Chapter 3

Po-Chun Huang
NCCU, Spring 2021

Road map

Chapter 2: labor supply

- We developed a neo-classical model of labor supply, relying on utility maximization
- We discussed the incentives individuals face

Chapter 3: Labor demand

- The actual outcome in the labor market, of course, also depends on firm decisions
- We will develop a neo-classical model of labor demand, relying on profit maximization
- We will discuss the incentives that firms face for hiring workers

Outline

1. The production function
2. Employment demand in the short run
3. Employment demand in the long run
4. Employment demand issues the basic model overlooks…

1. The production function

The production function

Production functions describe the technology firms use to turn factors of production into output (q)

- In practice, factors include labor, land, machines, physical inputs, technical expertise, etc.
- We initially assume two factors, employee hours (E) and capital (K)
- The function: $q=f(E,K)$

This formulation makes two restrictive assumptions about labor

- E abstracts from the number of workers versus the number of hours each worker provides. Thus, 2 workers at 20 hours each is assumed equivalent to 1 worker at 40 hours
- E abstracts from types of labor (manager, production worker, administrator etc.)

Marginal Products

Marginal product is the additional product that is obtained by using one more unit of one input, holding the other input constant

- In our model, we have two inputs, E and K, so there are two marginal products
- In terms of calculus
  - Marginal product of labor: $MP_E = \partial Q(E,K) / \partial E$
  - Marginal product of capital: $MP_K = \partial Q(E,K) / \partial K$

Compare the presentation above to Marginal Utility in Chap 2!

A Production Schedule

A tabular form of a production function

This table changes E, holding K constant

$MP_E = \Delta Q / \Delta E$

This is the discrete version of $\partial Q(E,K) / \partial E$

TABLE 3-1 **Calculating the Marginal and Average Product of Labor (Holding Capital Constant)**

Number of Workers Employed	Output (Units)	Marginal Product (Units)	Average Product (Units)	Value of Marginal Product ($)	Value of Average Product ($)
0	0	—	—	—	—
1	11	11	11.0	22	22.0
2	27	16	13.5	32	27.0
3	47	20	15.7	40	31.3
4	66	19	16.5	38	33.0
5	83	17	16.6	34	33.2
6	98	15	16.3	30	32.7
7	111	13	15.9	26	31.7
8	122	11	15.3	22	30.5
9	131	9	14.6	18	29.1
10	138	7	13.8	14	27.6

Note: The calculations for the value of marginal product and the value of average product assume that the price of the output is $2.

More on the production function

Average product: amount of output produced per input on average

$AP_E = q / E$

$AP_K = q / K$

The marginal product is the slope of the total product curve—which means it tells us something about technology

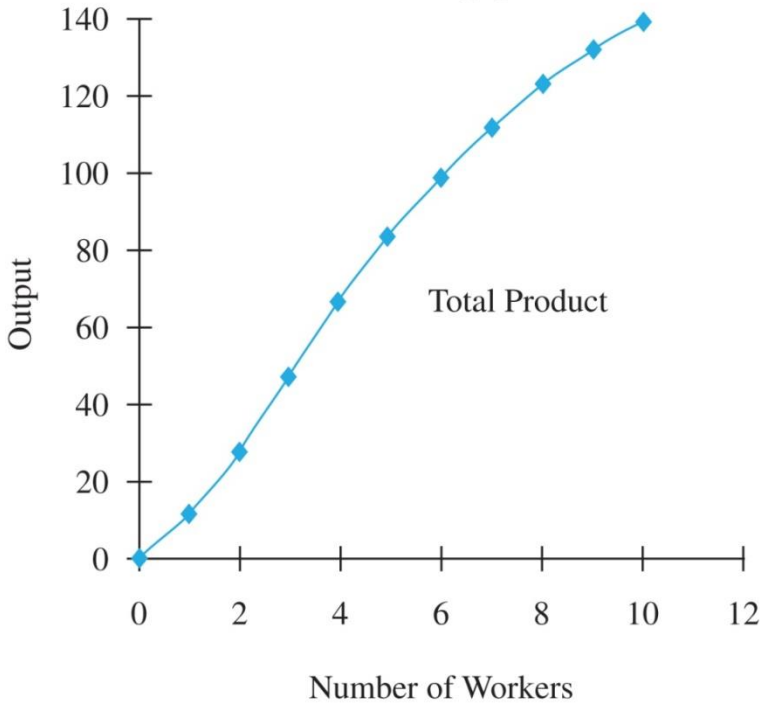
Our basic assumption: Law of Diminishing Returns

- The marginal product of labor eventually declines
- Why? Congestion, suitability of inputs, etc.

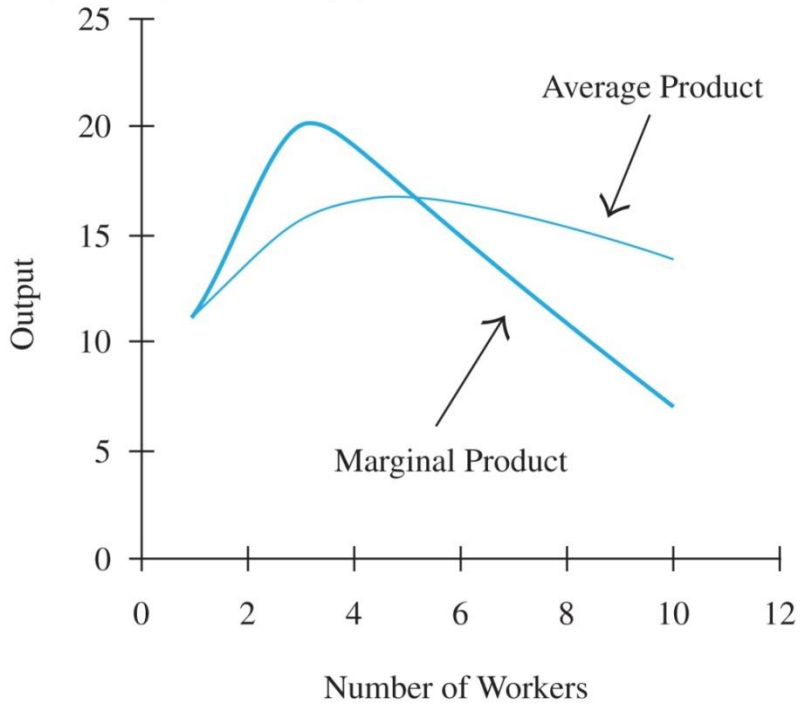
The pictures

If we graph the production schedule, we get..

1. TP is increasing
2. MP eventually declines (diminishing returns)



(a)

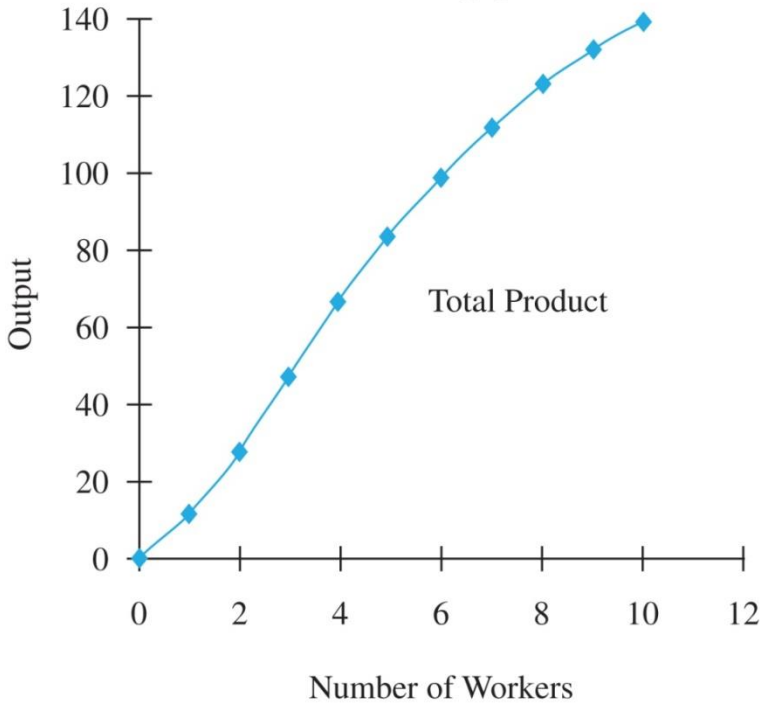


(b)

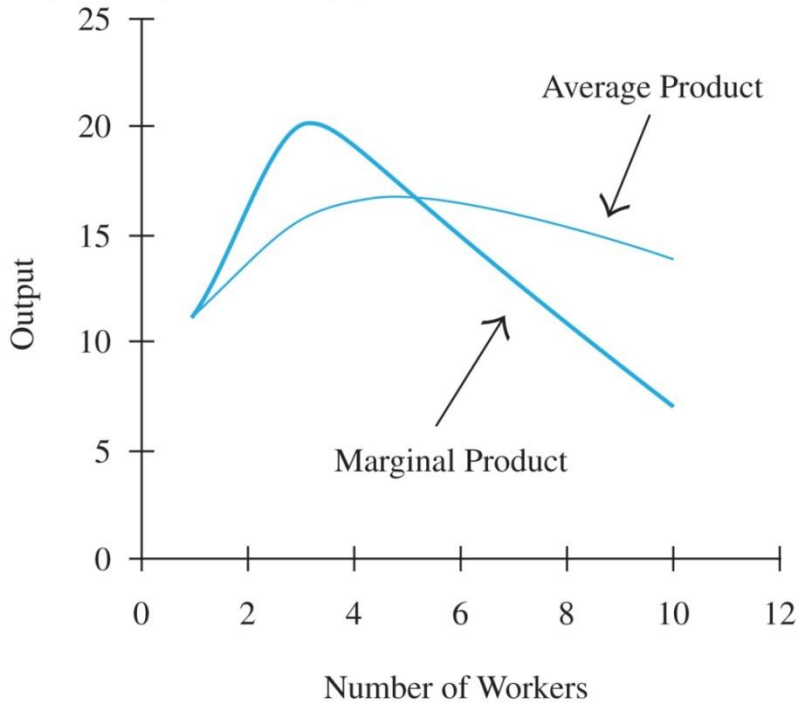
The pictures

3. MP must go through maximum of AP

   Why? The same reason MC must go through minimum of ATC and AVC….



(a)



(b)

Our basic firm assumptions

We assume that firms maximize profits

- Profits = Revenues – Costs = pq – (wE + rK)
- p=price of output q
- w=wage paid to unit of labor E
- r=rental price of a unit of capital K

We assume that the firm is operating in a perfectly competitive market

- The firm is small
- The firm is a “price taker”, or the firm takes p, w, and r as fixed

We relax these assumptions in later chapters

2. Employment demand in the short run

The firm's short run decision

Short run: timeframe over which K is fixed at K_0

This time we start with calculus

- The basic problem
  - Max Profits = Max pq – (wE + rK)
- But we assume we are in the short run, so $K=K_0$, and we can substitute in our production function
  - Max $pQ(E,K_0) - wE - rK_0$
  - The only unknown is E, and p, w, r, and K_0 are fixed
- Differentiate w.r.t. E and set equal to zero
  - $p\,\partial Q(E,K) / \partial E - w = 0$
  - $p\,MP_E = w$

Which gives us…

Hire workers until $p\ MP_E = w$

What is this?

- $p\ MP_E$ is the number of units that the last work produces multiplied by price—or the Value of the Marginal Product of Labor (VMP_E)
  - This is the marginal benefit of hiring the last worker
- w is the wage that must be paid to all workers
  - This is the marginal cost of hiring the last worker

And this is what economics is—do something as long as the marginal benefit of doing it is greater than the marginal cost

- Simply applied to the short run hiring decision

Or just think through the intuition

Just define the VMP and AMP curves

Value of the Marginal Product of Labor

$VMP_E = p\ MP_E$

The value of hiring one more worker, or the marginal benefit of hiring one more worker

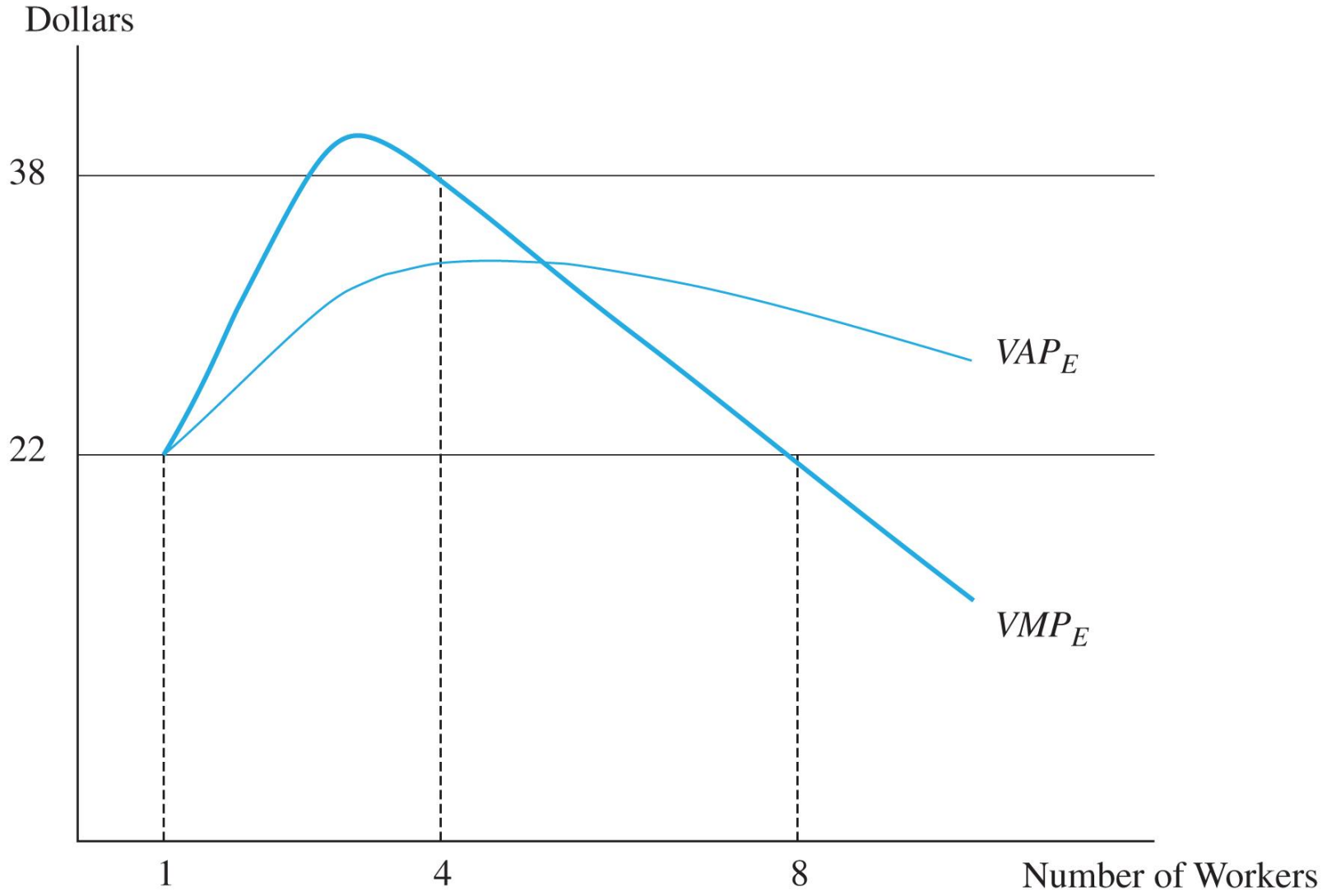
Value of the Average Product of Labor

$VAP_E = p\ AP_E$

The average value of the labor

Both are obtained by multiplying the MP and AP curves by p

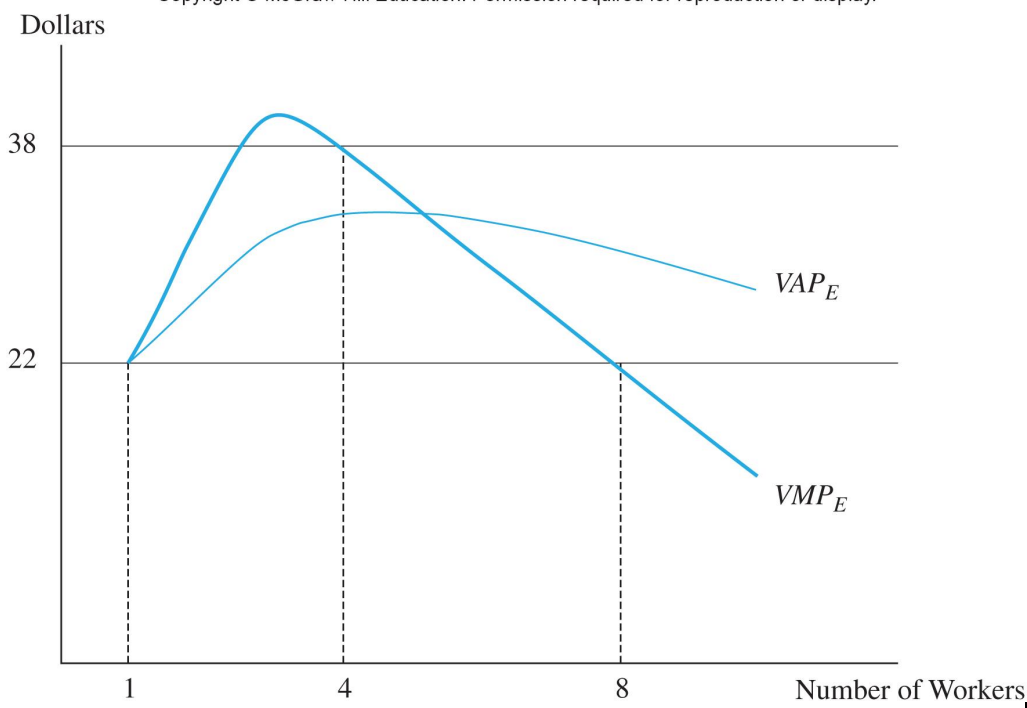
The picture



The intuition

So suppose the wage rate was $22

- The value of hiring the fourth worker is $38 – so the firm makes money by hiring that worker
- And the fifth, sixth…
- Keep hiring until VMP = 22, or hire eight workers



What is optimal?

- Hire until $VMP_E = w$, which was the calculus answer

The SRLD for a Firm

The short-run labor demand curve (SRLD) for a firm is the VMP_E curve

- Which is simply a restatement of "hire workers until VMP_E = w"
- Which should sound a lot like producer problem result from microeconomics, "the MC curve is the firm supply curve"
- Since we have assumed diminishing marginal returns, we know that the MP_E curve is downward sloping…which means that the VMP_E curve is downward sloping…which means the SRLD curve is downward sloping
  - A very good thing—a downward sloping demand curve

The SRLD for a market

We usually “horizontally sum” firm curves to get market curves

- But…

We can’t simply horizontally sum the curves in this case.

- Why? Because we are taking p as given
- But if each firm produces more of an output, p should change
- This can be included in the problem, but things get a little messier
- So, suffice it to say that the firm SRLD curve is a little steeper than the curve that one gets from simply horizontally summing firm SRLD curves

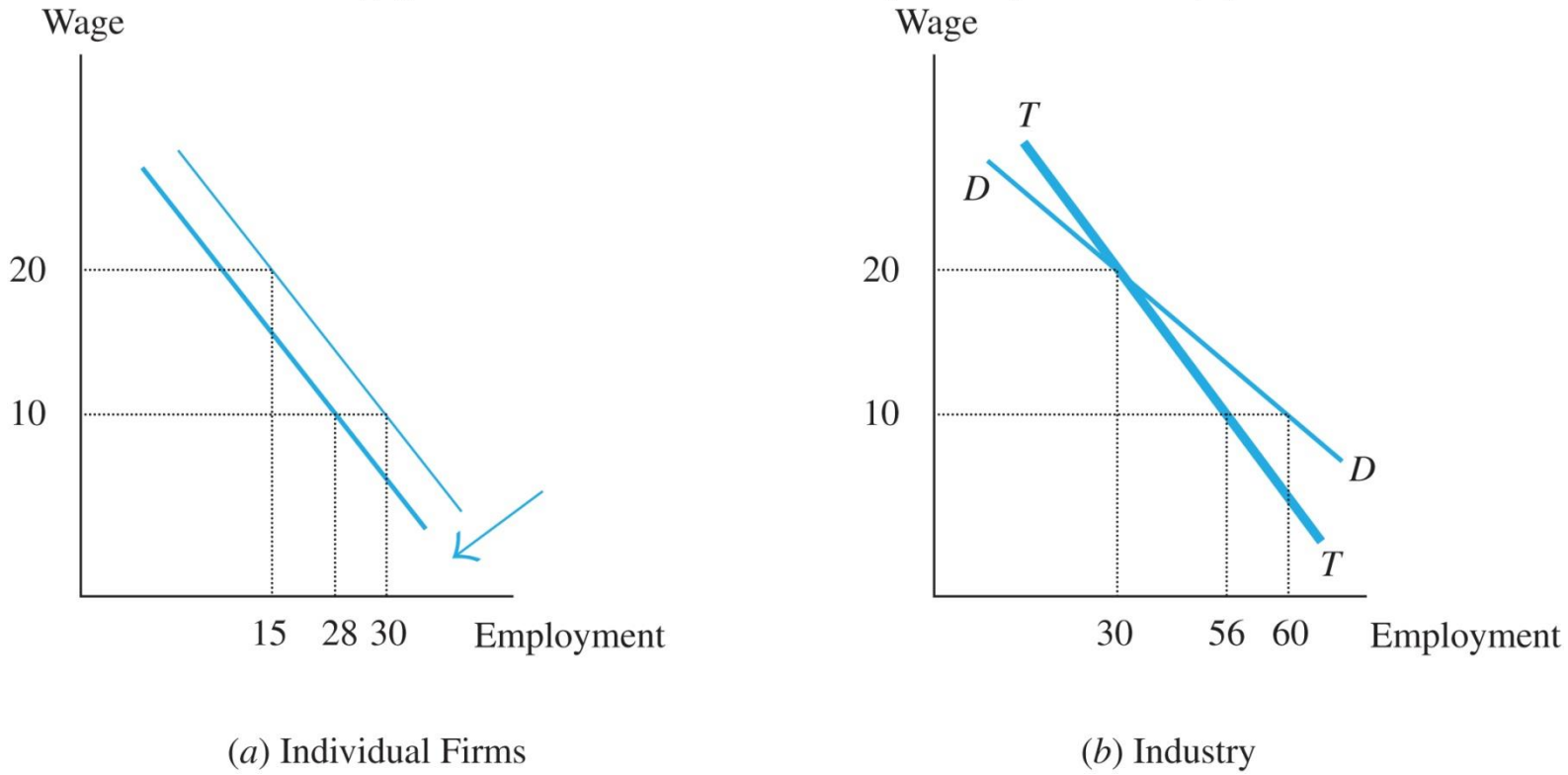
The picture

As firms hire more, the price drops

As the price drops, VMP shifts in

As VMP shifts in, each firm wants to hire fewer E

Net result: TT is steeper than DD



Measuring labor demand

Our general measure of responsiveness: Elasticity

Basic formula (Δ means "change" or "difference)

$$\text{A Elasticity of B} = \frac{\%\Delta B}{\%\Delta A}$$

Our current example: "Labor Demand Elasticity", or more appropriately, the "Wage Elasticity of Labor Demand"

$$\underbrace{\text{Wage}}_{A}\ \text{Elasticity of}\ \underbrace{\text{Labor Demand}}_{B} = \frac{\%\Delta E^{D\text{-sr}}}{\%\Delta w}$$

Tells us about the steepness of the short run labor demand curve

- Given our assumptions, we expect it to be negative
- Elastic if absolute value is greater than 1; inelastic if absolute value is less than 1

Measuring labor demand

Labor Demand Elasticity

$$\text{LDE} = \delta^{\text{SR}} = \frac{\%\Delta \text{E}^{\text{SR}}}{\%\Delta \text{w}}$$

Elastic labor demand: |LDE|>1

Employment is very responsive to a wage change—the LD curve is relatively flat

Inelastic labor demand: 0<|LSE|<1

Employment is not very responsive to a wage change—the LD curve is relatively steep

Evidence

Note: the book delays the discussion of evidence until the LR section…

Optimal q vs. Optimal E

The optimal level of production (q) was given by a firm producing until

p=MC

p is the marginal benefit of producing one more unit of output, and MC is the marginal cost of producing one more unit of output

We just derived a firms optimal level of employing workers (E) by a firm hiring until

$VMP_L=w$

But shouldn't these decisions be related? The optimal level of production and the optimal level of hiring workers?

Optimal q vs. Optimal E

Yes, they are related!

- Let's start with the optimal level of output
  - p=MC
- What is marginal cost of a unit of output in our current set up?
  - It is short run, so there is not additional capital cost
  - If our last worker is producing MP_L units of output, then it takes $1/MP_L$ units of labor to produce one more unit of output
  - The cost of producing that last unit of output is $w\ (1/MP_L)$, or in other words, $MC=w\ (1/MP_L)$
- Let's substitute that expression into p=MC
  - $p= w\ (1/MP_L)$
  - Rearranging, $p\ MP_L= w$ or $VMP_L=w$
- Thus, whether we solve the problem as choosing the optimal output or hiring the optimal amount of labor, we get the same answer!

In both cases we are solving for what is profit-maximizing for the firm. Of course, the answers are related.

3. Employment demand in the long run

The firm's long run decision

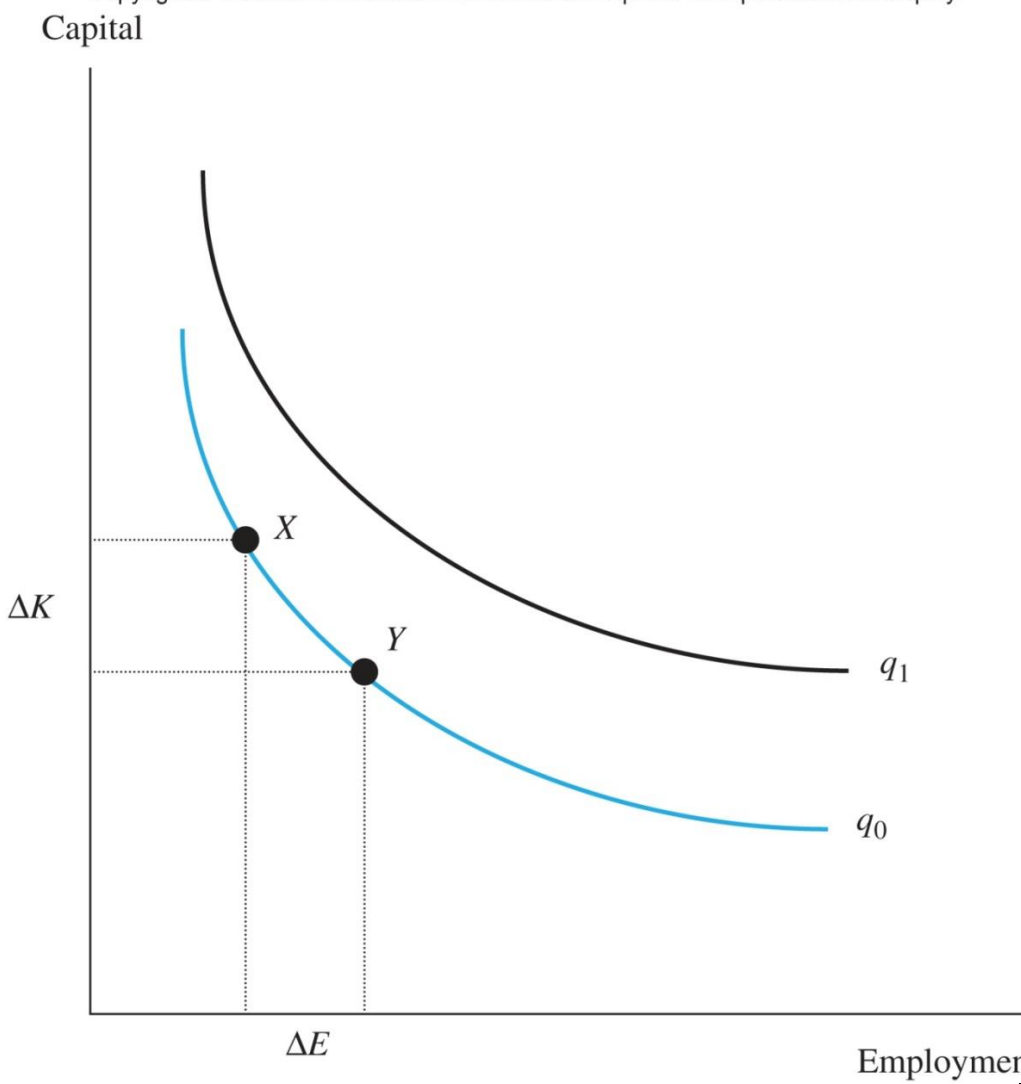
In the long run, a firm's capital stock is not fixed, so we must consider the profit-maximizing choice of labor and capital

The theory is very analogous to the consumer side

- Profit maximization as compared to utility maximization
- Isoquants describe the technological trade-off inherent in the production function as compared to indifference curves describing the utility trade-off inherent in utility functions
  - Both curves are convex to the origin
- Isocosts describe the financial trade-off between hiring capital and labor as compared to a budget line describing the cost trade-off in consumption
  - Both are straight lines
- Firms try to minimize costs of a desired level of output as compared to individuals maximizing utility for a given budget

Isoquants

- They must be downward sloping
  - If less K is used for some level of q, then more L will be needed
- They cannot intersect
  - It would lead to a contradiction
- Higher isoquants are associated with higher levels of output
  - More inputs, more outputs…
- Isoquants are convex to the origin
  - Diminishing marginal returns to a factor



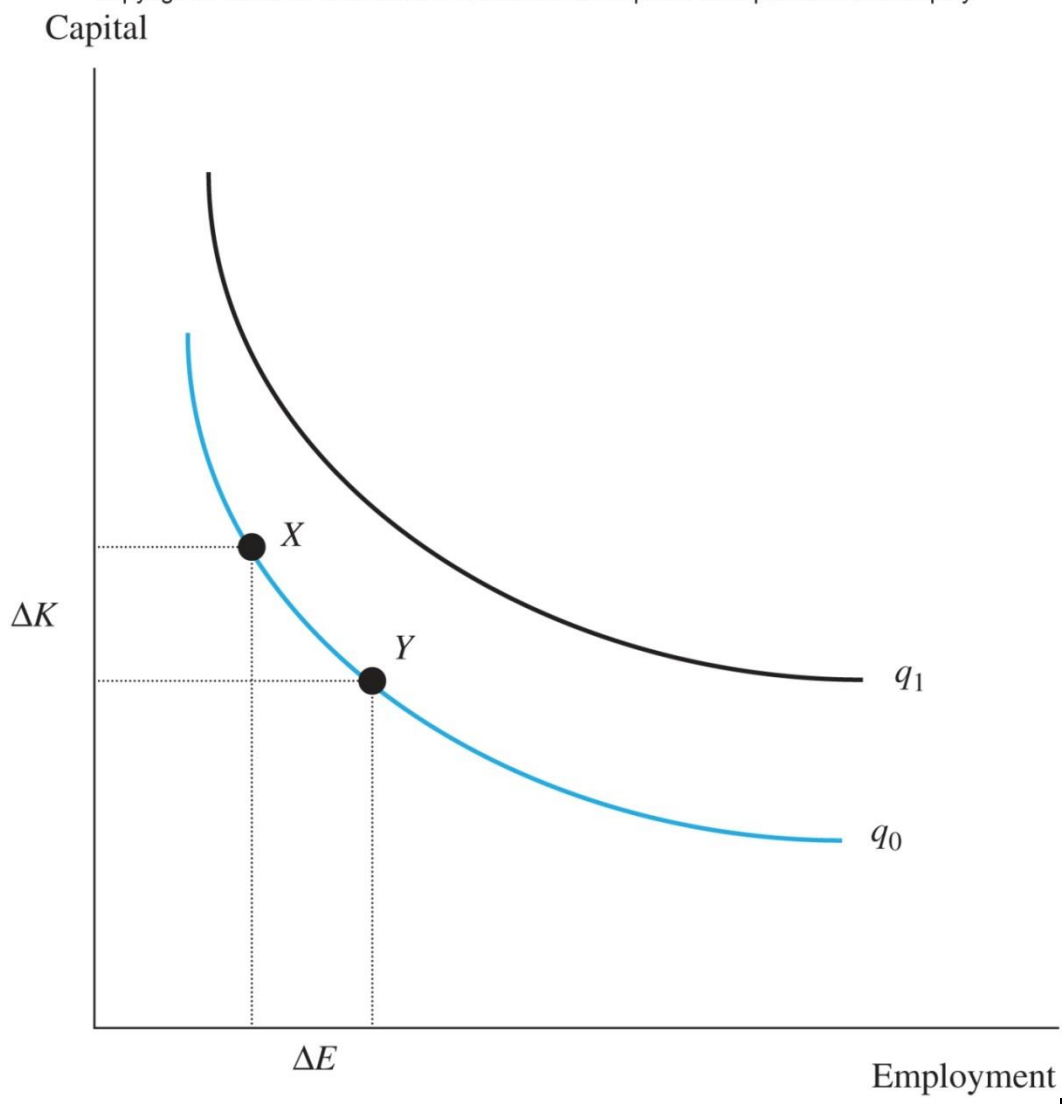
Isoquants

Marginal Rate of Technical Substitution (MRTS)

The exact analog to the MRS on the individuals side

$$\frac{\Delta K}{\Delta E} = -\frac{MP_E}{MP_K}$$

The slope of the isoquant



Isocosts

The firm's cost of production

$C = wE + rK$

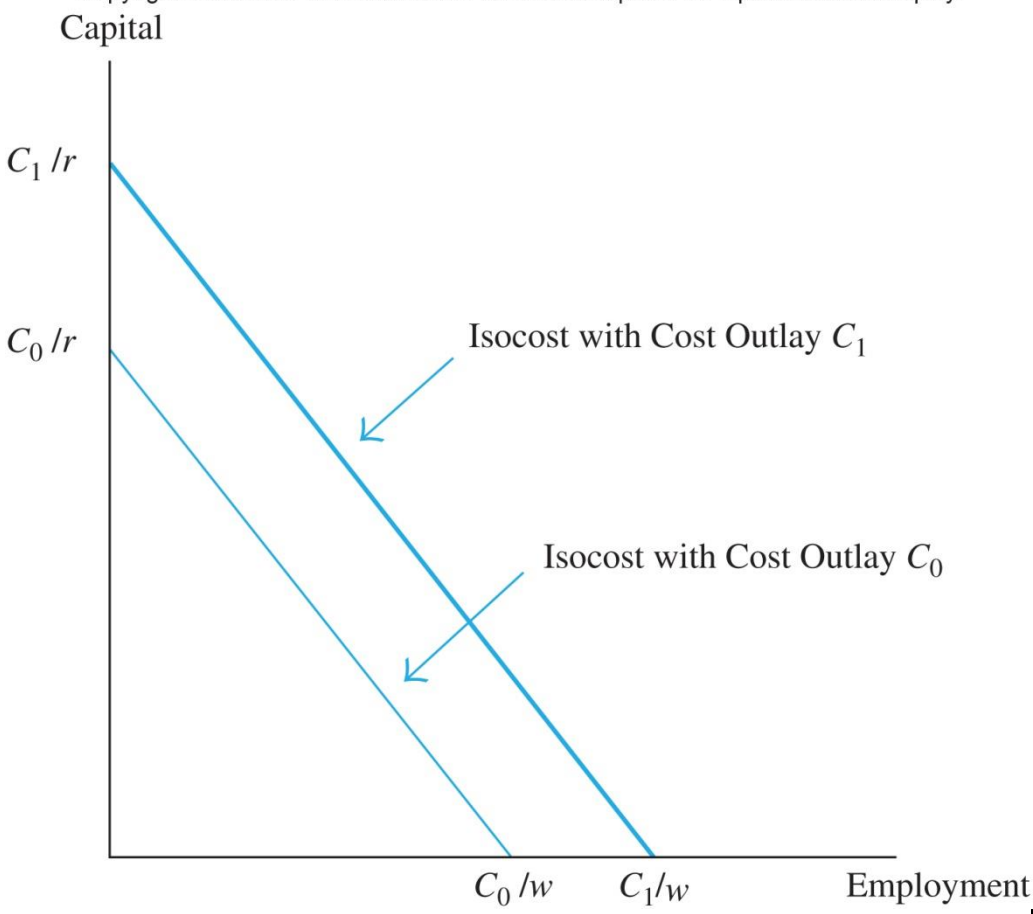
Isocost gives all the equal-cost ways to produce at specific cost C_0

A line

Why? Solve for K, which is on the y-axis

$K = C_0/r - (w/r)E$

Slope: (negative) ratio of factor prices



The firm decision problem

We first think about a cost minimization decision

- Suppose we knew a firm wanted to produce output q_0—what is the best way, or cheapest way, to produce it?
- This decision is true for any output level q_0, even if the output level is not optimal
- For profit maximization, we also need to know the optimal output
- Why do we start with the cost minimization behavior? It allows us to focus on the optimal mix of E and K

So how do we do it? Choose the cheapest way to produce q_0….which is going to be a tangency between an isoquant and an isocost curve

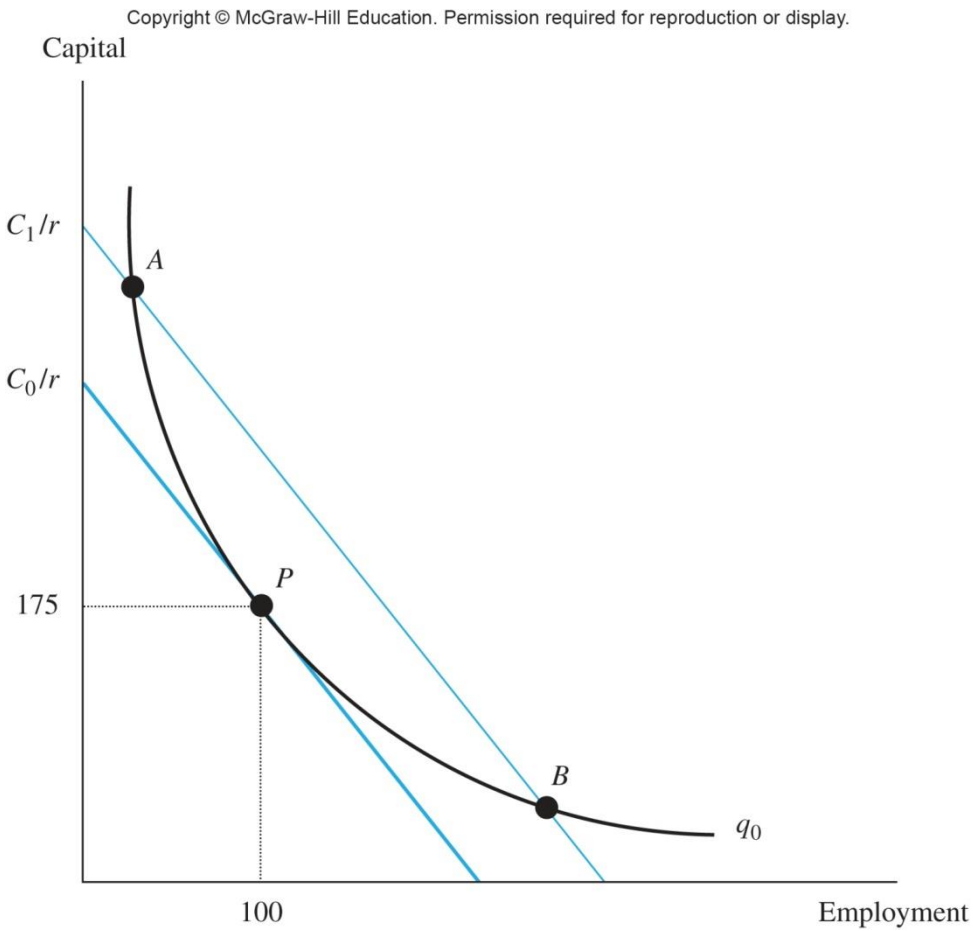
Cost minimization

The cheapest way to produce q_0 is at P

- A and B are higher cost ways of doing it

What is true here?

- MRTS = -w/r
- $MP_E / MP_K = w/r$
- $MP_E / w = MP_K / r$
- The output per cost for marginal worker and capital unit must be equal



The long-run firm decision

What have we learned?

- In the long-run, the firm will balance its labor and capital use so that its cost-adjusted output is equal between the two sources
- If not, the firm would benefit from shifts its factor mix

How do we get to the profit maximizing level of output?

- Two more conditions must be satisfied:
- $w=p \times MP_E$ and $r = p \times MP_K$
- These conditions relate costs to output prices
- Their ratio give back the optimal production mix on the previous slide—meaning that profit maximization is consistent with cost minimization
- Or, the long-run firm decision is simply applying our short-run decision to both inputs

Substitution and Scale Effects

The long-run firm demand curve

Long-run demand: How does a firm respond to wage changes?

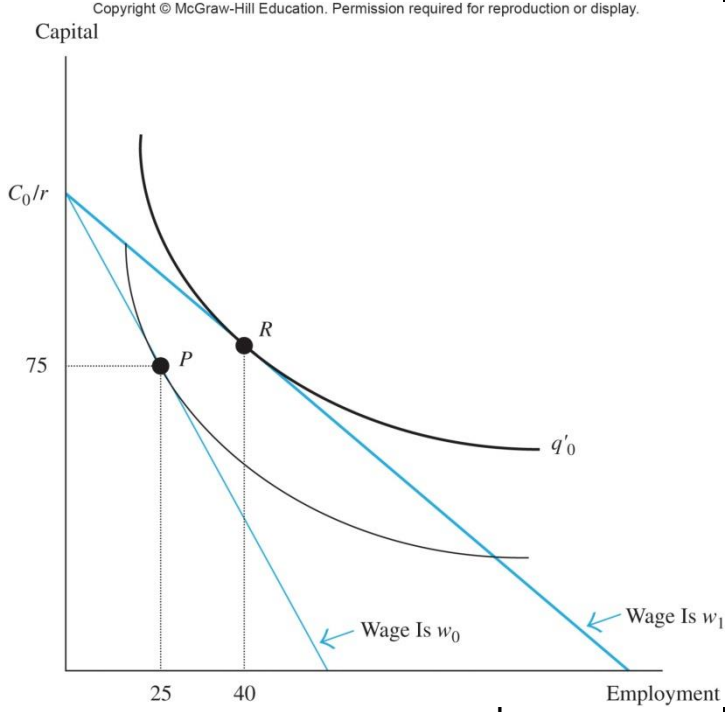
- What did we just learn? The optimal production decision can't be determined by just the input prices—it must include information on output prices

So….we <u>can't</u> just rotate the isocost curve to learn what happens with a wage change

- Firms DON'T try to hold costs constant

What DO firms do?

- Set $w = p \times MP_E$
- How do firms lower MP_E? <u>Increase q</u>



The long-run firm demand curve

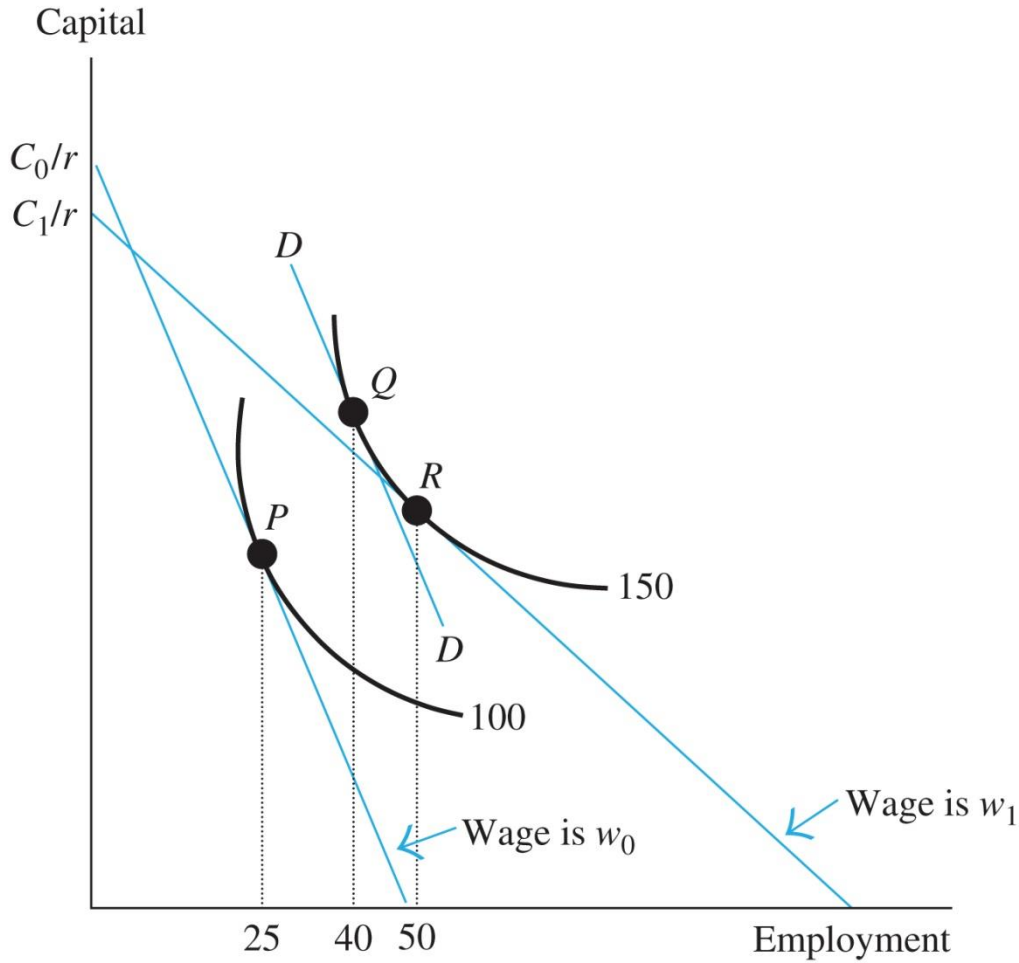
So what happens when the wage declines?

Step 1: figure out new q

- Wage decline means firm will increase q
- Cost of production is cheaper so increase production

Step 2: figure out new mix of E and K

- Cost minimization must be based on q!



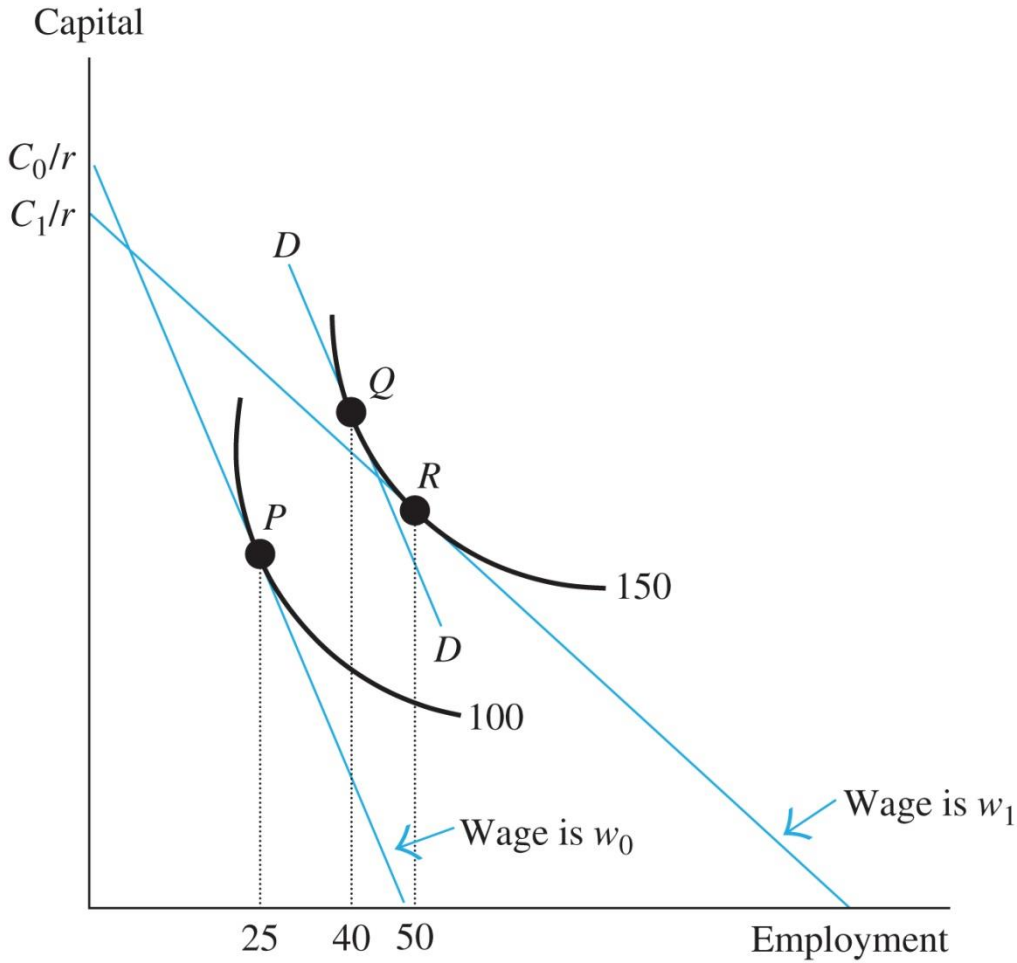
The long-run firm demand curve

So what happens? We can think about there being two effects

- Substitution effect: firms shift from K to E because E is cheaper
- Scale effect: firms use more K and E because they produce more

So on net

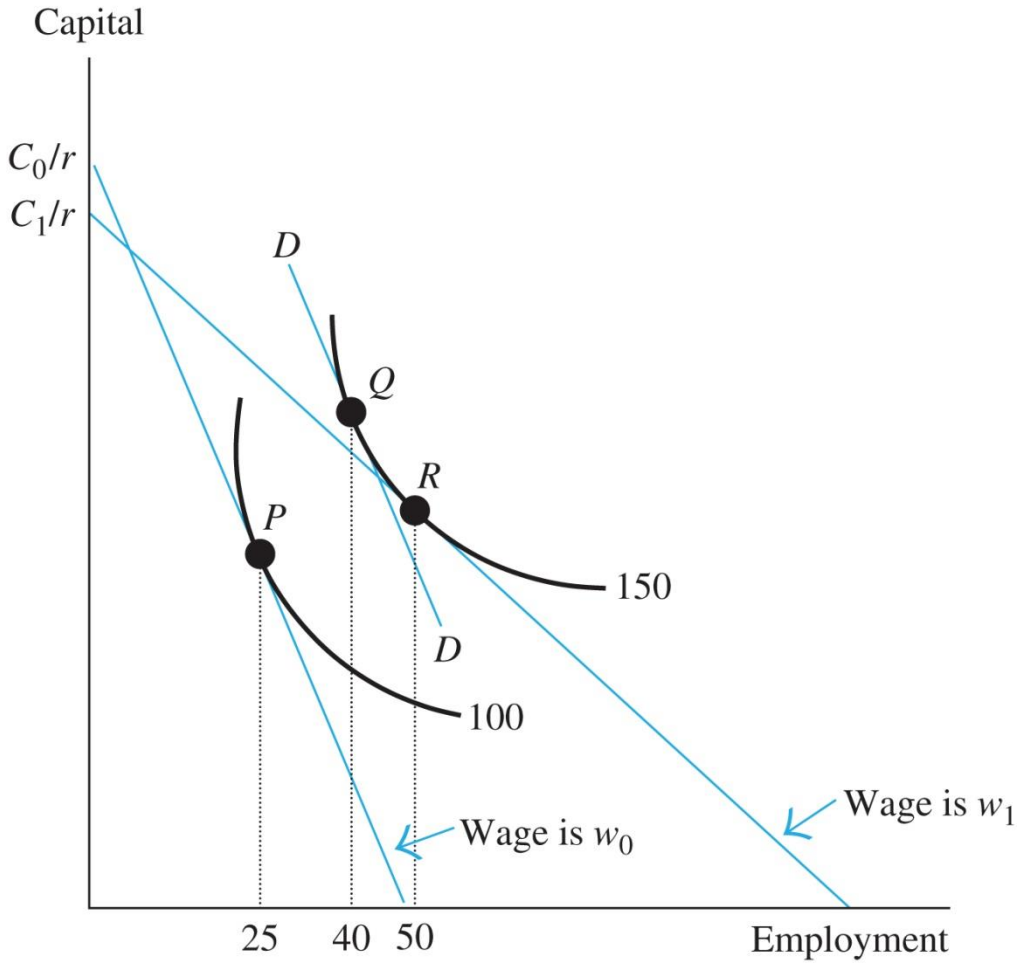
- Use of E increases
- Use of K ambiguous



The long-run firm demand curve

In pictures

1. Q from 100 to 150
2. Scale effect: P to Q
   - Holding (w/r) constant, but more q
   - More E and K
3. Subs effect: Q to R
   - Holding scale constant, but changing (w/r)
   - More E, but less K
4. Net effect from Q to R
   - More E, Ambig. K

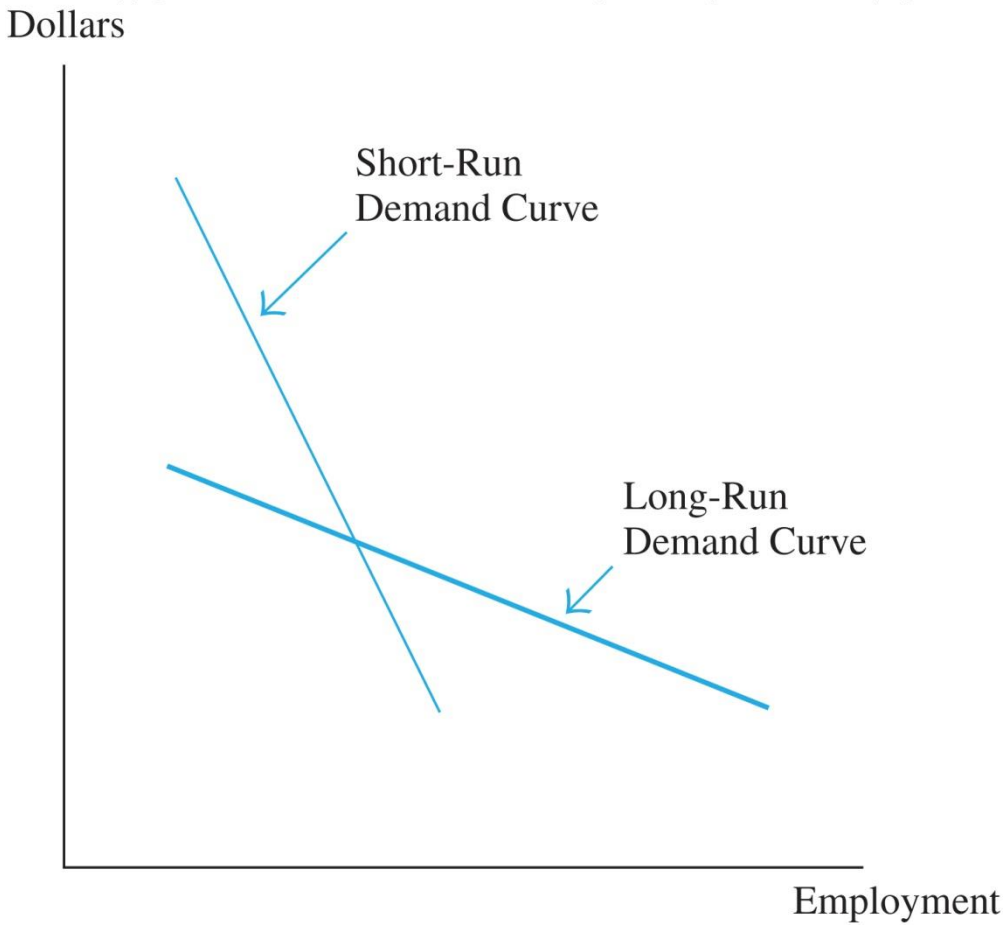


The long-run firm demand curve

So what do we get?

SRLD is steeper than LRLD

- In SR, firms higher some more workers as w declines because E is cheaper—but there are limits because K is fixed
- In LR, firms can hire more K too so that E and K are used efficiently, so E would increase even more



Measuring labor demand

Labor Demand Elasticity

$$\delta^{SR} = \frac{\%\Delta E^{SR}}{\%\Delta w}, \delta^{LR} = \frac{\%\Delta E^{LR}}{\%\Delta w}$$

Difference between the two: How long does one wait to see the employment changes

Evidence

SR: -.4 to -.5, so SRLD is downward sloping

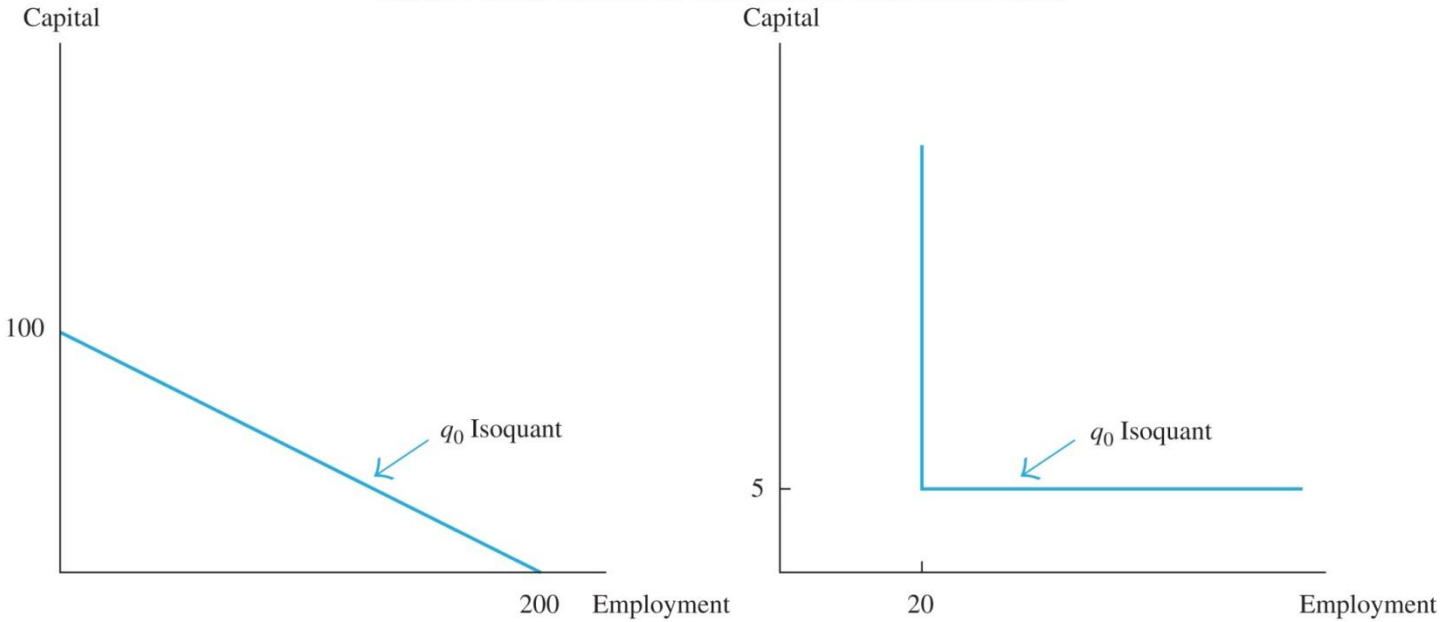
LR: -1, so LRLD is also downward sloping and more elastic than SRLD (like theory suggests

One third to the subs effect, two thirds to the scale effect

Elasticity of Substitution

The effect of a factor price change on the use of a factor will critically depend on how substitutable the factors are

- Right now, we have two factors, E and K
- The substitutability hinges on the shape of the isoquant
- Two polar cases: perfect substitutes vs. perfect complements



(*a*) Perfect Substitutes

(*b*) Perfect Complements

Elasticity of Substitution

When factors are perfect substitutes, the substitution effect will be large

- Firms can easily switch between E and K

When factors are perfect complements, the substitution effect will be non-existent

- Both factors are required for production

How do we measure the substitutability? The elasticity of substitution

$$ES = \frac{\%\Delta(K/E)}{\%\Delta(\mathrm{w/r})}$$

Elasticity of Substitution

In the real world, of course there is more than two types of factors…

The general theory goes through

- For all factors with price w_i that can vary in the short run, a firm sets $w_i = p \times MP_i$
- For the long run, set the same expression true for all factors

Similarly, the elasticity of substitution can the be discussed between all pairs of factors

- Such results are very important to labor economics because we often want to distinguish between different types of labor
- Immigrants vs. natives
- High-skilled vs. low-skilled
- Male vs. female
- Disabled vs. non-disabled

What determines LDE?

What determines the labor demand elasticity?

Marshall's classic discussion

- LD is more elastic the greater the elasticity of substitution?
  - The idea: when wages go up, the firm shifts to other factors of production more readily
- LD is more elastic the greater the elasticity of demand for the output
  - The idea: when wages goes up, prices go up—and consumers shift to other products more readily
- LD is more elastic the greater labor's share in total costs
  - The idea: when wages goes up, prices go by a lot
- LD is more elastic the greater the supply elasticity of other factors of production (like capital)
  - The idea: when wages increase, it is easier to substitute to other factors of production

The minimum wage

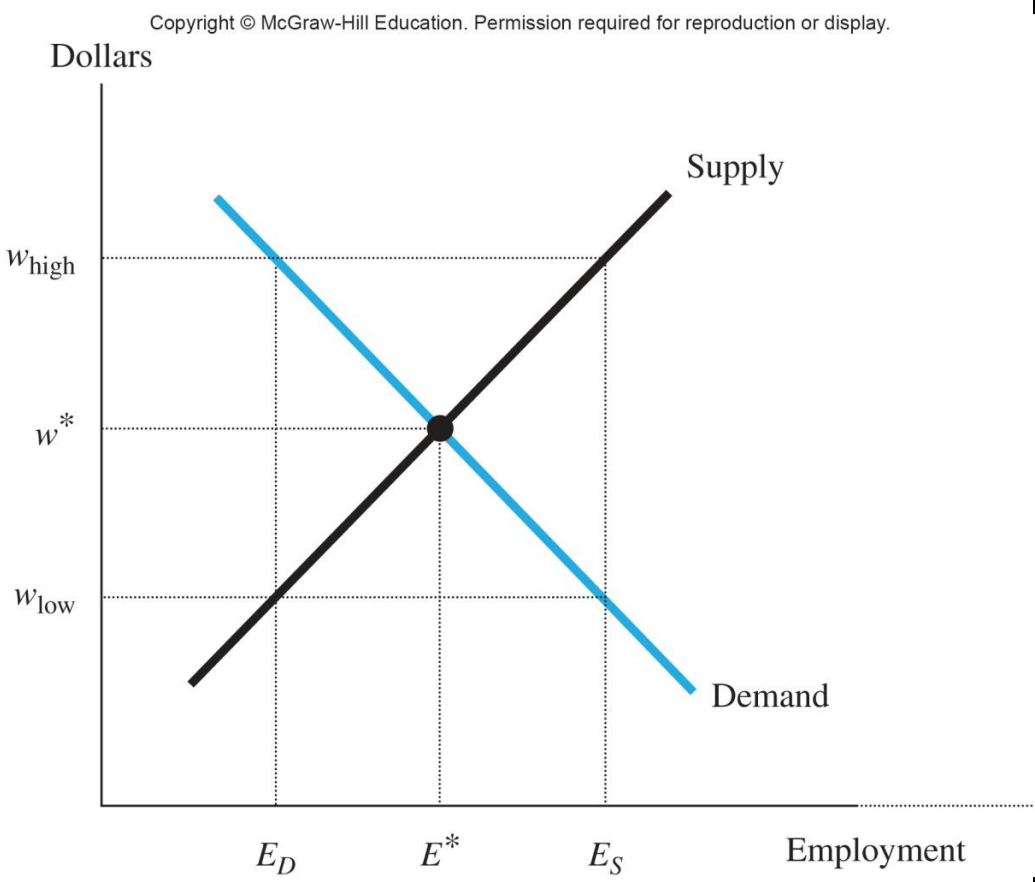
Why jump from LD to min. wage?

Normally, we would first talk about equilibrium

- We have developed LS and LD
- Equilibrium—w* and E*
- We discuss equilibrium at length in next chapter

Consider a min wage

- w_{low}: non-binding, so still w* and E*
- w_{high}: binding, so w_{high} and E_D, or employment loss of E^*-E_D



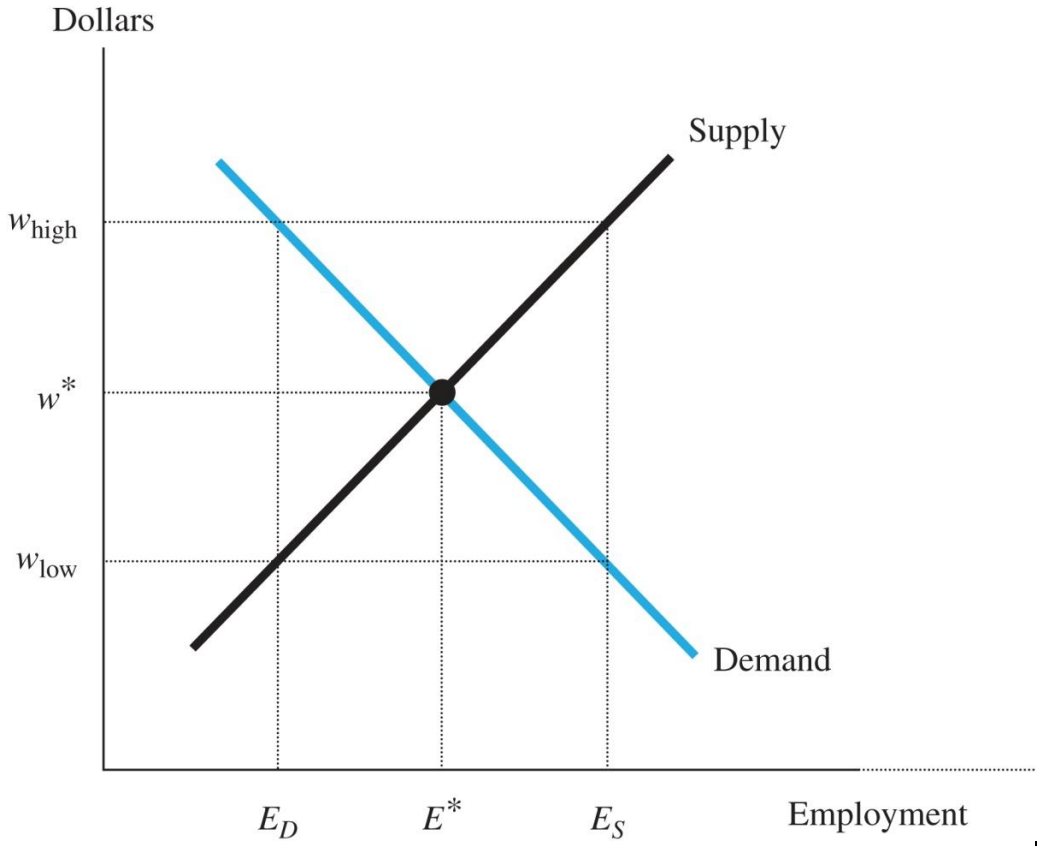
Why jump from LD to min. wage?

In other words, in perfect competition:

The effect of an increase in the minimum wage is determined by the steepness of LD curve

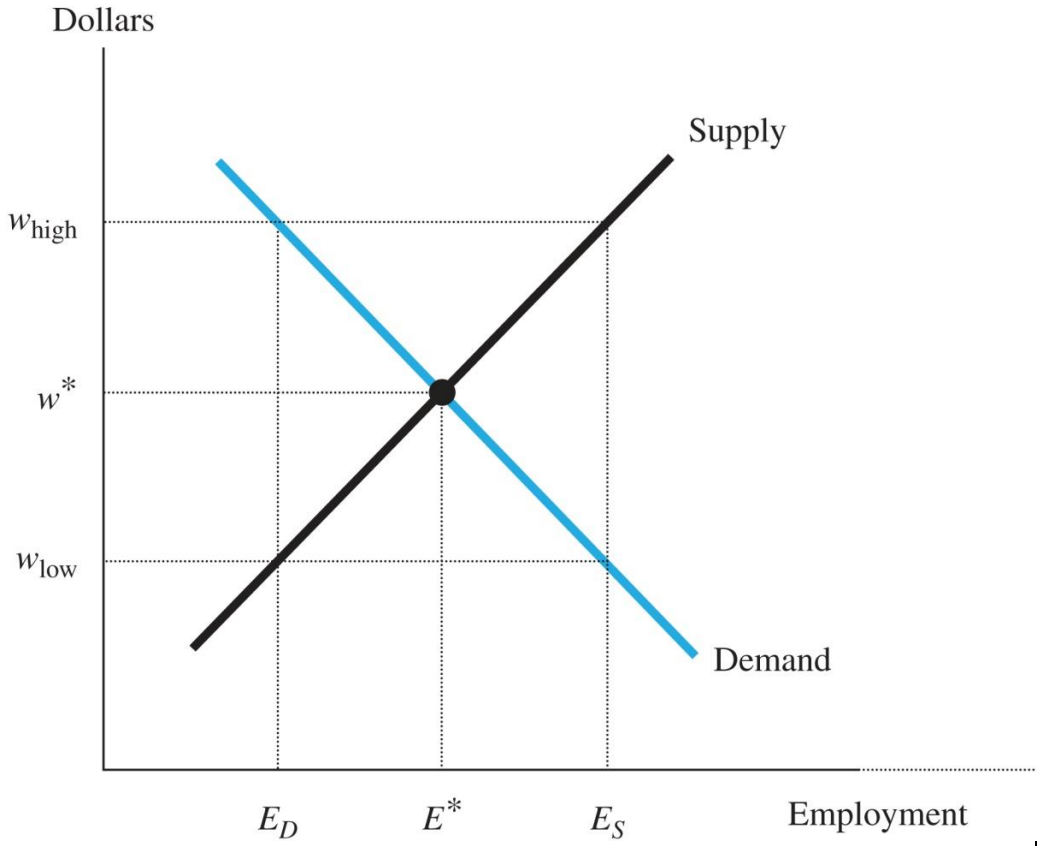
<u>Locally</u>, best guess of employment effect of min. wage increase is LDE x %ΔMinWage

Why locally? Perhaps LD is non-linear



Minimum wage and perfect comp.

- And to be clear…
  - The next chapter focuses on equilibrium, but we need more now
- The minimum wage keeps us from equilibrium
- The reduction in employment (E^*-E_D) is determined by LD
- The level of unemployment (E_S-E_D) is determined by LD and LS
- Workers who retain their job benefit
- Workers who lose their job lose
- Consumers lose (higher prices)



Evidence on the min. wage

Does the minimum wage reduce employment?

Most of the empirical literature focuses on teenage employment

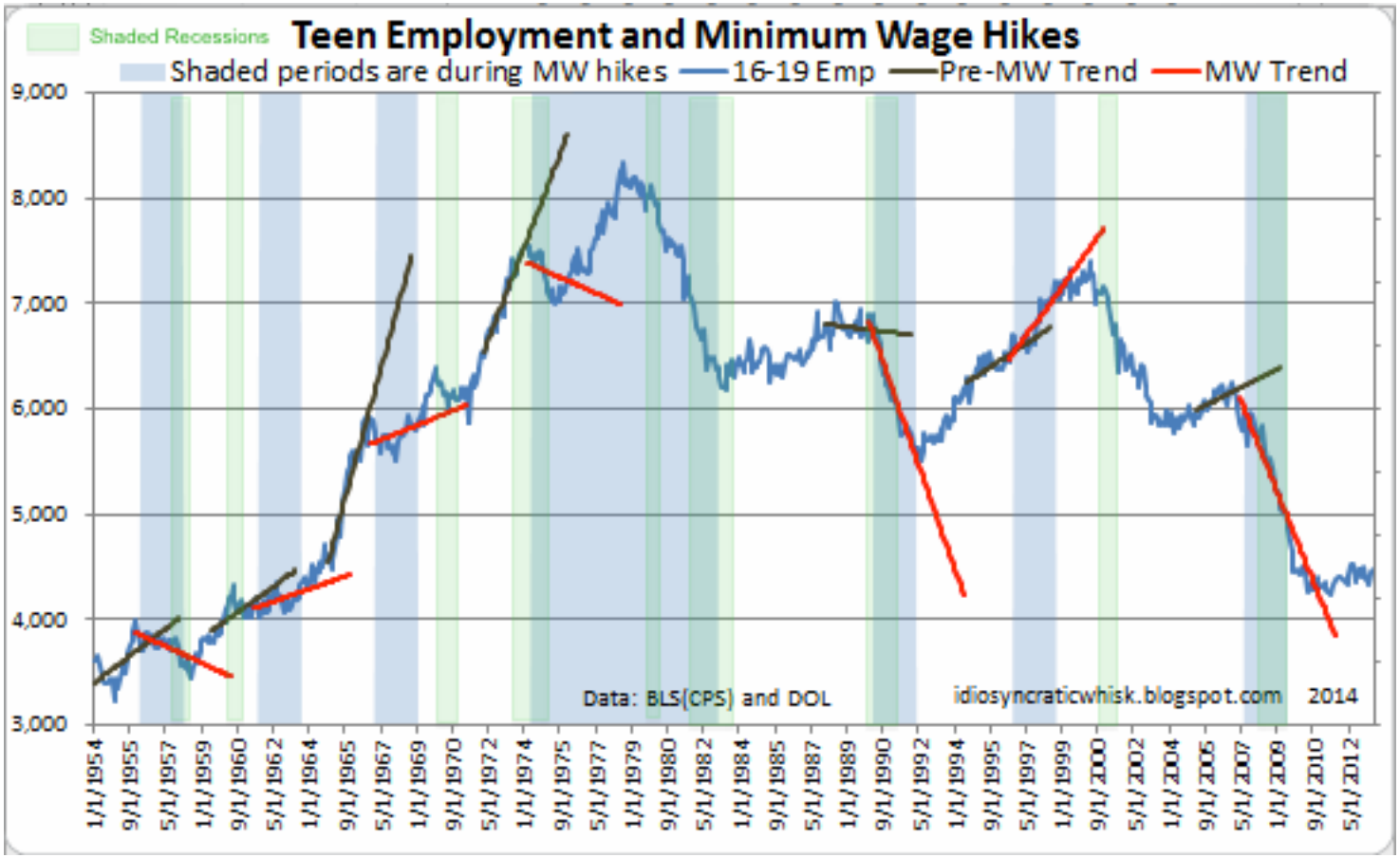
- The group most likely affected, so easier to find an effect…
- 2010: 25% of teenagers earned the minimum wage, but only 3.8% of workers over 25 did
- BUT: results might be incomplete. Do employers simply produce less, shift to technology, or shift to other types of workers? The latter effects in particular are important

Early studies

- Largely based on time series evidence—looking at changes in minimum wage on teenage employment over time
- Relevant LDE for teenagers was between -0.1 and -0.3
- Example: min. wage increased from $3.35 to $4.25 in 1991, or a 27% increase. If LDE is -0.15, then the reduction in teenage employment was 4%--or roughly 240,000 teenagers

Evidence on the min. wage

Dube: Casual versus Causal Inference: Time series edition



Evidence on the min. wage

1990s case studies

- Other case studies, such as in CA, found zero effects

Does this mean our model of perfect competition is wrong? Why did the studies differ?

- In some cases, further evidence (like using NJ/PA administrative data) gave us back estimates in the previous range of -0.1 to -0.3
- In other cases, it seems the case studies were using a shorter time period (LDE is more elastic in the long run) or focuses on existing/established stores (stores better able to pay more)
- Might fast food restaurants be different?

Where do we seem to be today?

- Although the reconciliation is not complete, it does appear we are back to -0.1 to -0.3
- Science works as it is supposed to—new ideas/differing results were further evaluated

Evidence on min. wage

It is an effective antipoverty tool?

- Employment losses are small relatively the wage gains (which would imply total earnings of the targeted group goes up)?
- Not so fast: Many minimum wage workers (say, teenagers living at home) are not in poverty

A Brown 1999 review article seems the most balanced to me

- "The effects of the minimum wage on employment are smaller than I would have supposed."
- "It is hard for me to see evidence that minimum wage increases have benefits which would overcome an economist's aversion to interfering with reasonably competitive markets. But the case against the minimum wage seems to me to rest more upon that aversion than on the demonstrated severity of any harm done to those directly affected."
- "The MW is overrated: by its critics as well as its supporters."

4. Employment demand issues the basic model overlooks…

Extensions…

Our simple model just looked at E—the number of employees a firm employees with all changes assumed to be instantaneous

- There may be different types of labor, skilled and unskilled
  - Might increases in the minimum wage cause a firm to adopt more skilled labor?
- There may be hiring costs
  - If it is expensive to interview and train, then you might not adjust downwards easily
- Can one 50-hour/week job be easily divided into two 25-hour/week jobs?
  - That would affect overtime/hiring decisions
- Might hours needs by a firm be highly variable?

It is possible to model some of these issues

Adjustment costs

The model acts as if a firm can instantly increase and decrease employment levels

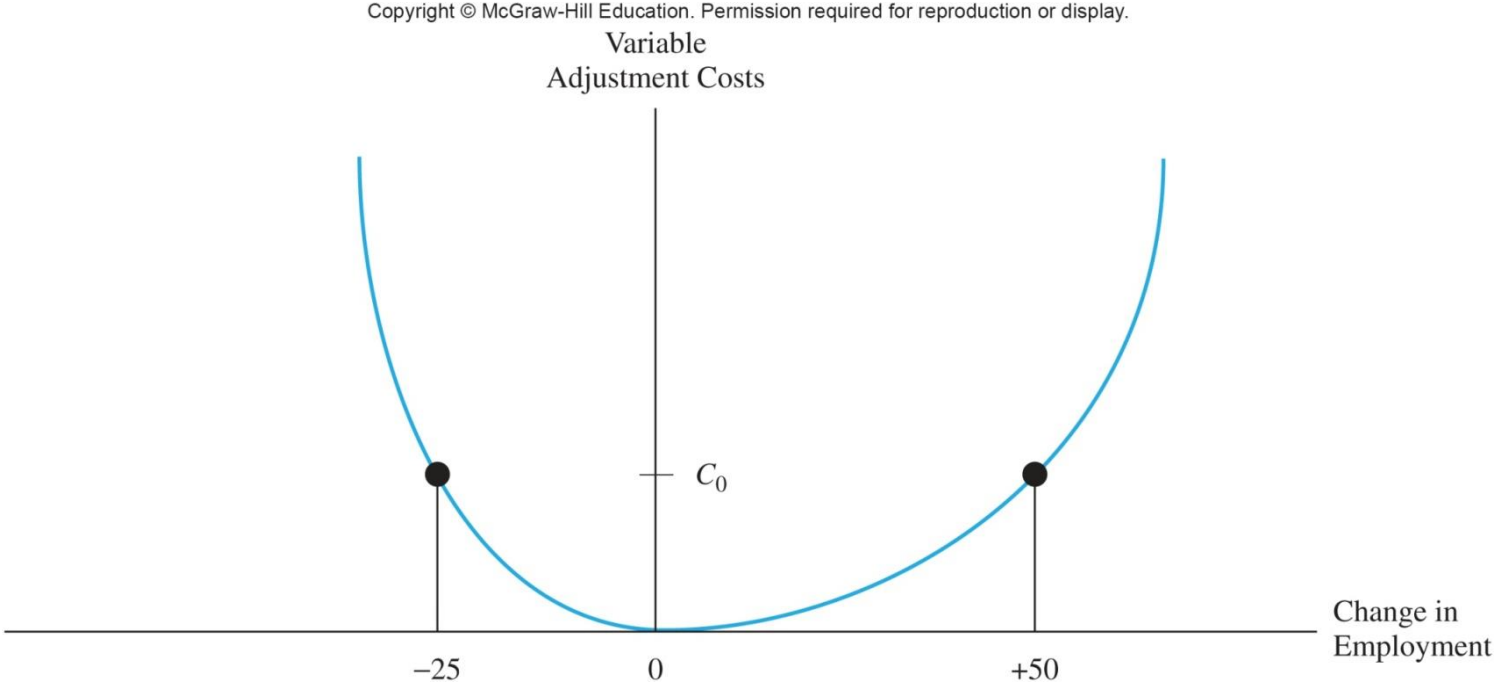
What if there are adjustment costs to varying E?

- It takes awhile to hire and train new workers
- Firing workers requires severance pay or reduces morale
- These adjustment costs need not be symmetric
- The adjustments costs could be variable
  - The costs varies by the number of people hired/fired
- The adjustment costs could be fixed
  - Some of the costs of running a personnel office might be fairly fixed compared to the number of hires/fires

Adjustment costs

How might this matter? Suppose adjustment costs looked like the graph below

- They are variable—they vary with employment change
- They asymmetric—firing is more costly than hiring
- They are increasing—the per-worker cost increases with the number of workers hired/fired



Adjustment costs

How would adjustment costs affect the employment decision?

Suppose LD changes, so that the firm would like to change employment levels

If there were fixed adjustment costs

- The firm would only adjust employment if the profit gains were greater than the fixed costs

If there were variable adjustment costs

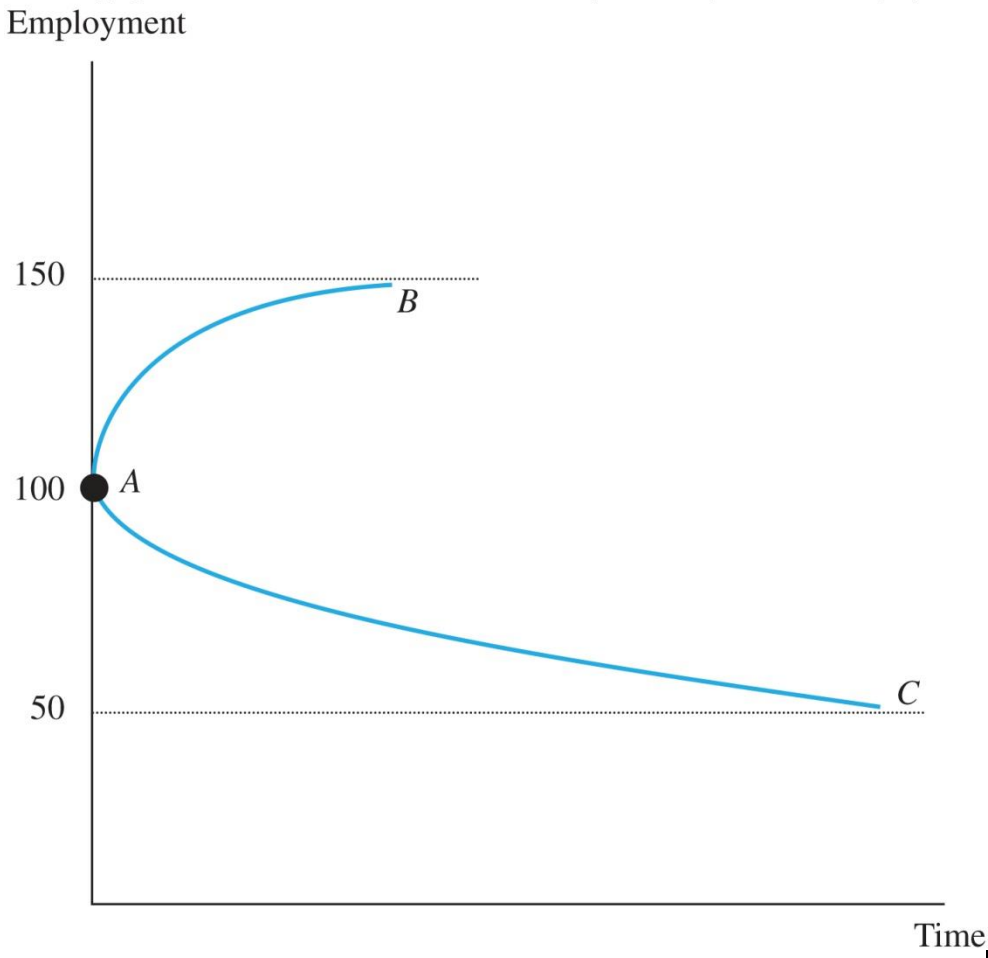
- The firm would undertake the adjustments slowly over time—balancing the additional profits with the adjustment costs
- What might that look like?

Adjustment costs

Consider the asymmetric variable costs from two slides ago

The firm would change E because small changes are inexpensive

A firm wanting to go from E=100 to E=150 would do so more quickly than a firm wanting to go from E=100 to E=50



Adjustment costs: the evidence

Both fixed and variable adjustment costs exist

Variable costs might account for as much as 5% of total wage bill (1980s study)

These costs suggest firms could take up to six months to adjust employment levels—implying firm's scale could be about 2% off of what it should be

Some industries, like auto, appear to face fixed adjustment costs more than variable adjustment costs

- Firms adjust labor suddenly in large quantities
- Why? Either the assembly line is working or not working?

Adjustment costs: policy

Many countries provide protections to workers that are hired/fired

- Unemployment insurance—which firms contribute to and can be "experienced rated"
- Severance pay / health insurance must be provided
- Litigation by dismissed workers
- These increase adjustments costs

How do these policies affect the employment relationship? Exactly as we just described

- Firms are less likely to hire/fire workers—less fluctuations
- Fired workers have more protections
- Employment levels are lower as firms are reluctant to hire workers (they cannot be fired easily)
- A movement towards temporary/contract workers

Bottom line: policies that change adjustment costs will have predictable, even if unintended, consequences

Workers vs. hours

Our model has treated these identical

They could be different for two reasons

- There could be fixed costs to hiring a worker: processing costs, training expenses, mandated benefits (health insurance), etc
- The production process might not be easily divisible: might a law case require highly specialized knowledge of facts?

The effect of fixed costs are obvious

- The higher the fixed costs, the more the employer would like to higher fewer workers, but have each work more hours

And the evidence follows suit

- Mandated benefits for fulltime workers can cause firms to shift to part-time workers
- Increased overtime provisions can cause firms to hire more workers