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Search, Heterogeneity, and Optimal Income Taxation

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Search, Heterogeneity, and Optimal Income Taxation*

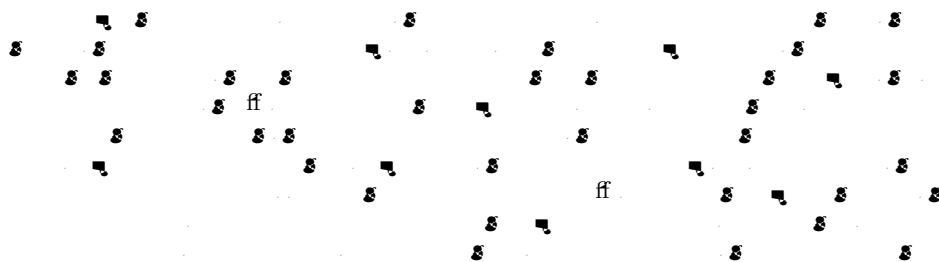
WORKING PAPER

Nikolay Dobrinov



November 9, 2009

Abstract



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2 Model

Let \mathbb{R}^n be a Euclidean space with the standard inner product $\langle \cdot, \cdot \rangle$ and the standard norm $\|\cdot\|$. Let F be a closed convex set in \mathbb{R}^n . Let H and L be two closed convex sets in \mathbb{R}^n such that $H \cap L = \emptyset$. Let I_k , $k = H; L$, be two closed convex sets in \mathbb{R}^n such that $I_k \cap I_m = \emptyset$, $m = H; L$. Let q_m , $m = H; L$, be two closed convex sets in \mathbb{R}^n such that $q_m \cap q_n = \emptyset$, $m, n = H; L$. Let $y_{km} > 0$, $k, m = H; L$, be two positive real numbers. Let $y_{Hm} > y_{Lm}$.

Let $I_k \in 0; 1$, $k = H; L$, be two real numbers. Let B be a closed convex set in \mathbb{R}^n such that $c_w(k)$, $k = H; L$, are two closed convex sets in \mathbb{R}^n such that $c_w(0) = 0$, $c'_w(0) = 0$, and $\lim_{\delta \rightarrow 1} c'_w(\delta) = +\infty$. Let V_m , $m = H; L$, be two closed convex sets in \mathbb{R}^n such that $c_\pi(V_m)$, $m = H; L$, are two closed convex sets in \mathbb{R}^n .

Let A be a closed convex set in \mathbb{R}^n such that $A \cap I_k = \emptyset$, $k = H; L$, and $A \cap V_m = \emptyset$, $m = H; L$. Let $I_k \cap V_m = \emptyset$, $k = H; L$, and $V_m \cap V_n = \emptyset$, $m, n = H; L$. Let $I_k \cap c_w(k) = \emptyset$, $k = H; L$, and $V_m \cap c_\pi(V_m) = \emptyset$, $m = H; L$.

On the other hand, if $\alpha \in \mathbb{R}^n$ is a vector, then $\alpha \cdot \alpha = \|\alpha\|^2$. For any two vectors $\alpha, \beta \in \mathbb{R}^n$, we have $\|\alpha + \beta\|^2 = (\alpha + \beta) \cdot (\alpha + \beta) = \alpha \cdot \alpha + 2\alpha \cdot \beta + \beta \cdot \beta = \|\alpha\|^2 + 2\alpha \cdot \beta + \|\beta\|^2$. This is the parallelogram law.

2.1 The matching technology

In this section, we will discuss the matching technology. Let $G = (V, E)$ be a graph with vertex set V and edge set E . A matching M in G is a set of edges such that no two edges in M share a common vertex. The maximum matching problem is to find a matching of maximum size.

The following theorem is a fundamental result in matching theory.

Theorem 2.1 (König's Theorem): In a bipartite graph, the size of a maximum matching is equal to the number of vertices in the smaller part minus the number of vertices in the maximum antichain.

The proof of this theorem is based on the concept of augmenting paths. An augmenting path is a path that starts and ends at free vertices and alternates between edges in the matching and edges not in the matching. By flipping the edges along an augmenting path, we can increase the size of the matching by one.

The following algorithm finds a maximum matching in a bipartite graph.

Algorithm 2.1 (Hungarian Algorithm):

- Find a maximum matching M in G .
- Find a minimum vertex cover C in G .
- Output M .

The correctness of this algorithm follows from König's Theorem.

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2.2 Output sharing

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2.4 Private expected utility functions

$$U_k = -c_w(\cdot) + \dots M(\cdot) \frac{V_H q_H}{m V_m q_m} \dots Y_{kH} + \frac{V_L q_L}{m V_m q_m} \dots Y_{kL} + (1 - M(\cdot))0 + (1 - \dots)0$$

$$U_k = -c_w(\cdot) + \dots M(\cdot) E_{(m)} \dots Y_{km}; \tag{5}$$

$E_{(m)}$... A ... $c(\cdot)$... $M(\cdot)$... $1 - M(\cdot)$...

3 Optimal search intensity and market inefficiencies

The search intensity I is determined by the first-order condition $\frac{\partial W}{\partial I} = 0$. This condition is derived from the social welfare function W and the market equilibrium conditions. The optimal search intensity I^* is found by solving this equation, which involves the marginal utility of consumption U^k and the marginal value of the market V^m .

3.1 Social Optimum

A social optimum is achieved when the search intensity I is chosen to maximize the social welfare function W . This involves balancing the benefits of search against the costs of search. The optimal search intensity I^* is determined by the first-order condition $\frac{\partial W}{\partial I} = 0$.

$$W = \int_{\delta, v} l_k U^k + q_m V^m$$

$$. . . k \geq 0; \quad v_m \geq 0:$$

Using (1), (2), (5), (6), the first-order condition is $\frac{\partial W}{\partial I} = -91.21$.

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$$E_{(m)}y_{km} - (1 - \alpha)E_{(k)}E_{(m)}y_{km} = E_{(k)}E_{(m)}y_{km} + E_{(m)}y_{km} - E_{(k)}E_{(m)}y_{km}.$$

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$$\begin{aligned} c'_\pi(\bar{v}_H) &= \frac{M(\bar{v}_H)}{\bar{v}_H} E_{(k)}y_{kH} - E_{(k)}E_{(m)}y_{km} & \left. \begin{array}{l} \bar{v}_H \leq 1; \\ \bar{v}_H > 0; \bar{v}_L > 0 \end{array} \right\} & (13) \\ c'_\pi(\bar{v}_L) &= \frac{M(\bar{v}_L)}{\bar{v}_L} E_{(k)}y_{kL} - E_{(k)}E_{(m)}y_{km} \end{aligned}$$

$$\begin{aligned} c'_\pi(\bar{v}_H) &= \frac{M(\bar{v}_H)}{\bar{v}_H} E_{(k)}y_{kH} - E_{(k)}E_{(m)}y_{km} & \left. \begin{array}{l} \bar{v}_H \leq 1; \\ \bar{v}_H > 0; \bar{v}_L = 0 \end{array} \right\} & (14) \\ c'_\pi(0) &\geq \frac{M(0)}{0} E_{(k)}y_{kL} - E_{(k)}E_{(m)}y_{km} \end{aligned}$$

3.2 Decentralized equilibrium

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$$\delta_k U_k = -c_w(\delta_k) + \delta_k M(\delta_k) E_{(m)} y_{km} \geq 0; \quad (15)$$

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$$-c'_w(k) + M E_{(m)} y_{km} \leq 0$$

$$k \geq 0 \tag{16}$$

$$(-c'_w(k) + M E_{(m)} y_{km}) k = 0;$$

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

$L_L \neq 0$ ($L_H = 0$), $y_{km} > 0$,

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$\frac{\partial}{\partial \tau} \left(\frac{1}{1 - \tau} \right) = \frac{1}{(1 - \tau)^2}$. On the other hand, $\frac{\partial}{\partial \tau} \left(\frac{1}{1 - \tau} \right) = \frac{1}{(1 - \tau)^2}$ if $\tau < 1$.

4.1 Characterizing externalities through Pigou taxes

$$\begin{aligned}
 c'_w(w_k) &= M'(w_k)(1 - \tau_k)w_k \\
 c'_\pi(v_m) &= \frac{M'(v_m)}{m}(1 - \tau_m)v_m
 \end{aligned}
 \left| \begin{array}{l} \leq 1; \\ k > 0; v_m > 0 \end{array} \right. ; \quad (22)$$

$$\begin{aligned}
 c'_w(0) &\geq M'(0)(1 - \tau_L)w_L \\
 c'_\pi(0) &\geq \frac{M'(0)}{L}(1 - \tau_L)v_L
 \end{aligned}
 \left| \begin{array}{l} \leq 1; \\ L = 0; v_L = 0 \end{array} \right. ; \quad (23)$$

4.1 Characterizing externalities through Pigou taxes

The first-order conditions for the planner's problem are:

$$\begin{aligned}
 \frac{\partial}{\partial w_k} &= (1 - \tau_k)M'(w_k)w_k - \frac{I_H}{k} \frac{\partial}{\partial w_k} W_H + \frac{I_L}{k} \frac{\partial}{\partial w_k} W_L + \frac{V_H q_H}{m v q} \frac{\partial}{\partial w_k} H + \frac{V_L q_L}{m v q} \frac{\partial}{\partial w_k} L \\
 \frac{\partial}{\partial v_m} &= \frac{M'(v_m)}{m}(1 - \tau_m)v_m - \frac{I_H}{m} \frac{\partial}{\partial v_m} H + \frac{I_L}{m} \frac{\partial}{\partial v_m} L
 \end{aligned}$$

where $\frac{\partial}{\partial w_k} W_H = \frac{1}{k} \frac{\partial}{\partial w_k} W_H$ and $\frac{\partial}{\partial v_m} H = \frac{1}{m} \frac{\partial}{\partial v_m} H$.

$$\begin{aligned}
 \tilde{R} &= (1 - \tau_k)M'(w_k)w_k - \frac{I_H}{k} \frac{\partial}{\partial w_k} W_H + \frac{I_L}{k} \frac{\partial}{\partial w_k} W_L + \frac{V_H q_H}{m v q} \frac{\partial}{\partial w_k} H + \frac{V_L q_L}{m v q} \frac{\partial}{\partial w_k} L \\
 0 &= \tilde{R} - \frac{I_k}{k} + \frac{I_m}{m} LS;
 \end{aligned}$$

$$(1 - \tau_k)M'(w_k)w_k = \frac{I_k}{k} - \frac{I_m}{m} LS + \frac{V_H q_H}{m v q} \frac{\partial}{\partial w_k} H + \frac{V_L q_L}{m v q} \frac{\partial}{\partial w_k} L$$

$$U_k = -c_w \frac{Z_k^w}{M'(w_k)w_k} + LS + (1 - \tau_k)Z_k^w \quad (24)$$

The first-order conditions for the planner's problem are:

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$$y_{LL} > 0, \quad \frac{\partial y_{LL}}{\partial \tau} = \frac{\partial}{\partial \tau} \left[\frac{1}{\theta} \left(\frac{V_L q_L}{m} - \frac{V_H q_H}{m} \right) \right] > 0$$

where $\frac{\partial}{\partial \tau} \left[\frac{1}{\theta} \left(\frac{V_L q_L}{m} - \frac{V_H q_H}{m} \right) \right] > 0$ because $\frac{\partial}{\partial \tau} \left(\frac{V_L q_L}{m} \right) > 0$ and $\frac{\partial}{\partial \tau} \left(\frac{V_H q_H}{m} \right) < 0$.

4.2 Optimal income taxes with positive government revenue

In this section, we consider the case where the government can raise revenue from income taxes. The government's budget constraint is given by

$$R = \int_0^1 y_{km} \tau_{km} \, dF(k) \quad (17)$$

$$W = \int_k I_k U^k + \int_m q_m V^m \quad ;$$

where I_k and V^m are the marginal utilities of income and the public good, respectively. Using (1), (2), (5), and (6), we can write the first-order conditions as

$$E_{(k)}(1 - \tau_{km}) y_{km} = \frac{Z_k^w}{M(k)} w_k, \quad Z_k^w = I_k M(k) w_k, \quad m =$$

$$E_{(k)}(1 - \tau_{km}) y_{km}, \quad Z_m^\pi = \frac{M(\theta)}{\theta} \int_k y_{km} \tau_{km} \, dF(k) \quad (18)$$

$$W = \int_k I_k \left[-c_w \frac{Z_k^w}{M(k) w_k} + \int_m q_m \left(-c_\pi \frac{Z_m^\pi}{M(\theta)} + \int_k I_k M(k) E_{(k)} E_{(m)} y_{km} \right) \right]$$

where $E_{(k)} I_k M(k) = N$ and $E_{(k)} E_{(m)} y_{km} = 1$. Using (18), we can rewrite the first-order conditions as

$$R \leq \int_k I_k M(k) \left[\frac{I_H}{k} I_H^w W_H + \frac{I_L}{k} I_L^w W_L + \frac{V_H q_H}{m v q} \frac{\pi}{H} + \frac{V_L q_L}{m v q} \frac{\pi}{L} \right] \quad ; \quad (30)$$

where $E_{(k)} I_k M(k) = M$ and $I_H^w W_H + I_L^w W_L = 1$. Using (30), we can write the government's budget constraint as

¹⁷The public good, even if valued by consumers, does not affect their choice on search intensity.

Text line 1.

$$\begin{aligned} W = & \frac{I_k}{k} - c_w \frac{Z_k^w}{M(\theta) w_k} + \frac{q_m}{m} - c_\pi \frac{Z_m^\pi}{M(\theta) m} \\ & + \left(\frac{I_H}{k} \right) M(\theta) \frac{I_H}{I} (1 - \frac{w}{H}) w_H + \frac{I_L}{k} \frac{I_L}{I} (1 - \frac{w}{L}) w_L \\ & + \frac{V_H q_H}{m v q} (1 - \frac{\pi}{H}) w_H + \frac{V_L q_L}{m v q} (1 - \frac{\pi}{L}) w_L + R: \end{aligned}$$

Main body of text with various symbols and references (1978, 1998).

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Text line 2.

$$\frac{I_k}{k} W = \frac{I_k}{k} - c_w \frac{Z_k^w}{M(\theta) w_k} + \frac{q_m}{m} - c_\pi \frac{Z_m^\pi}{M(\theta) m}$$

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The first part of the paper is devoted to the study of the
 asymptotic behavior of the solutions of the problem
 $\Delta u = f$ in the domain Ω as $\epsilon \rightarrow 0$.
 In the second part, we consider the problem of the
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 In the ninth part, we consider the problem of the
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 In the tenth part, we consider the problem of the
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$$i) @ \frac{w}{L} = @ \frac{E_{(m)} H_m}{E_{(m)} L_m} < 0 \tag{36}$$

$$ii) @ \frac{w}{\pi} = @ () < 0 \tag{37}$$

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5 Conclusion

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Appendices:

A Proofs of the main results

Proof of Corollary 3.

For $\theta > 0$, $\theta < 1$, $\theta \neq 1$. If $\theta > 1$, $v_H(\theta) > v_H(1)$, $v_L(\theta) > v_L(1)$, $v_H(\theta) < v_H(1)$, $v_L(\theta) < v_L(1)$. If $\theta < 1$, $v_H(\theta) > v_H(1)$, $v_L(\theta) > v_L(1)$, $v_H(\theta) < v_H(1)$, $v_L(\theta) < v_L(1)$.

$$\begin{aligned}
 \check{R} &= N \left[\begin{aligned} & \frac{\delta_H l_H}{k \delta l} (1 -) E_{(k)} E_{(m)} y_{km} - E_{(m)} (1 -_{Hm}) y_{Hm} \\ & + \frac{\delta_L l_L}{k \delta l} (1 -) E_{(k)} E_{(m)} y_{km} - E_{(m)} (1 -_{Lm}) y_{Lm} \\ & + \frac{v_H q_H}{m v q} (1 - (1 -)) E_{(k)} E_{(m)} y_{km} - E_{(k)}_{kH} y_{kH} \\ & + \frac{v_L q_L}{m v q} (1 - (1 -)) E_{(k)} E_{(m)} y_{km} - E_{(k)}_{kL} y_{kL} \end{aligned} \right] \\
 &= N \left[\begin{aligned} & \frac{\delta_H l_H}{k \delta l} (1 -) E_{(k)} E_{(m)} y_{km} - E_{(m)} (1 -_{Hm}) y_{Hm} \\ & + \frac{\delta_L l_L}{k \delta l} (1 -) E_{(k)} E_{(m)} y_{km} - E_{(m)} (1 -_{Lm}) y_{Lm} \\ & + \frac{v_H q_H}{m v q} (1 -) E_{(k)} E_{(m)} y_{km} - E_{(k)}_{kH} y_{kH} \\ & + \frac{v_L q_L}{m v q} (1 -) E_{(k)} E_{(m)} y_{km} - E_{(k)}_{kL} y_{kL} \end{aligned} \right]
 \end{aligned}$$

$$\check{R} = N (1 - (+))$$

$\frac{\partial U_k}{\partial w_k} = -c_w () + M() (1 - \frac{w}{k}) w_k$
 $= -c_w \frac{Z_k^w}{M() w_k} + (1 - \frac{w}{k}) Z_k^w$
 $\frac{\partial U_k}{\partial w_k} = -c'_w \frac{1}{M() w_k} \frac{\partial Z_k^w}{\partial w_k} - c'_w \frac{Z_k^w}{M()} - \frac{1}{w_k^2} + \frac{\partial Z_k^w}{\partial w_k} (1 - \frac{w}{k}) = c'_w \frac{Z_k^w}{M() w_k} > 0;$

Proof of Lemma 7.

$U_k = -c_w () + M() (1 - \frac{w}{k}) w_k$

$$\begin{aligned}
 U_k &= -c_w () + M() (1 - \frac{w}{k}) w_k \\
 &= -c_w \frac{Z_k^w}{M() w_k} + (1 - \frac{w}{k}) Z_k^w
 \end{aligned}$$

$\frac{\partial U_k}{\partial w_k} = -c'_w \frac{1}{M() w_k} \frac{\partial Z_k^w}{\partial w_k} - c'_w \frac{Z_k^w}{M()} - \frac{1}{w_k^2} + \frac{\partial Z_k^w}{\partial w_k} (1 - \frac{w}{k}) = c'_w \frac{Z_k^w}{M() w_k} > 0;$

$\frac{\partial U_k}{\partial w_k} = -c'_w \frac{1}{M() w_k} \frac{\partial Z_k^w}{\partial w_k} - c'_w \frac{Z_k^w}{M()} - \frac{1}{w_k^2} + \frac{\partial Z_k^w}{\partial w_k} (1 - \frac{w}{k}) = c'_w \frac{Z_k^w}{M() w_k} > 0;$

Proof of Proposition 8.

$$I_{\ast} \quad \text{||} \quad I \quad \xi \quad \text{||} \quad \ast \quad \ast \quad \ast : w_k = E_{(m)} w_{km} = E_{(m)} y_{km} \quad \xi \quad \xi \quad \xi \quad \bullet \quad \xi$$

$$\xi \quad \xi \quad \xi \quad \xi \quad \xi \quad k = H; L; z_k^w = M_{(k)} w_k \quad \xi \quad \xi \quad \xi \quad \bullet \quad \xi \quad \xi \quad \ast \quad \ast \quad \ast \quad \xi$$

$$\xi \quad \xi \quad k = H; L; \quad m = E_{(k)} y_{km} = E_{(k)} (1 - \xi_{km}) y_{km} \quad \xi \quad \xi \quad \xi \quad \bullet \quad \xi \quad \xi \quad \xi \quad \xi \quad \text{fi}$$

$$\xi \quad e \quad \ast \quad \ast \quad \ast \quad \xi \quad m = H; L; \quad \ast \quad z_m^\pi = v_m^M \quad \xi$$

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π

$\frac{dz_H^w}{z_H^w} = \frac{1}{\sigma_H^w} + (1 - \alpha) \frac{I_H}{k} = (1 - \alpha) E_{(m)} \frac{dz_m^\pi}{z_m^\pi} - \frac{I_L}{k} \frac{dz_L^w}{z_L^w} - \frac{d}{1 - \pi}$

$$\frac{dz_H^w}{z_H^w} = \frac{1}{\sigma_H^w} + (1 - \alpha) \frac{I_H}{k} = (1 - \alpha) E_{(m)} \frac{dz_m^\pi}{z_m^\pi} - \frac{I_L}{k} \frac{dz_L^w}{z_L^w} - \frac{d}{1 - \pi} \quad (L)$$

$$\frac{dz_H^\pi}{Z_H^\pi} \frac{1}{\pi_H} = \frac{E_{(k)} \left(\frac{dz_k^w}{z_k^w} + \frac{d\tau_L^\pi}{1-\tau_L^\pi} \frac{v_L q_L}{m v q} \pi_H - \frac{d\tau_H^\pi}{1-\tau_H^\pi} \left(1 + \frac{v_L q_L}{m v q} \pi_H \right) \right)}{\Delta_2} \quad (45)$$

$$\frac{dz_L^\pi}{Z_L^\pi} \frac{1}{\pi_L} = \frac{E_{(k)} \left(\frac{dz_k^w}{z_k^w} - \frac{d\tau_L^\pi}{1-\tau_L^\pi} \left(1 + \frac{v_H q_H}{m v q} \pi_H + \frac{d\tau_H^\pi}{1-\tau_H^\pi} \frac{v_H q_H}{m v q} \pi_H \right) \right)}{\Delta_2}; \quad (46)$$

$$\Delta_2 = 1 + E_{(m)} \frac{\pi_H}{\pi_m}. \quad (45) \quad (46)$$

$$E_{(m)} \frac{dz_m^\pi}{Z_m^\pi} = \frac{E_{(k)} \left(\frac{dz_k^w}{z_k^w} E_{(m)} \frac{\pi_H}{\pi_m} - E_{(m)} \left(\frac{\pi_H}{\pi_m} \frac{d\tau_m^\pi}{1-\tau_m^\pi} \right) \right)}{\Delta_2}; \quad (47)$$

$$(43) \quad (44)$$

$$E_{(k)} \frac{dz_k^w}{Z_k^w} = \frac{(1 -) E_{(m)} \left(\frac{dz_m^\pi}{z_m^\pi} E_{(k)} \frac{\pi_H}{\pi_m} - E_{(k)} \left(\frac{\pi_H}{\pi_m} \frac{d\tau_k^w}{1-\tau_k^w} \right) \right)}{\Delta_1}; \quad (48)$$

$$E_{(m)} \left(\frac{dz_m^\pi}{z_m^\pi} E_{(k)} \frac{\pi_H}{\pi_m} - E_{(k)} \left(\frac{dz_k^w}{z_k^w} \right) \right) = \dots$$

$$E_{(m)} \frac{dz_m^\pi}{Z_m^\pi} = - \frac{(\Delta_2 - 1) E_{(k)} \left(\frac{\pi_H}{\pi_m} \frac{d\tau_k^w}{1-\tau_k^w} + \Delta_1 E_{(m)} \left(\frac{\pi_H}{\pi_m} \frac{d\tau_m^\pi}{1-\tau_m^\pi} \right) \right)}{\Delta_1 + \Delta_2 - 1} \quad (49)$$

$$E_{(k)} \frac{dz_k^w}{Z_k^w} = - \frac{\Delta_2 E_{(k)} \left(\frac{\pi_H}{\pi_m} \frac{d\tau_k^w}{1-\tau_k^w} + (\Delta_1 - 1) E_{(m)} \left(\frac{\pi_H}{\pi_m} \frac{d\tau_m^\pi}{1-\tau_m^\pi} \right) \right)}{\Delta_1 + \Delta_2 - 1} \quad (50)$$

$$(49) \quad (43) \quad (44), \quad (50) \quad (45) \quad (46) \quad \dots$$

$$\frac{dz_H^w}{Z_H^w} \frac{1}{\pi_H} = - \frac{(1 -) (\Delta_2 - 1) E_{(k)} \left(\frac{\pi_H}{\pi_m} \frac{d\tau_k^w}{1-\tau_k^w} + \Delta_1 E_{(m)} \left(\frac{\pi_H}{\pi_m} \frac{d\tau_m^\pi}{1-\tau_m^\pi} \right) \right)}{\Delta_1 (\Delta_1 + \Delta_2 - 1)} + \frac{(\Delta_1 + \Delta_2 - 1) \frac{d\tau_L^w}{1-\tau_L^w} (1 -) \frac{\delta_L l_L}{\delta l} \pi_H - \frac{d\tau_H^w}{1-\tau_H^w} \left(1 + (1 -) \frac{\delta_L l_L}{\delta l} \pi_H \right)}{\Delta_1 (\Delta_1 + \Delta_2 - 1)}; \quad (51)$$

$$\frac{dz_L^w}{Z_L^w} \frac{1}{\pi_L} = - \frac{(1 -) (\Delta_2 - 1) E_{(k)} \left(\frac{\pi_H}{\pi_m} \frac{d\tau_k^w}{1-\tau_k^w} + \Delta_1 E_{(m)} \left(\frac{\pi_H}{\pi_m} \frac{d\tau_m^\pi}{1-\tau_m^\pi} \right) \right)}{\Delta_1 (\Delta_1 + \Delta_2 - 1)} + \frac{(\Delta_1 + \Delta_2 - 1) - \frac{d\tau_L^w}{1-\tau_L^w} \left(1 + (1 -) \frac{\delta_H l_H}{\delta l} \pi_H \right) + \frac{d\tau_H^w}{1-\tau_H^w} (1 -) \frac{\delta_H l_H}{\delta l} \pi_H}{\Delta_1 (\Delta_1 + \Delta_2 - 1)}; \quad (52)$$

$$\begin{aligned}
\frac{dz_H^w}{d\tau_H^\pi} \frac{1}{Z_H^w} &= - \frac{\frac{\varepsilon_H^\pi}{1-\tau_H^\pi} \frac{v_H q_H}{m v q} \frac{n_w}{H} (1 -)}{\Delta_1 + \Delta_2 - 1} \\
\frac{dz_L^w}{d\tau_H^\pi} \frac{1}{Z_L^w} &= - \frac{\frac{\varepsilon_H^\pi}{1-\tau_H^\pi} \frac{v_H q_H}{m v q} \frac{n_w}{L} (1 -)}{\Delta_1 + \Delta_2 - 1} \\
\frac{dz_H^\pi}{d\tau_H^\pi} \frac{1}{Z_H^\pi} &= \frac{\frac{n_H^\pi}{1 - \frac{\pi}{H}} \frac{n_H^\pi \frac{v_H q_H}{m v q}}{\Delta_1 + \Delta_2 - 1} - (\Delta_1 + \Delta_2 - 1)}{\Delta_1 + \Delta_2 - 1} \\
\frac{dz_L^\pi}{d\tau_H^\pi} \frac{1}{Z_L^\pi} &= \frac{\frac{\varepsilon_H^\pi}{1-\tau_H^\pi} \frac{v_H q_H}{m v q} \frac{n_\pi}{L}}{\Delta_1 + \Delta_2 - 1}
\end{aligned} \tag{57}$$

$$\begin{aligned}
\frac{dz_H^w}{d\tau_L^\pi} \frac{1}{Z_H^w} &= - \frac{\frac{\varepsilon_L^\pi}{1-\tau_L^\pi} \frac{v_L q_L}{m v q} \frac{n_w}{H} (1 -)}{\Delta_1 + \Delta_2 - 1} \\
\frac{dz_L^w}{d\tau_L^\pi} \frac{1}{Z_L^w} &= - \frac{\frac{\varepsilon_L^\pi}{1-\tau_L^\pi} \frac{v_L q_L}{m v q} \frac{n_w}{L} (1 -)}{\Delta_1 + \Delta_2 - 1} \\
\frac{dz_H^\pi}{d\tau_L^\pi} \frac{1}{Z_H^\pi} &= \frac{\frac{\varepsilon_L^\pi}{1-\tau_L^\pi} \frac{v_L q_L}{m v q} \frac{n_\pi}{H}}{\Delta_1 + \Delta_2 - 1} \\
\frac{dz_L^\pi}{d\tau_L^\pi} \frac{1}{Z_L^\pi} &= \frac{\frac{n_L^\pi}{1 - \frac{\pi}{L}} \frac{n_L^\pi \frac{v_L q_L}{m v q}}{\Delta_1 + \Delta_2 - 1} - (\Delta_1 + \Delta_2 - 1)}{\Delta_1 + \Delta_2 - 1}
\end{aligned} \tag{58}$$

τ_k^w, τ_m^π

$$\begin{aligned}
W &= I_k - c_w \frac{Z_k^w}{M(\cdot) w_k} + q_m - c_\pi \frac{Z_m^\pi}{\frac{M(\theta)}{\theta} m} \\
&+ {}_H I_H c'_w \frac{Z_H^w}{M(\cdot) w_H} + {}_L I_L c'_w \frac{Z_L^w}{M(\cdot) w_L} + v_H q_H c'_\pi \frac{Z_H^\pi}{\frac{M(\theta)}{\theta} H} + v_L q_L c'_\pi \frac{Z_L^\pi}{\frac{M(\theta)}{\theta} L} + R \\
&+ ({}_k I) M(\cdot) - \frac{{}_H I_H}{{}_k I} {}^w w_H + \frac{{}_L I_L}{{}_k I} {}^w w_L + \frac{v_H q_H}{m v q} \frac{\pi}{H} {}^H H + \frac{v_L q_L}{m v q} \frac{\pi}{L} {}^L L ;
\end{aligned}$$

D

$$a = \frac{{}_H I_H}{{}_k I} {}^w w_H + \frac{{}_L I_L}{{}_k I} {}^w w_L \quad b = \frac{v_H q_H}{m v q} \frac{\pi}{H} {}^H H + \frac{v_L q_L}{m v q} \frac{\pi}{L} {}^L L :$$

$\xi \quad \xi \quad \frac{w}{H}$

$$\begin{aligned}
 & \frac{\partial L}{\partial \frac{w}{H}} = \\
 & = \quad I_k - \frac{c'_w}{M(\cdot)w_k} \frac{dz_k^w}{d\frac{w}{H}} + \quad q_m - \frac{c'_\pi}{M(\theta)_m} \frac{dz_m^\pi}{d\frac{w}{H}} \\
 & + \frac{dz_H^w}{d\frac{w}{H}} \frac{1}{M(\cdot)w_H} l_H c'_w \frac{z_H^w}{M(\cdot)w_H} + \quad + {}_H l_H c''_w \frac{z_H^w}{M(\cdot)w_H} \frac{1}{M(\cdot)w_H} \frac{dz_H^w}{d\frac{w}{H}} \\
 & + \frac{dz_L^w}{d\frac{w}{H}} \frac{1}{M(\cdot)w_L} l_L c'_w \frac{z_L^w}{M(\cdot)w_L} + \quad + {}_L l_L c''_w \frac{z_L^w}{M(\cdot)w_L} \frac{1}{M(\cdot)w_L} \frac{dz_L^w}{d\frac{w}{H}} \\
 & + \frac{dz_H^\pi}{d\frac{w}{H}} \frac{1}{M(\theta)_H} q_H c'_\pi \frac{z_H^\pi}{M(\theta)_H} + \quad + {}_H q_H c''_\pi \frac{z_H^\pi}{M(\theta)_H} \frac{1}{M(\theta)_H} \frac{dz_H^\pi}{d\frac{w}{H}}
 \end{aligned}$$

$$+ \frac{dz_L^\pi}{d\frac{w}{H}} \frac{1}{M(\theta)_L} q_L c'_\pi \frac{z_L^\pi}{M(\theta)_L} + \quad + {}_L q_L c''_\pi \frac{z_L^\pi}{M(\theta)_L} \frac{1}{M(\theta)_L} \frac{dz_L^\pi}{d\frac{w}{H}}$$

$$\left[\quad + \left[\quad \frac{I_k}{M(\cdot)w_k} \frac{dz_k^w}{d\frac{w}{H}} \quad M(\cdot) + \left(\quad k \right) l) M(\cdot) \quad \frac{m}{k} \frac{\frac{q_m}{M(\theta)_m} \frac{dz_m^\pi}{d\frac{w}{H}}}{l} - \frac{(\quad m \ vq)}{\left(\quad k \right) l^2} \quad \frac{k \left(\frac{l_k}{M(\theta)_k} \frac{dz_k^w}{d\frac{w}{H}} \right)}{\left(\quad k \right) l^2} \quad \right] (a + b) \right]$$

$$+ \left(\quad k \right) l) M(\cdot)$$

$$\begin{aligned}
& \xi \quad \xi \quad \text{fi} \quad \xi \quad \xi \quad \xi \quad \xi \quad \xi \\
& {}_H l_H c''_w \frac{z_H^w}{M(\cdot) w_H} \frac{1}{M(\cdot) w_H} \frac{dz_H^w}{d \cdot} + {}_L l_L c''_w \frac{z_L^w}{M(\cdot) w_L} \\
& + v_H q_H c''_\pi \frac{z_H^\pi}{M(\theta)_H} \frac{1}{M(\theta)_H} \frac{dz_H^\pi}{d \cdot} + v_L q_L c''_\pi \frac{z_L^\pi}{M(\theta)_L} \\
& + \left(\begin{matrix} k \\ k \end{matrix} \right) M(\cdot) \left[\frac{k \left(\frac{l_k}{M(\theta) w_k} \frac{dz_k^w}{d \tau_H^w} \right)}{k} + \frac{M'(\cdot)}{M(\cdot)} \right] \frac{m}{\left(\frac{l_k}{M(\theta) w_k} \frac{dz_k^w}{d \tau_H^w} \right)} \Big| (a+b) =
\end{aligned}$$

$$\begin{aligned}
& = {}_H l_H c''_w \frac{z_H^w}{M(\cdot) w_H} \frac{1}{M(\cdot) w_H} \frac{dz_H^w}{d \cdot} \frac{z_H^w}{z_H^w} \frac{M(\cdot)}{c'_w(z_H^w = M(\cdot) w_H)} \\
& + {}_L l_L c''_w \frac{z_L^w}{M(\cdot) w_L} \frac{1}{M(\cdot) w_L} \frac{dz_L^w}{d \cdot} \frac{z_L^w}{z_L^w} \frac{M(\cdot) (1 - \frac{w}{L}) w_L}{c'_w(z_L^w = M(\cdot) w_L)} \\
& + v_H q_H c''_\pi \frac{z_H^\pi}{M(\theta)_H} \frac{1}{M(\theta)_H} \frac{dz_H^\pi}{d \cdot} \frac{z_H^\pi}{z_H^\pi} \frac{M(\cdot) (1 - \frac{\pi}{H})_H}{c'_\pi(z_H^\pi = \frac{M(\cdot)}{H})} \\
& + v_L q_L c''_\pi \frac{z_L^\pi}{M(\theta)_L} \frac{1}{M(\theta)_L} \frac{dz_L^\pi}{d \cdot} \frac{z_L^\pi}{z_L^\pi} \frac{M(\cdot) (1 - \frac{\pi}{L})_L}{c'_\pi(z_L^\pi = \frac{M(\cdot)}{L})} \\
& + \left(\begin{matrix} k \\ k \end{matrix} \right) M(\cdot) \left[\frac{k \left(\frac{l_k}{M(\theta) w_k} \frac{dz_k^w}{d \tau_H^w} \right)}{k} \right]
\end{aligned}$$

$$= {}_H l_H \frac{1}{d_H^w} \frac{dz_H^w}{z_H^w}$$

$\frac{\pi}{H}$ $\frac{\pi}{L}$

$$(\Delta_1 + \Delta_2 - 1) (1 -)^{1 - \frac{w}{L}}$$

$$\begin{aligned}
& \left[\begin{aligned}
& \left(\frac{\delta_{HL} l_H}{k} \frac{v_L q_L}{\delta l} \frac{v_H q_H}{m v q} + \frac{\delta_{LL} l_L}{k} \frac{v_H q_H}{\delta l} \frac{v_L q_L}{m v q} \right) W_{HH} + \left(\frac{\delta_{HL} l_H}{k} \frac{v_H q_H}{\delta l} \frac{v_L q_L}{m v q} + \frac{\delta_{LL} l_L}{k} \frac{v_L q_L}{\delta l} \frac{v_H q_H}{m v q} \right) W_{HL} \\
& + \left(\frac{\delta_{HL} l_H}{k} \frac{v_H q_H}{\delta l} \frac{v_L q_L}{m v q} + \frac{\delta_{LL} l_L}{k} \frac{v_L q_L}{\delta l} \frac{v_H q_H}{m v q} \right) W_{LH} + \left(\frac{\delta_{HL} l_H}{k} \frac{v_L q_L}{\delta l} \frac{v_H q_H}{m v q} + \frac{\delta_{LL} l_L}{k} \frac{v_H q_H}{\delta l} \frac{v_L q_L}{m v q} \right) W_{LL} \\
& + \left(\frac{\delta_{HL} l_H}{k} \frac{v_L q_L}{\delta l} \frac{v_H q_H}{m v q} + \frac{\delta_{LL} l_L}{k} \frac{v_H q_H}{\delta l} \frac{v_L q_L}{m v q} \right) W_{HH} + \left(\frac{\delta_{HL} l_H}{k} \frac{v_H q_H}{\delta l} \frac{v_L q_L}{m v q} + \frac{\delta_{LL} l_L}{k} \frac{v_L q_L}{\delta l} \frac{v_H q_H}{m v q} \right) W_{HL} \\
& + \left(\frac{\delta_{HL} l_H}{k} \frac{v_H q_H}{\delta l} \frac{v_L q_L}{m v q} + \frac{\delta_{LL} l_L}{k} \frac{v_L q_L}{\delta l} \frac{v_H q_H}{m v q} \right) W_{LH} + \left(\frac{\delta_{HL} l_H}{k} \frac{v_L q_L}{\delta l} \frac{v_H q_H}{m v q} + \frac{\delta_{LL} l_L}{k} \frac{v_H q_H}{\delta l} \frac{v_L q_L}{m v q} \right) W_{LL}
\end{aligned} \right]^{-1} \\
= & 1 - \frac{1 - \tau_H^w}{\varepsilon_H^w} W_H + \frac{1 - \tau_L^w}{\varepsilon_L^w} W_L + \frac{1 - \tau_H^\pi}{\varepsilon_H^\pi} W_H + \frac{1 - \tau_L^\pi}{\varepsilon_L^\pi} W_L ;
\end{aligned}$$

$$= 1 - \frac{E_{(s)} W_{Hs}^w + E_{(s)} W_{Ls}^w + E_{(s)} W_{Hs}^\pi + E_{(s)} W_{Ls}^\pi}{\frac{1 - \tau_H^w}{\varepsilon_H^w} W_H + \frac{1 - \tau_L^w}{\varepsilon_L^w} W_L + \frac{1 - \tau_H^\pi}{\varepsilon_H^\pi} W_H + \frac{1 - \tau_L^\pi}{\varepsilon_L^\pi} W_L} ; \quad (64)$$

$\left(\frac{\delta_{HL} l_H}{k} \frac{v_L q_L}{\delta l} \frac{v_H q_H}{m v q} + \frac{\delta_{LL} l_L}{k} \frac{v_H q_H}{\delta l} \frac{v_L q_L}{m v q} \right) W_{HH} + \left(\frac{\delta_{HL} l_H}{k} \frac{v_H q_H}{\delta l} \frac{v_L q_L}{m v q} + \frac{\delta_{LL} l_L}{k} \frac{v_L q_L}{\delta l} \frac{v_H q_H}{m v q} \right) W_{HL} + \left(\frac{\delta_{HL} l_H}{k} \frac{v_H q_H}{\delta l} \frac{v_L q_L}{m v q} + \frac{\delta_{LL} l_L}{k} \frac{v_L q_L}{\delta l} \frac{v_H q_H}{m v q} \right) W_{LH} + \left(\frac{\delta_{HL} l_H}{k} \frac{v_L q_L}{\delta l} \frac{v_H q_H}{m v q} + \frac{\delta_{LL} l_L}{k} \frac{v_H q_H}{\delta l} \frac{v_L q_L}{m v q} \right) W_{LL}$

Let c'

$$c' = \frac{1}{c} = \frac{1}{-1}.$$

Let $\gamma > 1$, $\beta > 1$, $A > 0$, $\gamma > \beta$: Let $\gamma > 1$, $\beta > 1$.

$$c = A(\gamma + \beta) \geq 3, \quad c' = A(\gamma^{-1} + \beta^{-1}),$$

$$c'' = A((\gamma - 1)^{\gamma-2} + (\beta - 1)^{\beta-2}) > 0;$$

$$c'' = \frac{\gamma^{-2} + \beta^{-2}}{(\gamma - 1)^{\gamma-2} + (\beta - 1)^{\beta-2}}.$$

Let $\gamma > 1$, $\beta > 1$, $A > 0$, $\gamma > \beta$, $\gamma > 1$, $\beta > 1$.

$$\frac{c''}{c} = -\beta^{\gamma-5}(\gamma - \beta)^2 < 0:$$

Let $\gamma > 3$, $\beta = -1$, $\gamma > 1$, $\beta > 1$. Let $\gamma > 3$, $\beta = -1$.

$$\gamma < 1, \quad \beta = 3, \quad \gamma = 2, \quad \beta > 1, \quad \gamma = 2, \quad \beta = 1.$$

$$\frac{1-\tau_H^w}{\varepsilon_H^w} W_H < \frac{1-\tau_L^w}{\varepsilon_L^w} W_L, \quad (66)$$

$$(1 - \frac{w}{H})W_H < (1 - \frac{w}{L})W_L, \quad \frac{w}{H} > \frac{w}{L}$$

(66) $\frac{w}{H} W_H > \frac{w}{L} W_L$. Let $(E_{(m)Hm}^{\pi} - E_{(m)Lm}^{\pi})$.

$$(E_{(m)HH}^{\pi} > E_{(m)LH}^{\pi}, \quad E_{(m)HL}^{\pi} > E_{(m)LL}^{\pi}) \quad (E_{(m)Hm}^{\pi} - E_{(m)Lm}^{\pi} > 0).$$

Let (66)

$$(1 - \frac{w}{H})W_H > (1 - \frac{w}{L})W_L, \quad H > L, \quad \frac{u_H^w}{H} \leq \frac{u_L^w}{L}. \quad \square$$

Proof of Proposition 11.

$$\text{fi} \quad \text{ii} \quad (65).$$

Let fi , ii , iii , iv , v , vi , vii , viii , ix , x , xi , xii , xiii , xiv , xv , xvi , xvii , xviii , xix , xx , xxi , xxii , xxiii , xxiv , xxv , xxvi , xxvii , xxviii , xxix , xxx .

Let ii , iii , iv , v , vi , vii , viii , ix , x , xi , xii , xiii , xiv , xv , xvi , xvii , xviii , xix , xx , xxi , xxii , xxiii , xxiv , xxv , xxvi , xxvii , xxviii , xxix , xxx .

$$\text{ii} \quad \text{fi} \quad (60)-(63)$$

Let ii , iii , iv , v , vi , vii , viii , ix , x , xi , xii , xiii , xiv , xv , xvi , xvii , xviii , xix , xx , xxi , xxii , xxiii , xxiv , xxv , xxvi , xxvii , xxviii , xxix , xxx .

Let ii , iii , iv , v , vi , vii , viii , ix , x , xi , xii , xiii , xiv , xv , xvi , xvii , xviii , xix , xx , xxi , xxii , xxiii , xxiv , xxv , xxvi , xxvii , xxviii , xxix , xxx .

Let ii , iii , iv , v , vi , vii , viii , ix , x , xi , xii , xiii , xiv , xv , xvi , xvii , xviii , xix , xx , xxi , xxii , xxiii , xxiv , xxv , xxvi , xxvii , xxviii , xxix , xxx .

Δ_1 Δ_2 Δ_3 Δ_4 (60) Δ_5 (61) Δ_6 Δ_7 Δ_8

$$\begin{aligned}
 & (\Delta_1 + \Delta_2 - 1) (1 - \Delta_3) \frac{1 - \Delta_4}{\Delta_5} w + (w^{\Delta_6} + \Delta_7 - (1 - \Delta_8) \bar{R}) = \\
 & = (1 - \Delta_3) [(1 - \Delta_4) w + (w^{\Delta_6} + \Delta_7 - (1 - \Delta_8) \bar{R}^{\Delta_5})]
 \end{aligned}$$

—

(68), $\epsilon \cdot 1$ (69), $\epsilon \cdot P$ 11. $\epsilon \cdot \epsilon$
 P 12 Π $\epsilon \cdot \epsilon \cdot 1$ $\epsilon \cdot \epsilon$ $\epsilon \cdot \epsilon$ $\epsilon \cdot \epsilon$ $\epsilon \cdot \epsilon$
 $\epsilon \cdot \epsilon$, $\epsilon \cdot \epsilon$ $\epsilon \cdot \epsilon \cdot 1$ $\epsilon \cdot (1 -)$, $(1 -) = \uparrow$, $\epsilon \cdot \epsilon$
 $\epsilon \cdot \epsilon$ $\epsilon \cdot \epsilon$ $\epsilon \cdot \epsilon$ $\epsilon \cdot \epsilon$, $\pi = w \downarrow$. \square