Intergenerational Human Capital Mobility and Industrial Restructuring

Joël Hellier* and Nicolas Fleury**

Abstract: *To explain the low upward mobility observed in regions that experience severe restructuring, we develop an intergenerational human capital model in which individuals choose between general education and industry-specific education. As long as the traditional industry behaves normally, a significant share of the region's population chooses to educate itself in traditional-specific skills. We introduce a restructuring process that restrains the demand for workers from the traditional sector. For families with traditional-specific human capital, this shock (i) reduces the income of the working generation, and (ii) lowers intergenerational upward mobility. It also causes certain dynasties to fall into a poverty trap.*

Key words: Intergenerational mobility, Human capital, Poverty trap, Restructuring.

JEL Classification: J24, J31.

Corresponding author:

Joël Hellier
EQUIPPE, Universities of Lille, and LEN, Univ. of Nantes
28 rue de Sévigné 75004 Paris
Tel. + 33 (0)1 42 77 57 40
joel.hellier@wanadoo.fr

This research was funded by the Region Nord-Pas-de-Calais.

* *EQUIPPE*, Universities of Lille, and LEN, University of Nantes.
***EQUIPPE*, Universities of Lille.

1 Introduction

The developments in the French Nord-Pas-de-Calais over the last thirty years show that, in this region characterised by severe restructuring and the disappearance of traditional industries, intergenerational upward mobility is lower, and intergenerational downward mobility higher, than in the rest of France (see Appendix 1). This observed fact suggests that regions that experience significant restructuring could display characteristics that hamper human capital accumulation.

Our purpose is to analyse the educational strategies and the resulting intergenerational human capital mobility for individuals located in a region specialised in traditional industries and subject to a substantial restructuring process.

Within a model with infinitely-lived agents and industry-specific human capital, Lucas and Prescott (1974) showed how moving from declining to expanding sectors creates steady state unemployment when this move requires time. Further works have analysed the impacts of moving from one sector to another within intergenerational approaches (e.g., Williamson, 1990, Chari and Hopenhayn, 1991, and Matsuyama, 1992). In a recent intergenerational model, Rogerson (2005) shows how shocks that affect the match between skill and technology modify the sectoral choice of younger generations and may push older generations out of the labour market. However, these works do not address the impact of restructuring shocks on intergenerational human capital mobility in the long term.

The literature on intergenerational human capital mobility may broadly be divided into two strands. Following Becker and Tomes (1979), a first range of models predicts the long term convergence of all dynasties to the same human capital steady state. Initially determined by assuming perfect competition on the credit market, this result has subsequently been extended to the case of imperfect competition on the credit market, the convergence being then slowed down (Becker and Tomes, 1986; Loury, 1981). These rather optimistic findings have afterwards been questioned, and the emergence of poverty traps has been analysed[1]. These are characterised by the coincidence of at least two steady states, one with high and the other with low human capital and income, families being distributed between these two states. Several factors can generate poverty traps: a fixed cost of education (Galor and Zeira, 1993), a privately funded education with uneven distribution of parents' human capital (Ceroni, 2001),

[1] Piketty (2000) and Gradstein, Justman and Meier (2005) provide surveys on poverty traps due to under-education.

a discontinuity in the payment for skill and a non competitive credit market (Barham et al., 1995), a technology that must combine skilled and unskilled labour (Bauduin and Hellier, 2006), a limitation of parental altruism (Das, 2007). The existence of a poverty trap may also be transitory, the trap disappearing in the long term when human capital externalities increase productivity in the education activity (Galor and Tsiddon, 1997). Within these approaches, the education function relates one individual's human capital to several factors: private and public expenditures for education, transmitted abilities and/or intra-family human capital externalities, local externalities (the impact of the neighbourhood's human capital on children's human capital: Benabou, 1993, 1996a, 1996b). Thus, one individual's human capital depends on her parents' situation through three main channels: their income that acts on educational expenditure, their human capital that is partially transmitted to their children through personal abilities or intra-family externalities, and the choice of the district they live in through local externalities.

Unfortunately, these approaches are not tailored to account for differences in intergenerational mobility that derive from differences in the developments between sectors. To do so, a straightforward solution consists in discriminating between general human capital and sector-specific human capital. In the literature, firm-specific and/or industry-specific human capital is typically accumulated through on-the-job training (Becker, 1964). There is now clear evidence of the impact on income of specific human capital and of its more rapid obsolescence than general human capital (e.g.: Topel, 1990; Neal, 1995; Parent, 2000; Kambourov and Manovskii, 2008; see the survey by De Grip, 2004). However, the on-the-job acquired specific human capital is rather irrelevant to the present issue since it has no intergenerational dimension. In such an approach, the only way through which restructuring may influence children's education is their parents' income: if wages decrease in the restructuring industries, the parents become impoverished and their spending for their children's education declines. Then, a policy that gives access to credit facilities to these children, cancelling thereby the effects of lower parents' income, is enough to prevent the unwanted effect of restructuring on human capital accumulation. However, if the acquisition of specific human capital is not a simple on-the-job story, i.e., if sector-specific human capital is acquired in the educational system and if it depends on parents' specific-human capital itself through the usual intra-family and local externalities, then sector restructuring has a far higher impact because the skills related to these sectors get obsolete.

To account for the intergenerational impact of industry-specific skills, we develop a model of intergenerational human capital mobility in which individuals choose between general and industry-specific education. As long as traditional industries develop normally, a significant share of the region's population chooses to educate itself, at least partially, in traditional-specific skills. We subsequently introduce a shock that substantially restrains the demand for workers from the traditional sector. This shock reduces the income of the contemporary working generation. It also (i) reduces the skill of the subsequent generations for those families whose human capital is to a large extent traditional-specific, (ii) reduces intergenerational upward mobility and (iii) causes certain families to fall into a poverty trap. These features result from the fact that the breakdown in traditional industries substantially curbs the intra-family human capital externalities by making the parents' specific skill obsolete and thus useless for their children's education.

We expose the model general framework in Section 2. The individuals' selection of their working sector and the related educational strategy and intergenerational mobility are subsequently determined in a situation in which traditional industries undergo the same development as the rest of the economy (Section 3). We then introduce a restructuring shock and we analyse its impact on intergenerational mobility (Section 4). Simulations exercises are implemented in Section 5 and we conclude in Section 6.

2 The model general framework

2.1. Sectors and production

There are two types of human capital, general and sector-specific.

The economy comprises three sectors, a traditional industry (sector *T*), a 'modern' manufacturing sector (sector *M*), and a service sector (sector S). Sectors *T* and *M* utilise both general human capital and sector-specific human capital. Services use general human capital only.

In sector *i*, $i = T, M, S$, the production function is $Y_i = A_i H_i$, with $H_i = \sum_{j \in H_i} h_{ij}$, and:

$$
\begin{aligned}
h_{ij} &= \left(h_j\right)^{\gamma}\left(s_{ij}\right)^{1-\gamma}, && \text{for } i = T, M \\
h_{ij} &= h_j, && \text{for } i = S
\end{aligned}
\tag{1}
$$

h_j is the general human capital possessed by individual *j*, s_{ij} her *i*-specific human capital, and h_{ij} the *i*-efficient human capital of *j*. Individual *j* has thus three different *i*-efficient human capitals corresponding to each of the three sectors of production.

The *i*-efficient human capitals are homogenous since h_{ij} and h_{ik} are perfectly substitutable in the production function of *i*. Assuming competitive labour markets, individual *j* who works in industry *i* is paid $w_i h_{ij}$, w_i being the wage per unit of *i*-efficient labour in this sector. In contrast, competitive labour markets do not imply an equalisation of the wages per unit of efficient labour in the three sectors because the efficiency of one individual's human capital endowment varies from one sector to another.

In both sectors *T* and *M*, we assume that A_i is, at least up to a certain level, positively related to the amount of production and the amount of sector-specific human capital located in the production region through local externalities. As a consequence, sectors *T* and *M* productions are concentrated in certain regions.

2.2. Education

Each individual has one parent and one child, and the successive generations linked by a parent-child relationship form a dynasty.

An individual lives two periods of time of different length. Being a child, the individual receives a basic education. She then becomes an adult and lives during a period of time of length 1. Once an adult she chooses, either to pursue further education, or to directly join the labour market. In the first case, she chooses to allocate time $e<1$ to further education. This choice depends on the related lifetime income.

Individual *j*'s human capital once adult is thus characterised by the vector $\theta_j = (h_j, s_{Tj}, s_{Mj})$ of her endowments in general human capital (h_j) and in the two specific human capital (s_{Tj} for the traditional sector and s_{Mj} for the modern one), and h_{ij} is the *i*-efficient human capital of this individual endowment, with $h_{ij} = h_j$ for *i* = *S* and $h_{ij} = \left(h_j\right)^{\gamma}\left(s_{ij}\right)^{1-\gamma}$ for *i* = *T,M*.

By convention, all individuals are born with the same initial endowment of human capital $\theta = (\lambda, \lambda, \lambda)$, with $0<\lambda<1$. The fact that the initial endowments are the same for the 3 types of human capital is assumed for the sake of simplicity. Inequality $\lambda > 0$ shows that the individual's productivity is not zero even without any education. Feature $\lambda < 1$ makes it possible to reduce the number of conditions in the education functions without effects on the outcomes.

Basic education is freely provided by the government whereas further education is financed by the individual's borrowing. The market for credit is perfect and the interest rate is assumed to be nil. These simplifying assumptions have little impact on the analysis because they only make the conditions of emergence of an under-education trap less severe.

Basic education increases general education only, according to the following function:

$$\underline{h}_j = \delta\left(h_j(-1)\right)^\eta \tag{2}$$

Where $h_j(-1)$ denotes the parent's general human capital.

Coefficient δ denotes the productivity of basic education and it is exogenous for the individual.

Expression $\left(h_j(-1)\right)^\eta$ measures the intra-family externality, i.e., the impact of the parent's human capital $h_j(-1)$ on her child's human capital at the end of basic education. We suppose that $0 < \eta < 1$, which indicates that the marginal impact of the intra-family externality is decreasing.

At the end of her basic education period, the individual is thus provided with human capital $\underline{\theta}_j = \left(\delta\left(h_j(-1)\right)^\eta, \lambda, \lambda\right)$.

The individual's further education is distributed between general and specific education. To follow on into further education, the individual must firstly disburse a fixed cost $\bar{f}$. She then allows a certain share e of her time to further education, with $e = e_G + e_M + e_T$. Since *i*-specific education provides return in sector *i* only, a rational individual selects one working sector and never allows time for both *M* and *T*-specific education.

The production function for general education is:

$$h_j = \begin{cases} \delta_G e_{Gj}{}^\varepsilon \left(h_j(-1)\right)^\eta & \text{iif} \quad \delta_G e_{Gj}{}^\varepsilon \left(h_j(-1)\right)^\eta > \underline{h}_j \Leftrightarrow e_{Gj} > \left(\delta / \delta_G\right)^{1/\varepsilon} \\ \underline{h}_j & \text{otherwise} \end{cases} \tag{3}$$

with e_{Gj} being the time individual *j* allocates to general education.

Equation $h_j = \delta_G e_{Gj}{}^{\varepsilon}\left(h_j(-1)\right)^{\eta}$ may be rewritten $h_j = \left(\delta_G / \delta\right)\underline{h}_j e_{Gj}{}^{\varepsilon}$, which indicates that basic education $\underline{h}_j$ is an input of the general further education activity. Ratio $\left(\delta_G / \delta\right)$ then represents the productivity of the general further education activity. Note that the education function implicitly integrate a minimal time of schooling since, for e_{Gj} to be efficient, $h_j = (\delta_G / \delta) e_{Gj}{}^{\varepsilon}\underline{h}_j$ must be higher than $\underline{h}_j$, and thus $e_{Gj} > \left(\delta / \delta_G\right)^{1/\varepsilon}$. Hereafter, this condition is shown to have no impact on the individual decision. Moreover, since $e_{Gj} < 1$, then $\delta_G > \delta$.

The *i*-specific education function is:

$$s_{ij} = \begin{cases} \delta_i e_{ij}{}^{\varepsilon}\left(s_{ij}(-1)\right)^{\eta} & \text{iif} \quad \delta_i e_{ij}{}^{\varepsilon}\left(s_{ij}(-1)\right)^{\eta} > \lambda \\ \lambda & \text{otherwise} \end{cases} \qquad (4)$$

With e_{ij} being the time individual *j* allows for *i*-specific education.

2.3. The individual's decision process

The individual maximises her lifetime income. At the end of basic education, she decides on both the sector in which she will work and her educational strategy. She firstly chooses her optimal educational pattern corresponding to working in each sector. She subsequently compares the incomes related to working in each sector and she selects the sector (and the related educational strategy) that provides her with the highest income.

In addition, we shall suppose that individuals who do not pursue specific education (their specific human capital is thus λ) always work in services. The supposedly met condition for this is[2]:

$$w_S / w_i \geq \left(\lambda^{1-\eta} / \delta\right)^{1-\gamma}, \qquad i = M,T \qquad (5)$$

[2] Proof available from the authors upon request.

3 Education strategy in each sector

The analysis is centred on a region that only produces traditional goods (*T*) and services (S). For this purpose, we shall suppose (i) that these two sectors only are present in the region so that any one who chooses to work in the third sector must migrate to other regions with moving being costly enough to prevent migration, (ii) that the parents have initially no specific human capital in the third sector, and (iii) that individuals meet no demand constraint on the labour markets, so that they can always find a position corresponding to their skill in the sector they have selected between the two located in the region. Given these assumptions, the rational choice of an individual is limited to sectors *T* (the only manufacturing located in the region) and *S* (services), and she selects the education pattern that maximises her lifetime net income, i.e. her earnings net of the fixed cost of education.

From now on, we shall thus concentrate on two sectors only, S and *T*, and thereby only consider general human capital and *T*-specific human capital. We successively analyse the education behaviour of the individual when she works in services and in sector *T*.

3.1. The individual works in services

When the individual works in services, she only accumulates general human capital.

We denote $\hat{e}_S$ the optimal education time when the individual works in services and pursues further education[3], and $\hat{h}_{jS}$ and $\hat{I}_{jS}$ her related (general) human capital and net income.

Since the individual works in services, her net income is (i) $\hat{I}_j = w_S(1-\hat{e}_S)\hat{h}_j - \overline{f}$ if she pursues further education, and (ii) $w_S \underline{h}_j$ if she directly joins the labour market, w_S being the wage per unit of efficient labour in services.

For individual *j* to pursue further education, the related income must be higher than the income without further education: $w_S(1-\hat{e}_S)\hat{h}_j - \overline{f} > w_S \underline{h}_j$.

By inserting $\hat{h}_{jS} = \delta_G \hat{e}_S{}^{\varepsilon} \left(h_j(-1)\right)^{\eta}$ and $\underline{h}_j = \delta\left(h_j(-1)\right)^{\eta}$ into $w_S(1-\hat{e}_S)\hat{h}_{jS} - \overline{f} > w_S \underline{h}_j$, we obtain after rearranging : $h_j(-1) > \left(\dfrac{\overline{f}/w_S}{\delta_G(1-\hat{e}_S)\hat{e}_S{}^{\varepsilon} - \delta}\right)^{1/\eta}$.

[3] Subscript *j* (for individual *j*) is omitted because, as shown hereafter, $\hat{e}_S$ is the same for all individuals.

The individual's education time e_S is thus determined by the following programme:

$$e_S = \begin{cases} \hat{e}_S = \arg\max_e I_j = w_3 \delta_G (1-e) e^{\varepsilon} \left(h_j(-1)\right)^{\eta} - \overline{f} & \text{iif} \quad h_j(-1) > \left(\dfrac{\overline{f} / w_S}{\delta_G (1-\hat{e}_S) \hat{e}_S{}^{\varepsilon} - \delta} \right)^{1/\eta} \\ 0 & \text{otherwise} \end{cases}$$

The corresponding value of $\hat{e}_S$ is[4]:

$$\hat{e}_S = \varepsilon / (1+\varepsilon) \tag{6}$$

We can firstly note that, for further education to be selected, its return must be higher than no education for the lowest possible fixed cost, i.e. $\overline{f} = 0$. This states the following condition that is supposedly met:

$$\delta_G / \delta > (1+\varepsilon)^{1+\varepsilon} / \varepsilon^{\varepsilon} \tag{7}$$

And the condition on $h_j(-1)$ is:

$$h_j(-1) > \underline{h}_S \ , \quad \text{with } \underline{h}_S \equiv \left(\frac{\overline{f} / w_S}{\varepsilon^{\varepsilon} (1+\varepsilon)^{-(1+\varepsilon)} \delta_G - \delta} \right)^{1/\eta} \tag{8}$$

We can consequently state the following lemma:

Lemma 1: If the individual works in services, there is a threshold value of her parent's human capital $\underline{h}_S$ below which she does not pursue further education and above which she allows time $\hat{e}_S = \varepsilon(1-\varepsilon)^{-1}$ for further education.

For condition (8) not to be met by all individuals, $\underline{h}_S$ must be higher than the smallest possible value of $h_j(-1)$, i.e. $\underline{h}_S > \delta \lambda^{\eta}$ (since all individuals are born with endowment λ). Assuming this, there is room for certain individuals not to go into further education.

---

4 $\partial I_j / \partial e = w_S \delta_G \left(h_j(-1)\right)^{\eta} (\varepsilon e^{\varepsilon-1} - (1+\varepsilon) e^{\varepsilon}) = 0 \Rightarrow \hat{e}_S = \varepsilon / (1+\varepsilon)$.

Table 1 depicts the values $\hat{h}_{jS}$ and $\hat{I}_{jS}$ of individual *j*'s human capital and net income determined by $\hat{e}_S$, and the related long term steady state, depending on the parent's human capital $h_j(-1)$.

Finally note that the steady state $\underline{h} = \delta^{1/(1-\eta)}$ of the dynamics without further education $\underline{h}_j = \delta\left(h_j(-1)\right)^\eta$ is also a steady state of the education dynamics only if $\underline{h} < \underline{h}_S$. Otherwise, all the dynasties sooner or later pursue further education.

Table 1: Educational strategy when working in Services

	Condition* on the parent's human capital $h_j(-1)$	
	$h_j(-1) < \underline{h}_S$	$h_j(-1) > \underline{h}_S$
e_S	0	$\hat{e}_S = \dfrac{\varepsilon}{1+\varepsilon}$
h_{jS}	$\underline{h}_j = \delta\left(h_j(-1)\right)^\eta$	$\hat{h}_{jS} = \delta_G\left(\dfrac{\varepsilon}{1+\varepsilon}\right)^\varepsilon \left(h_j(-1)\right)^\eta$
I_{jS}	$\underline{I}_{jS} = w_S\delta\left(h_j(-1)\right)^\eta$	$\hat{I}_{jS} = w_S\delta_G \dfrac{\varepsilon^\varepsilon}{(1+\varepsilon)^{1+\varepsilon}}\left(h_j(-1)\right)^\eta - \overline{f}$
Steady state	$\underline{h} = \delta^{1/(1-\eta)}$	$\overline{h}_S = \delta_G{}^{1/(1-\eta)}\left(\dfrac{\varepsilon}{1+\varepsilon}\right)^{\varepsilon/(1-\eta)}$

It can finally be noted that the minimal education time $e_G > \left(\delta/\delta_G\right)^{1/\varepsilon}$ has no impact on the individual decision because, since $e_S = \dfrac{\varepsilon}{1+\varepsilon}$, then $e_G > \left(\delta/\delta_G\right)^{1/\varepsilon} \Leftrightarrow \delta_G/\delta > \left((1+\varepsilon)/\varepsilon\right)^\varepsilon$, which is always true because $\delta_G/\delta > (1+\varepsilon)^{1+\varepsilon}/\varepsilon^\varepsilon$ (Relation 7).

3.2. The individual works in the traditional industry

We denote e_{GT}, e_{TT} and $e_T = e_{GT} + e_{TT}$ the time allocated by individual *j* to general education, *T*-specific education and total further education when she works in industry *T*. We denote h_{jT}, s_{Tj} and h_{Tj} respectively the general human capital of individual *j* when she opts to work in sector *T*, her *T*-specific human capital, and her *T*-efficient human capital $h_{Tj} = \left(h_{jT}\right)^\gamma \left(s_{Tj}\right)^{1-\gamma}$.

If the individual chooses to work in sector *T* and to invest in education, her income once adult is $I_j = w_T(1-e_T)h_{Tj} - \overline{f}$. Because of Relation (5), an individual who does not follow *T*-specific education does not work in industry *T*. There are thus two possible choices for the time allowed for education, i.e. $\left(e_{GT} > 0, e_{TT} > 0\right)$ and $\left(e_{GT} = 0, e_{TT} > 0\right)$.

The individual invests in both general and T-specific education

If the individual chooses to pursue both general and *T*-specific education, she determines the optimal time allocated to acquiring each type of human capital $\left(\hat{e}_{GT}, \hat{e}_{TT}\right)$ by maximising her net income $I_j = w_T h_{Tj}(1-e_{GT}-e_{TT}) - \overline{f}$. The related maximisation programme provides the following results (intermediate calculations available from the authors):

$$\hat{e}_{GT} = \gamma\frac{\varepsilon}{1+\varepsilon} \tag{9}$$

$$\hat{e}_{TT} = (1-\gamma)\frac{\varepsilon}{1+\varepsilon} \tag{10}$$

It can be noted that the total time allocated to education is $\hat{e}_T = \hat{e}_{GT} + \hat{e}_{TT} = \varepsilon/(1+\varepsilon)$, i.e. the same as when the individual works in services and pursue further education.

From the educations times (9)-(10), we can calculate the corresponding human capital $\hat{h}_{jT}$, $\hat{s}_{Tj}$ and $\hat{h}_{Tj}$, and the related net income $\hat{I}_{jT}$. We can finally compute these variables at the steady state. All these values are depicted in Table 2.

The individual must follow *T*-specific education to work in industry *T* (otherwise, her *T*-specific human capital is λ and she thereby works in services because of Relation 5). In addition, for the individual to pursue general education as well, the value $\hat{h}_{jT}$ must be higher than the general human capital $\underline{h}_j$ she possesses at the end of basic education: $\hat{h}_{jT} > \underline{h}_j$. This condition can be written $\hat{h}_{jT} = \delta_G\left(\frac{\varepsilon\gamma}{1+\varepsilon}\right)^{\varepsilon}\left(h_j(-1)\right)^{\eta} > \delta\left(h_j(-1)\right)^{\eta}$, and thus:

$$\delta_G/\delta > \left((1+\varepsilon)/\varepsilon\gamma\right)^{\varepsilon} \tag{11}$$

Table 2: Human capitals and net income when the individual works in Sector *T* and pursues both general and *T*-specific education $\left(\delta_G / \delta > \left((1+\varepsilon)/\varepsilon\gamma\right)^{\varepsilon}\right)$

	Human capitals and net income	***Steady states***
h_{jT}	$\hat{h}_{jT} = \delta_G \left(\frac{\varepsilon\gamma}{1+\varepsilon}\right)^{\varepsilon} \left(h_j(-1)\right)^{\eta}$	$\bar{h}_{GT} = \delta_G^{1/(1-\eta)} \left(\frac{\varepsilon\gamma}{1+\varepsilon}\right)^{\varepsilon/(1-\eta)}$
s_{Tj}	$\hat{s}_{Tj} = \delta_T \left(\frac{\varepsilon(1-\gamma)}{1+\varepsilon}\right)^{\varepsilon} \left(s_{Tj}(-1)\right)^{\eta}$	$\bar{s}_T = \delta_T^{1/(1-\eta)} \left(\frac{\varepsilon(1-\gamma)}{1+\varepsilon}\right)^{\varepsilon/(1-\eta)}$
h_{Tj}	$\hat{h}_{Tj} = \delta_G^{\gamma} \delta_T^{1-\gamma} \left(\frac{\varepsilon}{1+\varepsilon} \gamma^{\gamma} (1-\gamma)^{1-\gamma}\right)^{\varepsilon} \left(h_{Tj}(-1)\right)^{\eta}$	$\bar{h}_T = \delta_G^{\frac{\gamma}{1-\eta}} \delta_T^{\frac{1-\gamma}{1-\eta}} \left(\frac{\varepsilon}{1+\varepsilon} \gamma^{\gamma} (1-\gamma)^{1-\gamma}\right)^{\frac{\varepsilon}{1-\eta}}$
I_{jT}	$\hat{I}_{jT} = w_T \frac{\varepsilon^{\varepsilon} \delta_G^{\gamma} \delta_i^{1-\gamma}}{(1+\varepsilon)^{1+\varepsilon}} \left(\gamma^{\gamma}(1-\gamma)^{1-\gamma}\right)^{\varepsilon} \left(h_{Tj}(-1)\right)^{\eta} - \bar{f}$	$\bar{I}_T = w_T (1+\varepsilon)^{-1} \delta_G^{\frac{\gamma}{1-\eta}} \delta_T^{\frac{1-\gamma}{1-\eta}} \left(\frac{\varepsilon}{1+\varepsilon} \gamma^{\gamma}(1-\gamma)^{1-\gamma}\right)^{\frac{\varepsilon}{1-\eta}} - \bar{f}$

Lemma 2: When $\delta_G / \delta > \left((1+\varepsilon)/\varepsilon\gamma\right)^{\varepsilon}$ all the individuals who opt to work in industry *T* pursue both general and *T*-specific education, whereas they only pursue *T*-specific education when $\delta_G / \delta < \left((1+\varepsilon)/\varepsilon\gamma\right)^{\varepsilon}$.

Lemma 2 determines two types of economy depending on the value δ_G / δ, i.e., the productivity in general further education. If δ_G and δ apply to everyone, individuals pursuing both types of education and individuals only pursuing *T*-specific education cannot coexist in the same economy. The case where δ_G may differ across individuals is discussed thereafter.

The individual only invests in T-specific human capital

When $\delta_G / \delta < \left((1+\varepsilon)/\varepsilon\gamma\right)^{\varepsilon}$ individual *j* only invests in *T*-specific human capital and her maximisation programme is: $\max_{e_T} I_j = w_T \underline{h}_j^{\gamma} \left(\delta_i \left(s_{Tj}(-1)\right)^{\eta}\right)^{1-\gamma} (1-e_T) e_T^{\varepsilon(1-\gamma)} - \bar{f}$.

Resolving this programme (intermediate calculations available from the authors), we obtain (the tilde indicates a variable when the individual invests in *T*-specific skill only):

$$\tilde{e}_T = \frac{\varepsilon(1-\gamma)}{1+\varepsilon(1-\gamma)} \qquad (12)$$

Note that the education time is now lower than when the individual invests in both general and specific education.

From the education time $\tilde{e}_T$, we can calculate the corresponding human capital $\tilde{s}_{Tj}$ and $\tilde{h}_{Tj}$, and the related net income $\hat{I}_{Tj}$. We can finally compute all the variables at the steady state: $\overline{h}_{GT}'$, $\overline{s}_T'$, $\overline{h}_T'$ and $\overline{I}_T'$. All these values are depicted in Table 3.

We finally assume that λ is small enough so that condition $\delta_T e_T^{\varepsilon}\left(s_{Tj}(-1)\right)^{\eta} > \lambda$ in equation (4) is fulfilled (see the discussion in Appendix 2).

Table 3: Human capitals and net income when the individual works in sector *i* = *T*,*M* and follows *i*-specific education only $\left(\delta_G/\delta < \left((1+\varepsilon)/\varepsilon\gamma\right)^{\varepsilon}\right)$

	Human capitals and net income	***Steady states***
h_{jT}	$\delta\left(h_j(-1)\right)^{\eta}$	$\underline{h} = \delta^{1/(1-\eta)}$
s_{Tj}	$\tilde{s}_{Tj} = \delta_T\left(\dfrac{\varepsilon(1-\gamma)}{1+\varepsilon(1-\gamma)}\right)^{\varepsilon}\left(s_{Tj}(-1)\right)^{\eta}$	$\overline{s}_T' = \delta_T^{1/(1-\eta)}\left(\dfrac{\varepsilon(1-\gamma)}{1+\varepsilon(1-\gamma)}\right)^{\varepsilon/(1-\eta)}$
h_{Tj}	$\tilde{h}_{Tj} = \delta^{\gamma}\delta_T^{1-\gamma}\left(\dfrac{\varepsilon(1-\gamma)}{1+\varepsilon(1-\gamma)}\right)^{\varepsilon(1-\gamma)}\left(h_{Tj}(-1)\right)^{\eta}$	$\overline{h}_T' = \delta^{\frac{\gamma}{1-\eta}}\delta_T^{\frac{1-\gamma}{1-\eta}}\left(\dfrac{\varepsilon(1-\gamma)}{1+\varepsilon(1-\gamma)}\right)^{\frac{\varepsilon(1-\gamma)}{1-\eta}}$
I_{ji}	$\tilde{I}_j = w_T\dfrac{\delta^{\gamma}\delta_T^{1-\gamma}\left(\varepsilon(1-\gamma)\right)^{\varepsilon(1-\gamma)}}{\left(1+\varepsilon(1-\gamma)\right)^{1+\varepsilon(1-\gamma)}}\left(h_{Tj}(-1)\right)^{\eta} - \overline{f}$	$\overline{I}_T' = w_T\left(\dfrac{\delta^{\eta\gamma}\delta_T^{1-\gamma}\left(\varepsilon(1-\gamma)\right)^{\varepsilon(1-\gamma)}}{\left(1+\varepsilon(1-\gamma)\right)^{1-\eta+\varepsilon(1-\gamma)}}\right)^{1/(1-\eta)} - \overline{f}$

4 Education strategy, steady states and the poverty trap

As in the previous section, we consider a region where individuals can only choose between two sectors, services and the traditional industry *T*, and we suppose that the migration costs are high enough to prevent emigration.

Individual *j* selects the education strategy that maximises her lifetime net income I_j, i.e. her earnings net of the fixed cost of education. The individual thus compares her incomes deriving from working in sector *S* ($w_S h_j$) and working in sector *T* ($w_T h_{Tj}$).

4.1. Choice of the working sector

We can firstly discriminate between two situations. If $\delta_G/\delta < ((1+\varepsilon)/\varepsilon\gamma)^{\varepsilon}$, then all individuals do not pursue general education when deciding to work in industry *T*. In contrast, all individuals who work in *T* pursue general education when $\delta_G/\delta > ((1+\varepsilon)/\varepsilon\gamma)^{\varepsilon}$. Now, for each of these two cases, three possible decisions can occur: (i) not to go into further education and work in services, (ii) to pursue further education and work in services, and (iii) to pursue further education and work in industry *T*.

The precise analysis of each choice is described in Appendix 2. This analysis shows that for both case $\delta_G/\delta < ((1+\varepsilon)/\varepsilon\gamma)^{\varepsilon}$ and $\delta_G/\delta > ((1+\varepsilon)/\varepsilon\gamma)^{\varepsilon}$, the individual's decision depends on her parent's human capital endowment $(h_j(-1), s_{Tj}(-1))$. In Figure 1, this decision process is mapped in the plane $(h(-1), s_T(-1))$.

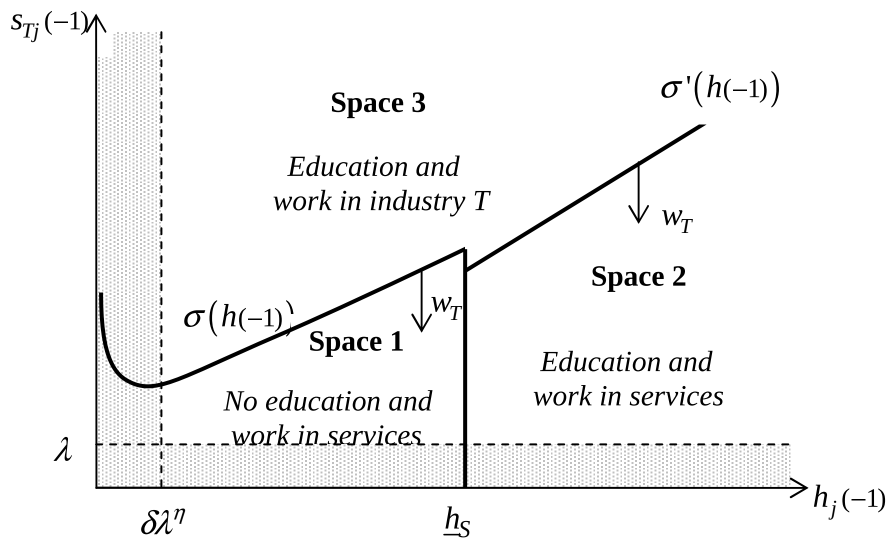


Figure 1: The individual's decision according to her parent's human capital endowment

The individual's decision depends on the location of her parent in the map $(h(-1), s_T(-1))$. Functions $\sigma(h(-1))$ and $\sigma'(h(-1))$ both differ depending on whether δ_G/δ is higher or lower than $((1+\varepsilon)/\varepsilon\gamma)^{\varepsilon}$, but they show the same shape in both cases (see the determination of these function in Appendix 2).

There are three spaces. When the parent's endowment $\left(h(-1), s_T(-1)\right)$ belongs to Space 1, the individual works in services without pursuing further education. When this endowment belongs to Space 2, she works in services and pursues further education. Finally, when it belongs to Space 3, the individual works in industry *T*.

Lemma 3: A decrease in the wage w_T per unit of *T*-efficient labour makes the condition to select industry *T* more constraining by moving upward curves $\sigma\left(h(-1)\right)$ and $\sigma'\left(h(-1)\right)$.

Proof: see Appendix 2.

This feature is logical because a reduction in w_T lowers the return from working in *T*. This also indicates that, for those individuals whose parents' general human capital is lower than $\underline{h}_S$, a decline in w_T increases the likelihood of being in the space without further education.

4.2. Intergenerational dynamics, Steady states and Poverty Traps

We now analyse the different human capital intergenerational dynamics. As we consider two sectors, these dynamics take place in the map $\left(h, s_T\right)$ of the endowments in general and *T*-specific human capital.

We suppose that $\underline{h} < \underline{h}_S$ [5], which signifies that steady state $\left(\underline{h}, \lambda\right)$ does exist because an individual with this endowment does not educate.

All the steady states presented in the following figures are taken from Tables 1, 2 and 3 above.

Let us firstly consider the case $\delta_G / \delta < \left((1+\varepsilon)/\varepsilon\gamma\right)^{\varepsilon}$ (Figure 2). The steady state of the dynamics corresponding to working in sector *T* is $\left(h, s_T\right) = \left(\underline{h}, \overline{s}_T{}'\right)$, because then the related individuals only pursue *T*-specific education (see the values of $\underline{h}$ and $\overline{s}_T{}'$ in Table 3 above).

[5] Remember that $\underline{h} = \delta^{1/\eta}$ is the steady state of the dynamics without further education and $\underline{h}_S$ the threshold above (under) which individuals pursue (do not pursue) further education when choosing to work in services.

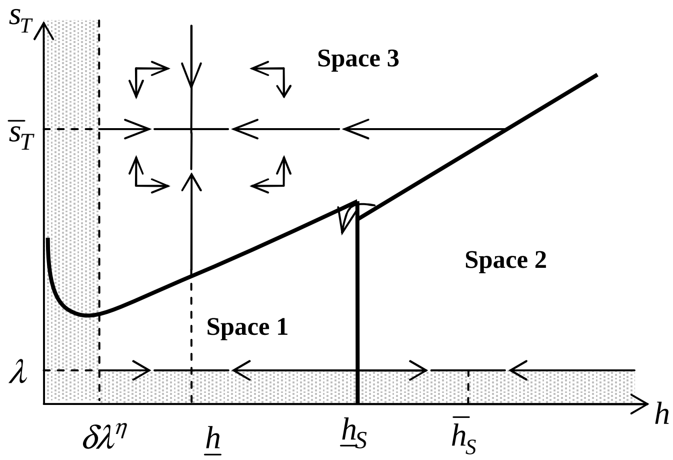


Figure 2: Intergenerational human capital dynamics when $\delta_G / \delta < \left((1+\varepsilon)/\varepsilon\gamma\right)^{\varepsilon}$

There are three possible steady states to which the different dynasties can converge (Figure 2). A dynasty initially (time 0) located in Space 1 ($h_0 < \underline{h}_S$ and $s_{T0} < \sigma(h)$) jumps onto path $s_T = \lambda$ and converge to steady state $\left(\underline{h}, \lambda\right)$. A dynasty who is initially in Space 2 ($h_0 > \underline{h}_S$ and $s_{T0} < \sigma'(h)$) jumps onto path $s_T = \lambda$ and converges to steady state $\left(\bar{h}_S, \lambda\right)$. Finally, a dynasty initially located in Space 3 ($h_0 < \underline{h}_S$ and $s_{T0} > \sigma(h)$ or $h_0 > \underline{h}_S$ and $s_{T0} > \sigma'(h)$) normally converges to steady state $\left(\underline{h}, \bar{s}_T'\right)$. Dynasties that initially stand at the vicinity of $\left(\underline{h}_S, \sigma'\left(\underline{h}_S\right)\right)$ can however fall into Space 1.

Consider now the case $\delta_G / \delta > \left((1+\varepsilon)/\varepsilon\gamma\right)^{\varepsilon}$ (Figure 3). The steady state of the dynamics corresponding to working in industry T is $\left(\bar{h}_{GT}, \bar{s}_T\right)$ because the related individuals then pursue both general and T-specific education (see the values of $\bar{h}_{GT}$ and $\bar{s}_T$ in Table 2).

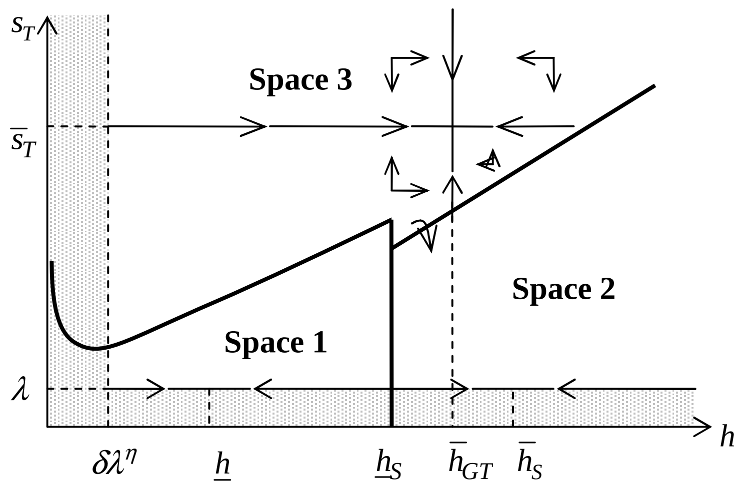


Figure 3: Intergenerational human capital dynamics when $\delta_G / \delta > \left((1+\varepsilon)/\varepsilon\gamma\right)^{\varepsilon}$

There are still three possible steady states to which the different dynasties can converge (Figure 3). A dynasty who is initially in Space 1 jumps onto path $s_T = \lambda$ and converges to steady state $\left(\underline{h}, \lambda\right)$. If the dynasty is initially in Space 2, this jumps onto path $s_T = \lambda$ and converges to steady state $\left(\bar{h}_S, \lambda\right)$. A dynasty who is initially in Space 3 ($h_0 < \underline{h}_S$ and $s_{T0} > \sigma(h)$ or $h_0 > \underline{h}_S$ and $s_{T0} > \sigma'(h)$) normally converges to steady state $\left(\bar{h}_{GT}, \bar{s}_T\right)$. Certain dynasties that initially stand in the vicinity of segment $\left[\sigma(\underline{h}_S), \sigma'(\underline{h}_S)\right]$ may however fall into Space 2 (Figure 3). Note that $\bar{h}_{GT}$ may be lower than $\underline{h}_S$, depending on the model parameters.

Finally, when $\underline{h} > \underline{h}_S$, all the dynasties pursue further education in the long term. As a matter of fact, when a dynasty initially stands in Space 1, it converges to $\underline{h}$. However, at the very moment it reaches $\underline{h}_S < \underline{h}$, the dynasty's members pursue further general education and thereby converge to $\bar{h}_S$. In this case, the steady state $\left(\underline{h}, \lambda\right)$ disappears from Figures 2 and 3 and there are only two steady states both with further education, one corresponding to the selection of industry *T* and the other to the selection of services.

We can consequently state the following two propositions:

Proposition 1: *If an individual chooses to work in services, then the successive generations of her offspring will work in services.*

Proposition 2: *If* $\underline{h} < \underline{h}_S$*, all the individuals with a general human capital of their parents lower that* $\underline{h}_S$ *and who choose to work in services do not pursue higher education, as well as all their descendants. All these dynasties then fall into an under-education trap and tend towards human capital steady state* $\left(\underline{h}, s_T\right) = \left(\delta^{1/\eta}, \lambda\right)$.

4.3. Discussion

We now discuss two points. The first relates to the persistence of a poverty trap when economic growth comes with an increase in the wage per unit of efficient labour in services. The second deals with the possible coexistence of two configurations (i.e., when certain individuals working in the traditional industry pursue general higher education and other do not) that are exclusive of each other in our model.

Under-education Trap and Growth

The condition for the existence of an under-education trap is $\underline{h} = \delta^{1/\eta} < \underline{h}_S$. Since $\underline{h}_S = \left(\frac{\bar{f} / w_S}{\varepsilon^{\varepsilon}(1+\varepsilon)^{-(1+\varepsilon)} \delta_G - \delta} \right)^{1/\eta}$, the persistence of the trap is conditioned by the fact that $\bar{f} / w_S$ does not decrease. If $\bar{f}$ is constant over time, and if economic growth comes with an increase in wage w_S (which is a usual outcome of growth theory), then the model reveals a development *à la* Galor and Tsiddon (1997): the poverty trap vanishes in the long term, i.e. at the very moment when w_S becomes high enough to make $\underline{h}_S$ fall below $\underline{h}$. In contrast, if we assume that the fixed cost consists of a fixed amount of educational services, which is very likely, then $\bar{f}$ increases at the same rate as w_S and ratio $\bar{f} / w_S$ remains constant over time. Then, the poverty trap is a permanent feature of the economy.

Different δ_G/δ across individuals

The model as defined until now assumes that δ_G / δ is the same for all individuals. This means that *all* the individuals who select to work in industry *T* either pursue or do not pursue general education. A situation where certain individuals work in sector *T* with general further education and others without is not a possible outcome of the model. This is however no longer the case if we assume that ratio δ_G / δ differs across individuals. In particular, the case where the offspring of the most educated families benefit from a higher ratio is rather likely for two reasons. Firstly, the most educated families can help their children into higher education, inducing intra-family human capital externalities that do not exist for less educated families. Secondly, higher general education is provided by universities that discriminate between students according to their levels at the end of basic education. As this level is higher for individuals from the most educated families, these typically enter the best universities with the highest δ_G. Both reasons result in a higher δ_G / δ for these families who benefit from the highest education and the highest incomes. In this case, the individuals from dynasties with high general education pursue both general and *T*-specific education, whereas those from low general education dynasties pursue *T*-specific education only. There are then two steady states for dynasties who work in industry *T*, one with high general education and with human capital endowment $(\bar{h}, \bar{s}_T)$, the other with endowment $(\underline{h}, \bar{s}_T')$. Such a situation is simulated in Section 6.

5 Restructuring

We now analyse the impact of a shock that entails a significant reduction in the demand met by the region's traditional industry, and we suppose that the adjustment to this shock is achieved by a substantial decrease in the wage per unit of *T*-efficient labour. This causes a restructuring process, i.e. a decrease in the weight of industry *T* in the region's production. We finally suppose that the service sector can employ all the workers who quit the traditional industry.

5.1. The impacts of restructuring

The demand shock lowers the return to education for those individuals who choose to work in the traditional sector whereas it has no impact on this return for individuals who decide to work in services. As a result, the change in the decision process only concerns the former, and the analysis can concentrate on the sole individuals who would have chosen to work in sector *T* without restructuring.

Proposition 3: *A decrease in the wage per unit of T-efficient labour* w_T *causes the following changes:*

(i) A move of certain working individuals from industry T to services, thereby reducing the weight of industry T in the region's production.

(ii) More restrictive conditions for young adults to select working in industry T and pursuing T-specific education.

(iii) A release of the conditions for falling into the poverty trap, thereby lowering upward mobility and increasing downward mobility.

(iv) A decrease in the earnings of individuals who would have opted to work in industry T without restructuring, whatever their new choice (staying in T or moving from T to S)

Proof: Feature (i) results from the fact that all the individuals such that $\overline{w}_T > w_S \left(h_j / s_{Tj}\right)^{1-\gamma} > \underline{w}_T$ will move from industry *T* to services[6]. Features (ii) and (iii) directly results from Lemma 3. Feature (iv) is straightforward.

[6] This comes from $\overline{w}_T h_j{}^{\gamma} s_{Tj}{}^{1-\gamma} > w_S h_j > \underline{w}_T h_j{}^{\gamma} s_{Tj}{}^{1-\gamma}$ after rearranging.

5.2. Discussion and possible extensions

In the case analysed here, the adjustment to the decrease in demand is totally achieved by a decrease in the real wage per unit of *T*-efficient labour. This is consistent with a shock that stems from the arrival of new competitors with low production costs, such as emerging countries in the clothing and textile industries. Other types of adjustment are however possible. For example, restructuring can reduce production and employment in the traditional industry without impact on wages. This story is now consistent with the decline of mining industries which has essentially been caused by a depletion of natural resources. When workers from the traditional industry can be employed in services, it can be shown that the outcome is very similar to that resulting from a decrease in wage[7]. Finally, introducing unemployment, i.e., by assuming that services cannot employ all the workers dismissed by the traditional industry, this does not change the outcomes either for the subsequent generations.

6 Simulations

We now illustrate the main findings of the theoretical model by simulating the developments of a region that hosts two sectors, services and a traditional industry, and experiences severe restructuring in the latter. Two cases are simulated. The first corresponds to the simplest form of the model. In the second, we suppose that individuals go to different schools according to their parents' educational levels, thereby dividing the dynasties between these with a high δ_G and those with a low δ_G. Finally note that a large number of simulations were implemented that exhibit very similar outcomes. These are available from the authors upon request.

6.1. Coefficients δ and δ_G are the same for all individuals

Table 4 depicts the parameters of the model, the initial values of w_S and w_T, and the value w_T' corresponding to the restructuring shock. The related thresholds, education times and steady states, and the functions that determine the decision spaces are described in Appendix 3.

[7] The proof is available from the authors upon request.

Figure 4 provides a diagrammatic presentation of the decision spaces and the related steady states.

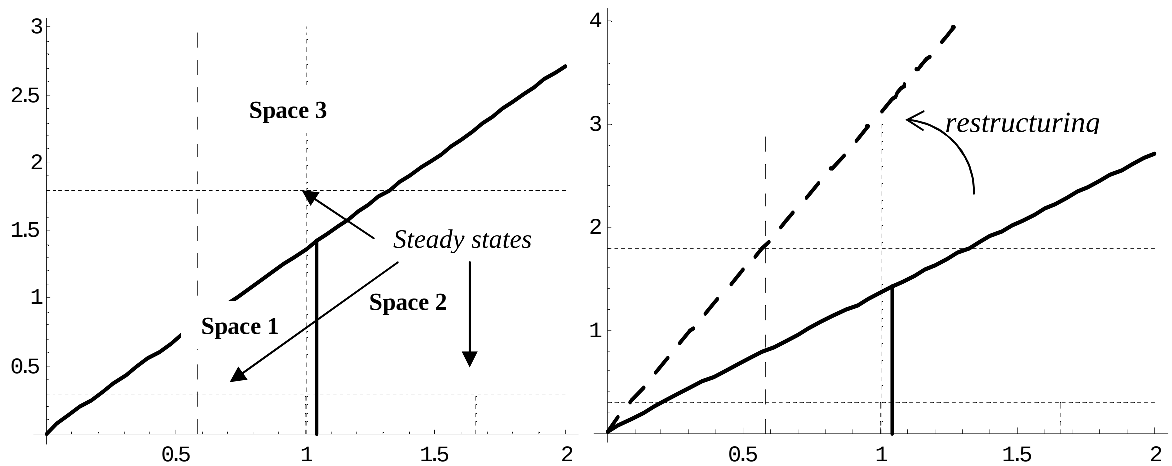
Table 4: The model's parameters and wages

γ	λ	η	ε	δ	δ_G	δ_T	δ_G/δ	$\bar{f}$	w_S	w_T	w_T'
0.4	0.3	0.45	0.3	1	2.05	2.5	2.05	0.016	1	1	0.8

The parameters are selected (i) so as to display plausible values, (ii) so that both sectors are chosen (all the individuals do not select the same sector), and (iii) to generate an under education trap. In addition, restructuring in the traditional industry consists in wage w_T falling from 1 to 0.8, i.e., a 20% decrease.

The calculations (see Appendix 3) show (i) that there are individuals who decide to work in services and to pursue further education $\left(\delta_G/\delta > (1+\varepsilon)^{1+\varepsilon}/\varepsilon^{\varepsilon}, \text{ condition (7)}\right)$, (ii) that all the individuals who choose to work in industry T pursue both general and specific education $\left(\delta_G/\delta > \left((1+\varepsilon)/\varepsilon\gamma\right)^{\varepsilon}\right)$, and (iii) that the steady state without education $\underline{h}$ is lower that the threshold under which individuals who select services decide not to pursue further education $\underline{h}_S$. This shows that an under-education trap does exist.

Figures 4 picture the three education decision spaces. It also shows that a 20% restructuring causes the traditional industry to disappear from the region in the long term because the steady state $\left(\bar{h}_{GT}, \bar{s}_T\right)$ is now under curve $\sigma(h)$.



Figures 4: Decision spaces and steady states before and after restructuring

Main results

The case described above is representative of the many simulations implemented with δ and δ_G being the same for all individuals. These simulations reveal several significant features:

1. The model is very sensitive to small changes in δ, δ_G and ε. This comes from condition $\delta_G/\delta > (1+\varepsilon)^{1+\varepsilon}/\varepsilon^{\varepsilon}$ and threshold $\underline{h}_S = \left(\frac{\bar{f}/\delta w_S}{\varepsilon^{\varepsilon}(1+\varepsilon)^{-(1+\varepsilon)}\delta_G/\delta - 1} \right)^{1/\eta}$. When $\delta_G/\delta < (1+\varepsilon)^{1+\varepsilon}/\varepsilon^{\varepsilon}$, no individual working in services pursues higher education and all dynasties in services drop into the under-education trap. When $\delta_G/\delta > (1+\varepsilon)^{1+\varepsilon}/\varepsilon^{\varepsilon}$, then $\underline{h}_S > 0$, but a rather small increase in δ_G/δ normally results in a substantial decrease in $\underline{h}_S$ that then falls under $\underline{h} = \delta^{1/(1-\eta)}$, thereby causing the under-education trap to disappear. Symmetrically, a rather small decrease in δ_G/δ results in a substantial increase in $\underline{h}_S$ that then becomes higher than $\bar{h}_S$, thereby causing all dynasties who work in services to fall into the under-education trap sooner or later. This shows that small changes in δ_G/δ across dynasties may have a crucial impact on the probability to fall into an under education trap.

2. The model with similar δ and δ_G also results in a very low income difference between dynasties in the trap and dynasties outside the trap at the steady state, which means that the impact of the trap on inequality is rather small. Here again, assuming differences in coefficient δ_G across dynasties can modify this result.

3. The restructuring, even when being rather modest (a decrease of 10-20% in wages in the traditional sector), always substantially enlarges the space of the under education trap. In addition, in the simulations implemented with plausible values of the parameters, a restructuring process leading to a 20% decrease in w_T causes industry *T*'s steady state to move outside Space 3, except for high levels of δ_T. This means that the traditional industry vanishes from the region. However, this disappearance can take a long time because the generation at work in sector *T*, and at least some of their children, normally continue to work in the traditional sector.

6.2. Partition of the dynasties according to ratio δ_G/δ

We now introduce a segmentation of families in higher education. This can derive from a minimal human capital at the end of basic education that is required for the young to enter the best universities. Since the human capital at the end of basic education is totally determined by the parent's human capital, the latter defines the threshold that splits individuals who pursue higher education into two groups. Families are thus distributed into two sets according to the parents' human capital, and we assume that parents' human capital threshold $h = 1.3$ separates these two groups. All the individuals from families under this threshold can go to schools providing general further education with productivity $\delta_G / \delta = 2.05$, whereas individuals above this threshold have access to schools with $\delta_G / \delta = 2.5$. In addition, we suppose that $\delta_T = 3$. All other parameters (including δ) have the same values as in Table 4. The related values of the thresholds, of the education times, of the steady states and of the functions $\sigma(h)$ and $\sigma'(h)$ are depicted in Appendix 3.

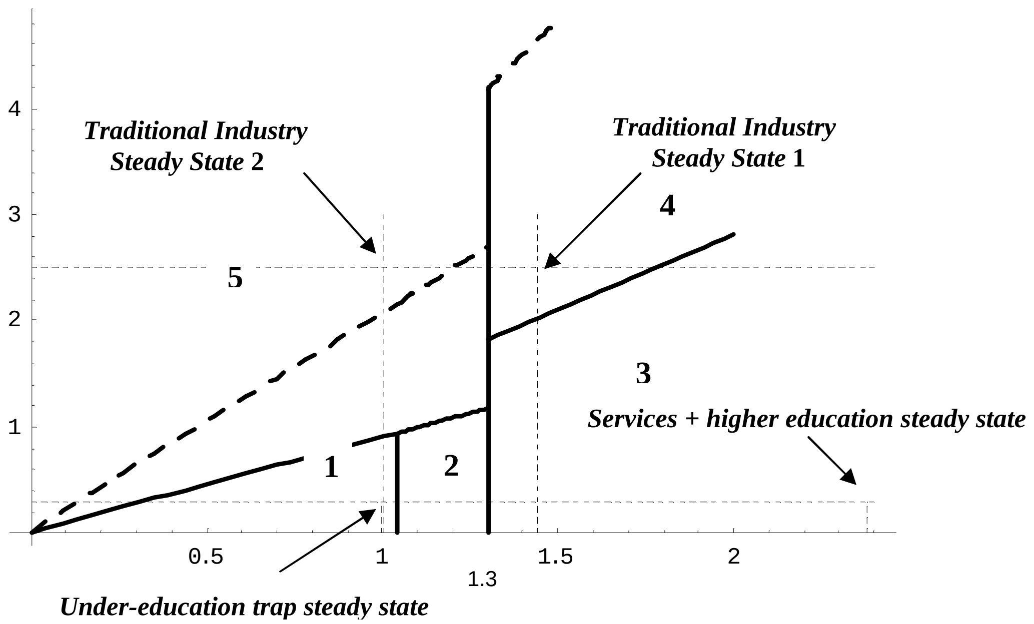


Figure 5: Decision spaces and steady states with different ratios δ_G/δ

Figure 5 describes the decision spaces, the steady states, and their changes with restructuring. Prior to restructuring, the curves in bold determine five decision spaces and four steady states. Space 1 defines the under-education trap. Space 2 corresponds to families working in services and belonging to the low education group ($h < 1.3$) who nevertheless pursue further general education. As the general education steady state determined by Space 2 dynamics is higher than 1.3, the related dynasties reach Space 3 sooner or later. The dynasties in Space 3 work in services and pursue higher education, and they tend to steady state $\left(\bar{h}_S = 2.38, s_T = 0.3\right)$. There are now two spaces of decision for the dynasties who work in the traditional industry, one with a high general education steady state (Space 4), the other with a low education steady state (Space 5). It can be noted that, in contrast with the situation simulated before, income inequality between educated and non educated individuals is now far from negligible at the steady state in services. This derives from the differences in productivity δ_G / δ between the two groups of families.

Restructuring displaces the frontiers that separate the choice between the working sectors. These frontiers move from the bold curves to the dashing curves (Figure 5). As expected, restructuring spreads out the under-education trap. In addition, the steady state corresponding to working in the traditional industry and pursuing general education now vanishes: after restructuring, all the dynasties above threshold $h = 1.3$ decide sooner or later to work in services (Figure 5).

It can finally be underlined that the simple introduction of a difference in productivity δ_G / δ across families produces outcomes that are more realistic and far less sensitive to small changes in the parameters. Further modifications such as differences in δ and δ_T (e.g., due to local externalities), and the introduction of the modern sector in the productive system, would provide a richer picture of regional developments, with however a high cost in term of modelling complexity.

7 Conclusion

We have built a model that accounts for the observed low intergenerational human capital mobility in regions that have experienced severe industrial restructuring. The region hosts two sectors, i.e. services and a traditional industry. By distinguishing general from industry-specific skills in the choice for education, we have shown that each individual selects one working sector and the related optimal education strategy, and that this twofold decision crucially depends on her parents' human capital. By introducing a restructuring process into the traditional industry, we have shown that this (i) results in a reduction in the upward intergenerational human capital mobility for those dynasties who work in the traditional sector, and (ii) causes certain dynasties to fall into the under-education trap. In its simplest form, our stylised model does not account for a number of features such as local externalities, skill polarisation and school differentiation. Introducing these features nevertheless reinforces our findings, as shown from the simulations that are carried out. In addition, the model is built by assuming a perfect credit market and a zero interest rate. Waiving these hypotheses would obviously extend the under-education trap. Finally note that such a model may be useful for understanding and anticipating the forthcoming developments in regions that are now specialised in sectors in which emerging countries are investing. It can also provide a basis to analysing the policies that can prevent the most unwelcome effects of restructuring on intergenerational upward mobility.

References

Barham, Vicky, Robin Boadway, Maurice Marchand and Pierre Pestieau. 1995. Education and poverty trap. *European Economic Review*. 39, no.7: 1257-1275.

Bauduin, Nicolas and Joel Hellier. (2006), Skill Dynamics, Inequality and Social Policies, *ECINEQ Working Paper Series*, N°34.

Bénabou, Roland J. 1993. Workings of a city: location, education, and production. *Quarterly Journal of Economics*. 108: 619-652.

-----------------------. 1996a. Heterogeneity, stratification and growth: Macroeconomic implications of community structure and school finance. *American Economic Review*. 86: 584-609.

-----------------------. 1996b. Equity and efficiency in human capital investment: The local connection. *Review of Economic Studies*. 63: 237-264.

Becker, Gary S. 1964. *Human capital. A theoretical and empirical analysis, with special reference to education*,.First Edition. New York: NBER

Becker, Gary S. and Nigel Tomes. 1979. An equilibrium theory of the distribution of income and intergenerational mobility. *Journal of Political Economy*. 87, no.6: 1153-1189.

--- . 1986. Human capital and the rise and fall of families. *Journal of Labor Economics*. 4, no.3: S1-39.

Ceroni, Carlotta B. (2001), Poverty Traps and Human Capital Accumulation **,** *Economica*, 68 (Issue 270): 203-219.

Chari, V.V. and Hugo Hopenhayn. 1991. Vintage human capital, growth and the diffusion of new technology. *Journal of Political Economy*. 99: 1142–1165.

Das, Mausumi. 2007. Persistent inequality: An explanation based on limited parental altruism. *Journal of Development Economics*. 84, no.1: 251-270.

De Grip, A. 2004. Evaluating human capital obsolescence. Research Paper for the EC-OECD Seminar on Human Capital and Labour Market Performance. Brussels, December 8, 2004.

Fleury, Nicolas. 2007. Dynamique des qualifications et mobilité intergénérationnelle dans la région Nord-Pas-de-Calais (Skill dynamics and intergenerational mobility in the Nord-Pas-de-Calais). EQUIPPE Report.

Galor, Oded and Daniel Tsiddon. 1997. The distribution of human capital and economic growth. *Journal of Economic Growth*. 2: 93-124

Galor, Oded and Joseph Zeira. 1993. Income distribution and macroeconomics. *Review of Economic Studies*. 60: 35-52

Gradstein, Mark, Moshe Justman and Volker Meier. 2005. *The political economy of education. Implications for growth and inequality*. The MIT Press: Cambridge and London.

Kambourov, Gueorgui and Iourii Manovskii. 2008. Occupational Specificity of Human Capital. Working Paper. http://www.econ.upenn.edu/~manovski/papers/occupation_specific_HC.pdf

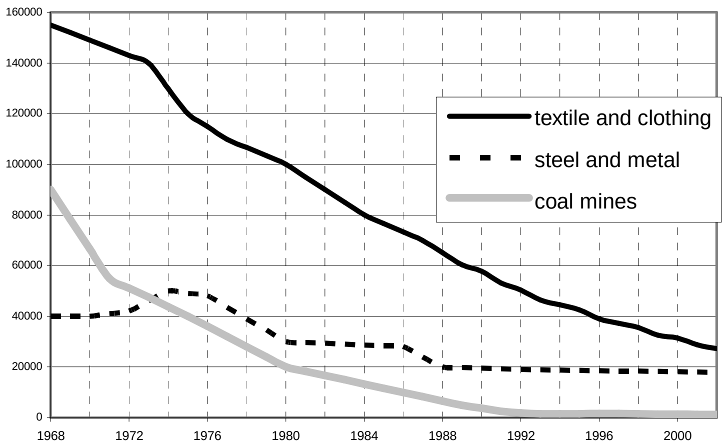
Loury, Glenn C. 1981. Intergenerational transfers and the distribution of earnings. *Econometrica*. 49, no.4: 843-867.

Lucas, Robert and E. Prescott. 1974. Equilibrium search and unemployment. *Journal of Economic Theory*. 7: 188–209.
Matsuyama, Kiminori. 1992. A simple model of sectoral adjustment. *Review of Economic Studies*. 59, no.2: 375–388.
Neal, Derek. 1995. Industry-Specific Human Capital: Evidence from Displaced workers. *Journal of Labor Economics*. 13, no.4: 653-677.
Parent, Daniel. 2000. Industry specific Capital and the Wage Profile: Evidence from the National Longitudinal Survey of Youth and the Panel Study of Income Dynamics. *Journal of Labor Economics*. 18, no.2: 306-323
Piketty, Thomas. 2000. Theories of Persistent Inequality and Intergenerational Mobility. in: A. Atkinson and F. Bourguignon (eds), *Handbook of Income Distribution*, Chapter 8: 429-476.
Rogerson, Richard. 2005. Sectoral shocks, human capital and displaced workers. *Review of Economic Dynamics*. 8: 89–105
Topel, R. 1990. Specific capital, mobility, and wages: wages rise with seniority. *NBER Working Paper*. no 3294.
Williamson, S. 1990. Sectoral shifts, labor market sorting, and aggregate fluctuations. *International Economic Review*. 31: 935–952.

Appendix 1: The example of the French Nord-Pas-de-Calais

Since the early sixties, the French Region Nord-Pas-de-Calais (NPC) has experienced a critical decline in traditional industries that initially accounted for almost 40% of the region's total employment (Figure A1).

Figure A1: Evolution of employment in the traditional industries in NPC (1968-2002)



Source: INSEE

This restructuring has come with a lasting low upward, and a lasting high downward, intergenerational mobility (Table A1).

Table A1: Intergenerational mobility in France and NPC (2003)

2003	Highest skills			Lowest skills		
	France	NPC	France-NPC	France	NPC	France-NPC
Ascending mobility rate (%)	0,00%	0,00%	(0)	**32,82%**	**23,57%**	+ 9,25
Descending mobility rate (%)	**60,57%**	**67,99%**	**-** 7,42	0,00%	0,00%	(0)
Total	100%	100%	-	100%	100%	-

Source: FQP database and Fleury (2007)

Appendix 2

Four choices are possible depending on ratio δ_G / δ and on $h_j(-1)$ in relation to $\underline{h}_S$:

	$\frac{\delta_G}{\delta} < \left(\frac{1+\varepsilon}{\varepsilon\gamma}\right)^{\varepsilon}$	$\frac{\delta_G}{\delta} > \left(\frac{1+\varepsilon}{\varepsilon\gamma}\right)^{\varepsilon}$
$h_j(-1) < \underline{h}_S$	**Choice 1**: *between working in S without further education and working in T with T-specific education only.*	**Choice 3**: *between working in S without further education and working in T with both general and T-specific education.*
$h_j(-1) > \underline{h}_S$	**Choice 2**: *choice between working in S with further education and working in T with T-specific education only.*	**Choice 4**: *between working in S with further education and working in T with both general and T-specific education.*

Let us firstly note that individual *j* spends time e_{TT} in *T*-specific education only if $\delta_T e_{TT}{}^{\varepsilon}\left(s_{Tj}(-1)\right)^{\eta} > \lambda$ (see the education function (4)). Since $s_{Tj}(-1) \geq \lambda$, this condition is always fulfilled if $\delta_T > \lambda^{1-\eta} / e_{TT}{}^{\varepsilon}$, i.e. $\delta_T > \left(\frac{1+\varepsilon}{(1-\gamma)\varepsilon}\right)^{\varepsilon}\lambda^{1-\eta}$ when $\frac{\delta_G}{\delta} > \left(\frac{1+\varepsilon}{\varepsilon\gamma}\right)^{\varepsilon}$ and $\delta_T > \left(\frac{1+\varepsilon(1-\gamma)}{(1-\gamma)\varepsilon}\right)^{\varepsilon}\lambda^{1-\eta}$ when $\frac{\delta_G}{\delta} < \left(\frac{1+\varepsilon}{\varepsilon\gamma}\right)^{\varepsilon}$. We assume that λ is small enough so that $\delta_T > \left(\frac{1+\varepsilon}{(1-\gamma)\varepsilon}\right)^{\varepsilon}\lambda^{1-\eta}$. Condition $\delta_T e_{TT}{}^{\varepsilon}\left(s_{Tj}(-1)\right)^{\eta} > \lambda$ is thus always fulfilled.

- <u>*Choice 1*</u>: $\delta_G / \delta < \left((1+\varepsilon)/\varepsilon\gamma\right)^{\varepsilon}$ *and* $h_j(-1) < \underline{h}_S$

Since $\delta_G / \delta < \left((1+\varepsilon)/\varepsilon\gamma\right)^{\varepsilon}$, individual *j* only pursues *T*-specific education and earns $\tilde{I}_{jT} = w_T \delta^{\gamma} \delta_T^{1-\gamma} \frac{(\varepsilon(1-\gamma))^{\varepsilon(1-\gamma)}}{(1+\varepsilon(1-\gamma))^{1+\varepsilon(1-\gamma)}}\left(h_{Tj}(-1)\right)^{\eta} - \overline{f}$ if she works in industry *T*. As $h_j(-1) < \underline{h}_S$, she does not pursue further education and earns $w_S \delta\left(h_j(-1)\right)^{\eta}$ if she works in services. She thus follows the *T*-specific education programme if $\tilde{I}_{jT} > w_S \delta\left(h_j(-1)\right)^{\eta}$, which can be written:

$$s_{Tj}(-1) > \sigma_1\left(h_j(-1)\right) = C_1 \times \left(\left(h_j(-1)\right)^{\eta(1-\gamma)} + \frac{\overline{f}/w_S}{\delta\left(h_j(-1)\right)^{\eta\gamma}}\right)^{\frac{1}{\eta(1-\gamma)}}$$

with $C_1 \equiv \left(\frac{w_S}{w_T}\left(\frac{\delta}{\delta_T}\right)^{1-\gamma}\frac{(1+\varepsilon(1-\gamma))^{1+\varepsilon(1-\gamma)}}{(\varepsilon(1-\gamma))^{\varepsilon(1-\gamma)}}\right)^{\frac{1}{\eta(1-\gamma)}}$

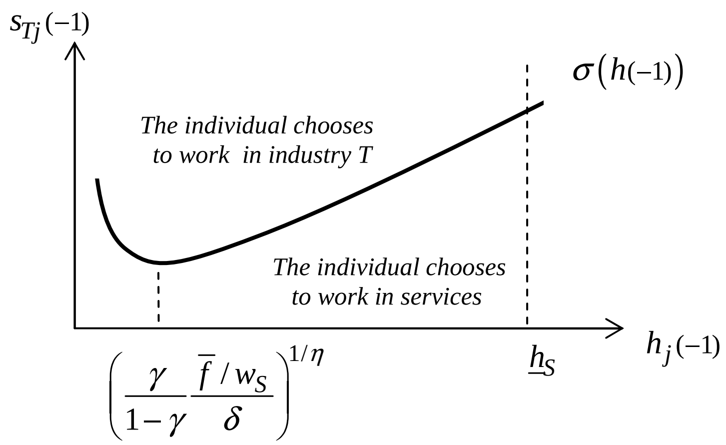


Figure A2: The individual's decision when $h_j(-1) < \underline{h}_S$ *and* $\delta_G / \delta < ((1+\varepsilon)/\varepsilon\gamma)^{\varepsilon}$

Function $\sigma_1(h_j(-1))$ is U-shaped, with its minimum for $h_j(-1) = \left(\frac{\gamma}{1-\gamma}\frac{\bar{f}/w_S}{\delta}\right)^{1/\eta}$ [8], and tends towards line $s_{Tj}(-1) = C_1 \times h_j(-1)$ when $h_j(-1)$ tends towards infinite, as depicted on Figure A1. Note that the function's minimum is always smaller than $\underline{h}_S$ for plausible values of the parameters.

● <u>Choice 2</u>: $h_j(-1) > \underline{h}_S$ and $\delta_G / \delta < ((1+\varepsilon)/\varepsilon\gamma)^{\varepsilon}$

The individual chooses to educate when working in *S* ($h_j(-1) > \underline{h}_S$) and she only pursue *T*-specific education when working in *T* $\left(\delta_G / \delta < ((1+\varepsilon)/\varepsilon\gamma)^{\varepsilon}\right)$. She chooses to work in *T* (in *S*) if and only if $\hat{I}_{jS} < \tilde{I}_{jT}$ (if $\hat{I}_{jS} > \tilde{I}_{jT}$), which can be written:

$$s_{Tj}(-1) < \sigma_1'(h_j(-1)) = C_1' \times h_j(-1)$$

with $C_1' \equiv \left(\frac{w_S}{w_T}\frac{\delta_G}{\delta^{\gamma}\delta_T^{1-\gamma}}\frac{\varepsilon^{\varepsilon}(1+\varepsilon(1-\gamma))^{1+\varepsilon(1-\gamma)}}{(\varepsilon(1-\gamma))^{\varepsilon(1-\gamma)}(1+\varepsilon)^{1+\varepsilon}}\right)^{1/(1-\gamma)\eta}$

The line $\sigma_1'(h_j(-1))$ determines the spaces of decision in the map $(h_j(-1), s_{Tj}(-1))$ of the parent's human capital endowments, as depicted on Figure A3.

[8] Proof available from the authors upon request.

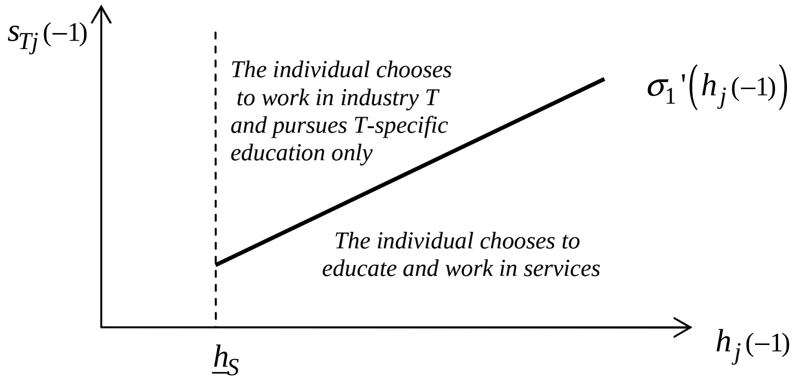


Figure A3: The individual's decision when $h_j(-1) > \underline{h}_S$ and $\delta_G/\delta < \left((1+\varepsilon)/\varepsilon\gamma\right)^{\varepsilon}$

- *Choice 3*: $\delta_G/\delta > \left((1+\varepsilon)/\varepsilon\gamma\right)^{\varepsilon}$ and $h_j(-1) < \underline{h}_S$

As $\delta_G/\delta > \left((1+\varepsilon)/\varepsilon\gamma\right)^{\varepsilon}$, individual *j* pursues both general and specific education and earns $\hat{I}_j = w_T(1-\hat{e}_T)\hat{h}_{Tj} - \overline{f}$ if she works in sector *T*, and she does not educate and earns $w_S\delta\left(h_j(-1)\right)^{\eta}$ when working in *S* ($h_j(-1) < \underline{h}_S$). The condition for her to choose to work in industry *T* is thus $w_T(1-\hat{e}_T)\hat{h}_{Tj} - \overline{f} > w_S\delta\left(h_j(-1)\right)^{\eta}$, which gives after rearranging:

$$s_{ij}(-1) > \sigma_2\left(h_j(-1)\right) = C_2 \times \left(\left(h_j(-1)\right)^{(1-\gamma)\eta} + \frac{\overline{f}/w_S}{\delta\left(h_j(-1)\right)^{\gamma\eta}}\right)^{\frac{1}{(1-\gamma)\eta}}$$

with $C_2 \equiv \left(\frac{w_S}{w_T}\frac{(1+\varepsilon)^{1+\varepsilon}\delta}{\varepsilon^{\varepsilon}\delta_G{}^{\gamma}\delta_T{}^{1-\gamma}\left(\gamma^{\gamma}(1-\gamma)^{1-\gamma}\right)^{\varepsilon}}\right)^{1/(1-\gamma)\eta}$

Function $\sigma_2\left(h_j(-1)\right)$ is U-shaped with its minimum for $h_j(-1) = \left(\frac{\gamma}{1-\gamma}\frac{\overline{f}/w_S}{\delta}\right)^{1/\eta}$, and its shape is similar to that depicted on Figure A2.

- *Choice 4*: $h_j(-1) > \underline{h}_S$ and $\delta_G/\delta > \left((1+\varepsilon)/\varepsilon\gamma\right)^{\varepsilon}$

Since $h_j(-1) > \underline{h}_S$, the optimal choice of individual *j* is $\hat{e}_G = \frac{\varepsilon}{1+\varepsilon}$ if she works in sector *S*, and $\left(\hat{e}_{GT}, \hat{e}_{TT}\right) = \left(\frac{\varepsilon}{1+\varepsilon}\gamma, \frac{\varepsilon}{1+\varepsilon}(1-\gamma)\right)$ if she works in sector *T*. Consequently, the condition for individual *j* to select industry *T* is $\hat{I}_{jT} > \hat{I}_{jS}$, which can be written:

$w_i \delta_G{}^{\gamma} \delta_T{}^{1-\gamma} \left(\gamma^{\gamma}(1-\gamma)^{1-\gamma}\right)^{\varepsilon} \left(h_j(-1)\right)^{\eta\gamma} \left(s_{Tj}(-1)\right)^{(1-\gamma)\eta} > w_S \delta_G \left(h_j(-1)\right)^{\eta}$. This gives after rearranging:

$$s_{Tj}(-1) > \sigma_2{}'\left(h_j(-1)\right) = C_2{}' \times h_j(-1), \quad \text{with } C_2{}' \equiv \left(\frac{w_S}{w_T} \frac{(\delta_G/\delta_T)^{1-\gamma}}{\gamma^{\varepsilon\gamma}(1-\gamma)^{\varepsilon(1-\gamma)}} \right)^{\frac{1}{\eta(1-\gamma)}}$$

In the map $\left(h_j(-1), s_{Tj}(-1)\right)$, line $\sigma_2{}'\left(h_j(-1)\right)$ separates the space where the individual chooses to work in industry *T* (above the line) from the space where she works in services (beneath the line), and the corresponding Figure is thus similar to that of choice 2.

In both cases $\delta_G/\delta < \left((1+\varepsilon)/\varepsilon\gamma\right)^{\varepsilon}$ and $\delta_G/\delta > \left((1+\varepsilon)/\varepsilon\gamma\right)^{\varepsilon}$, the curves $\sigma_k\left(h_j(-1)\right)$ and $\sigma_k{}'\left(h_j(-1)\right)$, k = 1,2, determine three spaces of decision depicted on Figure 2.

From the values C_1, $C_1{}'$, C_2, $C_2{}'$ in functions σ_1, $\sigma_1{}'$, σ_2, $\sigma_2{}'$, it is straightforward that $\frac{\partial \sigma_1}{\partial w_T} < 0$, $\frac{\partial \sigma_1{}'}{\partial w_T} < 0$, $\frac{\partial \sigma_2}{\partial w_T} < 0$, $\frac{\partial \sigma_2{}'}{\partial w_T} < 0$, which establishes Lemma 3.

Appendix 3

Table A1: Thresholds, Education times and Steady states in Simulation 6.1.

$\underline{h}$	$\frac{(1+\varepsilon)^{1+\varepsilon}}{\varepsilon^{\varepsilon}}$	$\left(\frac{1+\varepsilon}{\varepsilon\gamma}\right)^{\varepsilon}$	$\underline{h}_S$	$\hat{e}_S$	$\hat{e}_{GT}$	$\hat{e}_{TT}$	$\overline{h}_S$	$\overline{h}_{GT}$	$\overline{s}_T$
1	2.018	2.044	1.044	0.23	0.092	0.138	1.658	1.0055	1.80

Table A2: Functions determining the decision spaces in Simulation 6.1.

Without restructuring:	$\sigma(h) = 1.2829\left(h^{0.27} + \frac{0.016}{h^{0.18}}\right)^{3.7}$; $\sigma'(h) = 1.359 \times h$
With restructuring:	$\sigma(h) = 2.932\left(h^{0.27} + \frac{0.016}{h^{0.18}}\right)^{3.7}$; $\sigma'(h) = 3.106 \times h$

Table A3: Thresholds, Education times and Steady states in Simulation 6.2*

$\underline{h}$	$\frac{(1+\varepsilon)^{1+\varepsilon}}{\varepsilon^{\varepsilon}}$	$\left(\frac{1+\varepsilon}{\varepsilon\gamma}\right)^{\varepsilon}$	case 1 $\underline{h}_S$	case 2 $\underline{h}_S$	$\hat{e}_S$	$\hat{e}_{GT}$	$\hat{e}_{TT}$	case 1 $\overline{h}_S$	case 2 $\overline{h}_S$	case 1 $\overline{h}_{GT}$	case 2 $\overline{h}_{GT}$	$\overline{s}_T$
1	2.018	2.044	1.044	0.002	0.23	0.092	0.138	1.658	2.377	1.0055	1.4425	2.51

* case 1 refers to families under threshold h = 1.3, and case 2 to families above h = 1.3

Table A4: Functions determining the decision spaces in Simulation 6.2.

Without restructuring			
Case 1:	$\sigma(h) = 0.8555\left(h^{0.27} + \frac{0.016}{h^{0.18}}\right)^{3.7}$	;	$\sigma'(h) = 0.9063 \times h$
Case 2:	$\sigma(h)$ has no impact	;	$\sigma'(h) = 1.4086 \times h$
With restructuring			
Case 1:	$\sigma(h) = 1.955\left(h^{0.27} + \frac{0.016}{h^{0.18}}\right)^{3.7}$	;	$\sigma'(h) = 2.071 \times h$
Case 2:	$\sigma(h)$ has no impact	;	$\sigma'(h) = 3.219 \times h$

Remark: The functions that determine the intergenerational human capital mobility (functions $\underline{h}_j = \delta\left(h_j(-1)\right)^{\eta}$, $\hat{h}_{jS} = \delta_G\left(\frac{\varepsilon}{1+\varepsilon}\right)^{\varepsilon}\left(h_j(-1)\right)^{\eta}$, $\hat{h}_{jT} = \delta_G\left(\frac{\varepsilon\gamma}{1+\varepsilon}\right)^{\varepsilon}\left(h_j(-1)\right)^{\eta}$ and $\hat{s}_{Tj} = \delta_T\left(\frac{\varepsilon(1-\gamma)}{1+\varepsilon}\right)^{\varepsilon}\left(s_{Tj}(-1)\right)^{\eta}$) are available from the authors upon request.