TOPIC 2

The Supply Side of the Economy

Goals of Topic 2

Introduce the Supply Side of the Macro Economy:

1. Production Function

2. Labor Market:

   – Labor Demand

   – Labor Supply

   – Equilibrium Wages and Employment

Production Function

The Production Function

- GDP (Y) is produced with capital (**K**) and labor (**N**):

$$\mathbf{Y = A\ F(K,N)}$$

where ***A*** is Total Factor Productivity (TFP)
= an index of efficiency in the use of inputs (technology)

- Sometimes, I will modify the production function as follows:

$$\mathbf{Y = A\ F(K,N,\ other\ inputs)}$$

where other inputs include energy/oil!

- Realistic Example is a Cobb Douglas function for F(.):

$$\mathbf{Y = A\ K^{\alpha}\ N^{1-\alpha}}$$

with $0< \alpha <1$

Measurement

- **Y is GDP** (it is measured in dollars). As noted above, we want to measure Y in "real" terms.<<you should know what this means from lecture 2>>.

- For our Cobb Douglas production function, N is measured in number of workers and K in dollars:

  - **K often is measured as the replacement cost of capital**
  - **N often is measured in number of workers**

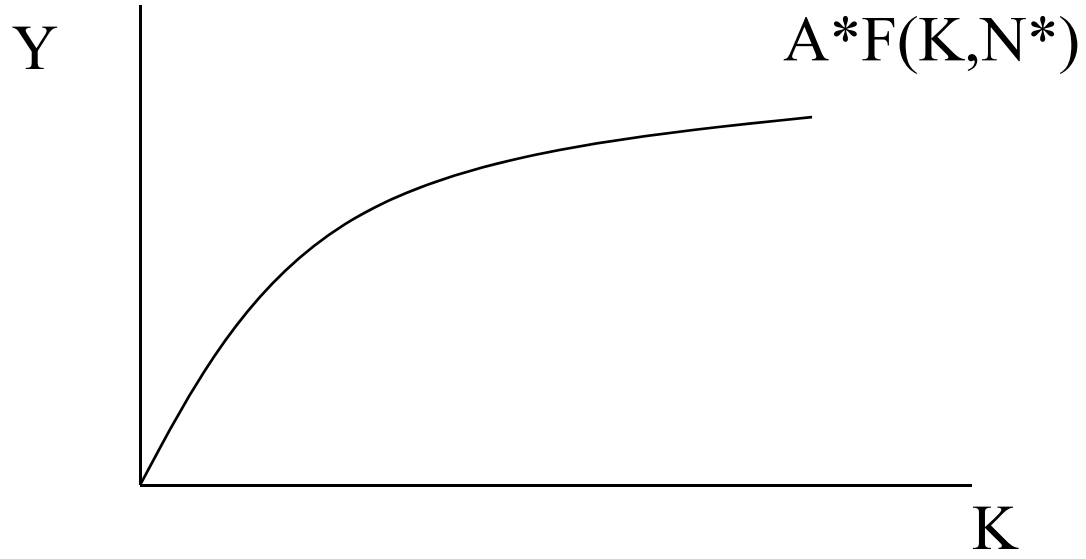
- N can also be measured using
  total hours worked = number of workers × hours per worker

- Wage differentials can help to measure "effective labor supply", taking into account "skill" differentials.

N.B.: sometimes we will use N to denote total population (e.g. income per capitaY/N)

Graphical Representation 1

- Hold A and N constant (at levels A* and N*)
- Graph Y as a function of K

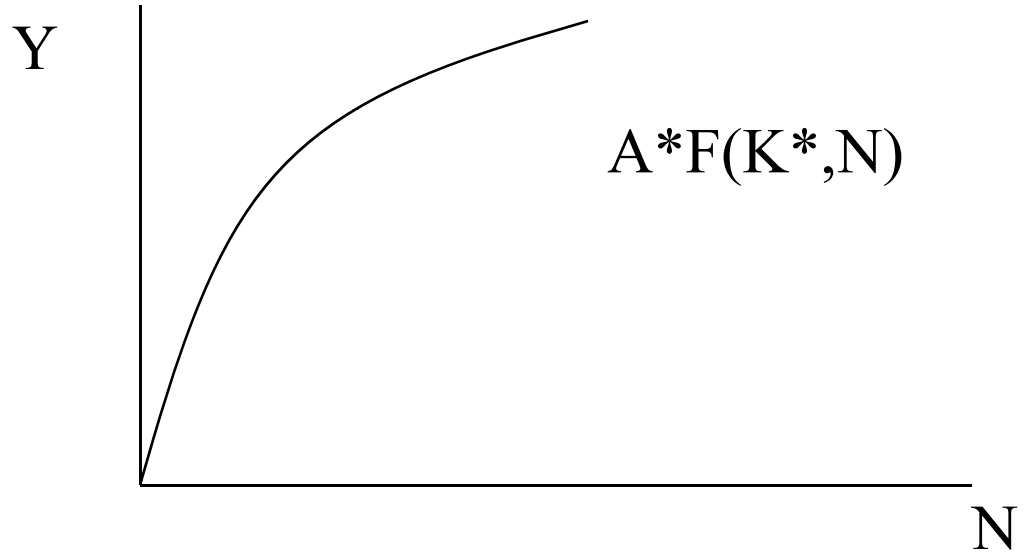


1. As K increases Y increases (the curve is upward-sloping)

2. As K increases the marginal increase in production decreases (the curve becomes flatter as K increases)

Graphical Representation 2

- Hold A and K constant (at levels A* and K*)
- Graph Y as a function of N



1. As N increases Y increases (the curve is upward-sloping)

2. As N increases the marginal increase in production decreases (the curve becomes flatter as N increases)

Aggregate Production Function: Fact 1

1. Constant Returns to Scale

FACT 1: If you double the inputs, you double the output!

$$2Y = AF(2K,2N)$$

Cobb-Douglas:

$$\mathbf{2Y = A\,(2K)^{\alpha}\,(2N)^{1-\alpha} = 2A\,K^{\alpha}\,N^{1-\alpha}}$$

CRUCIAL: $\alpha + (1-\alpha) = 1$!

Aggregate Production Function: Fact 2

2. Diminishing Returns to N and K

Define **MPN** = Marginal Product of Labor = dY/dN
Define **MPK** = Marginal Product of Capital = dY/dK

FACT 2: MPN decreases with N and MPK decreases with K

Cobb-Douglas:

- $MPN = (1- \alpha) A (K/N)^{\alpha}$

  Fixing A and K, MPN falls when N increases

- $MPK = \alpha A (N/K)^{(1- \alpha)}$

  Fixing A and N, MPK falls when K increases

Aggregate Production Function: Fact 3

3. Complementarities between A, K and N

FACT 3: The higher the level of capital (or technology), the higher the marginal product of labor (and symmetrically for capital!)

Cobb-Douglas:

- $MPN = (1- \alpha)\, A\, (K/N)^{\alpha}$

  Increasing A or K, increases MPN

- $MPK = \alpha\, A\, (N/K)^{(1- \alpha)}$

  Increasing A or N, increases MPK

Aggregate Production Function: Fact 4

4. Elasticities and Income Shares

- Elasticity is the percentage increase in Y (dependent variable) resulting from a 1% increase in X (independent variable), everything else constant

η_N = % change in Y / % change in N = (dY/Y)/ (dN/N) = MPN / (Y/N)

FACT 4: Labor Elasticity ~ .7
Capital Elasticity ~ .3

Cobb-Douglas:

$$\eta_N = (1-\alpha) \quad \text{and} \quad \eta_K = \alpha$$

That's why we pick α = .3 !!

- Share of labor income out of total GDP is about 70%
  Share of capital income out of total GDP is about 30%

Two Notions of Productivity

- **Labor Productivity** = $Y/N = A\,(K/N)^{.3}$

  Driven by A and K/N

- **Total Factor Productivity (TFP)** = $Y/F(K,N) = A$
  Basically TFP is a 'catch-all' for anything that effects output other than K and N.

  - Workweek of labor and capital
  - Quality of labor and capital
  - Regulation
  - Infrastructure
  - Specialization
  - R&D, Innovation
  - Strategy (Entrepreneurial methods/new management techniques)

- Some of the above tend to make TFP procyclical (capital utilization)
  (Definition of Procyclical: Variable increases when Y is high, decreases when Y is low)

Simple examples (in words)

1. Technology : “It costs FedEx $2.40 to track a package for a customer who calls by phone, but only $0.04 for one who visits its website”, says Rob Carter (2003), the firm's technology boss.

2. Technology (2005): “Airline kiosks reduce costs of boarding to less than a third.”

3. Management: Southwest’s oil hedging. Estimated oil price paid by SW: $31. United: $56.

4. Infrastructure: Imagine what it takes to buy intermediate inputs from a different region with roads like in Nigeria.

Measure of Labor productivity

Productivity levels

United States = 100

Country	GDP per capita		Labour productivity			
			Per person employed		Per hour worked	
	1995	**2003**	**1995**	**2003**	**1995**	**2003**
United States	100	100	100	100	100	100
Euro area	72	70	84	77	95	89
Germany	77	70	81	73	97	90
France	75	74	83	88	108	107
Italy	75	70	93	80	104	88
Spain	57	62	78	73	83	75
Netherlands	78	78	80	73	107	98
Belgium	78	76	98	92	111	106
Austria	84	79	81	74	98	87
Greece	47	52	64	70	61	64
Portugal	47	49	47	49	47	51
Finland	69	72	81	76	87	80
Ireland	64	87	86	92	86	99
Japan	81	74	82	69	71	69
United kingdom	72	77	76	79	81	83
Canada	80	87	89	86	92	86
Sweden	77	75	70	71	80	86
Denmark	81	80	76	75	92	89
Norway	86	96	84	92	110	123
Iceland	81	76	83	74	84	73

The Labor Market

Part I: Labor Demand

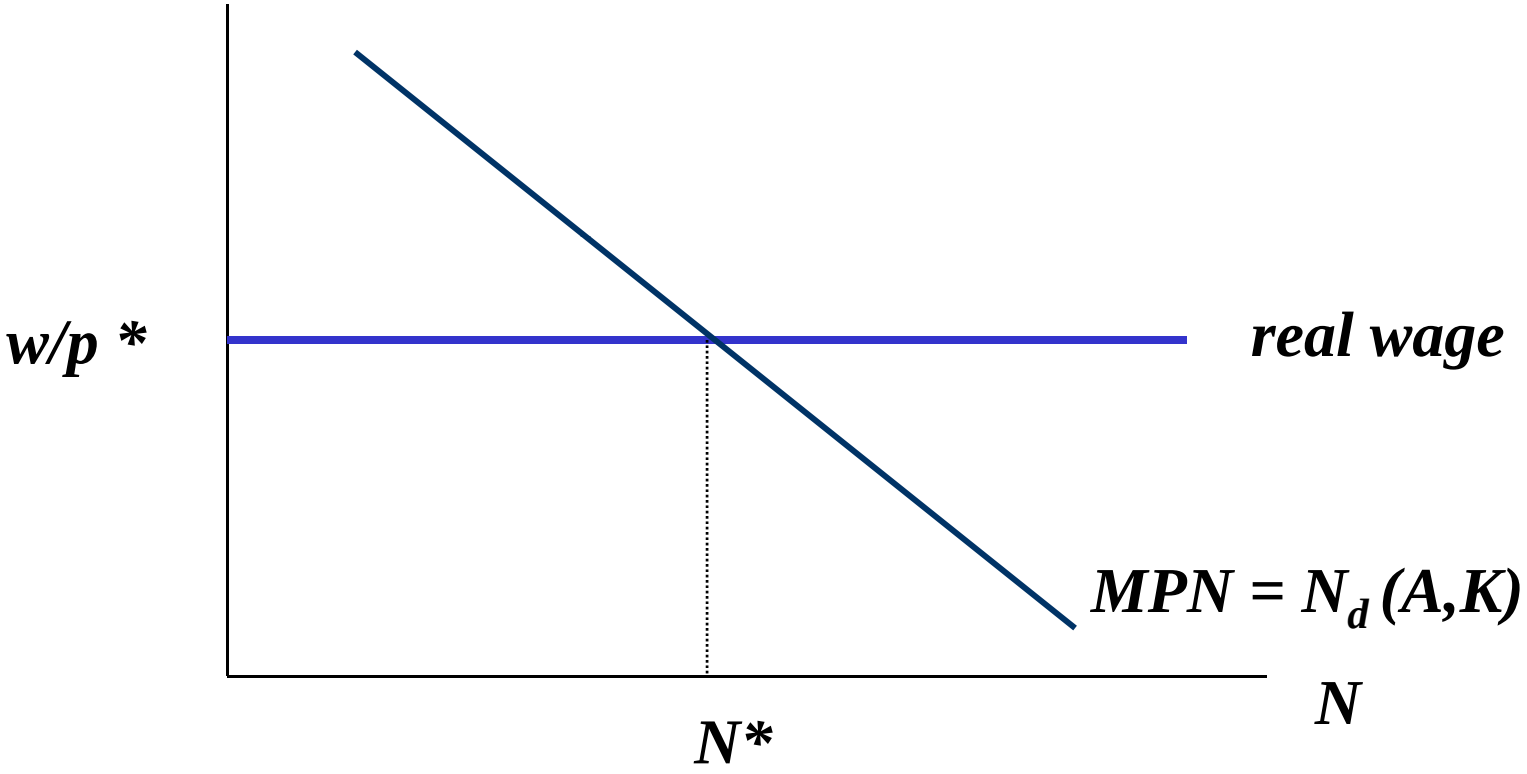
- In a competitive market, a firm can sell as much Y as it wants at the going price p, and can hire as much N as it wants at the going wage w.

- Facing w and p, a **profit maximizing firm** hires N to the point where MPN = w/p (the benefit from an additional worker, in terms of additional output, must equal the cost of hiring him). <<*This is straight from micro*>>

  Why? MPN is decreasing in N, hence:
  - If MPN > w/p then the firm can increase profits by increasing N.
  - If MPN < w/p then the firm can increase profits by decreasing N.

- With Cobb-Douglas: $MPN = .7\ Y/N = .7\ A\ (K/N)^{-.3}$
- If firms maximize profits: $w/p = .7\ Y/N = .7\ A\ (K/N)^{-.3}$

The Labor Demand Curve



Notes on the Labor Demand Curve

- For the moment keep A and K constant.
- N_d slopes downward : $N_d = MPN = .7\ A * (K/N)^{.3}$
- N_d shifts up with A and K (complementarity)
- Caveat: Who says that there is a demand for more Y?
  - Need to look at the demand side of economy (next lectures).

Part II: Labor Supply

- Labor Supply (N_s) Results from **Individual Optimization Decisions**
- Households compare benefits of working (additional lifetime resources) with cost of working (forgone leisure + effort)
- How much labor an household will choose to supply as the real wage (before taxes) w/p varies?
- 2 effects:

1. **Substitution effect:** higher real wage means higher reward to working, hence you want to work more!
2. **Income effect:** higher real wage means you are richer, hence you need to work less to consume the same goods!

Refresh your memory from Micro!

- Think of an agent who gets utility from consuming apples and bananas
- From the utility maximization problem you get

$$MU(apples)/ MU(bananas) = P(apples)/P(bananas)$$

- If P(apples) increases:

1. **Substitution effect:** you want to increase MU(apples)/ MU(bananas). By the law of diminishing marginal utility you need to consume less apples and more bananas! You subsitute away from apples towards bananas

2. **Income effect:** you spend more for the apples that you buy, so you are poorer. You will consume less apples AND bananas!

From Micro to Macro…

- The two goods that the household can consume are now consumption (C) and leisure (L)
- The household can spend 1 unit of time either working (N) or having fun (L), that is **N + L = 1**
- The **budget constraint** is WN = PC (and P(C)=P for simplicity) with N=1-L. Then we can write a static version of the maximization problem as:

$$\text{Max } U(C,L)$$
$$\text{s.t. } W = PC + WL$$

- The **price of leisure is the foregone wages**, that is P(L) = W. Then

$$MU(L)/\ MU(C) = W/\ P$$

- If W/P increases:

1. **Substitution effect:** you want to increase MU(L)/ MU(C). By the law of diminishing marginal utility you need to subsitute away from leisure towards consumption goods. Then you need to work more!
2. **Income effect:** you have higher wages, so you are richer. You will consume more C and L. To consume more L you need to work less!

Back to the Labor Supply

- In reality the household problem is not static. Define PVLR = present value of life time resources, that determines the household income.

- For simplicity to graph the Labor Supply we **separate income and substitution** effects by separating PVLR from the current real wage w/p.

- PVLR represents the income effect and w/p the substitution effect.

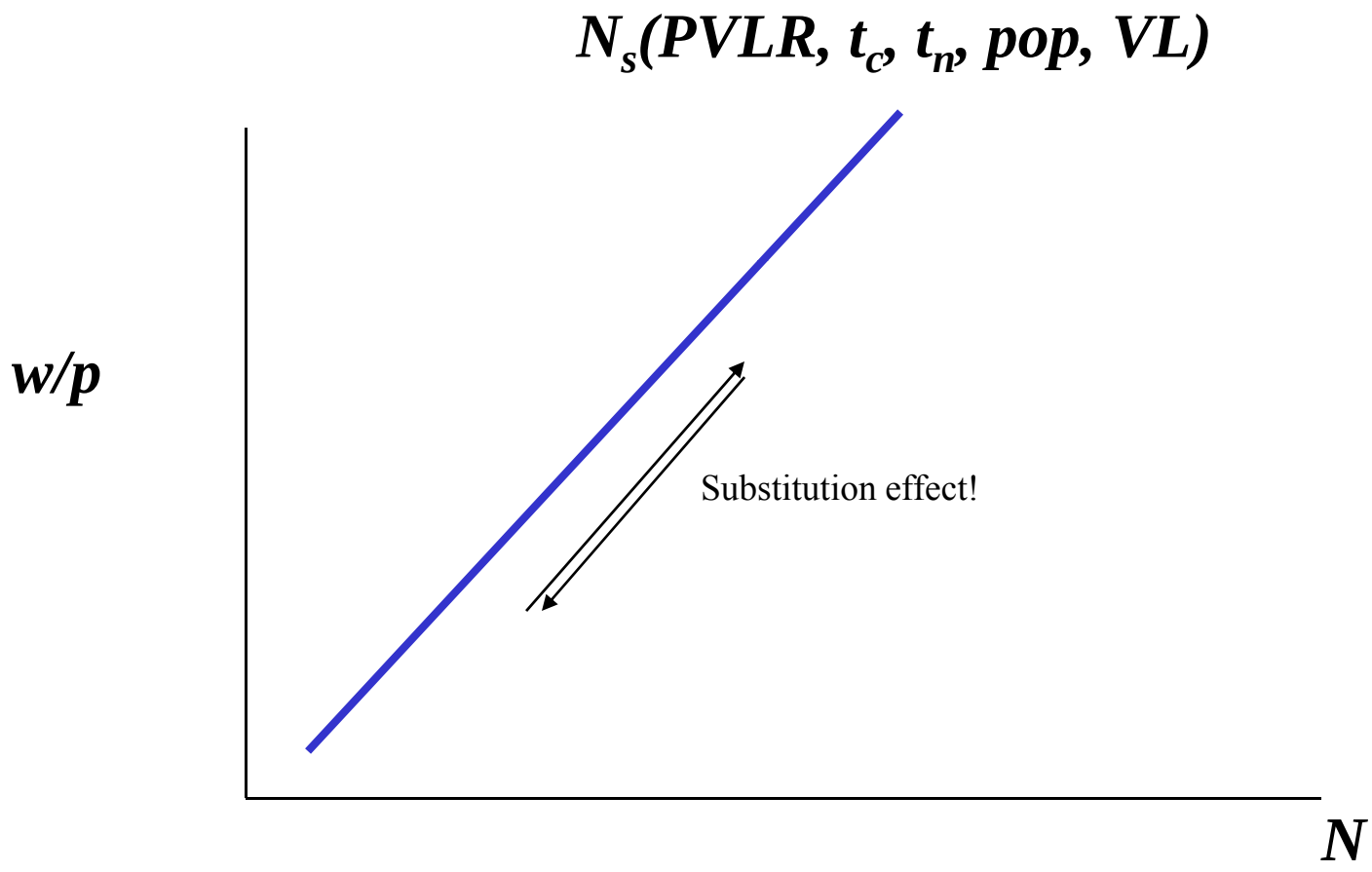
- **SHORTCUT:** if w/p increases **permanently** PVLR increases as well, BUT if w/p increases **temporarily** only, then PVLR increases just a tiny bit so that we assume that **PVLR does not change**!

The Labor Supply Curve

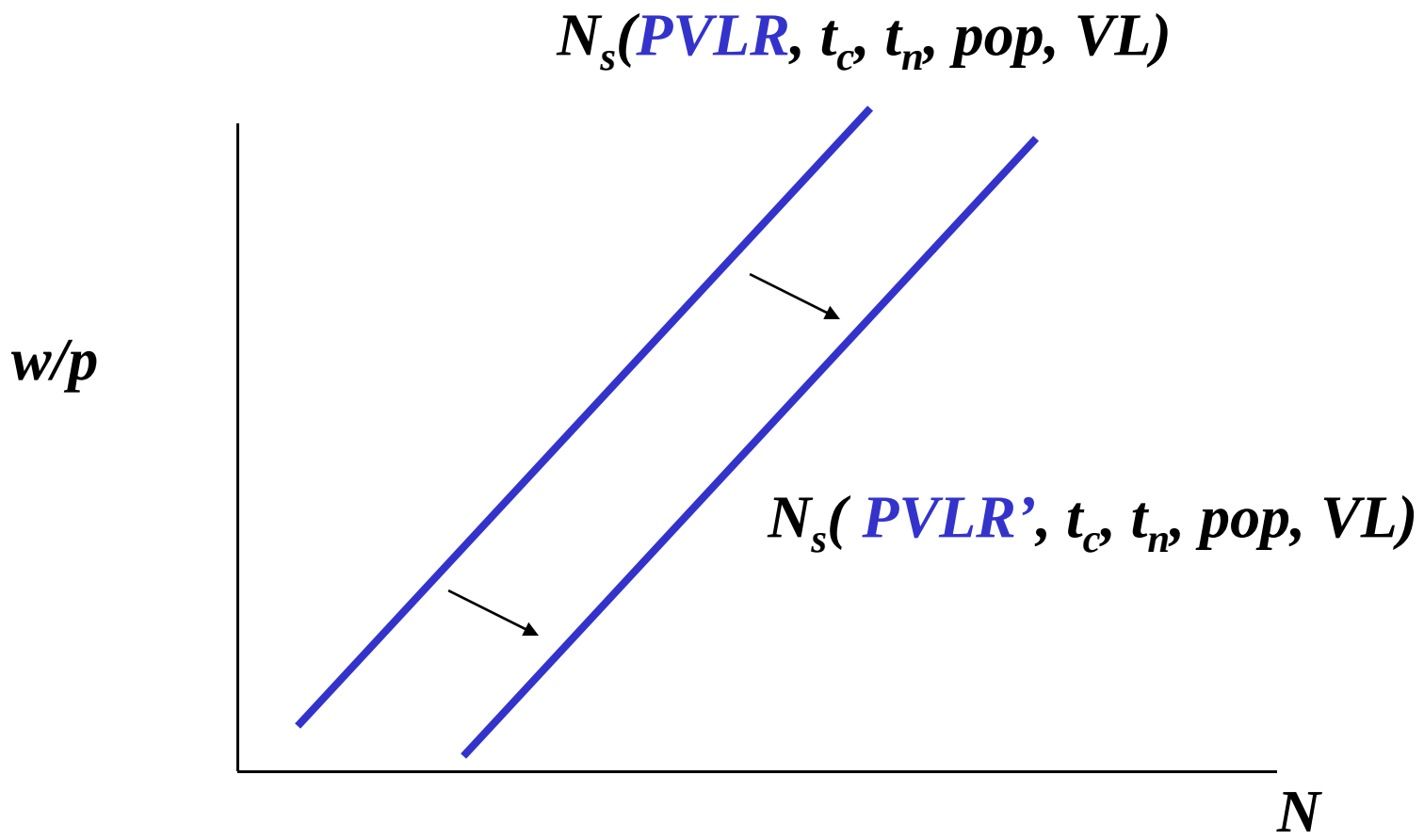
- Factors Affecting Labor Supply
  - The Real Wage (**w/p**)
  - The Household's Present Value of Lifetime Resources (**PVLR**)
  - The Marginal Tax Rate on Labor Income (**t_n**)
  - The Marginal Tax Rate on Consumption (**t_c**)
  - Value of Leisure (reservation wage) - non-'work' status (**VL**)
  - The Working Age Population (**pop**)

- Labor Supply (N_s) shows the relationship between real wages and hours worked holding everything else constant (included PVLR!)

The Labor Supply Curve: Substitution Effect



The Labor Supply Curve: Income effect



PVLR → PVLR'(< PVLR) = income effect!

What affect the Labor Supply?

- The **Real Wage** - HOLDING PVLR fixed: A higher w/p encourages individuals to substitute away from leisure toward work (leisure becomes more expensive). This is a substitution effect. <<**This is why the labor supply curve slopes upwards**>>

- Estimating this substitution effect is difficult since PVLR is not easily held constant. Estimates range from 0 - 2 (For a 1% increase in after-tax w/p holding PVLR fixed, labor supply either increases between 0% and 2%). Very Wide Range – little consensus.

- PVLR = initial wealth + present discounted value of earnings

- A higher **PVLR** induces individuals to work less (lower N_s) for a given after-tax wage, allowing them to enjoy more leisure (If leisure is preferred to work – as I get richer, I can afford to work less). <<**This is represented by a shift of the supply curve** >>

- PVLR is net of taxes and non-work governmental transfers and inclusive of all other transfers.

What affect the Labor Supply? (continued)

- **Marginal tax rate on labor income** - Should have same substitution effect as the before tax real wage. Studies of the 1986 U.S. Tax Reform found that only high-earning married women worked more in response to lower marginal income tax rates.

- **Marginal tax rate on consumption** - see above

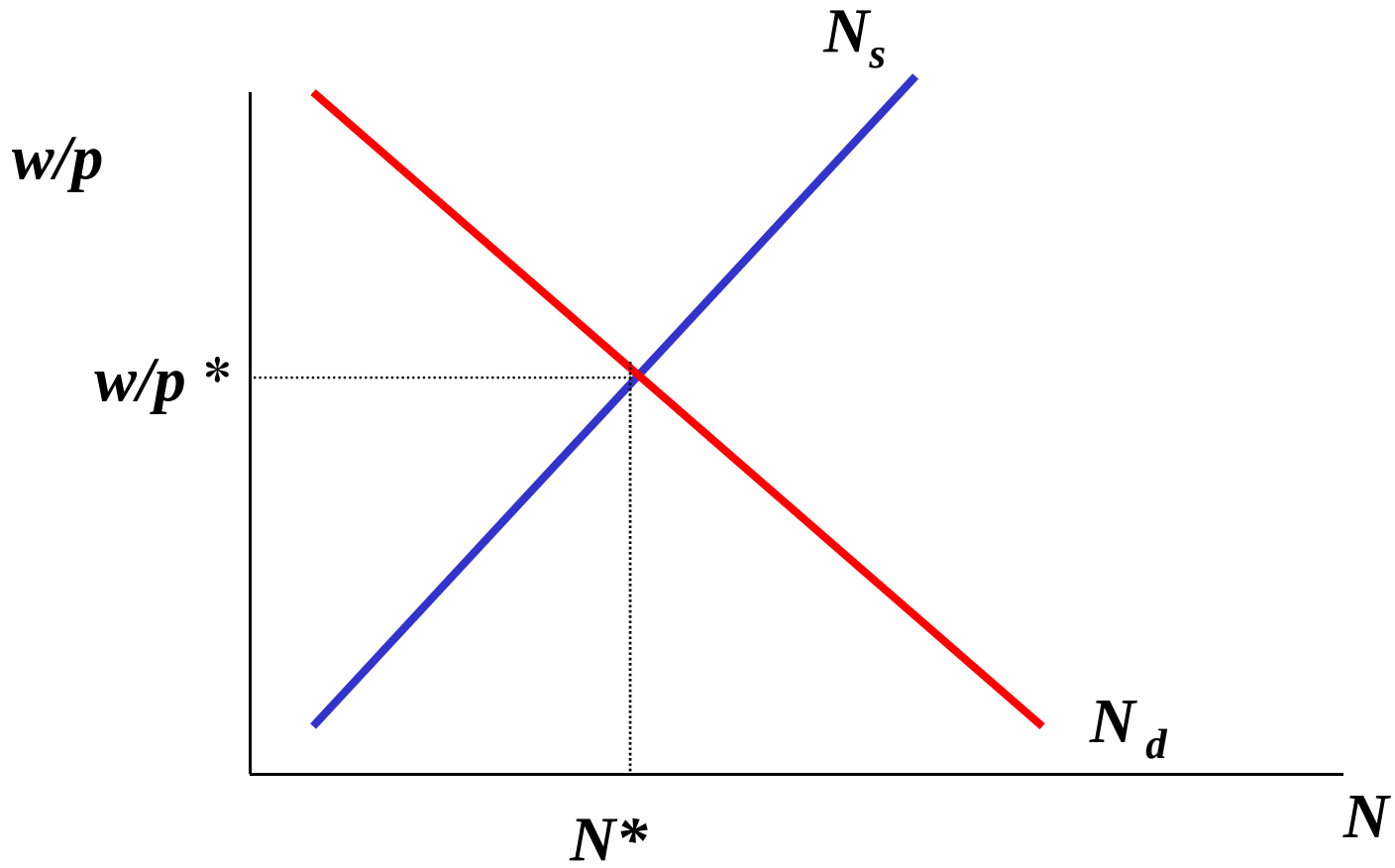
- **Value of Leisure** - If leisure/no-work becomes more/less attractive, households will work less/more (think about welfare programs, child care,…)

- **Working Age Population**: Usually defined as 16-64 (includes changes in Labor Force Participation Rates)

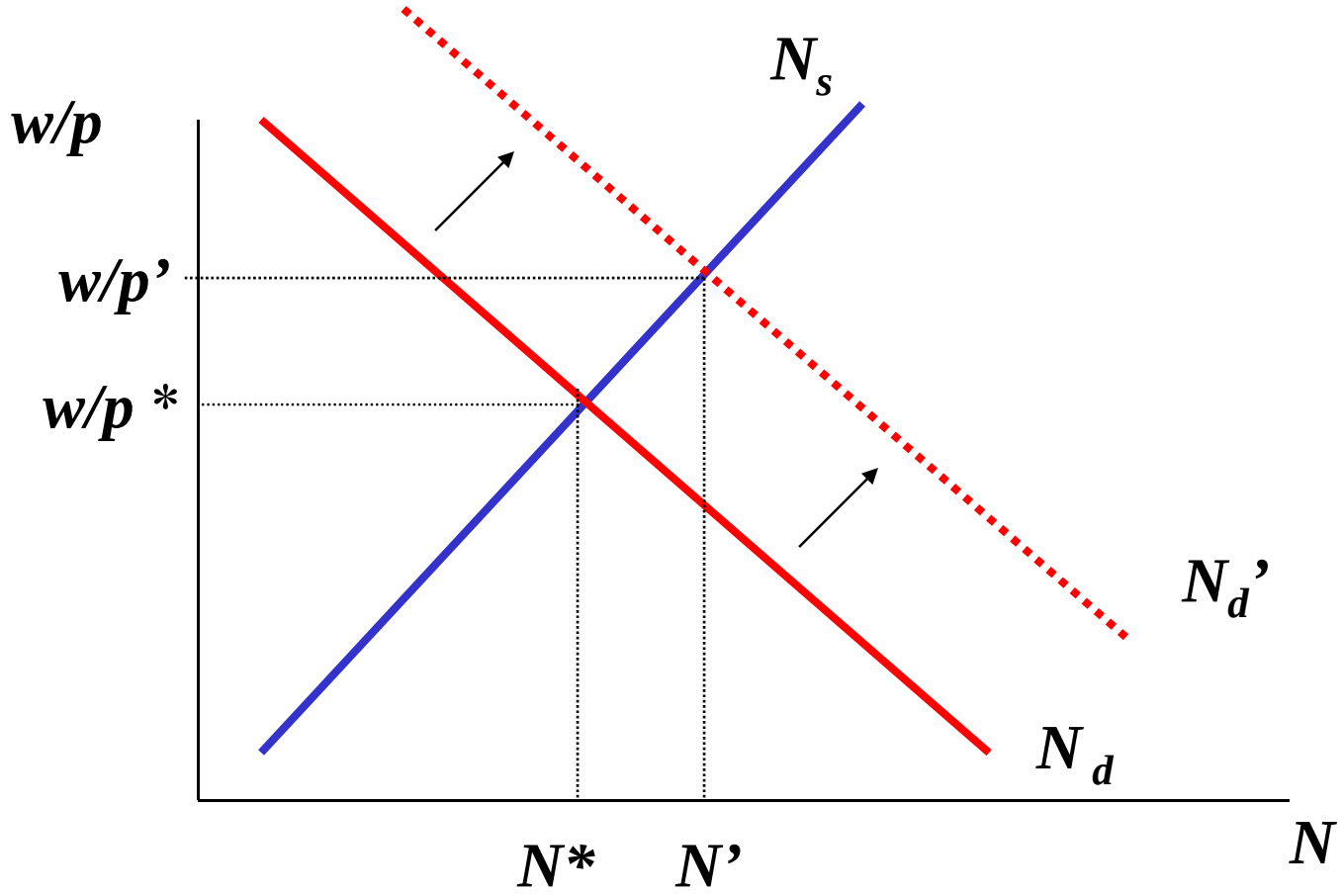
Recap on Labor Supply

- Substitution Effect:
  - For a given PVLR, a higher after tax wage increases N_S.
    - This is why Labor Supply Curve Slopes Upward
- Income Effect
  - For a given after-tax wage, higher PVLR decreases N_s.
- Evidence:
  - Weak Consensus is that, with equal (%) increase in PVLR and after-tax wage, N_s falls (income effect dominates).

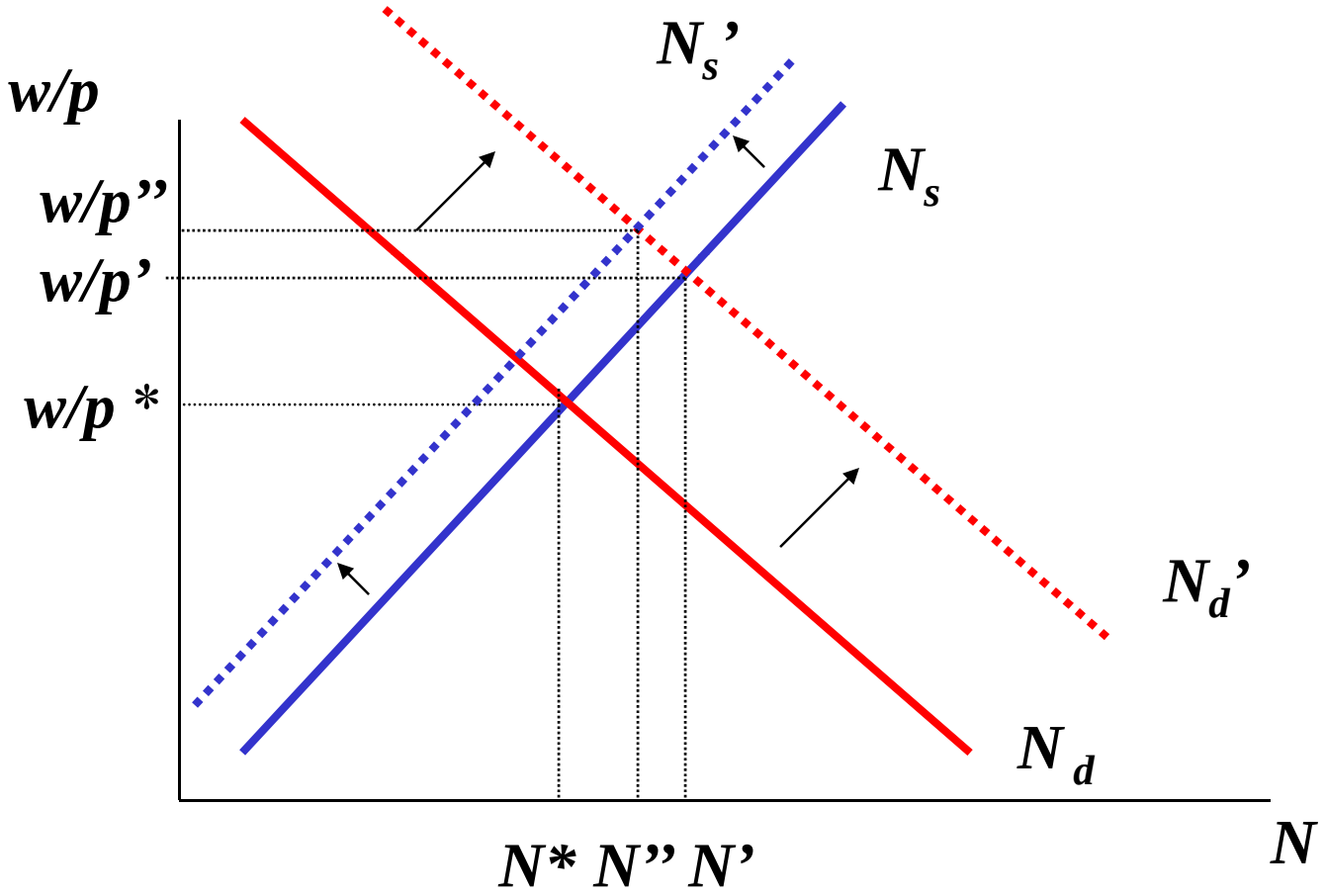
Part III: Labor Market Equilibrium



Temporary Increase in A



Permanent Increase in A



N* < N'' → **Here income effect is dominated!**

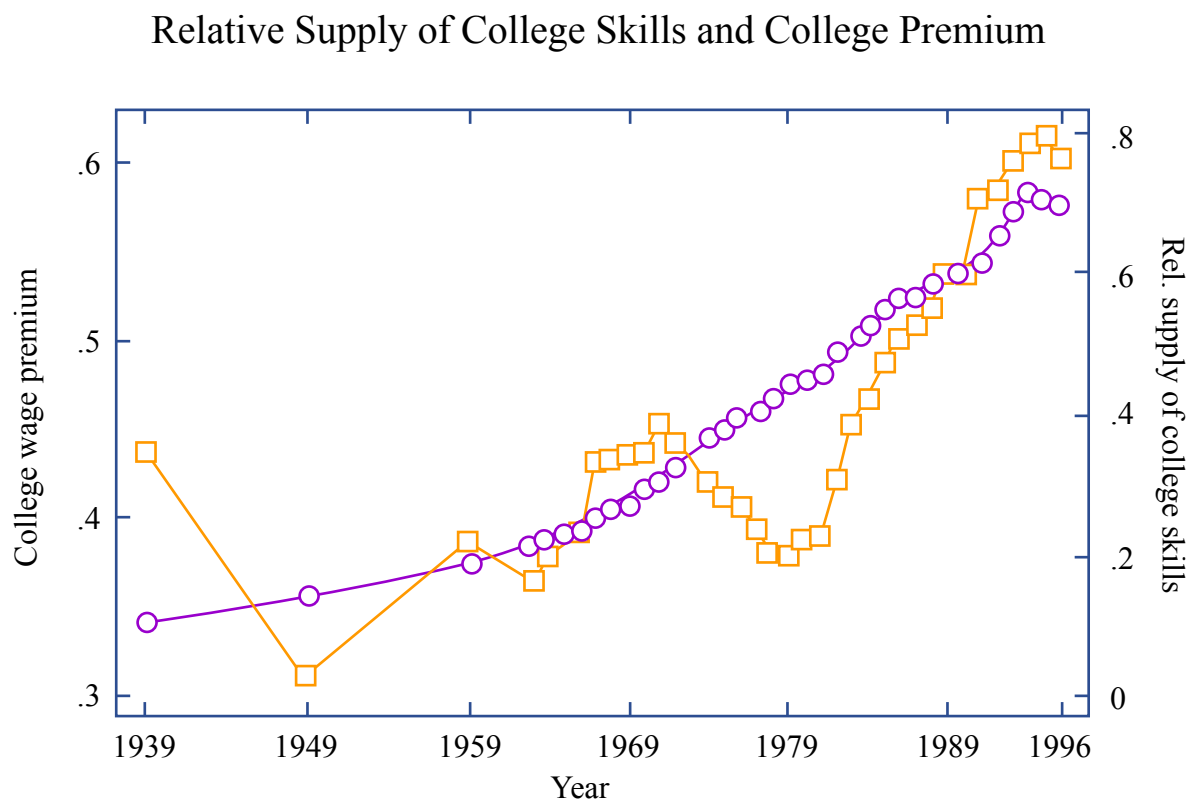
Can Technological Progress destroy jobs?

Facts: A, N, w/p are trending up over time.
N/pop is trending down (except in U.S. since 1980).
Higher A countries have higher w/p and lower N/pop.

Implications:

Adjusting for pop, higher A goes with lower N.
Higher A reduces N_d and destroys jobs? - NO! Labor Demand Increases.
Higher A increases PVLR and reduces N_s. It is Labor Supply that falls.

What happened to US Wage inequality?



The behavior of the (log) college premium and relative supply of college skills (weeks worked by college equivalents divided by weeks worked of noncollege equivalents) in the U.S. between 1939 and 1996.

Differential shift of A on different skill markets

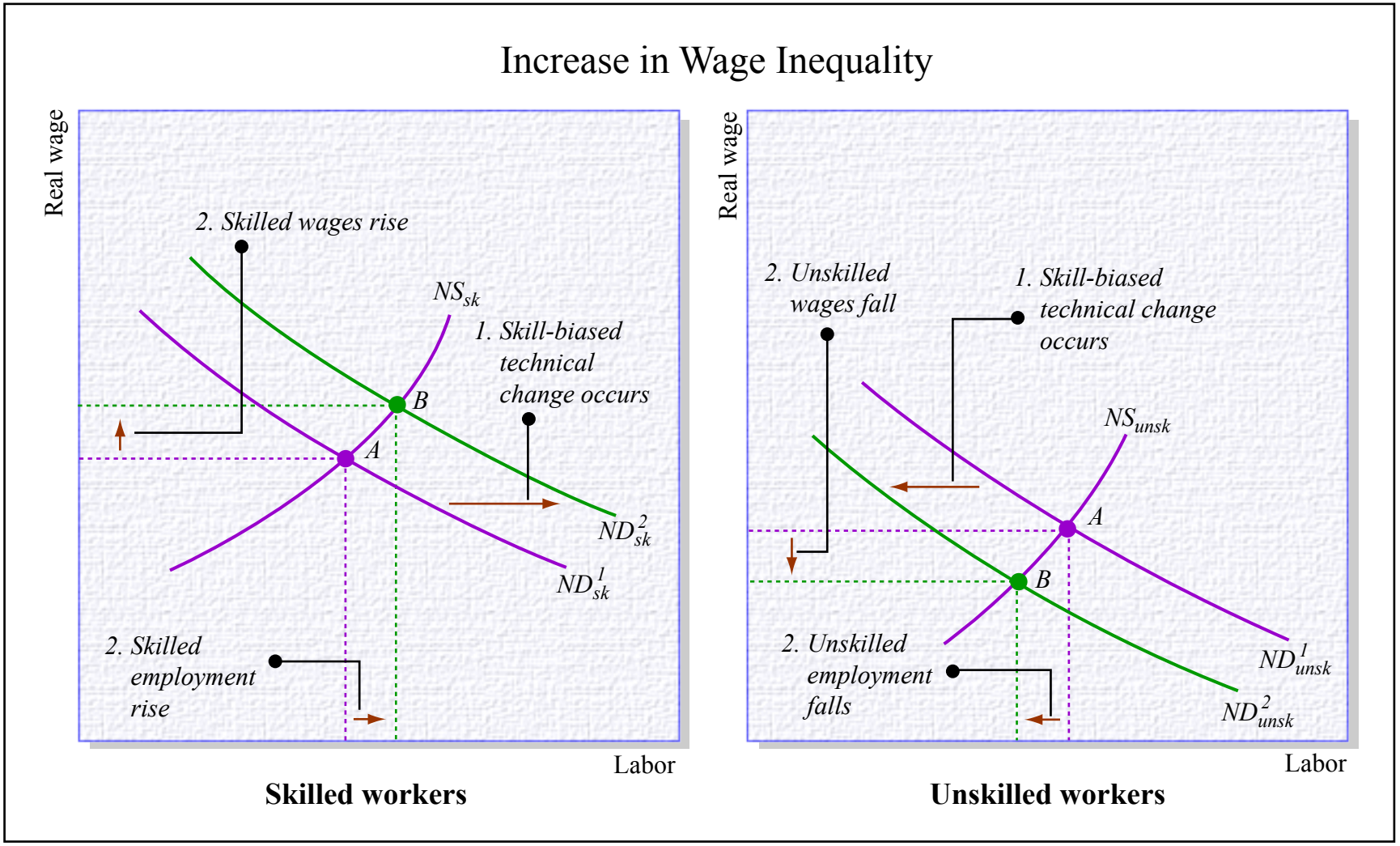
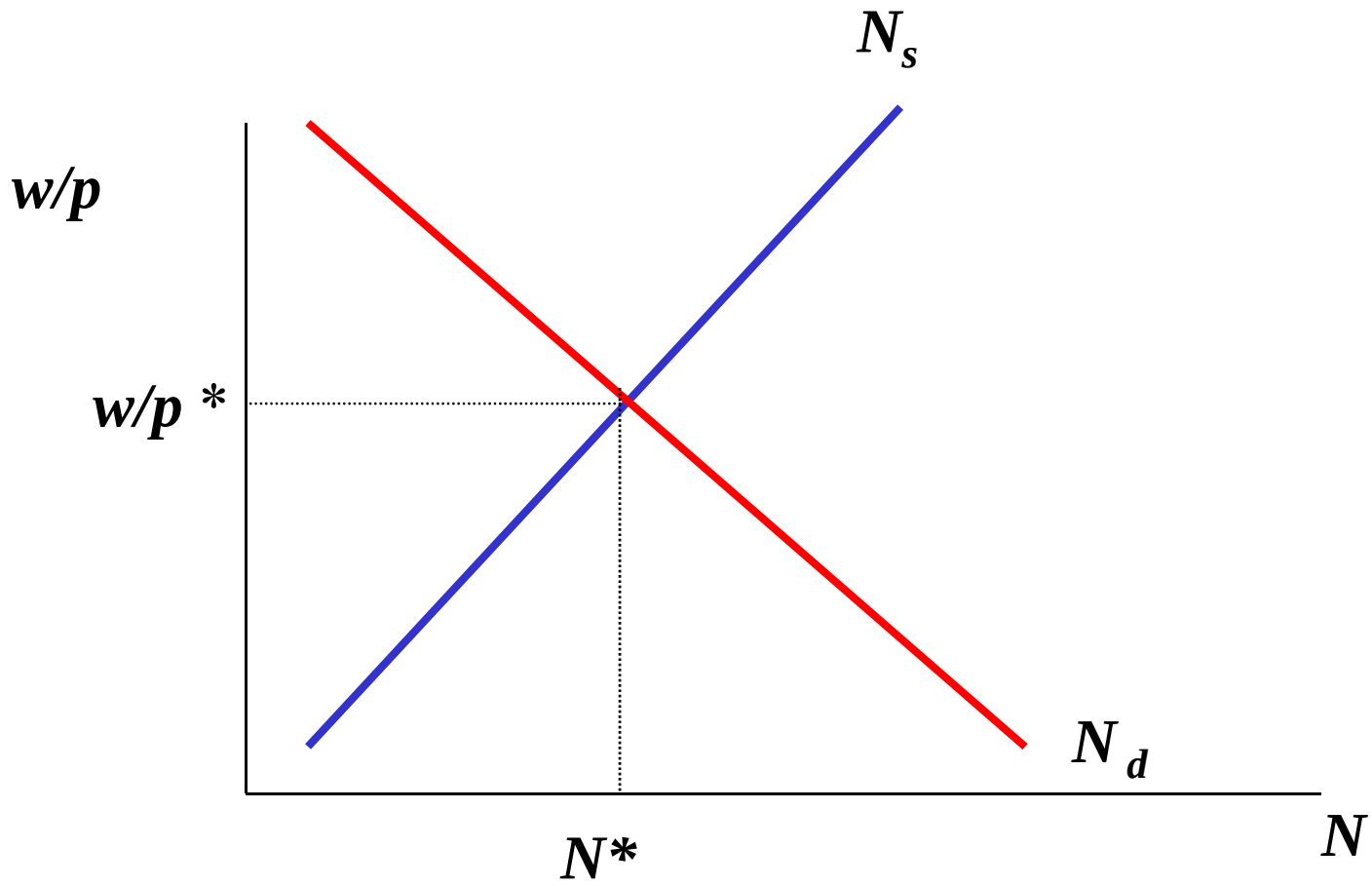
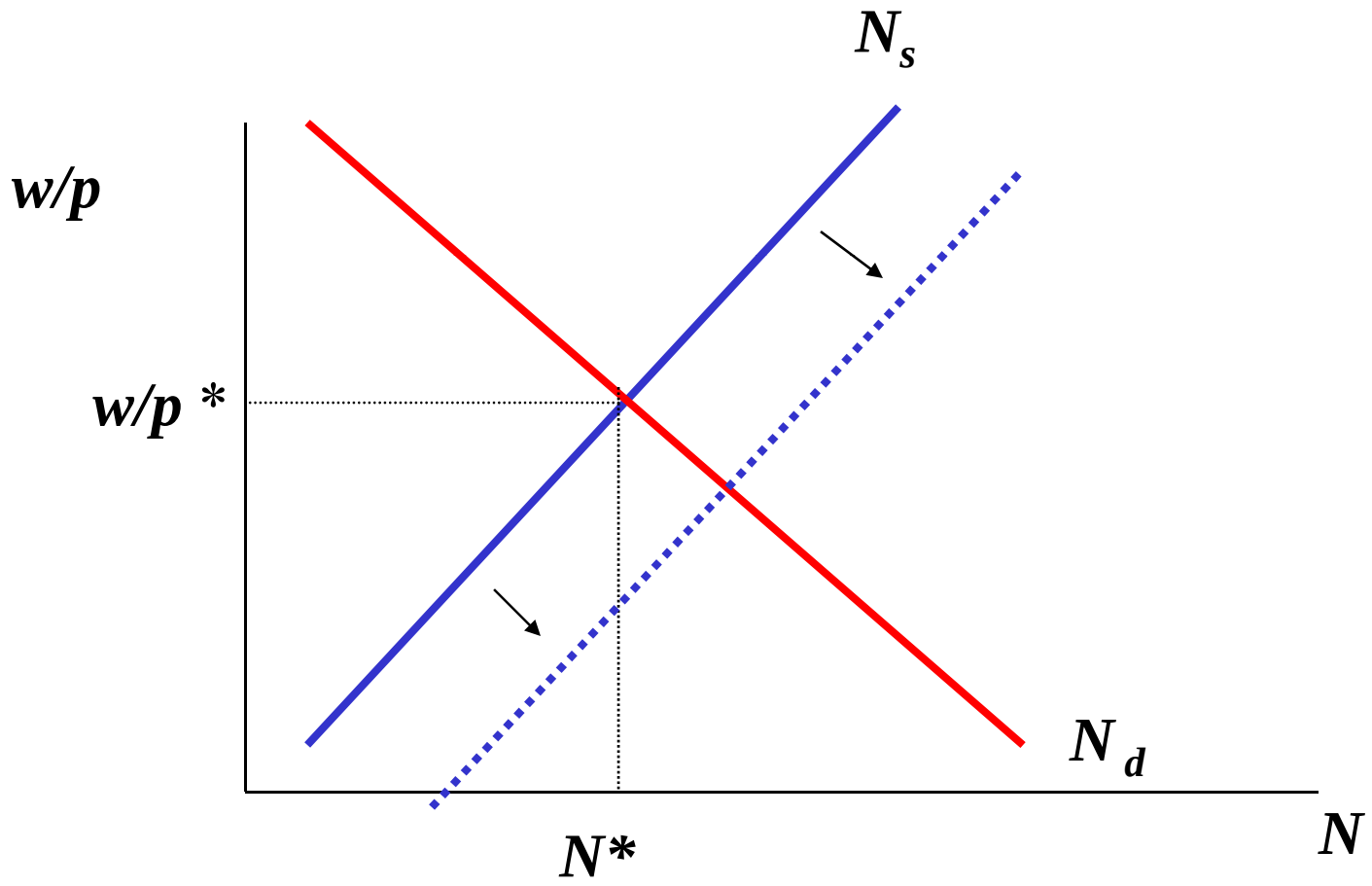


Figure by MIT OpenCourseWare.

Permanent Increase in pop ...

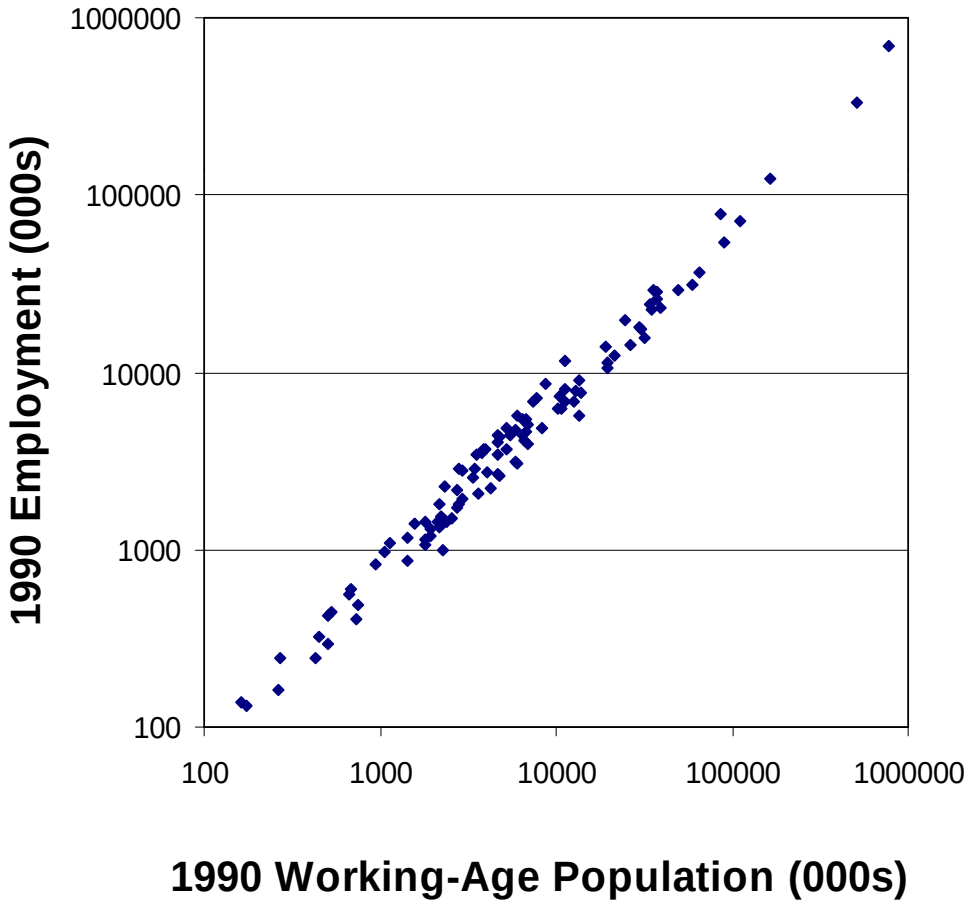


Permanent Increase in pop ...

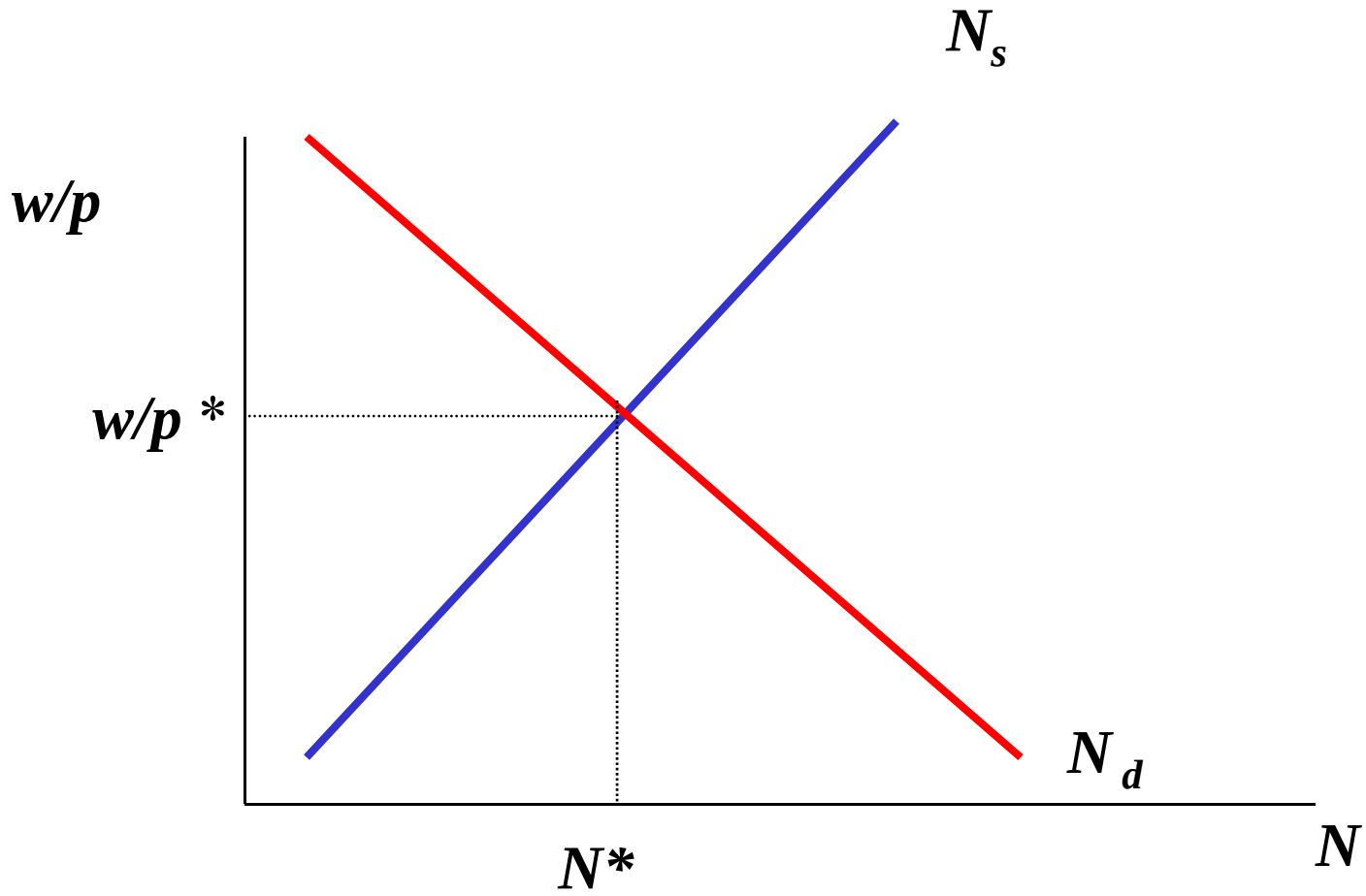


Population and Jobs

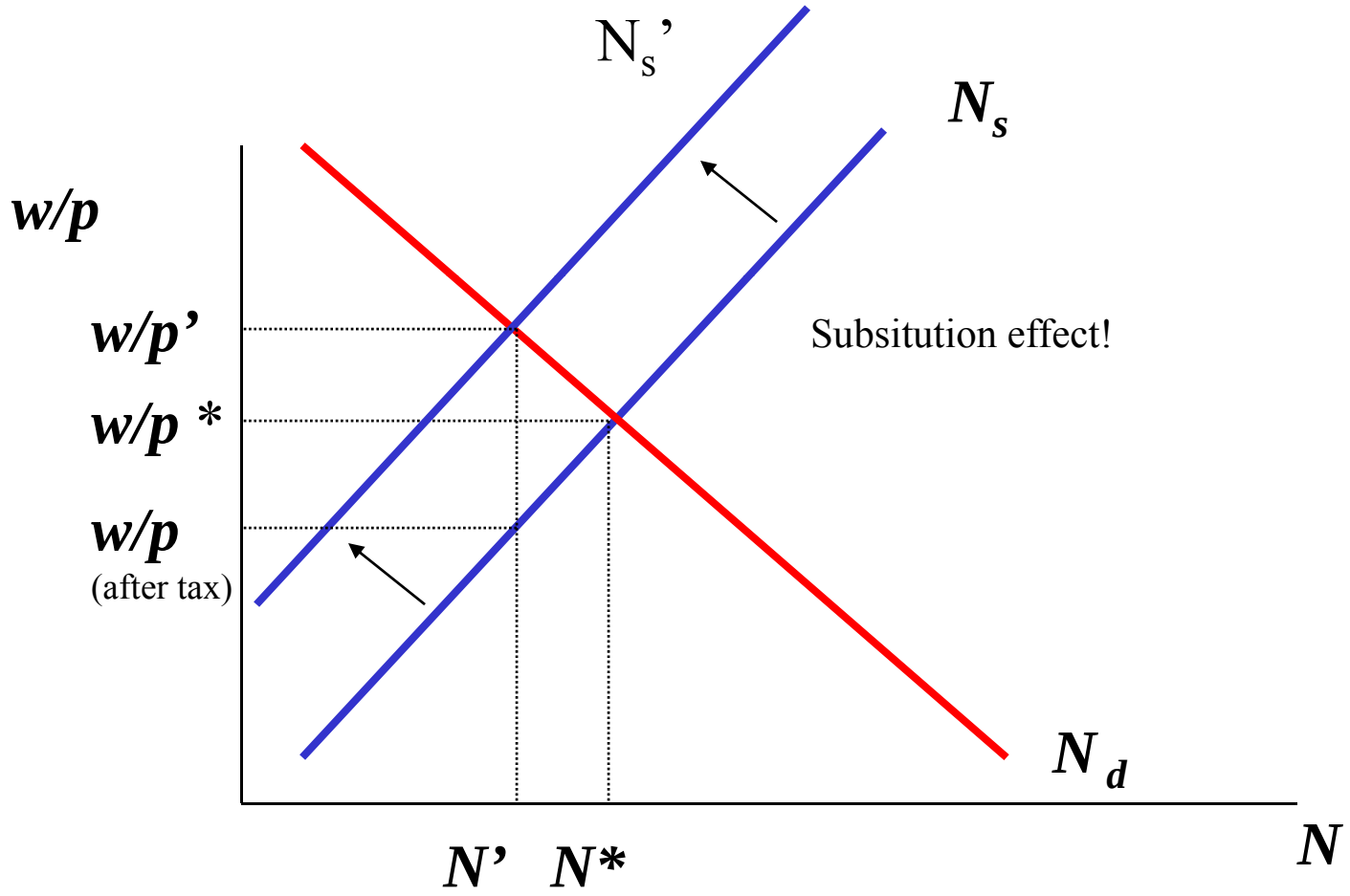
More People = More Jobs



Temporary vs Permanent Increase in Taxes (t_c or t_n)

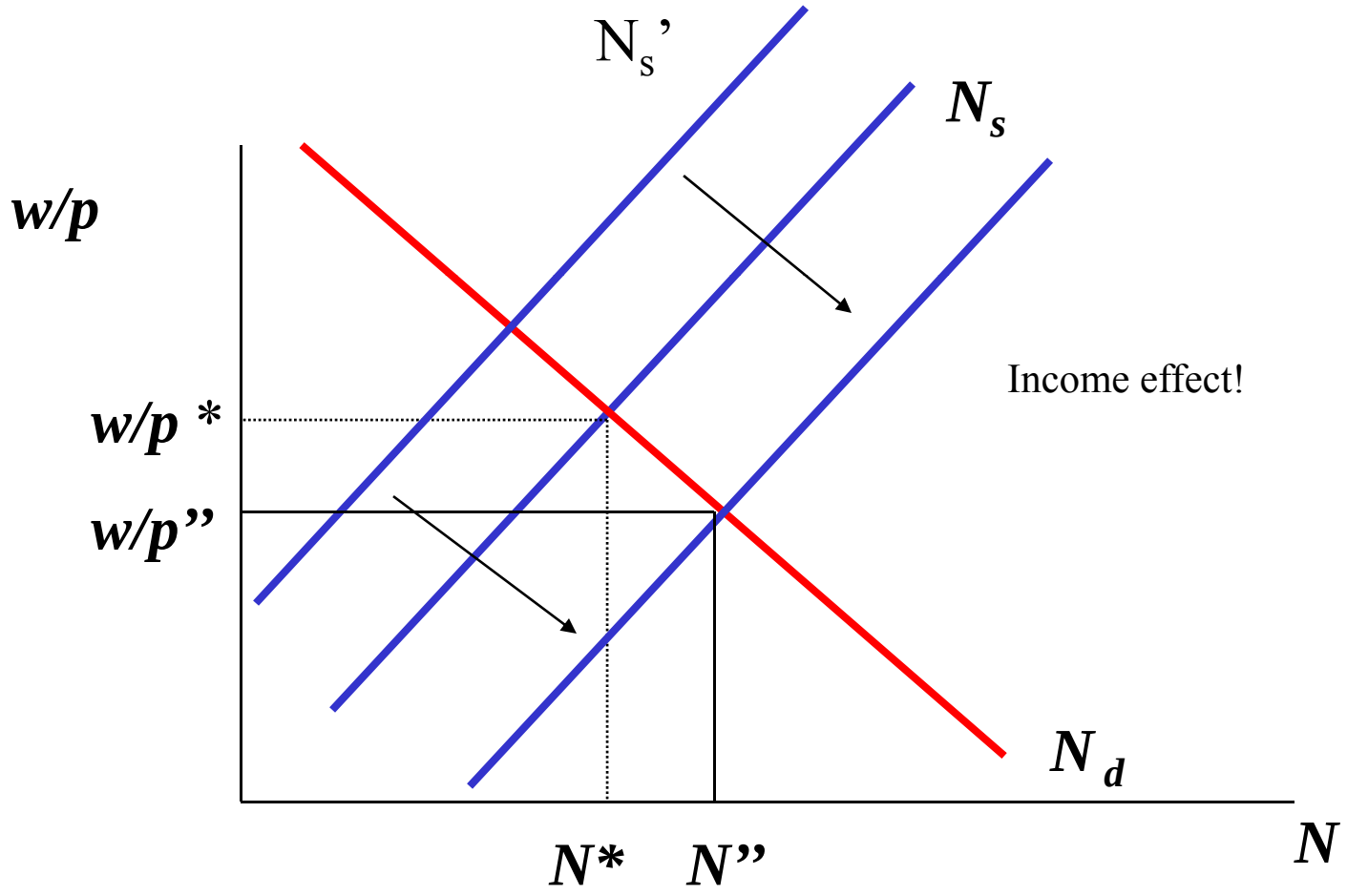


Temporary Increase in Taxes (t_c or t_n)



After tax wage SHIFTS the supply curve!!

Permanent Increase in Taxes (t_c or t_n)



Income effect can dominate or not! Try the other case…

Labor Market Equilibrium (Long Run)

- **We define Long Run Equilibrium in macroeconomics as occurring when the labor market clears.**

- By definition, long run macro equilibrium exists when N = N*.

- At N*, **labor demand = labor supply**. So, by definition, all workers who want a job (the suppliers) are able to find a firm looking for a worker (the demanders).

  Long run equilibrium is characterized by zero cyclical unemployment!

- It is an equilibrium such that there is no incentive for **real wages** to change at N*

  Real wages have 2 components: nominal wages (w) and the price level (p).

- Define Y* as the long run equilibrium level of output (output when labor market is in equilibrium):

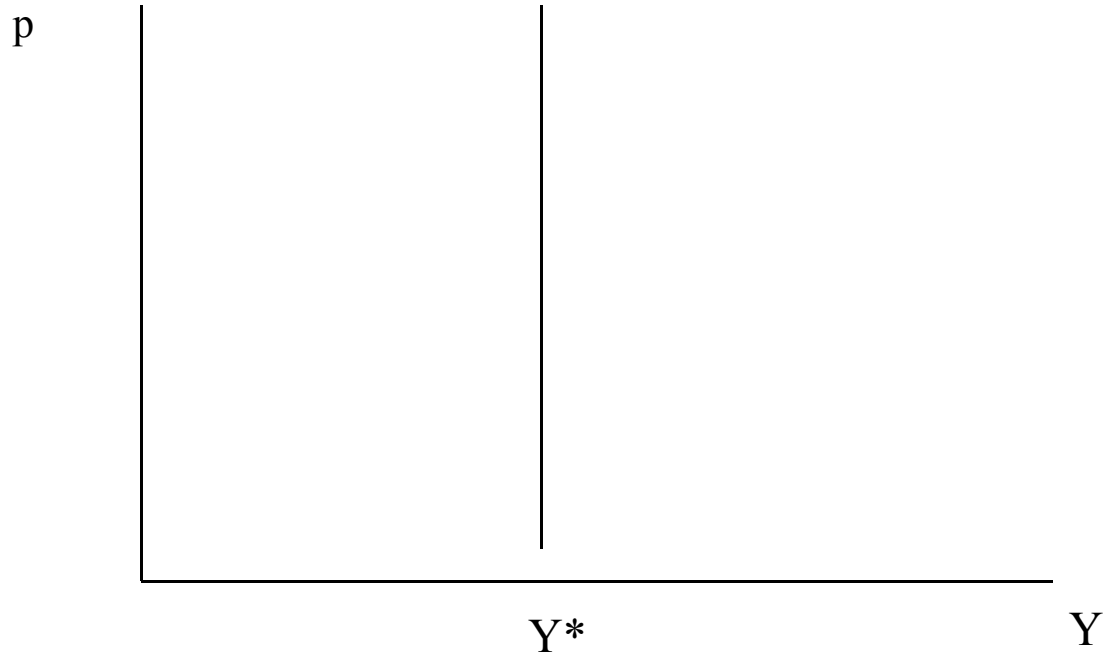
$$Y^* = A\,K.3(N^*).7$$

Long Run Aggregate Supply

- Suppose prices (p) increase. What happens in the labor market?
  - In terms of equilibrium, nothing happens!
  - Increasing prices have no effect on labor demand (A and K do not change).
  - Increasing prices have no effect on labor supply (taxes, population, etc. do not change).
  - You may ask "Doesn't PVLR change when prices increase???" No!
    - As long as nominal wages adjust, real wages will be unchanged when p increases.
    - The % change in prices will be matched exactly by the % change in nominal wages – real wages will not change (so PVLR will not change).
    - No effect on labor supply.
  - Key: Because real wages will not change, changes in prices will have NO effect on the labor market (i.e., it will have no effect on N*).
  - Conclusion: Changing prices will have NO effect on Y* (since N* is constant).

Long Run Aggregate Supply curve

LRAS – Long Run Aggregate Supply Curve



- If labor market clears, changes in prices will lead to equal changes in nominal wages. As a result, there will be no change in N* and hence, no change in Y*.
- Leads to a vertical LRAS curve. **Prices do not affect production in the long run!**

What shifts Y*? (the LRAS)

- Anything that affects the **labor market** will affect Y*!
- If N* increases, Y* will shift to the right.
- If N* decreases, Y* will shift to the left.
- Summary: Y* will shift right if:
  - A increases
  - K increases
  - population increases
  - labor income taxes fall (and income effect is small relative to substitution effect)
  - labor income taxes rise (and income effect is large relative to substitution effect)

Take out

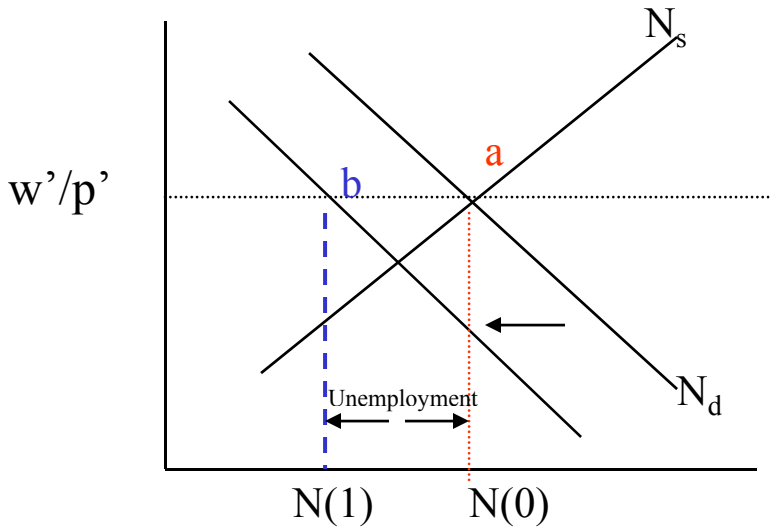
- In the **long run** – when labor markets clear.
  - Supply side of economy (labor market, K, A, other inputs like oil) determines output.
  - Demand side of economy (C+I+G+NX) will determine prices.
- In the **short run** – when labor markets do not clear:
  - Demand and Supply jointly determine prices and output.
  - Three outstanding issues (we will get to them soon):
    - What determines demand?
    - When is the labor market NOT in equilibrium?
    - What does the supply curve look like when labor market doesn't clear?

Preview: Disequilibrium in Labor Markets

- When do we get cyclical unemployment in our models? So far NO unemployment! We need some **frictions** in the labor market to get cyclical unemployment.

- Cyclical unemployment occurs when **labor demand is smaller than labor supply** at current wages (one story: nominal wages do not adjust to clear the labor market).

- **Cyclical unemployment occurs *only* in disequilibrium!**



Suppose TFP falls

Trends in Actual (Standardized) Unemployment Rates

	1994	1996	1998	2000	2001	2002	2004	2007	2008Q2
Britain	9.6	8.2	6.3	5.5	5.0	5.1	4.7	5.3	5.4
Japan	2.9	3.4	4.1	4.7	5.0	5.4	4.7	3.9	4.0
USA	6.1	5.4	4.5	4.0	4.8	6.0	5.5	4.6	5.3
France	12.3	12.4	11.7	9.5	8.5	8.9	9.6	8.3	7.7
Germany	8.4	8.9	9.4	7.9	7.7	8.7	9.5	8.4	7.4
Spain	24.1	22.1	18.3	14.1	10.6	11.3	10.9	8.3	10.6
Poland					18.5	19.8	18.8	9.6	7.3

www.oecd.org

Trends in Actual (Standardized) Unemployment Rates

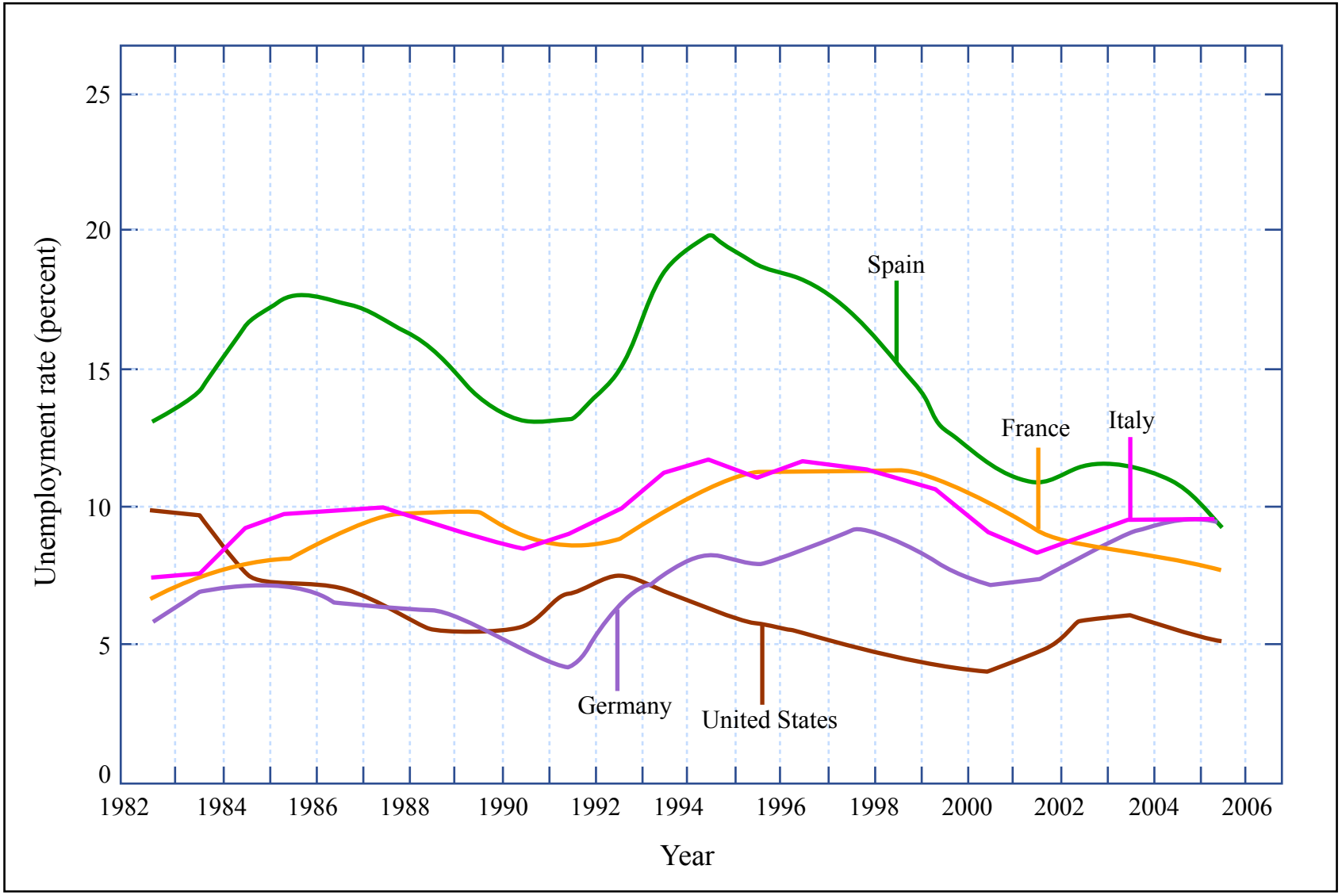


Figure by MIT OpenCourseWare.

OECD Factbook 2006

Why is Unemployment So High In Europe?

1. High labor income tax rates (t_n)
2. Firing restrictions
3. Centralized wage setting
4. High minimum wages
5. Powerful unions and insiders
6. Generous unemployment benefits

14.02 Principles of Macroeconomics

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