ON SOME ENDOGENOUS PROBABILITY-MIGRATION MODELS

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ABSTRACT. We analyze a probability-migration model in which the probability of migration depends on human capital, as in H.-J. Chen [3]. We show that the human capital can converge to a low or high value depending not only on the functional dependence of the probability of migration on human capital, but also on the initial human capital conditions and on beliefs of the population. Thanks to some new selection mechanisms of migration, we can analyze precisely how economies with similar backgrounds may follow different equilibrium paths because they have different beliefs about their future probability of migration.

1. INTRODUCTION

We are interested in the spacial economy in the sense where one considers at least two geographical places where can be carried out a migration of the individuals. We study here a mathematical model of Chen related to the probability of migration from a country A towards a country B. Work founders of the economic analysis of the decision to migrate place the search of better returned like an essential reason for the decision of migration: see Hicks [9], Sjaastad [14], and see Bhagwati and Rodriguez [1], Wilson [18], Lien and Wang [11], Mountford [12] and also Docquier et al. [7] for "Brain-Drain" litterature.

But, other reasons can influence the individuals in their decision. Krugman [10] was interested in the mobility of the workers in Europe and their integration which would facilitate their migration. On the regional migration, Zenou [19] developed a model on the rural urban migration taking into account other endogenous parameters. The search of a more pleasant framework of life, of

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a culture or a more lenient climate, are reasons likely to reinforce the choice of migration. Moreover, even if the migration can make it possible to the individual to reach a better situation, other factors can force this decision obviously.

The choice to migrate thus seems the result of an "arbitration" between the anticipated profits in the new situation obtained after the consecutive migration and costs with this decision and "probability models" may apply. It seems obvious that in this arbitration the weight of these elements can differ from one individual to another according to his preferences and from his objectives, which depend themselves on the life cycle of the individual (see Sanchez [13], De La Croix [6], Stark et al. [15][16]). Considering here two periodes t and $t+1$, the individuals are able to migrate if their human capital (primarily education) is high in a sense that we will describe below. To our knowledge, the work by Chen [3] is the first one, where the probability of migration is endogenous with the model. Here, the migration influences the level of human capital (education) of the country of origin. Choices to invest in education or not, acted on the formation of the human capital in the country of origin.

Education is very important because it facilitates the migration of the individuals wishing to migrate from a country A towards another country B. Unlike [9], the wages in our article are less important parameters, hence, education is an essential factor in the study of migration of the individuals here. An interesting example is that of the migration between Mexico and the USA. A study of Caponi [2] shows that the individuals with a level of education very high, and those with a level of very low education, are more numerous to migrate than those with an average level of education.

The probability of migration of a developing country depends on the economic growth in an essential way, since people living in a source country with higher average human capital are traditionally more incited to emigrate to a foreign country than those living in a source country with lower average human capital. Chen [3] and Vidal [17] have proposed to endogenize the probability of migration and to make it, naturally, dependent on human capital. In [3] an economic model is introduced in which the probability of migration can take only two values: the low (respectively high) value is taken when the human

capital is smaller (respectively larger) than a threshold level. In this model there is a possibility of club convergence occurring in the short run, and conditional convergence occurring in the long run following the two possible scenarii:
- The first scenario is when the probability of migration depends on *prior* human capital, which is the one inherited from the parents or equivalently the one of the agents before their education period; we will call it in this paper the *traditional* case. In this scenario, the threshold level affects the economic behavior in the long run. More exactly, if the human capital threshold is sufficiently low (respectively high), then the economy converges to a high (respectively low) steady state level. However, if the human capital threshold is at the median level, club convergence may occur and the initial condition matters.
- In the second scenario, the probability of migration depends on *current* human capital, which is the one of the agents at the end of their education period; we will call it the *anticipative* case. In this scenario, the dynamic transition of the economy is determined by perceptions of the future. In [3] it is found that a belief in the higher probability of migration in the future provides an incentive for agents to invest more in their education, thereby raising their accumulation of human capital, which in turn lead to a higher probability of migration. These heuristic arguments indicate that beliefs can change the picture in the anticipative case.

In our paper we show that migration can be used to explain some important economic growth phenomena. The two scenarii introduced above give rise to two distinct lines of research in the literature on economic growth:
- The occurrence of multiple steady states in the first scenario can help to explain the findings of club convergence in the empirical studies.
- The second scenario indicates that migration can be a source of indeterminacy, and therefore emphasizes the role of beliefs. This implies that when embracing migration, economies with similar backgrounds may well follow different equilibrium paths simply because they have different beliefs about their future probability of migration.
The model that we address allows for a detailed analysis and exhibits the relevant features.

2. Position of the problem

In a small open economy characterized by an infinite horizon, Chen [3] considers a no-growth overlapping generations model, where agents live for two successive periods. In each period a new generation is born, agents born in period t are endowed with parental human capital h_t, and are supposed to allocate their time between gaining education e_t and engaging in leisure $1 - e_t$ in the first period of life. In the second period, agents can migrate to a foreign country (country B) with probability $p_{t+1} \in [0, 1]$ or remain into the home country (country A) with probability $1 - p_{t+1}$. During this second period of life, agents spend all of their time working to earn income for consumption.

Moreover, if w_A and w_B represent the respective real wage per unit of human capital in countries A and B, the earnings of agents are equal to their level of human capital h_{t+1} multiplied by the real wage per unit of human capital of the country in which they live. That is, the expected utility function, which is identical for all agents, is defined for $\beta > 0$ and $\theta > 1$ by:

$$u_t = \ln(1 - e_t) + \beta \left[(1 - p_{t+1}) \ln(w_A h_{t+1}) + p_{t+1}\theta \ \ln(w_B h_{t+1})\right]. \tag{1}$$

As in [3], from period t to period $t + 1$ the human capital evolves following the relation

$$h_{t+1} = Ae_t^{\gamma} h_t^{\delta}, \qquad \gamma, \delta \in (0, 1). \tag{2}$$

We distinguish two migration processes: the traditional process of migration in which the probability of migration is defined as $p_{t+1} = \mathcal{P}(h_t)$, where $\mathcal{P}$ is an increasing function, and the anticipative process in which the probability of migration is defined as $p_{t+1} = \mathcal{P}(h_{t+1})$. In the traditional process the probability of migration of the young adults p_{t+1} is determined by the human capital of the parents h_t. In the anticipative process the probability of migration of the young adults p_{t+1} is determined by the human capital of the young adults at the end of their first period h_{t+1}. As we will see indeterminacy can occur in this anticipative situation, since the time spent in education e_t, and therefore the human capital of the young adults at the end of their first period h_{t+1}, then depend on the probability of mutation p_{t+1}. Indeed, the variation of the utility function u_t with respect of the education function e_t is given by

$$\frac{\partial u_t}{\partial e_t} = \frac{-1}{1-e_t} + \beta\left[(1-p_{t+1})\frac{\gamma}{e_t} + \theta p_{t+1}\frac{\gamma}{e_t}\right], \tag{3}$$

and the optimal decision e_t^* which is reached at $(\partial u_t)/(\partial e_t) = 0$ is given by

$$e_t^* = \frac{\gamma\beta\left[1+(\theta-1)p_{t+1}\right]}{1+\gamma\beta\left[1+(\theta-1)p_{t+1}\right]}. \tag{4}$$

3. The traditional model

The probability of migration is assumed to be dependent on average human capital H_t. We suppose that the agents are homogeneous, then the average human capital is equal to the personal human capital in each period $H_t = h_t$. In this subsection, we consider the traditional model of migration, that is:

$$p_{t+1} = \mathcal{P}(h_t), \tag{5}$$

which means that the probability of migration is dependent on average human capital lagged by one period (i.e. the average human capital of the parents). We also suppose that

$$\mathcal{P}(h) = \begin{cases} p_1 & \text{if} \quad h < h^{\#} \\ p_2 & \text{if} \quad h \geq h^{\#} \end{cases} \tag{6}$$

for some probability constants $0 \leq p_1 < p_2 \leq 1$, where $h^{\#}$ is a nominative threshold human capital as in [3]. For $j = 1, 2$, we finally denote

$$e_j = \frac{\gamma\beta\left[1+(\theta-1)p_j\right]}{1+\gamma\beta\left[1+(\theta-1)p_j\right]}. \tag{7}$$

Note that we have $e_1 < e_2$.

Proposition 1. *The sequence of human capitals $(h_t)_t$ converge to a fixed point as $t \to \infty$.*
The two possible fixed points are $\bar{h}_1$ and $\bar{h}_2$ (with $\bar{h}_1 < \bar{h}_2$) defined by

$$\bar{h}_j = \left(A\, e_j^{\gamma}\right)^{\frac{1}{1-\delta}}, \quad j = 1, 2. \tag{8}$$

We have the following:
- *If $\bar{h}_1 > h^{\#}$, then the sequence $(h_t)_t$ converges to $\bar{h}_2$ for every h_0.*
- *If $\bar{h}_2 < h^{\#}$, then the sequence $(h_t)_t$ converges to $\bar{h}_1$ for every h_0.*
- *If $\bar{h}_1 < h^{\#} < \bar{h}_2$, then*

(a) if $h_0 < h^{\#}$*, the sequence* $(h_t)_t$ *converges to* $\bar{h}_1$*,*

(b) if $h_0 > h^{\#}$*, the sequence* $(h_t)_t$ *converges to* $\bar{h}_2$*.*

∎

This proposition is an application of standard results on the convergence of sequences defined by a recursive relation of the form $h_{t+1} = \mathcal{H}(h_t)$:

$$h_{t+1} = \begin{cases} Ae_1^{\gamma} h_t^{\delta} & \text{if} \quad h_t < h^{\#}, \\ Ae_2^{\gamma} h_t^{\delta} & \text{if} \quad h_t \geq h^{\#}. \end{cases} \tag{9}$$

With this traditional migration model (i.e when the probability of migration is dependent on the human capital of the parents), the human capital threshold $h^{\#}$ determines the growth of the economy which will converge to one of the two fixed points $\bar{h}_1$ and $\bar{h}_2$ given by (8).

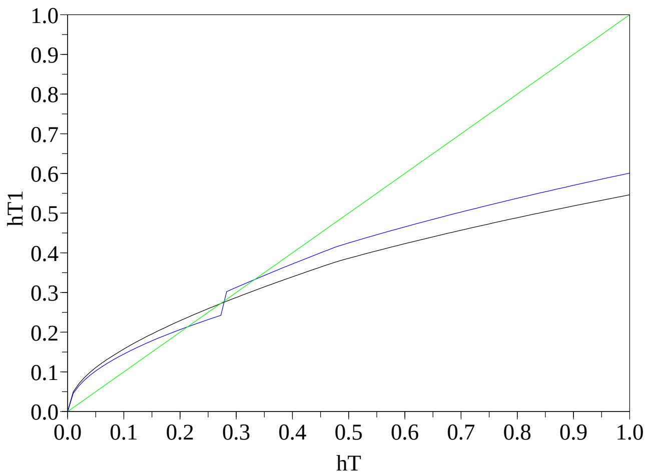

Figure 1. The traditional case

4. The anticipative model

In this section we assume that the probability of migration is dependent on the average human capital in period $t + 1$ [3, 5]:

$$p_{t+1} = \mathcal{P}(h_{t+1}), \tag{10}$$

with $\mathcal{P}$ defined by (6). Then (9) becomes an implicit relation (h_{t+1} is on the right and on the left of the relation):

$$h_{t+1} \quad = \quad \begin{cases} A\, e_1^\gamma\, h_t^\delta & \text{if} \quad h_{t+1} < h^\#, \\ A\, e_2^\gamma\, h_t^\delta & \text{if} \quad h_{t+1} \geq h^\#. \end{cases} \tag{11}$$

Let us define

$$h_o^\# = \left(\frac{h^\#}{Ae_2^\gamma}\right)^{\frac{1}{\delta}} \qquad \text{and} \qquad h_p^\# = \left(\frac{h^\#}{Ae_1^\gamma}\right)^{\frac{1}{\delta}}. \tag{12}$$

Note that we have

$$h_o^\# < h^\# < h_p^\#. \tag{13}$$

Equation (11) is implicit and, given the value h_t, there may be several possible values for h_{t+1}. This shows that the dynamics of human capital depends on households perceptions and beliefs about the future. The following lemma addresses the easy situation in which there is no indeterminacy.

Lemma 2. *Let h_t be the human capital at period t. The human capital h_{t+1} at period $t+1$ must satisfy equation (11). Then we have the following:*
1) If $h_t < h_o^\#$ then there exists a unique possible value $h_{t+1} = Ae_1^\gamma h_t^\delta$.
2) If $h_t > h_p^\#$ then there exists a unique possible value $h_{t+1} = Ae_2^\gamma h_t^\delta$.

The proof of Lemma 2 is easy and follows from (13) and (9). ■

From now on in this paper we consider the case in which the following hypothesis is fulfilled by the parameters of our model:

$$e_1^{\gamma(\delta-1)} e_2^{-\gamma\delta} < A\big(h^\#\big)^{\delta-1} < e_1^{-\gamma\delta} e_2^{\gamma(\delta-1)}. \tag{14}$$

We now discuss useful equivalent formulations of Hypothesis (14) and a convergence result in the following proposition:

Proposition 3. *Hypothesis (14) is fulfilled if and only if*

$$[0, h_o^\#) \text{ and } (h_p^\#, +\infty) \text{ are stable through the relation (11)} \tag{15}$$

if and only if the two possible fixed points given by (8) satisfy

$$\bar{h}_1 \in [0, h_o^\#) \text{ and } \bar{h}_2 \in (h_p^\#, +\infty). \tag{16}$$

Moreover, if (14) is satisfied, and if $h_0 > 0$ is the initial human capital, then we have the following assertions:

(1) *If $h_0 < h_o^{\#}$ then the resulting human capital sequence $(h_t)_t$ converges to the fixed point $\bar{h}_1$.*
(2) *If $h_0 > h_p^{\#}$ then the resulting human capital sequence $(h_t)_t$ converges to the fixed point $\bar{h}_2$.*

The complementary case of (14) is addressed in [8]. Hypothesis (14) ensures the stability of the intervals $[0, h_o^{\#})$ and $(h_p^{\#}, +\infty)$ through the anticipative model (11), and shows that the two fixed points belong to the two different stable regions. Moreover, Proposition 3 states that stability and existence of the two fixed points in the stable regions implies convergence of the sequence defined by (11).

The proof of Proposition 3 is given in the Appendix. We need now to address the case in which $h_o^{\#} < h_0 < h_p^{\#}$. In this case indeterminacy occurs, as stated in the following lemma.

Lemma 4. *Let h_t be the human capital at period t. If $h_o^{\#} < h_t < h_p^{\#}$, then there exist two different possible values for the solution h_{t+1} of (11):*

$$h_{t+1,j} = A\, e_j^{\gamma}\, h_t^{\delta} \qquad \textit{for} \quad j = 1, 2. \tag{17}$$

The lemma shows that it is necessary to give a mechanism to select between the two possible solutions for h_{t+1} in the case in which $h_o^{\#} < h_t < h_p^{\#}$. We will address different selection mechanisms in Subsection 4.1 and Subsection 4.2 below.

4.1. **Optimistic and pessimistic selection mechanisms.** The pessimistic selection mechanism consists in choosing the smallest value for the human capital when there are two possible choices. The optimistic selection mechanism consists in choosing the largest value for the human capital when there are two possible choices. These are the two extremal selection mechanisms. We will consider an intermediate mechanism later in Subsection 4.2.

The following proposition gives the main result in the case of the two selection mechanisms.

Proposition 5. *Let h_0 be an initial human capital in the multivalued region i.e $h_o^\# < h_0 < h_p^\#$. We have the following assertions:*

(1) *With the pessimistic selection mechanism, the sequence $(h_t)_t$ converges to the fixed point $\bar{h}_1$ if $h_0 < h_p^\#$, and converges to the fixed point $\bar{h}_2$ if $h_0 > h_p^\#$.*
(2) *With the optimistic selection mechanism, the sequence $(h_t)_t$ converges to the fixed point $\bar{h}_1$ if $h_0 < h_o^\#$, and converges to the fixed point $\bar{h}_2$ if $h_0 > h_o^\#$.*

This proposition shows that the threshold value for the initial condition below which the human capital converges to the low fixed point is *smaller* with the optimistic mechanism than with the pessimistic mechanism.

4.2. **Conservative selection mechanism.** We still use Hypothesis (14). The conservative selection mechanism consists in choosing for the human capital h_{t+1} at period $t+1$ the value that is the closest from h_t when there are two possible choices.
Let us define

$$h_c^\# = \left(A\frac{e_1^\gamma + e_2^\gamma}{2}\right)^{\frac{1}{1-\delta}}. \tag{18}$$

Lemma 6. *Let h_0 be an initial human capital in the multivalued region i.e $h_o^\# < h_0 < h_p^\#$. We have the two following assertions:*

(a) If $h_0 > h_c^\#$, then we have $h_t > h_c^\#$ for all t and $h_{t+1} = Ae_2^\gamma h_t^\delta$ is the solution selected by the conservative mechanism. Moreover, the sequence $(h_t)_t$ converges to the fixed point $\bar{h}_2$.

(b) If $h_0 < h_c^\#$, then we have $h_t < h_c^\#$ for all t and $h_{t+1} = Ae_1^\gamma h_t^\delta$ is the solution selected by the conservative mechanism. Moreover, the sequence $(h_t)_t$ converges to the fixed point $\bar{h}_1$.

We recall that the threshold value in the traditional case is $h^\#$. In the anticipative case with the optimistic (resp. pessimistic) selection mechanism it is $h_o^\#$ (resp. $h_p^\#$). The following proposition summarizes the convergence results when the conservative selection mechanism is used:

Proposition 7. *With the conservative selection mechanism, the sequence $(h_t)_t$ converges to the fixed point $\bar{h}_1$ (resp. $\bar{h}_2$) if $h_0 < H$ (resp. $h_0 > H$) where we have:*

(a) $H = h_p^\#$ if $h_c^\# > h_p^\#$,
(b) $H = h_o^\#$ if $h_c^\# < h_o^\#$,
(c) $H = h_c^\#$ if $h_o^\# < h_c^\# < h_p^\#$.

In the goal to have a high economy level, we notice that the optimistic anticipation mechanism is the one that gives the smallest threshold value H from which we have convergence to the highest fixed point $\bar{h}_2$. Conversely, the pessimistic anticipation mechanism is the one that gives the largest threshold value.

5. Conclusion

It is worthwhile to note that, whatever the type of evolution equation for the human capital (traditional or anticipative) and for any selection mechanism, the result can always be expressed by an assertion of the form: if the initial capital h_0 is smaller than a threshold value H, then the human capital will converge to the low fixed point $\bar{h}_1$, while if the initial capital h_0 is larger than a threshold value H, then the human capital will converge to the high fixed point $\bar{h}_2$. The values of the fixed points $\bar{h}_1$ and $\bar{h}_2$ do not depend on the type of evolution equation and on the selection mechanism. Only the threshold value H depends on the type of evolution equation and on the selection mechanism. In particular we show that beliefs can have a strong impact on the threshold value H.

6. Appendix - Proofs and complementary results

6.1. **Proof of Proposition 3.** We prove the stability of the interval $[0, h_o^\#)$ in (15). Let h_t be such that $h_t < h_o^\#$. This is equivalent to $Ae_2^\gamma h_t^\delta < h^\#$. From Lemma 2 we have $h_{t+1} = Ae_1^\gamma h_t^\delta$. Using the RHS of Hypothesis (14) we have $A\left(h^\#\right)^{\delta-1} < (e_1^\gamma)^{-\delta}(e_2^\gamma)^{\delta-1}$ which is equivalent to $Ae_1^\gamma < \left(\frac{h^\#}{Ae_2^\gamma}\right)^{\frac{1-\delta}{\delta}}$. This implies:

$$h_{t+1} = Ae_1^\gamma h_t^\delta < \left(\frac{h^\#}{Ae_2^\gamma}\right)^{\frac{1-\delta}{\delta}} h_t^\delta = \left(\frac{Ae_2^\gamma h_t^\delta}{h^\#}\right) h_o^\# < h_o^\#,$$

which proves the stability of the interval $[0, h_o^\#)$.
For the stability of the interval $(h_p^\#, +\infty)$ we use the same type of arguments: if $h_t > h_p^\#$, then we use the LHS of Hypothesis (14), i.e $e_1^{\gamma(\delta-1)}e_2^{-\gamma\delta} < A\left(h^\#\right)^{\delta-1}$

to prove that $h_{t+1} > h_p^{\#}$.

Now we prove (16). We have the following equivalence with (14):

$$A\left(h^{\#}\right)^{\delta-1} < (e_1^{\gamma})^{-\delta}(e_2^{\gamma})^{\delta-1} \quad \text{iff} \quad (Ae_1^{\gamma})^{\delta} < \left(\frac{h^{\#}}{Ae_2^{\gamma}}\right)^{1-\delta} \quad \text{iff} \quad \bar{h}_1 < h_o^{\#},$$

and

$$A\left(h^{\#}\right)^{1-\delta} > e_1^{\gamma(\delta-1)}e_2^{-\gamma\delta} \quad \text{iff} \quad (Ae_2^{\gamma})^{\delta} > \left(\frac{h^{\#}}{Ae_1^{\gamma}}\right)^{1-\delta} \quad \text{iff} \quad \bar{h}_2 > h_p^{\#}.$$

We end by proving the convergence result:

Case (1) If $h_0 < h_o^{\#}$, then the above stability shows that $h_t < h_o^{\#}$, which defines $h_{t+1} = Ae_1^{\gamma}h_t$ by Lemma 2. Therefore, the sequence $(h_t)_t$ converges to the fixed point $\bar{h}_1$, which is the unique fixed point of the recursive relation $h_{t+1} = Ae_1^{\gamma}h_t$ in $(0, h_o^{\#})$ by (16).

Case (2) The same type of arguments can be used and the result holds true.■

6.2. **Proof of Proposition 5.** Case (1) If $h_0 < h_p^{\#}$ then we can show by induction that for all t we have $h_t < h_p^{\#}$ and $h_{t+1} = Ae_1^{\gamma}h_t^{\delta}$. Indeed, if $h_t < h_p^{\#}$, then the pessimistic mechanism selects $h_{t+1} = Ae_1^{\gamma}h_t^{\delta}$ and therefore $h_{t+1} < Ae_1^{\gamma}(h_p^{\#})^{\delta} = h^{\#} < h_p^{\#}$. Note that this argument also shows that $h_t < h^{\#}$ as soon as $t \geq 1$. Since $\bar{h}_1$ is the unique fixed point of the recursive relation $h_{t+1} = Ae_1^{\gamma}h_t^{\delta}$ in $(0, h^{\#})$, the sequence $(h_t)_t$ must converge to the fixed point $\bar{h}_1$.

From the other side, if $h_0 > h_p^{\#}$ then by applying Proposition 3 we find that the sequence $(h_t)_t$ converges to the fixed point $\bar{h}_2$.

Case (2) can be addressed in the same way. ■

6.3. **Proof of Lemma 6.** Let the initial condition be such that $h_o^{\#} < h_0 < h_p^{\#}$. In Case (a) we have $h_0 > h_c^{\#}$. By induction we can show that $h_t > h_c^{\#}$ and $h_{t+1} = Ae_2^{\gamma}h_t^{\delta}$ for all t. Indeed, if $h_t > h_c^{\#}$, then we have two possible solutions by Lemma 4 : $h_{t+1,1} = Ae_1^{\gamma}h_t^{\delta}$ and $h_{t+1,2} = Ae_2^{\gamma}h_t^{\delta}$. However $h_t > h_c^{\#}$ is equivalent to $2h_t > A\left(e_1^{\gamma} + e_2^{\gamma}\right)h_t^{\delta}$, and therefore we have $h_t - h_{t+1,1} > h_{t+1,2} - h_t > 0$. Consequently the conservative mechanism selects $h_{t+1,2}$. This point is larger than h_t, which is itself larger than $h_c^{\#}$, which completes the proof of the induction. Finally, the unique fixed point of the recursive relation $h_{t+1} = Ae_2^{\gamma}h_t^{\delta}$ in $(h_c^{\#}, \infty)$ is $\bar{h}_2$ by (16). Therefore the sequence $(h_t)_t$ must converge to $\bar{h}_2$. We use the same arguments for the proof of Case (b). ■

Remark 8. *To be complete we can mention that Cases* (a) *and* (b) *in Lemma 6 can indeed occur. More exactly, Case* (a) *occurs if* $h_c^\# < h_p^\#$. *Case* (b) *occurs if* $h_c^\# > h_o^\#$. *The fact that* $h_c^\# < h_p^\#$ *is equivalent to* $A(h^\#)^{\delta-1} < e_1^{\gamma(\delta-1)}\left(\frac{e_1^\gamma+e_2^\gamma}{2}\right)^{-\delta}$, *which is compatible with Hypothesis (14). The fact that* $h_c^\# > h_o^\#$ *is equivalent to* $A(h^\#)^{\delta-1} > e_2^{\gamma(\delta-1)}\left(\frac{e_1^\gamma+e_2^\gamma}{2}\right)^{-\delta}$, *which is also compatible with Hypothesis (14).*

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