

The Price of Talent

The origins of an equilibrium wage distribution

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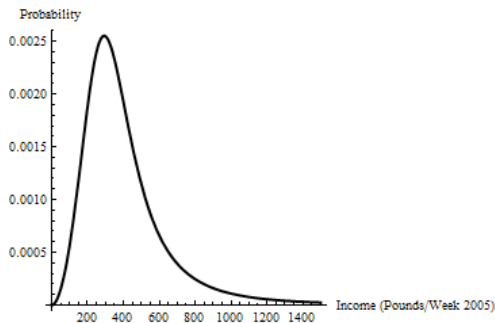
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Introduction

The empirical attributes of the earnings distribution, Neal and Rosen (2000):

"Earnings distributions . . . are always skewed to the right. Their density functions are asymmetric and display a long right tail and positive skewness measure . . . and have a "fat tail."

Typical wage distribution
Wage PDF



British income distribution from Jenkins (2009) using the GB2 distribution

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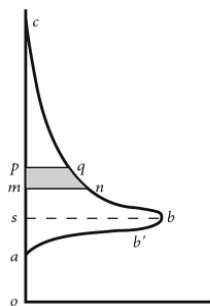
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A ubiquitous phenomenon



Pareto (1909)

- ▶ These attributes are ubiquitous when we measure wages across countries and economies.
- ▶ When wage distribution is more equal, there is less spread and when less equal the spread is higher.
- ▶ **What are the forces shaping this wage distribution?**
- ▶ We need a theory of an equilibrium wage distribution.

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A question with historic roots

"to determine the laws which regulated the distribution . . . of rent, profit and wages . . . is the principal problem in Political Economy."

D. RICARDO (1817)

"It is a social law, ... something ... in the nature of man."

V. PARETO (1895)

"The great idea of investigating the relationship between wage differences and differences in ability opens a vast perspective. The new trail is steep and stony, but it must be followed."

J. SCHUMPETER (1916)

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A yet unanswered question

"Any interesting theory of wage dispersion must be able to explain the shape as well as the extent of the dispersion in the distribution of wages paid across firms."

D. MORTENSEN (1999)

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Summary

A theoretical framework to study the wage as an endogenous price of ability

- ▶ A frictional labor market with search and matching.
- ▶ Workers are **hierarchically heterogeneous** in their abilities.
- ▶ Ex-ante identical firms **endogenously** create vacancies with **different ability requirements**.
- ▶ Wage setting is achieved via Axiomatic Nash bargaining.
- ▶ Later: A competitive differentiated goods market where the demand for all goods is the same.

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- ▶ The economy
- ▶ Workers and the production technology
- ▶ Vacancies and unemployment
- ▶ The search technology and the wage setting
- ▶ The agents' strategies
- ▶ An equilibrium

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The Economy

- ▶ An infinite horizon economy, with full information.
- ▶ Two types of economic agents: firms and workers.
- ▶ Agents are risk neutral, infinitely lived and discount the future with parameter $\beta = \frac{1}{1+r}$.

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Hierarchical heterogeneity of ability

- ▶ Workers are endowed with some heterogeneous ability.
- ▶ Ability is hierarchical, i.e. a worker with higher ability can perform any job a worker with less ability can.
- ▶ **No specific ability distribution is assumed**, only hierarchy matters.
- ▶ Example: If the IQ score is taken as a measure of ability, the normal distribution of these scores is ignored.
- ▶ The scores are used exclusively to rank the workers, such that a worker with a higher IQ score has a higher rank.
- ▶ WLOG: Let a' be the ability and let $F(\cdot)$ be its distribution function then $a = F(a')$ is the transformed ability which is uniformly distributed.
- ▶ The workers' ability can be considered their **type**.
- ▶ The measure of workers is normalized to 1.

The production technology

- ▶ The good that is produced in any certain job is defined solely by that job.
- ▶ Example: A teacher and a janitor of a class.
 - ▶ Let us assume that teaching a class requires more ability than cleaning that class.
 - ▶ Any worker who can fill a janitor's position will produce the same cleaning, regardless of that worker's higher ability.
- ▶
$$p(x, a) = \begin{cases} P(x) & x \leq a \\ 0 & x > a \end{cases}$$
- ▶ The productivity of a match is defined by the price of the good produced $P(x)$ as long as the worker's ability a exceeds that firm's ability requirement x .
- ▶ For now, I assume $P(x)$ is exogenous.
- ▶ The jobs' ability requirement can be considered their **type**.

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Summary

- ▶ **The ex-ante identical firms can open vacancies that are heterogeneous in their ability requirements.**
- ▶ There is free entry of firms (one job per firm).
- ▶ Sustaining an open vacancy is associated with a flow cost $C(x)$.
- ▶ The measure of open vacancies is denoted by v .
- ▶ The distribution of the vacancies is denoted by G_V .

The unemployment

- ▶ **Each worker may be employed or unemployed.**
- ▶ The measure of unemployed workers (determined in equilibrium) is denoted by u .
- ▶ I denote the distribution of unemployed workers by F_U .
- ▶ I denote the distribution of employed workers by F_W .

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Search technology, production and destruction

- ▶ **Only unemployed workers search (No on the job search).**
- ▶ The search technology is quadratic:
 - ▶ The rate of an unemployed worker finding a vacancy is $\lambda \cdot v$ (drawn in random).
 - ▶ The rate of an open vacancy finding a worker is $\lambda \cdot u$ (drawn in random).
- ▶ Not all matches are compatible:
 - ▶ The worker's ability a must be higher than the firm's ability requirement x (otherwise the production will be 0).
 - ▶ The worker decides whether to accept the job.
- ▶ After a job is matched by a suitable worker, it produces until destroyed by nature with rate δ .
- ▶ When a job is destroyed, the worker becomes unemployed and the firm is left with nothing.

- ▶ The wage is determined by Nash bargaining with parameter b , dividing the surplus from the match.
- ▶ The outside option value of the firm is zero (due to the free entry of firms).
- ▶ The outside option value of the worker is the value of continuing the search.
- ▶ The worker may opt to reject the offer if he values being employed as lesser than continuing the search.

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Agents' strategies

- ▶ The worker has to decide whether to accept a job offer or to continue searching.
 - ▶ This decision is a function of the worker's ability and is denoted by $x_L(a)$.
- ▶ The firm has to decide what vacancy to open (where vacancies are differentiated by their ability requirement).
 - ▶ The firm's strategy is the vacancy offer distribution over the ability requirements G_V .
- ▶ The workers' strategy $x_L(a)$ induces a function that defines for each firm what is the worker with the highest ability that is still willing to take that job.
 - ▶ This is a function of the firm's ability requirement and is denoted by $a_H(x)$.

An equilibrium

- ▶ **A stationary equilibrium in the above economy is the following:**
 - ▶ A measure $0 < u < 1$ of unemployed workers distributed F_U in workers' ability.
 - ▶ A measure $(1 - u)$ of employed workers distributed F_W in workers' ability.
 - ▶ A measure $(1 - u)$ of occupied jobs distributed G_J in jobs' ability requirements.
 - ▶ A measure $v > 0$ of offered vacancies distributed G_V in vacancies' ability requirements.
 - ▶ A workers' strategy $a \rightarrow x_L(a)$.
- ▶ **such that in every period:**
 - ▶ All workers maximize their present discounted income.
 - ▶ All firms maximize their present discounted value.
 - ▶ For all attributes of a match (i.e. both the worker's ability and the job's ability requirement), the measure of jobs destroyed is equal to the measure of matches formed.

The solution

- ▶ The wage
- ▶ The firm's zero profit equation
- ▶ The worker's reservation wage equation
- ▶ Equations of labor market flows
- ▶ An existence theorem

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The wage

- ▶ A wage $w(x, a)$ is paid to a worker with a certain ability being employed in a job with a certain ability requirement.
- ▶ The wage is a separable function of the worker's ability and the job's ability requirement.
 - ▶ Explicitly: $w(x, a) = w_R(a) + b(P(x) - w_R(a))$
- ▶ were:
 - ▶ $P(x)$ is the price of the good produced in the job.
 - ▶ $w_R(a)$ is the reservation wage of the worker.
 - ▶ b is the Nash bargaining power of the worker parameter.
- ▶ When the worker's strategy is internal
 - ▶ $x_L(a) > 0 \Rightarrow w_R(a) = P(x_L(a))$
- ▶ The surplus created by a successful match is
 - ▶ $P(x) - P(x_L(a))$

Zero profit equation

- ▶ The Firm's equal (zero) profit condition
 - ▶ $C(x) = \lambda \cdot u \cdot \frac{1}{r+\delta} \cdot (1-b) \cdot \int_{a=x}^{a_H(x)} (P(x) - P(x_L(a))) dF_U(a)$
- ▶ The zero profit equation states that the cost of keeping the vacancy open $C(x)$ must equal the discounted expected profit from filling that vacancy.
- ▶ The expected profit is a multiplication of:
 - ▶ The rate of finding a worker $\lambda \cdot u$.
 - ▶ The discount factor $\frac{1}{r+\delta}$.
 - ▶ The share of the firm $(1-b)$.
 - ▶ The weighted average of the surplus $P(x) - P(x_L(a))$ over the unemployed distribution F_U .

Worker's threshold equation

- ▶ The Worker's threshold condition

- ▶
$$P(x_L(a)) = \lambda \cdot v \cdot \frac{1}{r+\delta} \cdot b \cdot \int_{x=x_L(a)}^a (P(x) - P(x_L(a))) dG_V(x)$$

- ▶ The worker's threshold condition states that the worker's strategy $x_L(a)$ is set so that the reservation wage $P(x_L(a))$ must equal the discounted expected wage from continuing the search.

- ▶ The expected wage is a multiplication of:

- ▶ The rate of finding a vacancy $\lambda \cdot v$.
 - ▶ The discount factor $\frac{1}{r+\delta}$.
 - ▶ The share of the firm b .
 - ▶ The weighted average of the surplus $P(x) - P(x_L(a))$ over the vacancy distribution G_V .

Equations of labor market flows

- ▶ In equilibrium the $(1 - u)$ filled jobs are distributed according to $f(x, a)$.
- ▶ The worker and job flow equation is
 - ▶ $\delta \cdot (1 - u) \cdot f(x, a) = \lambda \cdot u \cdot F'_U(a) \cdot v \cdot G'_V(x)$
- ▶ The destruction rate of a job is a multiplication of:
 - ▶ The rate of job destruction: δ .
 - ▶ The measure of employed workers: $(1 - u)$.
 - ▶ The distribution of workers with ability a working in jobs with ability requirement x : $f(x, a)$.
- ▶ The creation rate of a new job is a multiplication of:
 - ▶ The rate of finding a match λ .
 - ▶ The measure of the unemployed u distributed according to $F'_U(a)$.
 - ▶ The measure of opened vacancies v distributed according to $G'_V(x)$.

Equations of labor market flows

This can be integrated into two equations:

▶ Flow equilibrium of workers' abilities

$$\delta \cdot (1 - u) F_W(a) = \lambda \cdot \int_{a'=0}^a \left(v \cdot \int_{x=x_L(a')}^{a'} G'_V(x) dx \right) \cdot u \cdot F'_U(a') da'$$

▶ Flow equilibrium of firms' ability requirements

$$\delta \cdot (1 - u) G_J(x) = \lambda \cdot \int_{x'=0}^x \left(u \cdot \int_{a=x'}^{a_H(x')} F'_U(a) da \right) \cdot v \cdot G'_V(x') dx'$$

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An existence Theorem

Theorem

Some regularity conditions on $P(x)$ and $C(x)$ are **sufficient** for the **existence** of an internal equilibrium.

Proof.

I build a continuous functional operator \mathbb{L} from

$$\mathbb{Q} \subset L^1([0, 1]) \oplus L^1([0, 1])$$

composed of pairs of two functions $(x'_L(\cdot), u \cdot F'_U(\cdot))$

s.t. when

$\mathbb{L}(x'_L(\cdot), u \cdot F'_U(\cdot)) = (x'_L(\cdot), u \cdot F'_U(\cdot))$, all equations are satisfied.

By Schauder fixed point theorem:

Every continuous function \mathbb{L} from a convex compact subset \mathbb{Q} of a Banach space to \mathbb{Q} itself has a fixed point. \square

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Labor market outcomes

- ▶ The matching set
- ▶ The wages
- ▶ Equal wage lines
- ▶ The unemployment
- ▶ Jobs
- ▶ Vacancies
- ▶ The price function's attributes

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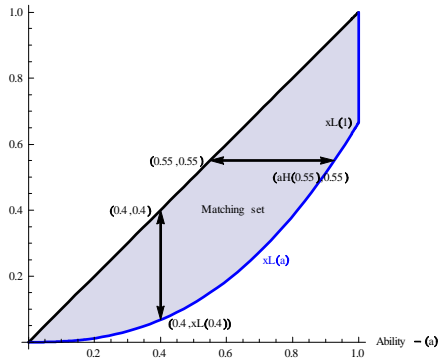
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The matching set

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Full productivity span

Ability Requirement - (x)



- ▶ The matching set are the pairs of workers and jobs that exist in equilibrium.
- ▶ Workers have an acceptance range bounded above by their ability and below by their strategy.
- ▶ Jobs have an acceptance range bounded below by their ability requirements and above by the workers'

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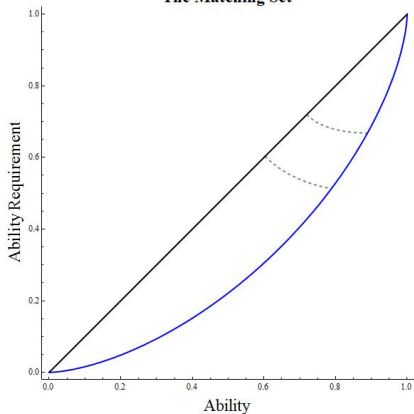
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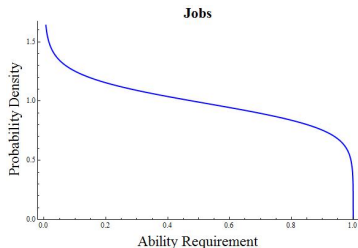
Equal wage lines

The Matching Set



- ▶ On the 45° line the worker receives the highest wage and the firm obtains the highest instantaneous profit.
- ▶ The more talented workers working in less demanding jobs receive the same wage as less talented workers working in more demanding jobs, thus creating the equal wage lines.

- ▶ **Identical workers are being paid differently** (although all firms are ex-ante identical).
 - ▶ Workers settle for "good enough" offers, in order to avoid continuing their search.
- ▶ Identical jobs are paying different wages and thus their instantaneous profits are different.
 - ▶ Nash bargaining forces firms to pay higher wages to workers with higher abilities due to their outside options' value.
- ▶ There is a **markup** between the average wage paid in jobs producing a good and the price of that good.



- ▶ On the lower side of the labor market there is an abundance of workers and therefore of jobs.
- ▶ On the high side of the labor market the scarcity of the workers induces a declining number of jobs.

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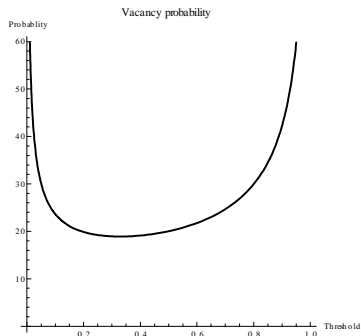
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Vacancies



- ▶ At the bottom of the labor market there are many vacancies due to abundance of workers.
- ▶ At the top of the labor market the probability of a vacancy depend on two forces:
 - ▶ The scarcity of talented workers governs the probability of finding a match.
 - ▶ The profit from a more talented worker is higher.

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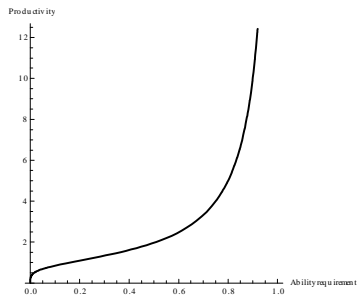
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How should the price function look like?



- ▶ $P(0) = 0$ $P'(0) = \infty$
- ▶ $P(1) = \infty$ $P|_{x \approx 1} \approx \frac{1}{1-x}$
- ▶ These conditions are required in order to exploit the full productivity range.
- ▶ Intuition: The probability of worker with ability higher than x is $(1 - x)$.

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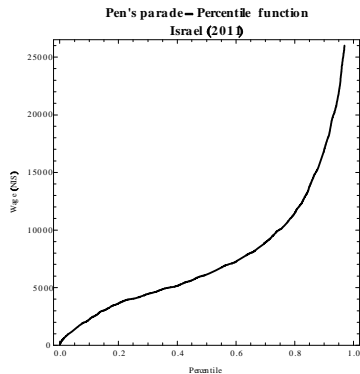
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The price function and the wage distribution

The wage percentile of Israel wages (2011)



Author's computation from CBS Survey of income data

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General equilibrium

- ▶ A competitive goods market
- ▶ Consumer utilities and demand
- ▶ An endogenous price function
- ▶ A general equilibrium
- ▶ An existence theorem
- ▶ The properties of the endogenous wage distribution

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- ▶ The consumer problem with CES utility is:

$$\begin{aligned} & \max \int_{x=0}^1 U(Q(x)) dx \\ & s.t. \int_{x=0}^1 Q(x) P(x) dx \leq M \end{aligned}$$

- ▶ **Note: This is a competitive goods market.**

- ▶ not a monopolistic competition goods market.

- ▶ Goods are different, but the **demand function is the same**

- ▶ The goods market clearing condition:

$$\ulcorner (1 - u) G'_j(x) = Q(x)$$

An endogenous price function

- ▶ Assume U is CRRA utility:
 - ▶ $U(Q) = \ln(Q) \quad \eta = 0$
 - ▶ $U(Q) = -\text{sgn}(\eta) Q^{-\eta}$ for $-1 < \eta \neq 0$
- ▶ The price can be computed to be:
 - ▶ $P(x) = Q(x)^{-\eta-1} \frac{\bar{P}}{Q^{-\eta-1}}$
- ▶ η is the "love of variety" (Dixit and Stieglitz 1977).
- ▶ Higher η means more disutility from the consumption of a small amount of a good.
- ▶ In equilibrium the endogenous price function $P(x)$ exhibits all the necessary properties of the exogenous price function defined above.

An equilibrium

- ▶ **A stationary equilibrium in the above economy is the following:**
 - ▶ $P(x)$ a price function
 - ▶ A measure $0 < u < 1$ of unemployed workers distributed F_U in workers' ability.
 - ▶ A measure $(1 - u)$ of employed workers distributed F_W in workers' ability.
 - ▶ A measure $(1 - u)$ of occupied jobs distributed G_J in jobs' ability requirements.
 - ▶ A measure $v > 0$ of offered vacancies distributed G_V in vacancies' ability requirements.
 - ▶ A workers' strategy $a \rightarrow x_L(a)$.
- ▶ **such that in every period:**
 - ▶ **The clearing of the goods market.**
 - ▶ All workers maximize their present discounted **utility**.
 - ▶ All firms maximize their present discounted value.
 - ▶ For all attributes of a match, the measure of jobs destroyed is equal to the measure of matches formed.

An second existence Theorem

Theorem

*Some regularity conditions on $C(x)$ are **sufficient** for the **existence** of an internal equilibrium.*

Proof.

I build a continuous functional operator \mathbb{L} from

$$\mathbb{Q} \subset L^1([0, 1]) \oplus L^1([0, 1]) \oplus L^1([0, 1])$$

composed of triplets of functions

$$(x'_L(\cdot), u \cdot F'_U(\cdot), (1 - u) G'_J(\cdot))$$

$$\text{s.t when } \mathbb{L}(x'_L(\cdot), u \cdot F'_U(\cdot), (1 - u) G'_J(\cdot)) =$$

$$(x'_L(\cdot), u \cdot F'_U(\cdot), (1 - u) G'_J(\cdot)),$$

all equations are satisfied.

By Schauder fixed point theorem. □

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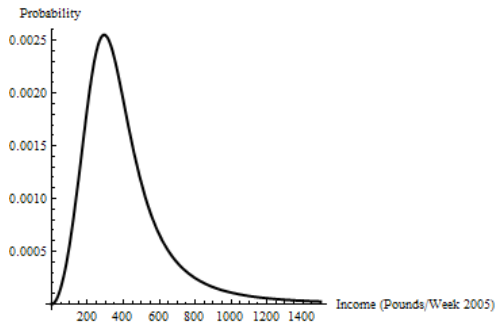
Summary

A reminder of the introduction

The empirical attributes of the earnings distribution, Neal and Rosen (2000):

"Earnings distributions . . . are always skewed to the right. Their density functions are asymmetric and display a long right tail and positive skewness measure . . . and have a "fat tail."

Typical wage distribution
Wage PDF



British income distribution from Jenkins (2009) using the GB2 distribution

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The properties of the wage distribution

The resulting wage distribution has the following properties:

1. Is asymmetric
2. Has at least one mode
3. Has a positive skewness
4. Has a positive kurtosis
5. Has a right tail with a Pareto index ranging from -2 to $-\infty$

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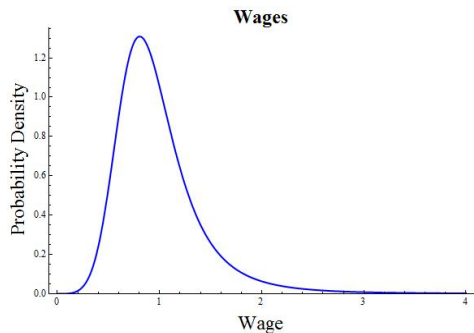
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An example



- ▶ The above wage distribution is a numerical solution of the model with parameters calibrated following Shimer (2005):
 - ▶ Discount rate 0.012, Separation rate 0.1, Bargaining power 0.72.
 - ▶ The Match probability is calibrated such that the resulting unemployment rate is 0.0567.

Summary

- ▶ I have introduced workers with a hierarchical ability into the standard search and matching model.
- ▶ As a result the ex-ante identical firms offer vacancies with different ability requirements.
- ▶ Wages and prices of goods are determined endogenously.
- ▶ Identical workers are being paid different wages due to labor market frictions.
- ▶ The equilibrium is defined and its existence is proven.
- ▶ The emergent endogenous wage distribution is proven to have the standard attributes found in empirical studies.

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Policy questions

- ▶ What is the efficiency of an assignment?

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Policy questions

▶ What is the efficiency of an assignment?

▶ Efficiency: $\int f(x, a) \frac{P(a)}{P(x)} dx da$

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Policy questions

- ▶ What is the efficiency of an assignment?
- ▶ Efficiency: $\int f(x, a) \frac{P(a)}{P(x)} dx da$
- ▶ What is the impact of income tax τ on wage distribution? How would it change the wage inequality

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- ▶ What is the efficiency of an assignment?
- ▶ Efficiency: $\int f(x, a) \frac{P(a)}{P(x)} dx da$
- ▶ What is the impact of income tax τ on wage distribution? How would it change the wage inequality
 - ▶ $C(x) = \lambda \cdot u \cdot \frac{1}{r+\delta} \cdot (1-b) \cdot \frac{(1-t)}{b+(1-b)(1-t)} \int_{a=x}^{a_H(x)} (P(x) - P(x_L(a))) dF_U(a)$

- ▶ What is the efficiency of an assignment?
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- ▶
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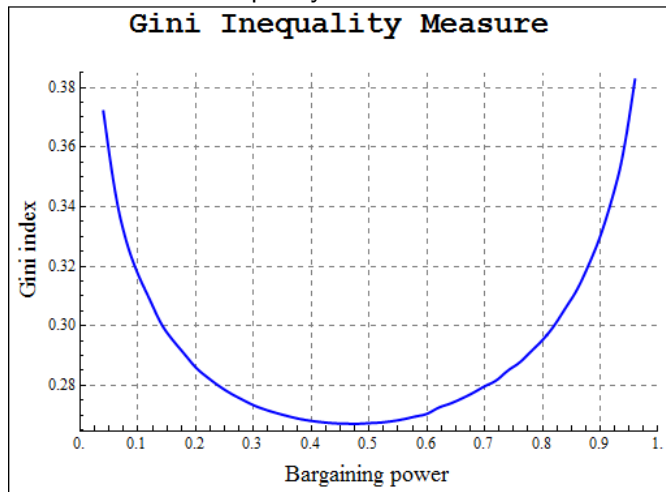
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 - ▶ $P(x_L(a)) = \lambda \cdot v \cdot \frac{1}{r+\delta} \cdot b \cdot (1-t(1-b)) \int_{x=x_L(a)}^a (P(x) - P(x_L(a))) dG_V(x)$

- ▶ What would happen if we were to decrease the bargaining power of workers?

Bargaining power and inequality

Inequality is minimal when bargaining power is balanced.
When bargaining power is imbalanced in favor of the workers or the firms the inequality rises.



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