Skill wage premium

Labour Economics - set 6

Lorenzo Rocco

Department of Economics - Padova

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Acemoglu and Autor 2011 I

"Skills, Tasks and Technologies: Implications for Employment and Earnings"
in Handbook of Labour Economics 4b, cap. 12
David Card and Orley Ashenfelter eds.

Empirical data show that college/high school wage premium steadily increased in the last decades. However also supply of college graduates increased much.

Since Timbergen (1974, 1975) economists think that the behavior of the college wage premium is the result of a race between two forces
1) increasing demand of skilled work because of the continuous skill-biased technological progress
2) increasing supply of college graduates

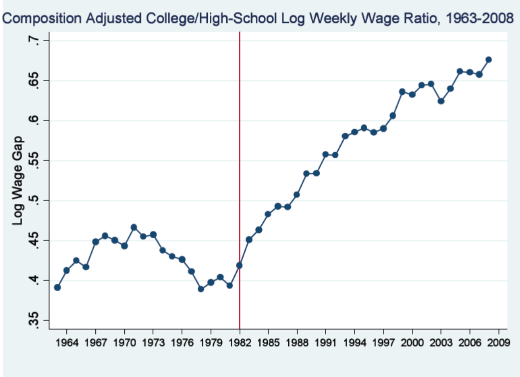
Acemoglu and Autor 2011 II

A simple model, the "canonical model" has been able to fit data quite good, at least until 1987. Unfortunately, it falls short as regards more recent data and a number of other predictions. Acemoglu and Autor (2011) propose a new model that fits empirical facts much better.

Outline:
1) empirical facts in the US
2) the canonical model and its implications
3) the Acemoglu & Autor model and its implications

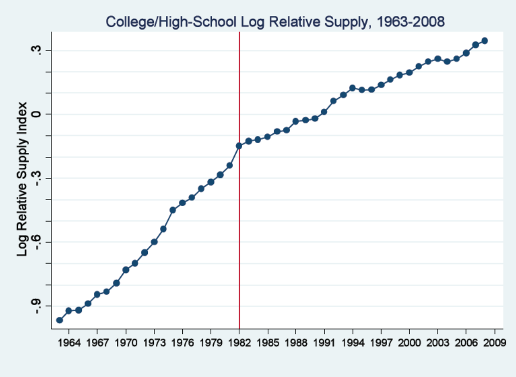
Empirical facts in the US I

- College/High School wage premium (based on March Continuous Population Survey - CPS - adjusted to keep constant the proportion of college and high school workers)



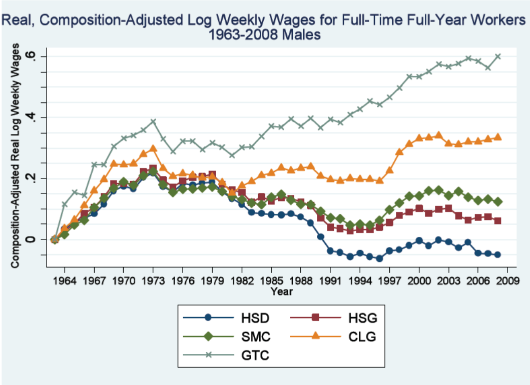
- Reversal in the Seventies, otherwise steady increase.

- College/High School relative supply



  - moderate slow down after 1982 (due to a smaller relative supply of young males after the end of the Vietnam period)

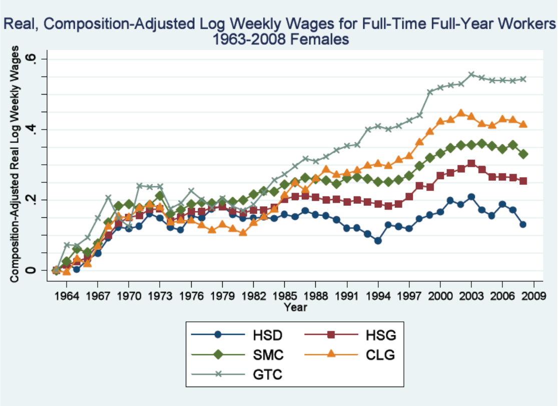
- real wage levels by skill
  - males



  - (HSD = high school drop out; SMC = some college; xxG = xx graduate; GTC = greater than college)
  - A rising college wage premium is consistent with increasing college wage and/or decreasing high school wages.

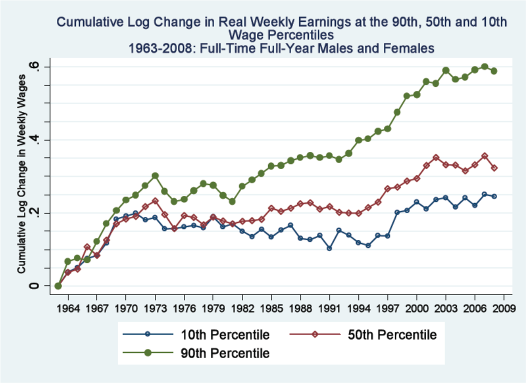
- In the Sixties all wages increase, as the canonical model will predict
- Next stagnation and from the Eighties, college wages increase and high school wages decrease. However the larger contributor to rising gap is the decline of high school wages. Gap stabilized in recent years.

- • females



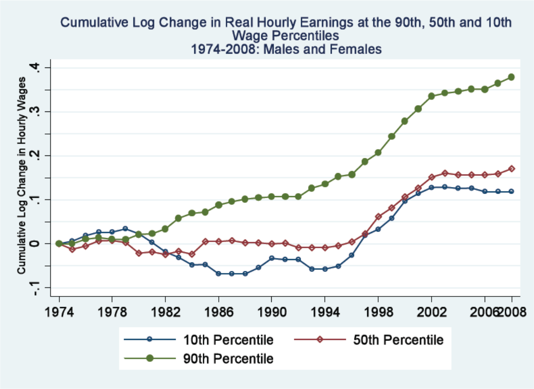
Real, Composition-Adjusted Log Weekly Wages for Full-Time Full-Year Workers
1963-2008 Females
Composition-Adjusted Real Log Weekly Wages
0
.2
.4
.6
1964
1967
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
Year
HSD
HSG
SMC
CLG
GTC

- Wage inequality (cumulative log change over-time per wage percentile)
  - weekly wages

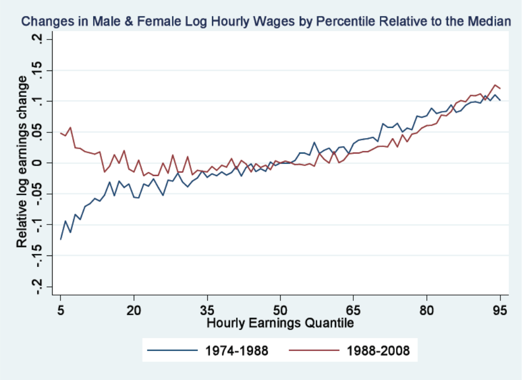


  - Since the Seventies the lowest real wages experienced a small increase only in the late Nineties
  - Top wages experienced a continuous increase

- hourly wages (account better for part-time jobs, more important in recent decades)

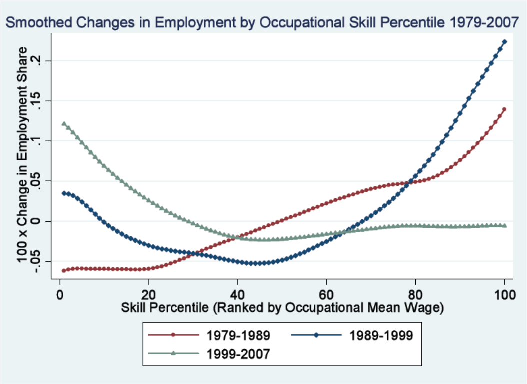


- Changes in wage distribution in two periods - relative changes by quantile compared to the median wage



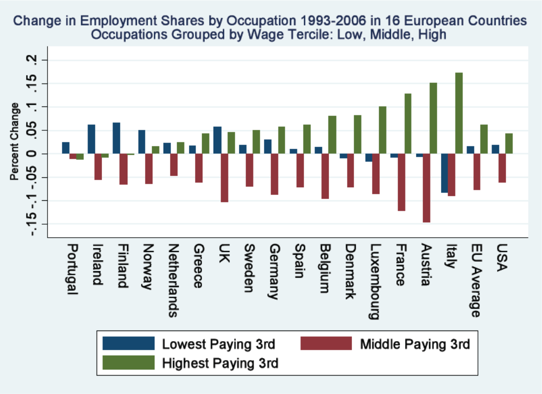
  - First evidence of polarization in more recent time (even if college/high school wage premium increases)

- More evidence of polarization



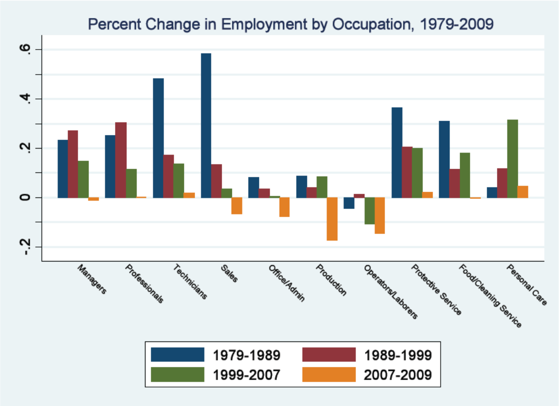
  - low-skilled jobs and high-skilled jobs (sorted according to their mean wage) increase employment relative to middle-skilled jobs

- Evidence of polarization also in EU, perhaps more than in US



- In all countries low-skilled employment increases relatively to middle-skilled employment

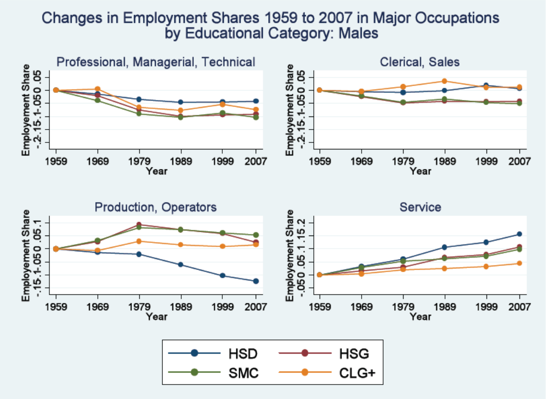
- What occupations gain and what loose employees? Further evidence of polarization

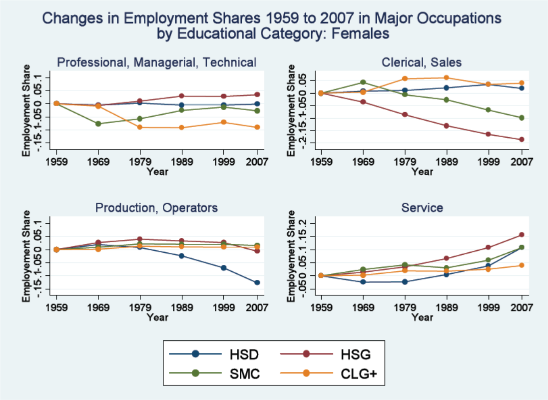


- Three groups:
  a) first three columns: managerial, professional and technical occupations. These are highly-educated and highly-paid occupations.
  b) next four columns: middle-skill occupations that require high school or some college (sales; office and administrative support; production, craft and repair; and operator, fabricator and laborer) (the first two columns are white collar, mostly held by women; the last two columns are blue collar, mostly held by men)
  c) last three columns: service occupation with no high school education

Remark: what could be an explanation for polarization? all routine tasks can be codified and executed by machines and computers or executed off-shore. The cost of calculus has decreased so fast. Creative occupations can expand (they use information to find new associations and intuitions). Instead, manual jobs cannot be automated.

- overtime the same occupations (tasks) change their skills content





- simultaneous growth of high and low-skill occupations is particularly striking in light of the substantial increases in male educational attainment in this time interval.

- simultaneously, the fraction of males at each education level employed in the highest occupational category (professional, managerial and technical occupations) declined while the fraction of males at each educational level in the lowest occupational category (service occupations) rose.
- thus, the 'polarization' of male employment occurs despite of, rather than because of, changes in male educational attainment.

Remark: This fact suggest that skills can perform alternative tasks and that there is no a one-to-one relation as assumed by the canonical model. An implication of this fact is that occupations predict wages better than education.

The canonical model. I

(References: Katz and Murphy, 1992; Card and Lemieux 2001)
Idea: college wage premium (i.e. the differential remuneration of high skills to lower skills - defined as log wage-ratio) depends on the relative supply of college graduates and the relative demand for skilled labour. Since technological progress is skill-biased, relative demand increases overtime. This model thus captures Timbergen's conjecture about the race between technology and supply of skills in determining relative wages.

Ingredients:

- Two types of workers, high skilled (H) and low skilled (L)
- Within each type workers are different, in the sense that they supply different amounts of efficiency units. A worker i of type H provides h_i efficiency units of skilled work and a worker j of type L provides l_j units of unskilled work.

The canonical model. II

- Work supply is inelastic. The sum of all h_i is H and the sum of all l_j is L.
- Aggregate production function in the economy is

$$Y = \left[(A_L L)^{\frac{\sigma - 1}{\sigma}} + (A_H H)^{\frac{\sigma - 1}{\sigma}} \right]^{\frac{\sigma}{\sigma - 1}}$$

  where $\sigma \in [0, +\infty)$ is the elasticity of substitution between skilled and unskilled work. If $\sigma < 1$ the two inputs are gross complements and if $\sigma > 1$ they are gross substitutes; $\sigma = 1$ is the Cobb-Douglas case.
- Parameters A_L and A_H represent factor-augmenting technological progress. Depending on σ an increase in A_i can either increase or decrease the demand of the other input.
- Labour markets are competitive.

Results

- –> Wages (i.e. prices of one efficiency unit) are equal to marginal productivity

$$w_L = \frac{\partial Y}{\partial L} = A_L^{\frac{\sigma-1}{\sigma}} \left[A_L^{\frac{\sigma-1}{\sigma}} + A_H^{\frac{\sigma-1}{\sigma}} (H/L)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{1}{\sigma-1}}$$

w_L is increasing with H/L and with both A_L and A_H.

$$w_H = \frac{\partial Y}{\partial H} = A_H^{\frac{\sigma-1}{\sigma}} \left[A_L^{\frac{\sigma-1}{\sigma}} (H/L)^{-\frac{\sigma-1}{\sigma}} + A_H^{\frac{\sigma-1}{\sigma}} \right]^{\frac{1}{\sigma-1}}$$

w_H is decreasing with H/L and increasing with both A_L and A_H.

The canonical model. IV

- Therefore, this production function suggests that technological progress rises the level of both wages regardless of the kind of technological progress. Moreover if the relative supply of skilled work increases, the level of w_H (resp. w_L) goes down (resp. up) for reasons linked with relative abundance (resp. relative scarcity).

- Wages actually earned by workers are $W_i = w_H h_i$ or $W_j = w_L l_j$.
- The skill premium is then

$$\varpi = \frac{w_H}{w_L} = \left(\frac{A_H}{A_L}\right)^{\frac{\sigma-1}{\sigma}} \left(\frac{H}{L}\right)^{-\frac{1}{\sigma}}$$

and in logs it is

$$\log \varpi = \frac{\sigma - 1}{\sigma} \log \frac{A_H}{A_L} - \frac{1}{\sigma} \log \frac{H}{L}$$

log skill premium depends linearly and negatively on log relative supply.

- The recent increase in the supply of college graduates should have reduced the skill premium if technological progress were not skill-biased
  - (Of course this occurs only if $\sigma > 1$ i.e. only if skilled and unskilled labour are gross substitutes: suppose they are not - in that case an increase in A_H will boost demand of low skilled jobs much more than demand of skilled jobs implying a skill premium decline).
  - Anyway, most estimates put σ somewhere between 1.4 and 2.

Empirics

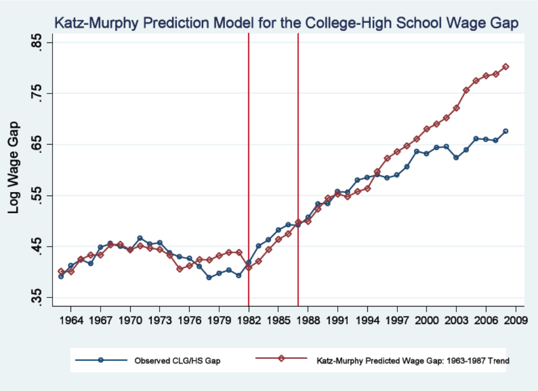
- The term $\log \frac{A_H}{A_L}$ cannot be directly observed. Katz and Murphy (1992) among others suggest to simply proxy it by a linear trend. This way the skill premium equation can be readily estimated

$$\log \varpi = \frac{\sigma - 1}{\sigma}\gamma_0 + \frac{\sigma - 1}{\sigma}\gamma_1 t - \frac{1}{\sigma}\log\frac{H}{L}$$

The canonical model. VI

- Katz and Murphy (1992) estimated it between 1963 and 1987 with remarkably good fit. This means that the canonical model is able to reproduce real data.
- When the model is estimated over a longer period results are still good but less satisfactory

The canonical model. VII



The canonical model. VIII

Table 8. Regression Models for the College/High-School Log Wage Gap, 1963-2008

	1963-1987		1963-2008		
	(1)	(2)	(3)	(4)	(5)
CLG/HS Relative Supply	-0.612 (0.128)	-0.339 (0.043)	-0.644 (0.066)	-0.562 (0.112)	-0.556 (0.094)
Time	0.027 (0.005)	0.016 (0.001)	0.028 (0.002)	0.029 (0.006)	0.020 (0.006)
Time X post-1992			-0.010 (0.002)		
$Time^2/100$				-0.013 (0.006)	0.036 (0.012)
$Time^3/1000$					-0.007 (0.002)
Constant	-0.217 (0.134)	0.059 (0.039)	-0.254 (0.066)	-0.189 (0.122)	-0.145 (0.103)
Observations	25	46	46	46	46
R-squared	0.558	0.935	0.961	0.941	0.960

Source: March CPS data for earnings years 1963-2008. See notes to Figures 2 and 21.

The canonical model. IX

- The model suggests that a significant deceleration in trend relative demand takes place sometime during the 1990s while the elasticity of substitution remained around 1.6.
- But this is inconsistent with the common perception that demand for college graduates actually accelerated during the 1990s, the decade when ICT exploded.
- Another implication of the canonical model regards income inequality.
  - within-group inequality should depend only on the endowment of efficiency units: take to workers of type H (or L). Their relative wage is $\frac{W_i}{W_{i'}} = \frac{w_H l_i}{w_H l_{i'}} = \frac{l_i}{l_{i'}}$. Thus within-group inequality should not change overtime and should be independent of the wage premium
  - between group inequality should reflect the wage premium.
  - this facts contradicts data: wage premium increased in recent years while inequality stagnated.

- The canonical model predicts that wage levels increase for both types, while we have seen that low skilled wages actually decreased in level.
- The canonical model is silent about the phenomenon of polarization.

- **key:**
  - tasks do not coincide with skills. The same skill can be used to achieve different tasks, although some skills have a comparative advantage to perform certain tasks compared to others.
  - Technological progress modifies the pattern of comparative advantages, so that certain tasks previously performed more efficiently by a given skills can, ex-post, be accomplished by other skills.

Ingredients

- There is a continuum of tasks $i \in [0, 1]$ in the economy

A Ricardian model of the labour market. II

- The aggregate production function is a Cobb-Douglas defined on the continuum

$$Y = \exp \left[\int_0^1 \ln y(i) di \right]$$

  where $y(i)$ is the service or the production level of task i
- There are three types of skills (i.e. three types of workers): high, medium and low.
- The supply of all skills is inelastic and equal to L, M, H
- Each task is produced according to

$$y(i) = A_L \alpha_L(i) l(i) + A_M \alpha_M(i) m(i) + A_H \alpha_H(i) h(i)$$

  where
  - A_j captures factor-augmenting technological progress (equal across all tasks), low/medium/high skill biased.

A Ricardian model of the labour market. III

- $\alpha_j(i)$ indicates the productivity of each type of work in performing tasks i
- $l(i)$ $m(i)$ $h(i)$ are the amounts of factors (i.e. number of workers) allocated to task i in the economy

- **Assumption 1.**
  $\alpha_L(i)/\alpha_M(i)$ and $\alpha_M(i)/\alpha_H(i)$ are continuously differentiable and strictly decreasing in i.

- This assumption specifies the structure of comparative advantage in the model. It can be interpreted as stating that higher indices correspond to more complex tasks in which high skill workers are better than medium skill workers and medium skill workers are better than low skill workers.

A Ricardian model of the labour market. IV

Allocation of skills to tasks

- **Lemma 1**: there exist two thresholds I_L and I_H in the space of tasks such that all tasks $i < I_L$ will be performed by low skill workers, all tasks $I_L < i < I_H$ will be performed by the medium skilled and all tasks $i > I_H$ will be performed be the high skilled.
- Hint about the proof: at each threshold, given market prices of labour, the cost of producing a unit of, say, $y(I_L)$ is the same using either low skill or medium skill workers. But given Assumption 1 (monotonicity), each task $i < I_L$ will be produced more efficiently by the low skilled and each task $i > I_L$ by the medium skilled. Given that market prices of labour are flexible and the whole labour supply will be employed at equilibrium, certainly I_L and I_H are internal points.
- Note: I_L and I_H are endogenous and depend on A_j and on the supply of skills. This opens for the possibility of *substitution of skills across tasks.*

The equilibrium price of skills (wages).

- The price of the final good is normalized to 1 (numeraire).
- In the final good market, at equilibrium, it must be price = marginal cost. The marginal cost is constant given the technology assumed (constant returns to scale). This implies

$$MC = \exp\left[\int_0^1 \ln p(i)\,di\right] = 1$$

where $p(i)$ is the price of one unit of task i.

A Ricardian model of the labour market. VI

- Given that tasks are performed by only one type of workers, at equilibrium (Lemma 1), the price of each task reflects to the wage rate of the type of workers employed. For instance take a task i performed only by the low skilled. It must be:

$$p(i)y(i) = w_L l(i)$$

(revenues for task i = costs for task i) so that

$$w_L = p(i)A_L\alpha_L(i)$$

given that $y(i) = A_L\alpha_L(i)l(i)$.

A Ricardian model of the labour market. VII

- Furthermore, a low skill worker needs to receive the same wage whatever task he performs (law of one price): otherwise he would move to the better paying task. Indeed, for any i and i' in $[0, I_L)$ it must be

$$p(i)\alpha_L(i) = p(i')\alpha_L(i') \equiv P_L$$

  where P_L is a sort of price index for the tasks performed by the low skill workers.

- Summing up

$$w_L = P_L A_L$$

- **Remark:** the Cobb-Douglas function implies that expenditure for each task must be equalized. Thus tasks produced more abundantly need to be paid less.

A Ricardian model of the labour market. VIII

- Similarly, for the tasks performed by the medium and the high skill workers:

$$w_M = p(i)A_M\alpha_M(i) = P_M A_M$$

$$w_H = p(i)A_H\alpha_H(i) = P_H A_H$$

Labour allocation

Expenditure for two tasks performed by the same worker type must be equal.

- Thus for any i and i' in $[0, I_L)$ it must be

$$p(i)A_L\alpha_L(i)l(i) = p(i')A_L\alpha_L(i')l(i')$$

which implies

$$l(i) = l(i')$$

i.e. that each task should be allocated the same amount of labour.

A Ricardian model of the labour market. IX

- Indeed

$$l(i) = \frac{L}{I_L} \quad \text{for } i < I_L$$

and, similarly for the tasks performed by medium and high skill workers

$$m(i) = \frac{M}{I_H - I_L} \quad \text{for } I_L < i < I_H$$

$$h(i) = \frac{H}{1 - I_H} \quad \text{for } i > I_H$$

- Equality of expenditure for tasks holds for every two i. Take a medium skill and a high skill task:

$$p(i)A_M\alpha_M m(i) = p(i')A_H\alpha_H h(i')$$

is equivalent to

$$P_M A_M \frac{M}{I_H - I_L} = P_H A_H \frac{H}{1 - I_H}$$

which amounts to

$$\frac{P_H}{P_M} = \left(\frac{A_H H}{1 - I_H}\right)^{-1} \left(\frac{A_M M}{I_H - I_L}\right)$$

(task relative price indices are inversely related to the relative supply of skills)
Similarly

$$\frac{P_M}{P_L} = \left(\frac{A_M M}{I_H - I_L}\right)^{-1} \left(\frac{A_L L}{I_L}\right)$$

Determination of I_L and I_H.

- Task I_L can be indifferently produced by low skill and medium skill workers. Similarly task I_H can be indifferently produced by medium skill and high skill workers. Moreover, expenditure needs to be the same regardless of the type of skill employed.

$$p(I_L)A_L\alpha_L(I_L)l(I_L) = p(I_L)A_M\alpha_M(I_L)m(I_H)$$

$$p(I_H)A_M\alpha_M(I_H)m(I_H) = p(I_H)A_H\alpha_H(I_H)h(I_H)$$

- These conditions imply two key **arbitrage conditions**

$$\frac{A_L \alpha_L(I_L) L}{I_L} = \frac{A_M \alpha_M(I_L) M}{I_H - I_L} \qquad \text{(noarbitrage1)}$$

$$\frac{A_M \alpha_M(I_H) M}{I_H - I_L} = \frac{A_H \alpha_H(I_H) H}{1 - I_H} \qquad \text{(noarbitrage2)}$$

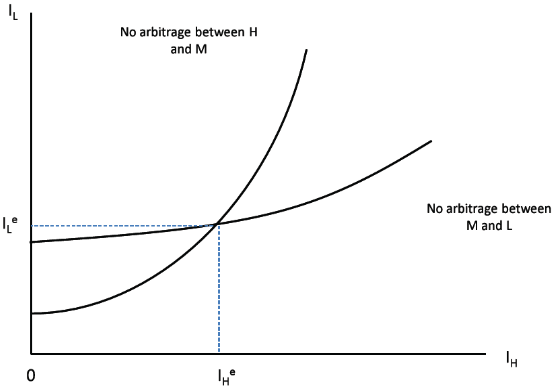
Equilibrium wages

- Once I_L and I_H are determined, wages are determined as well.
- Relative wages are

$$\frac{w_H}{w_M} = \frac{P_H}{P_M}\frac{A_H}{A_M} = \frac{1 - I_H}{I_H - I_L}\left(\frac{H}{M}\right)^{-1}$$

$$\frac{w_M}{w_L} = \frac{P_M}{P_L}\frac{A_M}{A_L} = \frac{I_H - I_L}{I_L}\left(\frac{M}{L}\right)^{-1}$$

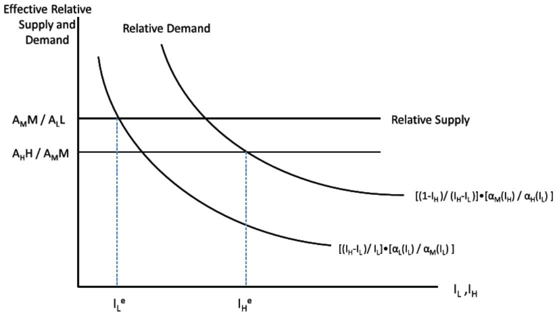
- **Proposition 1**. Equilibrium exists and it is unique.
  - Threshold determination: there is a unique solution



  - Allocation of skills to tasks

A Ricardian model of the labour market. XIV

- (no arbitrage conditions rewritten)

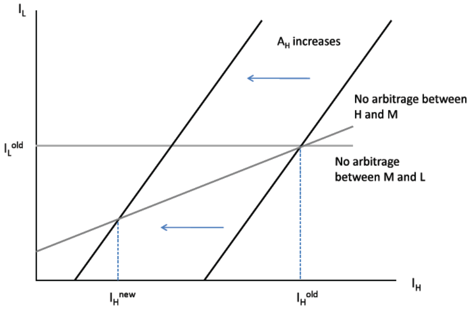


- Note: It is possible to easily show that this model can be specialized (two types) in order to reproduce the canonical model.

Comparative statics.

A Ricardian model of the labour market. XV

- consider an increase in A_H
  - take logs of the arbitrage conditions and represent these conditions in the (l_H, l_L) space. The two conditions now are increasing with the slopes as in figure:



A Ricardian model of the labour market. XVI

- Both I_H and I_L decrease. High skill workers occupy more tasks. Some expelled medium skill occupy lower tasks.
- Moreover it is possible to show that the region of tasks $(I_H - I_L)$ performed by the medium skilled reduces.

- Effect on relative wages

2. *(The response of relative wages to skill supplies):*

$$\frac{d\ln(w_H/w_L)}{d\ln H} < 0, \ \frac{d\ln(w_H/w_M)}{d\ln H} < 0, \ \frac{d\ln(w_H/w_L)}{d\ln L} > 0,$$
$$\frac{d\ln(w_M/w_L)}{d\ln L} > 0, \ \frac{d\ln(w_H/w_M)}{d\ln M} > 0, \ \text{and}$$
$$\frac{d\ln(w_H/w_L)}{d\ln M} \lesseqgtr 0 \ \text{if and only if} \ \left|\beta'_L(I_L)I_L\right| \gtreqless \left|\beta'_H(I_H)(1-I_H)\right|.$$

A Ricardian model of the labour market. XVII

3. (The response of wages to factor-augmenting technologies):

$$\frac{d\ln(w_H/w_L)}{d\ln A_H} > 0, \; \frac{d\ln(w_M/w_L)}{d\ln A_H} < 0, \; \frac{d\ln(w_H/w_M)}{d\ln A_H} > 0;$$
$$\frac{d\ln(w_H/w_L)}{d\ln A_L} < 0, \; \frac{d\ln(w_M/w_L)}{d\ln A_L} < 0, \; \frac{d\ln(w_H/w_M)}{d\ln A_L} > 0;$$
$$\frac{d\ln(w_H/w_M)}{d\ln A_M} < 0, \; \frac{d\ln(w_M/w_L)}{d\ln A_M} > 0, \text{ and}$$
$$\frac{d\ln(w_H/w_L)}{d\ln A_M} \lesseqqgtr 0 \text{ if and only if } \left|\beta_L'(I_L)\, I_L\right| \gtreqqless \left|\beta_H'(I_H)\,(1-I_H)\right|.$$

- Effect on wage levels:
  - an increase in A_H can reduce the wages of medium skilled workers because it erodes their comparative advantage and displaces them from (some of) the tasks that they were previously performing.

A Ricardian model of the labour market. XVIII

- This contrasts with the predictions of the canonical model and provides a useful starting point for interpreting the co-occurrence of rising supplies of high skill labor, ongoing skill biased demand shifts (stemming in part from technical change), and falling real earnings among less educated workers.

Extension: task replacing technologies

- Suppose that tasks can be produced also by machines and extend the task production function to

$$y(i) = A_L \alpha_L(i) l(i) + A_M \alpha_M(i) m(i) + A_H \alpha_H(i) h(i) + A_K \alpha_K(i) k(i)$$

and assume that $\alpha_K(i) >> 0$ for $i \in [I', I''] \subset [I_L, I_H]$ and $\alpha_K(i) = 0$ outside.
- This means that within the region of the middle skill workers there exist now some tasks which can be produced more efficiently by machines.
- The implication is that all three regions change: medium skill workers will now start performing some of the tasks previously allocated to low skill workers, thus increasing the supply of these tasks (the same will happen at the top with an expansion of some of the high skill tasks).
- It is possible to show that w_H / w_M increase, w_M / w_L decrease

Extension: endogenous technological progress

- There exist oligopolistic profit maximizing firms that invest to produce intermediate goods which modify the $\alpha_j(i)$. They sell this technology to the final good producers.
- At equilibrium, an increase in the supply of factor $f \in \{L, M, H\}$ will induce technical change biased towards that factor.
- The endogenous response of technology to changes in relative supplies leads to many changes in both task productivities and the allocation of skills to tasks.

Extension: endogenous skill supply I

- Each worker j is endowed with a vector of skills (l_j, m_j, h_j) and has 1 unit of time that he has to decide how to share among job. Each job, at equilibrium, requires only one skill. Generally workers will prefer to allocate all their time to the job that gives him higher income. So each worker at equilibrium supplies only one skill.
- In this setting, a shift in A_H induces also skill supply to change.
- There is not only substitution of skills across tasks but also of workers across skills (i.e. workers can change what skill to supply).

- The rising penetration of information technology that replaces middle skill tasks (i.e., those with a substantial routine component) will depress both the wages of medium skill workers and reduce employment in tasks that were previously performed by these medium skill workers.

Extension: endogenous skill supply II

- This process is amplified if we also allow for substitution of workers across skills. In that case, some of the workers previously supplying medium skills to routine tasks switch to supplying low skills to manual and service tasks.

Concluding remarks

A key implication of this model is that technical change favoring one type of worker can reduce the real wages of another group. Therefore, distinct from canonical model, technical change need not raise the wages of all workers

What's missing

- the importance of organizational changes within firms. New forms of organization might require new tasks
- labour marker imperfections: frictions can intervene in the matching tasks-skills. The effect of technical change can be quite different from what we obtain in competitive markets
- labour market institutions: unions might block substitutions of labour with machines