mkt. dominated by fuel, power & spec. & ~~some~~ traditions, moves slowly.

e. Land: rent comes first, price derived from rent. Capl: cost comes first, cash flow comes from that.

f. Cap. competes w. Cap. worldwide arbitrage - the same. Rents remain different.

11. ^{g. Land is permanent base for many.} Getting lost in detail, nuts & bolts, is often called "~~realism~~".

"being realistic". Mgr. must keep big picture in mind.

Don't ~~get~~ go down rearranging deck chairs on The Titanic.

Same time, limit your bite to what you can chew.
Reconcile by optimizing.

Error of over-abstraction is also bad. "Feet firmly off the ground," is common academic error - and disposed on Econ. by grad. council, a specialist in theory, i.e. someone who never writes or thinks of anything real!

12. Rewriter needed

a. Proving

b. Pass-through

13. Means of spreading rent.

a. Open access (only land has this)

b. Minute subdivision

c. Underpricing. All pricing. Cf. 9, supra.

6

d. Extending infrastructure.

Spatial x-sub., a variant of AC pricing.

e. Taxif. Profit sharing.

14. Net Product graph.

a. Not in notes - they just cite a lecture.

b. Introduce earlier

head in from 9, supra. As soon as you have established Net Proceeds as the Performance Standard. Wait! Intermediate step, see #17.

15. 1. Q

Use re Δ s of low quality, etc.

" " quantum leaps.

$$1. Q = \frac{\text{Non-land}}{S} = \frac{\cancel{S} - C}{\cancel{S}} = \frac{C}{S} = \frac{1}{S/C} = \frac{1}{aP}$$

$$\frac{\text{Net}}{\text{Gross}} = \frac{S - C}{S} = \cancel{1} - \frac{C}{S} = 1 - 1. Q$$

$$1. Q = 1 - \frac{\text{Net}}{\text{Gross}}$$

16. Fallacy of Rationalizing the Status Quo
 U.C. Davis - Robt. Hargan.

There is a living in it - if you ^{are so untalented} have to sell your soul to survive.

17. First pass at MP curves, use one input, one crop.
 2, try another crop
 " " input
 " both
 3, " another scale.

18. "Fallacy of Partial Effici."

19. Land Potential is the Great Invisible Input -
 most often neglected.

Second is Time, where interest not charged, on ~~usable~~ invts. of slow payback.

20. Learn about "Cost Accounting", perhaps temper statements re acctg.

21. Intro. Acctg. yields too much -- is impersonal, while productive input. Choices are in rem.
 Acctg. makes arbitrary assignments

of costs like deprec., o' head, where they may not fit, may distort choices.

22. E.S. of X-subsidy.

Young lawyers & old ones.

Pay the ~~junior~~ lawyer \$20/hr; charge customer \$150/hr.

23. a) #17, Corollary, Fallacy of Ignoring ~~A~~ Value of Fixed Input.

b) Distinguish Value & Cost. Cost has long connoted non-land inputs, so make it explicit & consistent. Land has Value, but no Cost.

Calling Accuracy Value an ~~cost~~ "opp-cost" is the ~~snake~~ worm in the apple.

Land has a "notional rent": Imputed rent (not "cost")

a) Uncle Merrill's house.

'Easy come, easy go' is bad ecs.

Imputed cost easily ignored.

Esply when Value is rising.

✓ 24. #17. At max AP, a 1% $\Delta W \rightarrow$ 1% ΔS .

But ~~AW~~ $\frac{\Delta W}{W+G^*}$ is $< 1\%$, i.e. you ΔE by adding W .

$$\text{At max } E, \quad \frac{W+G}{W+G^*} = 1 = \frac{S}{W+G^*}. \quad G = G^*.$$

$$\text{So } S' = W' \quad \text{so} \quad S'/S = W'/S = W'/W+G^*. \quad \text{A } 1\% \Delta \text{ in } \frac{W}{W+G} \rightarrow 1\% \Delta S$$

25. $P = k a^a b^B$

a. $\frac{MP}{AP}$ remains constant.

at least MP & AP fall together.

Could be true over a limited range of
St. II. Has a stopping point when MP falls to = MC.

b. Comply. is bad.

c. CES?

26. #10. "Markup"

Let $x =$ a bundle of $(w + k) \equiv$ working capt. or expenses.
Then ~~ST~~ $S' - (w + k) = \text{markup}$.

27. When you take rent or L.V. as an exogenous cost you are letting the market set the figure. But land has no cost of prodn, only a scarcity value. How did the market find the figure?

Most people don't know how to figure L.V. ~~There is a cost~~ So they take conventional value as a firm cost. And they follow herd movements (which become herd movements.) A herd follows the herd. ~~They follow the herd~~ he is the herd. But then the determination of land value is entirely circular. It has

no objective basis. It can ~~become~~ ^{depart} differ widely from a true value before anyone notices: too low, too high, too stable, too trendy.

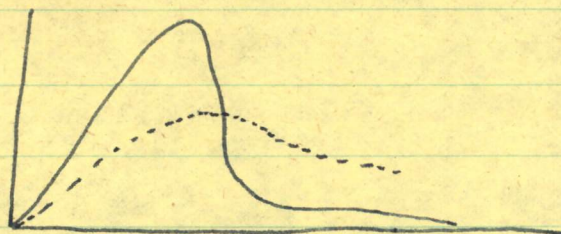
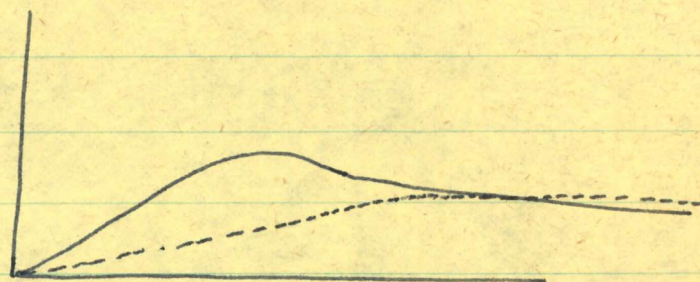
This is the more time when ~~the~~ G_1 is short, so that values and n must be found simultaneously. See Priscilla Douglas, p. 7.

Tougher yet is to determine n on a rising market.

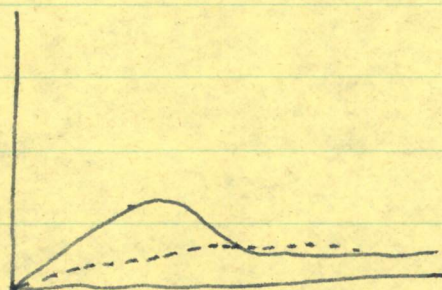
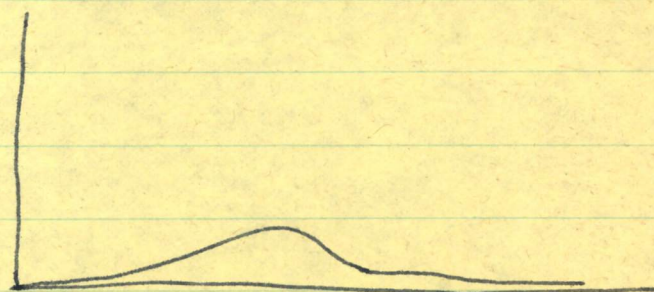
~~Barley~~
Barley

Tomatoes

Tulane City.



~~Idaho~~
Mont.



$$1. \text{ Intensity} = 1/aP = \frac{\text{Input (non-land)}}{\text{Output}}$$

$$2. \frac{\text{Wage bill}}{TP} = \frac{(\text{Price of labor})(\text{Workers})}{TP} = \frac{w.r.}{aP}$$

$$\text{If } w.r. = \frac{1}{4} aP, \quad \frac{w.r.}{aP} = \frac{1}{4}, \quad \text{then:}$$

a. Low intensity

b. Low sensitivity to $\Delta w.r.$

c. Low elast. of prodn. bcs. if $w.r. = MP$, then

$$w.r./aP = \frac{MP}{aP}$$

Write this all down and distribute to class.
This is why ext. of prodn. is useful. Leads to i.g., etc.

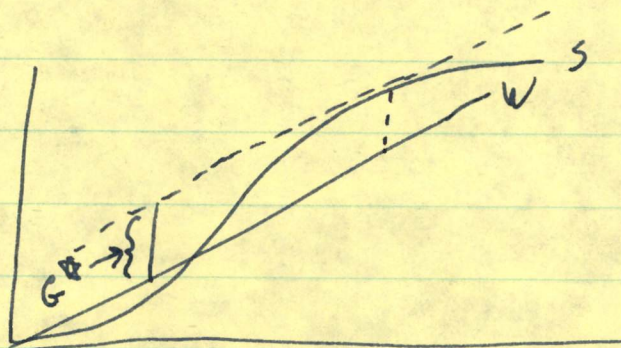
Add To Notes on Prodn, Ecs.

$$\text{Efficiency} = \frac{W + G}{W + G^*} = \frac{S}{W + G^*}$$

2 conditions for max:

1. $S' = W'$

2. $S = W + G^*$



They are satisfied simul.

Another diff. of land: Value is not a fund.
No way to draw it down.

Even a bldg., ~~can be~~ you can consume the cap.
By neglecting maint., can ~~not~~ even utilize it faster. E.g. in war.
Never so w. sites (but is so w. depln.)

L.V. is a "false fund"

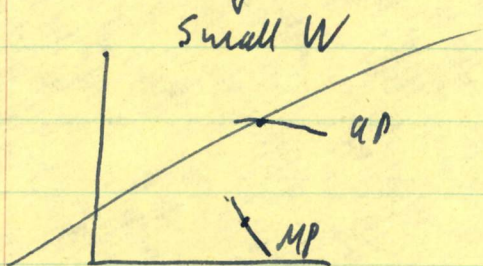
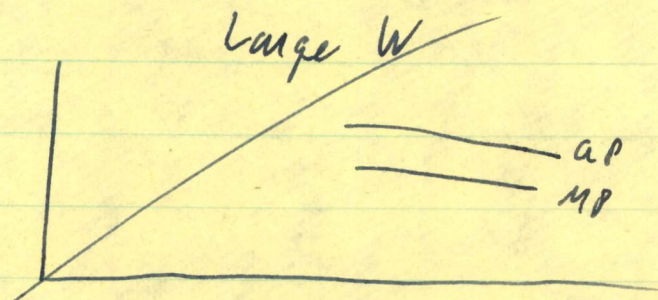
In war, you utilize all the K. Postwar, $\therefore$ all land uses are more labor-using.

But shortage of priv. funds to invest keeps L.V. low.

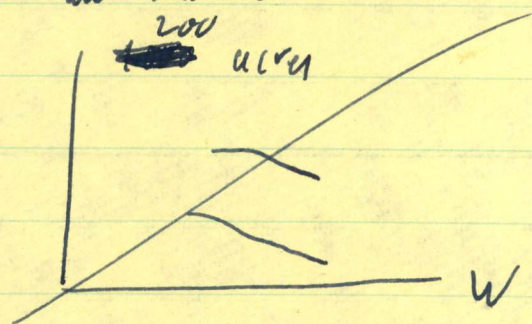
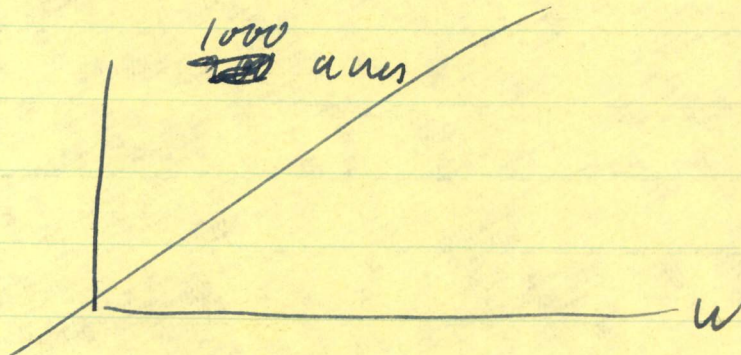
Tues. 11-13-84

12. TP is exhausted.
Lim. returns implies ~~not~~
Rent is residual.

13. Proving land

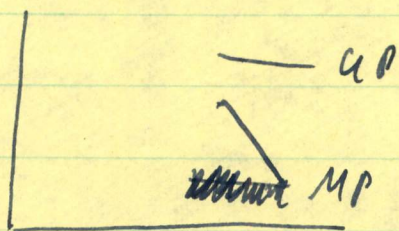


Prostate labor



- a. MP's may differ, due to different costs
b. MP's may rise differently

14. Fallacy of pass-through
 Δ Wage
Tax
Mtrls.



If $\frac{MP}{AP}$ is small, little
decline in output.

- a. MP is steep
- b. ϵ is low

E.g. oil severance tax.

15. Fallacy of max AP.

Ignores fixed costs.

$\% \Delta P > \% \Delta$ all inputs.

Fallacy of arrogation

Need for performance standards

Points re firm. rets.

1. Intl. comparisons.

Work land to lower margins in Japan.

Work urban + urban to lower margin in U.S. than 3d world; in Europe than U.S.

2. Depopulation of Vt. Deserted towns - Kelly Stand.
Due to higher wages, urban land.

3. Capl. may sub. for labor, or complement labor.
a. As bldg. ages, O + M rise. Less capl. more labor.

(A bldg. is a factory producing resid. services.)

✓ b. A battery of ^{sewing} machines makes many jobs per unit of floor space.

In one sense, capl. always sub. for labor, otherwise you wouldn't have it? Yes, if it sub. for land.
E.g. hi-rise bldg; landfill.

4. How to ^{adapt to higher i.r. ex. on K.} ~~sub. labor for K.~~

a. Defer replant. of existg K.
(This also sub. land for K.)

b. Build less life into new K.

c. Use K longer hrs. & seasons.

d. Use more labor per hr.

e. ~~Reduce~~ Use more land w. given K.

(High i.r. doesn't make you ex. on land, b.c. price falls.)

f. Defer new invts. until demand is stronger.

E.g., Vista Point; or La Mont Fuel Center.

Esp. look out for preemptive & preclusive invts.
Geothermal?

g. Replace CIAs by Man systems; often.

5. What to max?

✓ Gain per unit $\times$ no. of units. Neither one alone!

Why I don't use or recommend Cobb-Douglas fns.

a. $\frac{MP}{aP}$ is const.

$$P = K a^{\alpha}$$

$$\ln P = \ln K + \alpha \ln a$$

$$\frac{MP}{aP} = \epsilon = \frac{d \ln P / da}{d \ln a / da} = \frac{0 + \alpha \frac{1}{a}}{\frac{1}{a}} = \alpha$$

b. $b + a$ are always complements.