CESifo *Working Paper Series*

LOCAL HUMAN CAPITAL EXTERNALITIES: AN OVERLAPPING GENERATION MODEL AND SOME EVIDENCE ON EXPERIENCE PREMIA

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Working Paper No. 219

December 1999

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* I am grateful to Antonio Ciccone, David Romer, Maury Obstfeld, Edward Glaeser and one anonymous referee for extremely helpful comments. I am also indebted with participants to various seminars in University of Chicago, Columbia Business School and Universitat Pompeu Fabra for suggestions. I acknowledge the Alfred P. Sloan Foundation for funding part of this project. This paper was first circulated with the title: “Dynamic Human Capital Externalities: Theory and Evidence”.

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Abstract

In an interesting and influential paper Robert Lucas (1993) considering the experience of East Asian small economies, suggests that “on the job“ learning could be the principal engine of their miraculous growth in the last 20 years. In this paper I develop an overlapping generation model where on the job learning, via local spillovers and local interactions, is the main channel of human capital accumulation in small open economies (as cities). The model predicts that skills‘ accumulation, due to experience in the local environment, has an effect on the experience premia of the workers and on the dispersion of their wages. I find the balanced growth path of the model and I simulate the adjustment path after a technological shock. The second part of the paper conveys some suggestive evidence on what local characteristics affect the accumulation of skills, using data from 236 U.S. cities. Local characteristics which seem to have a strong impact on the accumulation of skills are the “technological intensity“ of the local manufacturing sector, the average level of education and the density of teachers in the city. This seems to confirm that the “quality“ of local environments is very important for skills‘ accumulation.

JEL Classification: R0, R3, J3

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1 Introduction

The intuition of the economists who have originated the revival of interest in the theory of growth has indicated two crucial factors that may be considered as engines of fast and sustained growth: learning by doing (Arrow [1], Romer [18] and Lucas [16]), and human capital externalities (Lucas [15]). Physical proximity seems to be a necessary condition to bene…t from these externalities. The process of learning through local interactions and in the local environment is an important channel that links geographic agglomerations to technological growth, as already noted by Jacobs [8] among others. In the present paper I will consider a purely "technological" externality, coming from the fact that a local environment, rich of highly skilled workers and high-tech industries, promotes the rapid learning and the accumulation of skills of local workers. This externality will increase the skills of old workers relative to those of young workers and therefore will a¤ect the pro…le of their wages (and productivity)[1] .

This is the main intuition that I will use to show that the experience premium, i.e. the di¤erence in wage between old and young workers, captures the skill di¤erences accumulated with time and will di¤er across cities, depending on the intensity of the local externalities. The model presented in this paper, abstracts from any other complication. It assumes perfect competition in the local economies, therefore eliminating any externality driven by monopolistic competition and transport costs (as in the "new geography" models, Krugman [11], [12] and Krugman and Venables [13]). It assumes labor mobility and allows for crowding e¤ects in a city, due to the increasing cost of land, so that workers move to equate their consumption wage and in equilibrium all cities have the same rate of growth in per capita income. The e¤ect of the externalities, therefore, is a level e¤ect that generates higher wages in the cities where they are stronger.

A second interesting insight from using the experience premia as a measure of cumulated skills and therefore of the intensity of learning by doing, is that, as the labor literature has proven, this premium has increased substantially in the 80's[2] .The introduction of computers and information technology, associated with the technological revolution of the 70's and 80's, may have increased substantially the potentiality of learning by doing and of learning from personal interactions. This technological shock may be magni…ed by local characteristics increasing the intensity of local learning more in some cities than in others. This would be the case if, as Gaspar and Glaeser [6] argue, the information obtained in face-to-face interaction is a complement to the information obtained via "electronically mediated" interaction.

We propose some more suggestive evidence, showing that, in 1990, most of the variation in experience premia across cities is not explained by di¤erent individual characteristics, but is idiosyncratic to the cities. Interestingly, about one third of the unexplained variance in experience premia across cities is ex-

[1] Glaeser and Mare' [7] stress the role of urban agglomerations in promoting rapid accumulation of skills.

[2] See, among the others Katz and Murphy [14] and Bound and Johnson [2].

plained by city-wise characteristics as average education of the workers, density of high-tech industries and density of teachers. We interpret this as preliminary evidence that the local environment matters for the accumulation of individual skills, and in particular some local characteristics improve the environment for on-the-job learning.

If the local characteristics that affect skills' accumulation are historically determined, it might be efficient for some municipalities to subsidize local education or to attract more technology-intensive firms in order to benefit from the externalities that they generate. The present paper does not develop policy implication from the analysis but brings theoretical considerations and some evidence to stress the importance of local environment for the productivity of workers.

The paper is organized as follows: section 2 develops the model and solves for the equilibrium growth path, section 3 analyzes and simulates the transition dynamics after a technological shock, section 4 describes some empirical evidence on experience premia in cities and their determinants and section 5 concludes.

2 The OLG model and its Balanced Growth Path

2.1 The Production Function

The model presented in this section describes an economy with two locations (I will call them cities[3]) and mobility of goods and workers between them. I will abstract from many complications that do not add insight to the model, assuming that the two cities produce an homogeneous good using the same technology that employs only labor and exhibit constant returns to scale[4] . No physical capital is used in production[5] , and the labor input is made of two types of workers "old" and "young", to allow for on-the-job learning between the two periods of their life. People live for two periods and generations of workers overlap as in Diamond [5], so that in each period young and old are employed in the production of the good and interact generating learning that increases their skills. The production functions for the tradable homogeneous good in the two cities are, therefore, as follows:

$$Y_t^i = \left[\left(l_1^i H_1^i\right)_t^{\gamma} + \left(l_2^i H_2^i\right)_t^{\gamma}\right]^{\frac{1}{\gamma}} \qquad i = A; B \quad 0 < \gamma < 1 \qquad (1)$$

In expression 1 l_1^i represents the number of young workers employed in city "i" and l_2^i is the number of old workers employed in the same city, while H_1^i and

[3] Nothing prevents us from thinking about regions

[4] The model is therefore silent on the trade implications and on the specialization in production of each city.

[5] In earlier versions of the paper I explored the possibility of having capital in the local production functions. As long as capital is mobile between cities none of the results obtained is affected by the simplification adopted in the current version.

H_2^i are their level of human capital (skills) expressed as units of effective labor. The restriction on the parameter γ implies that the elasticity of substitution between old and young workers is larger than one. This seems very reasonable in view of the normal assumption of unit elasticity of substitution between labor and capital (Cobb-Douglas) and in view of the available estimates of the above elasticity[6] .

I will introduce here two simplifying assumptions, one completely harmless and the other justifiable on the basis of a reasonable approximation. The first (harmless) is that the total number of people in each generation is standardized to one. I therefore eliminate population growth and introduce the standardization: $l_1^B = 1 - l_1^A$ and $l_2^B = 1 - l_2^A$ that will hold for each period t. The second simplification is that while young workers, at the beginning of their first period of work, are perfectly mobile between the two cities, old workers, at the beginning of their second period, are not mobile. This may be due to an increase in costs of moving or to specific skills, cumulated during their working life[7], that will be lost if the workers move. This assumption implies that $(l_1^i)_t = (l_2^i)_{t+1}$. We can therefore consider only the variable $(l_1^A)_t$ and recall the above mentioned assumptions to recover a full description of the allocation of young and old workers in the two cities in each period.

2.2 Skills' accumulation and the local externality

The whole "action" of the present model is in the mechanism of accumulation of human capital via on-the-job learning and interactions. Given that human capital is not transferred to future generations the lifetime of the workers is the limit for the accumulation of skills. In each city, young workers begin their activity with a certain amount of human capital, determined by the level of global knowledge and the nationwide level of schooling. This human capital, increases from one generation to the next, at an exogenous rate g, which could be thought as the exogenous rate of growth of global knowledge of a classic Solow [19] model. Therefore, we will have that $(H_1^A)_t = (H_1^B)_t = (H_1)_t$ and the dynamic evolution of young workers' human capital will be:

$$(H_1)_{t+1} = (1 + g)(H_1)_t \tag{2}$$

The central equation of the model is the one that describes how workers accumulate human capital, through learning in their local environment. Equation 3 below, which describes how workers accumulate skills, shows that characteristics of the local industries, of the local co-workers and of the local environment may affect the intensity of this externality. Workers have to operate in the same location to affect each other learning. Also, technological and cultural characteristics of the location affect the intensity of their learning. The average

[6] Katz and Murphy [14] estimate an elasticity between "young" (1-5 years of experience) and "old" (26-35 years) of 2.9.

[7] See for example Topel [20]

human capital of a worker, who worked in city i during the first period of life, is described by the following difference-equation:

$$(H^i_2)_{t+1} = (1+g)(H^i_1)_t + E(k_i;\phi)(\bar{H}^i)_t \quad 0 < E(k_i;\phi) < 1 \tag{3}$$

Equation 3 shows that part of the skills learned on-the-job are independent from the location, and come merely from incorporating global knowledge (first term on the right hand side). The other part (second term) depends on the population-weighted average level of human capital of other people in the same location $(\bar{H}^i)_t = \frac{1}{2}\left[(H^i_1)_t + (H^i_2)_t\right]$ and on a coefficient $E(k_i;\phi)$ that determines the "intensity" in the "absorption" of skills during the working experience . This coefficient E, is a function of a global technological factor, ϕ, and of a location-specific factor k_i. An higher value of ϕ increases the value of E in both locations $(\partial E/\partial \phi) > 0$ and can be thought as a larger flow of communication that takes place among workers. This parameter has probably experienced a dramatic increase in the 80's with the introduction and diffusion of the information technology. An higher value of the parameter k_i captures local characteristics that induce higher quality and intensity of local interactions and local learning $(\partial k_i/\partial \phi) > 0$. These characteristics could be the technological intensity of industries, the density of more educated workers, the density of teaching institutions and the ethnic and linguistic composition of the city[8].

This simple characterization of the local on-the-job learning externalities, generated by the average level of human capital and other exogenous local characteristics, allows a simple analysis of the balanced growth path (BGP) of the economy. In particular I will analyze the accumulation of human capital, the location decision of workers and the wage profile of workers in the two cities when the economy is on a balanced growth path.

As in BGP all the variables grow at constant rate in each city, the number of workers in a city $(l^i)_t$ must be constant, given that it cannot grow indefinitely, being bounded by the level of total population $(L = 1)$. Therefore, I can denote with l^A the number of workers in city A on a balanced growth path.

Dividing both sides of equation 3 by $(H^i_1)_{t+1}$ and substituting for $(\bar{H}^i)_t$, we obtain the following expression:

$$(h^i)_{t+1} = 1 + \frac{E(k_i;\phi)}{(1+g)}\left(\frac{1}{2} + \frac{1}{2}h^i_t\right) \quad i = A; B \tag{4}$$

where $h^i_t = \frac{(H^i_2)_t}{(H^i_1)_t}$

As can be seen in Figure 1 below, the dynamics of equation 4 lead to a globally stable equilibrium at (h^*_i) . This means that in BGP the ratio of old to young average human capital will be constant and also that, starting from

[8] If information flows better within culturally homogeneous groups, the fractionalization of the local environment could be armful to interactions and learning.

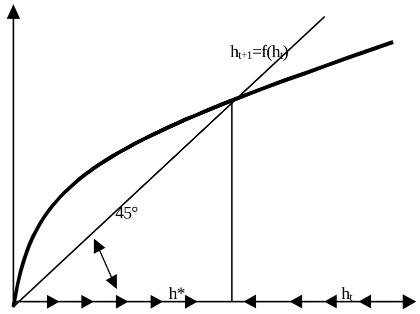

Figure 1: Phase Diagram for the level of human capital

any other level, the process of on-the-job skills' accumulation will lead to the stable value (h_i^*). Solving the difference equation we find an explicit expression for (h_i^*) :

$$h_i^* = \frac{2(1+g) + E(k_i;\Omega)}{2(1+g) - E(k_i;\Omega)} \quad i = A; B \tag{5}$$

The BGP ratio of skills depends positively on Ω and k_i and negatively on g. This means that the skills of old workers will be larger relative to the skills of young, the larger is the intensity of local learning and the smaller is the growth of the initial level of skills.

As (h_i^*) depends only on exogenous parameters I will determine the values of the other variables in BGP as functions of (h_i^*) so that it will be straightforward to infer their dependence on the location-specific exogenous characteristics.

2.3 Consumption, Price Index and the Interest Rate

The main decisions of the workers in the economy are the following two: where to locate in their first period and how to allocate their labor income for consumption over the two periods and between the tradable good and the housing service. The utility function for worker i in generation t is as follows:

$$\log(G_i)_t + \frac{1}{1+\delta}\log(G_i)_{t+1} \tag{6}$$

where δ is the inter-temporal discount rate that I assume, for simplicity, equal to g, the growth rate of the economy[9] , and $G = C^{\alpha}T^{1-\alpha}$ is a composite

[9] This assumption eliminate issues of consumption tilting.

good combining consumption of the tradable good C and of the service from a fixed factor (housing) T. I assume that the rent for the land service is paid to non working local land owners, who spend all their income to maximize their utility from the same composite good G. Without loss of generality I assume the amount of land in each city to be equal and I normalize it to one. Also, I consider the tradable good (produced and consumed) as the numeraire and I denote with p_T^i the price of land (housing service) in city i. If we call S_t the total expenditure of a worker in each period then the optimal allocation between C and T implies that $C_t = \alpha S_t$ and $T_t = (1 - \alpha)S_t$. The level of utility reached in each period will be a linear function of S_t. Therefore the optimal inter-temporal allocation of expenditure, given that worker receive only wage income, is as follows:

$$(S_1)_t = \frac{1+\delta}{2+\delta}\left[(w_1)_t + \frac{(w_2)_t}{1+r}\right] \tag{7}$$

$$(S_2)_t = \frac{1+r}{2+\delta}\left[(w_1)_t + \frac{(w_2)_t}{1+r}\right] \tag{8}$$

where w_1 and w_2 are the wages for young and old workers respectively (we have omitted all the superscript denoting the city as these relations hold for both cities) and r is the one-period interest rate prevailing on the bond market[10]. The term in brackets represents the present discounted value of lifetime income for a worker. Equation 7 and 8 apply to workers in both locations. In equilibrium workers are paid their marginal productivity so we have:

$$(w_1^i)_t = \frac{\partial Y_t^i}{\partial l_1^i} = \frac{Y_t^i}{[1 + (h_i^*)^\gamma]\, l^i} \tag{9}$$

$$(w_2^i)_t = \frac{\partial Y_t^i}{\partial l_2^i} = \frac{Y_t^i}{[1 + (h_i^*)^\gamma]\, l^i}(h_i^*)^\gamma \tag{10}$$

In 9 and 10 I have not used time subscripts for those variables that are constant in BGP. Now let's substitute 9 and 10 into 7 and 8 in order to calculate the total expenditure of workers, young and old, in location i as a function of local income. I use the fact that in BGP income grows at rate $(1 + g) = (1 + \delta)$ in each city and I get, as total expenditure, the following expression:

$$(S_{i;TOT})_t = \left[\left(\frac{1+\delta}{2+\delta} + \frac{1+r}{(1+\delta)(2+\delta)}\right)\left(\frac{1 + \frac{1+g}{1+r}(h_i^*)^\gamma}{1 + (h_i^*)^\gamma}\right)\right] Y_t^i \tag{11}$$

[10] We assume the existence of an international bond market

Let's denote with χ^i the constant term in front of Y_t^i in 11 which will depend on the interest rate, on the discount rate and on the skills of old relative to young workers in city i. We are now able to find the value of p_T^i in location "i" by equating the total expenditure on land services of people living in city "i" with the total income accruing to land owners in the same city. Recall that the total quantity of land is one and that each person spends a fraction $(1-\alpha)$ of her total expenditure on land, we get:

$$(1-\alpha)\chi^i Y_t^i + (1-\alpha)p_T^i = p_T^i \tag{12}$$

And solving we get: $p_T^i = \frac{1-\alpha}{\alpha}\chi^i Y_t^i$. The price of land in a city is proportional to the total production of the city, and this is due to the fact that larger total production implies more local workers and higher expenditure of each worker on land services, whose supply is fixed (a typical crowding effect). The increase in price of land represents the channel through which congestion effects induce decreasing returns in the more productive (and crowded) city.

Finally we can evaluate the total demand for the traded good in the economy and set it equal to its total production, to find the interest rate that will prevail in equilibrium. The condition that total consumption for the whole economy in BGP must be equal to total production can be justified in two ways. First let's think of the economy as a closed one. As there is no capital, in the aggregate, there cannot be transfer of resources to the future, and so the interest rate must be such that the inter-generational trade in a city is the only one taking place. The second and better justification considers the economy as open. As we are solving for the balanced growth path, which must be an equilibrium sustainable in the long run, it must be true that even if the economy trades assets with the foreign market it cannot have a systematic trade deficit or surplus. Therefore a balanced budget in each period, is the only sustainable situation for the long run.

We can think of this, as a situation where our economy is a representative economy in the world, so that the equilibrium condition guarantees a world interest rate compatible with the long run balanced trade budget for all countries, while temporary departures from this situation create temporary trade deficit or surplus. The equilibrium condition will be obtained by equalizing total expenditure on the good to total production of the good for the sum of the two economies:

$$\chi^A Y_t^A + \chi^B Y_t^B = Y_t^A + Y_t^B \tag{13}$$

The only value of r that solves equation 13 preventing one city from always consuming less than it produces, with a permanent trade surplus, is : $r = g = \delta$ that implies $\chi^A = \chi^B = 1$. Each city produces the amount of tradable that it consumes.

In this equilibrium, each city and the country as a whole have balanced trade budget in each period, but there may be trade of consumption goods between young and old .

2.4 Location decision and relative density

>From the analysis of the previous section we can derive a "natural" price index for the economy, which is the price to purchase one unit of utility: $(p^i) = \zeta (p_T^i)^{1-\alpha}$; where ζ is a constant and is independent from the location.

As workers are mobile at the beginning of their first period of life, they will chose the city that will maximize their life-time labor income. I will assume, without loss of generality, that city A is the one whose local characteristics promote a larger learning and accumulation of skills ($k_A > k_B$). Therefore workers, who are forward looking and aware of the city characteristics, will locate in city A. This will drive up rents in that city to the point where, in terms of real purchasing power, the workers are indifferent between the two cities. Therefore cities, whose characteristics are "good" for the accumulation of skills should be more crowded and should pay higher nominal wages[11] .

The equilibrium condition determines the relative supply of workers in the two cities by equating the "real" disconuted lifetime income for workers in each city, as follows:

$$\frac{(w_1^A)_t}{(p^A)_t} + \frac{(w_2^A)_{t+1}}{(1+r^R)(p^A)_{t+1}} = \frac{(w_1^B)_t}{(p^B)_t} + \frac{(w_2^B)_{t+1}}{(1+r^R)(p^B)_{t+1}} \tag{14}$$

In 14 the term $(1+r^R)$ is the "real interest rate", that expresses the interest rate between the two periods in terms of the composite good rather than in terms of the numeraire. Using the definition of the price index which grows at rate $(1+g)^{(1-\alpha)}$ we will have that: $(1+r^R) = (1+r)/(1+g)^{1-\alpha}$.

Substituting into expression 14 the definition of wages and price-indices for the two cities and simplifying we get the following equilibrium condition on relative density between the two cities in BGP:

$$\frac{l_A}{1-l_A} = \left(\frac{1+(h_A^*)^\gamma}{1+(h_B^*)^\gamma}\right)^{\frac{\alpha}{(1-\alpha)\gamma}} > 1 \tag{15}$$

The relative density of workers will depend on the relative intensity of the local externality, and this effect will be stronger, the less workers care about housing in their consumption (α large).

[11] This is a channel through which density and production could be related, as shown in Ciccone and Hall [4], but without having increasing returns.

2.5 Experience Premia, Wage Dispersion and Relative Income

Condition 5 and 15 and the determination of the interest rate and of the price index give the full characterization of the BGP. The values of the other variables can be recovered from these conditions. Let me describe in the present section the derivation of the main variables of interest in BGP.

The first variable on which our model has an implication is the experience premium, namely the ratio of the wage of old to young workers.

$$\frac{(w_2^i)_t}{(w_1^i)_t} = (h_i^*)^{\gamma} > 1 \tag{16}$$

As equation 16 shows the experience premium in each location is an increasing function of the relative old-to-young skill ratio. This immediate implication says that the local characteristics affecting the intensity of local learning will determine the experience premium of workers in a city as long as old workers are not very mobile compared to young workers. Equation 16 is valid on the BGP, it assumes that the relative supply of young and old is the same from one generation to the following. In the next section, analyzing the transition from one balanced growth path to a new one, we will derive the condition that should hold also during the transition .

A second implication is that total production and production per worker is larger in the city with high externalities, because there are more workers and they have more human capital per capita . Nevertheless, due to higher prices of land the per capita "consumption" income of workers is the same in the two cities. The following are the BGP relative values:

$$\frac{(Y^A)_t}{(Y^B)_t} = \left(\frac{1+(h_A^*)^{\gamma}}{1+(h_A^*)^{\gamma}}\right)^{\frac{1}{(1-\alpha)\gamma}} > 1 \tag{17}$$

$$\frac{\frac{(Y^A)_t}{l_A}}{\frac{(Y^B)_t}{l_B}} = \left(\frac{1+(h_A^*)^{\gamma}}{1+(h_B^*)^{\gamma}}\right)^{\frac{1}{\gamma}} > 1 \tag{18}$$

$$\frac{\frac{(Y^A)_t}{p_t^A l_A}}{\frac{(Y^B)_t}{p_t^B l_B}} = 1 \tag{19}$$

Finally, let me consider wages of each group of workers. In "consumption" terms, as the average per capita income is equal in the two cities, young workers in the city with high externalities will have lower "consumption" wages than workers in the city with low externalities. The reverse will be true for old workers.

$$\frac{\frac{(w_1^A)_t}{p_t^A}}{\frac{(w_1^B)_t}{p_t^B}} = \left(\frac{1 + (h_A^*)^\gamma}{1 + (h_B^*)^\gamma}\right)^{-1} < 1 \tag{20}$$

$$\frac{\frac{(w_2^A)_t}{p_t^A}}{\frac{(w_2^B)_t}{p_t^B}} = \frac{1 + (h_A^*)^\gamma}{1 + (h_B^*)^\gamma}\frac{(h_A^*)^\gamma}{(h_B^*)^\gamma} > 1 \tag{21}$$

On the other hand, looking at wages in terms of the numeraire, they are larger in the high externality city for both groups, but the premium between cities is larger for the old workers.

$$\frac{(w_1^A)_t}{(w_1^B)_t} = \left(\frac{1 + (h_A^*)^\gamma}{1 + (h_B^*)^\gamma}\right)^{\frac{1-\gamma}{\gamma}} > 1 \tag{22}$$

$$\frac{(w_1^A)_t}{(w_1^B)_t} = \left(\frac{1 + (h_A^*)^\gamma}{1 + (h_B^*)^\gamma}\right)^{\frac{1-\gamma}{\gamma}} \frac{(h_A^*)^\gamma}{(h_B^*)^\gamma} >> 1 \tag{23}$$

3 Transition Dynamics after an Information Technology Shock

Equations 16-23 of the previous section allow us to perform exercises of comparative statics, to see how population, relative income, relative wages and wage premia change when we vary the exogenous parameters. In particular, we see that anything that will increase the gap between h_A and h_B will generate higher density in city A, will increase experience premia in A relative to B, and nominal income in A relative to B. These are the effects that will prevail once the new balanced growth path has been reached. As the model is an overlapping generation model and each period is reasonably around 20 years, it is interesting to see what happens on the adjustment path along the new balanced growth path. In particular we are interested in considering what happens if the economy undergoes a particular shock, namely an increase in the parameter - , which captures the flow of information or the ability of organizing this information among workers within a city. This parametrization is intended to capture the shock that took place in the late 70's early 80's, with the introduction of new information technologies (fax, computer, networks), that allowed a much larger intensity of information exchange and ability of learning from it.

Some labor economist have tried to relate the "computer revolution" to the change in the structure of wages that took place in the 80's (Krueger [10]), and many have suggested that an increase in the price of skills underlies the increase in the education and experience premia in the 80's (see Katz and Murphy [14], Bound and Johnson [2], Juhn, Murphy and Pierce [9] among many others).

My exercise, here, considers the possibility that this "revolution" has affected the rate of on-the-job learning. This implies that the rate of skills' accumulation during the working life of a person has increased, and the importance of these skills, relative to the initial human capital (schooling), has also increased. This view of the "information revolution" of the late 70's is somewhat different from the one normally considered that emphasizes the change in the production function, due to the introduction of new types of machines and new techniques (as in Caselli [3]). Many of these machines, though, affected importantly the ability of learning and communicating in the local environment, as "Technical data networks, Factory networks, Intercompany Computers network, computer used on the factory floor"[12] and so on. Therefore in the present paper I concentrate on this effect of the technological shock of the 70's and on its effect on the experience premia.

I will also make the assumption that these new technologies for "communicating" and "processing of information" are complements with "good" local characteristics. Mathematically this amounts to consider a functional form for $E(\theta; k_i)$ in which θ, and k_i are complements[13] (for simplicity I will assume $E = \theta * k_i$). This assumption implies that better information technology has a stronger impact in places where the local environment is already helping on-the-job learning and interactions. The new technologies act as a magnifier of the effects of "good" local characteristics (sector composition, cultural level, ethnic composition). I will slightly simplify the analysis of the transitional dynamics considering the interest rate fixed at the long-run level ($=\delta=g$). This is as if, as the economy is open , movements of the interest rate are not allowed.

To learn about the transition dynamics we will consider the following system of three nonlinear difference equations. They describe the evolution of local human capital for city A and B and the evolution of the population in each city, as workers move to equate their present discounted lifetime income.

$$(h^*_A)_{t+1} = 1 + \frac{E(\theta; k_A)}{1+g} \left(\frac{l^A_t}{l^A_t + l^A_{t-1}} + \frac{l^A_{t-1}}{l^A_t + l^A_{t-1}} (h^*_A)_t \right) \tag{24}$$

$$(h^*_B)_{t+1} = 1 + \frac{E(\theta; k_B)}{1+g} \left(\frac{1 - l^A_t}{(1 - l^A_t) + (1 - l^A_{t-1})} + \frac{(1 - l^A_{t-1})}{(1 - l^A_t) + (1 - l^A_{t-1})} (h^*_B)_t \right) \tag{25}$$

[12] These are among the machines, defined by the Bureau of Census as giving rise to the Information-Technology Revolution.

[13] Glaeser and Gaspar [6] show that this seems to be the case.

$$
\begin{aligned}
&(l_A)_t^{\gamma-1}\left[(l_A)_t^{\gamma} + (l_A)_{t-1}^{\gamma}(h_A^*)_{t+1}^{\gamma}\right]^{\frac{\alpha}{\gamma}-1} + \\
&(h_A)_t^{\gamma}(l_A)_t^{\gamma-1}\left[(l_A)_{t+1}^{\gamma} + (l_A)_t^{\gamma}(h_A^*)_t^{\gamma}\right]^{\frac{\alpha}{\gamma}-1} \\
= \;&(1-l_A)_t^{\gamma-1}\left[(1-l_A)_t^{\gamma} + (1-l_A)_{t-1}^{\gamma}(h_B^*)_{t+1}^{\gamma}\right]^{\frac{\alpha}{\gamma}-1} + \\
&(h_B)_t^{\gamma}(1-l_A)_t^{\gamma-1}\left[(1-l_A)_{t+1}^{\gamma} + (1-l_A)_t^{\gamma}(h_B^*)_t^{\gamma}\right]^{\frac{\alpha}{\gamma}-1}
\end{aligned}
\tag{26}
$$

Concerning the stability of the above system we know that, for fixed $(l_A)_t$, 24 and 25 are globally stable and, for fixed h_A^* and h_B^*, 26 has a unique steady state which is given by the solution of 15. This implies that there is only one adjustment trajectory (saddlepath) that will converge to the new steady state and workers with perfect foresight will choose to move in accordance with that trajectory. In particular, in the experiment we consider, starting from a balanced growth path, after a change in the parameters of the model, if workers have perfect foresight, they know that they will move towards the new BGP compatible with new parameter values. Therefore besides an initial condition, determined by the distribution of old people, the other condition that identifies the solution to the second order difference equation 26 is that $\lim_{t\to\infty}(l_{t+1}^A - l_t^A) = 0$.

In Table 1 below we report the dynamics of the experience premia and relative wages after a shock in - that increases the intensity of the externality in each city by 100%. This simulation should not be taken too seriously, as the model is very simplistic representation of the reality, but is useful to give a sense of the evolution of the system in the first periods after the shock, towards a new steady state.

The simulation assumes that each period is 20 years and the exogenous growth rate is 2% a year ($g = 0.5$): The elasticity of substitution between workers is equal to 2 ($\gamma = 0.5$), and the share of rent services in personal expenditure is 0.2 ($\alpha = 0.8$). The initial intensity of the externality is $E_A = 0.5$ and $E_B = 0.25$ that implies an intensity of on-the-job learning externalities in city A twice as large as in city B. We are mostly interested to what happens to wages, experience premia and population movements in the first and second period after the shock. To obtain this we simulate the dynamics of the difference equation system assuming that in five periods the system has reached its new steady state where $(l_A)_{t+1} = (l_A)_t$. The dynamics in the first three periods are basically identical if we assume convergence after six or more periods, rather than five, given that after four periods the value of l_A is basically at its new BGP value . The main difference between the adjustment path and the BGP is that, as young people move towards the city that has been more strongly favored by the shock, the relative supply of young and old people in a city is varying and is not equal to one.

Table 1 reports the evolution of the experience premia within cities and of nominal wage dispersion across cities for young and old.

Period	E_A	E_B	h_A	h_B	l_A	w^A_2/w^A_1	w^B_2/w^B_1	w^A_1/w^B_1	w^A_2/w^B_2
t=0	0.5	0.25	1.4	1.18	0.58	1.18	1.08	1.04	1.13
1	1	0.5	1.79	1.36	0.63	1.22	1.02	0.99	1.08
2	1	0.5	1.92	1.39	0.66	1.37	1.11	1.11	1.27
3	1	0.5	1.97	1.40	0.68	1.40	1.15	1.11	1.30
4	1	0.5	1.99	1.40	0.68	1.40	1.17	1.10	1.31
5	1	0.5	2.00	1.40	0.69	1.41	1.17	1.10	1.31
6	1	0.5	2.00	1.40	0.69	1.41	1.18	1.10	1.31
new BGP	1	0.5	2.00	1.40	0.69	1.41	1.18	1.10	1.31

A very interesting e¤ect is visible in the …rst period. Although the e¤ects of the shock have not been incorporated yet in the amount of skills accumulated by the workers, and therefore have not a¤ected the productivity, the experience premia increase in city A, due to a larger supply of young workers who moved there attracted by larger future wages. In city B, on the other side, experience premia decrease. Nevertheless as city A is the most populous one and also its population is increasing, the result at the national level will be that we will observe an increase in the average experience premium before observing an increase in productivity. Also this will be accompanied by a decrease in the wage of the young which is particularly strong in the city with the most intense externality[14]. If we consider the qualitative characteristics of experience premia, wage di¤erentials and population changes, the stylized facts emerging from the analysis along the adjustment path are the following, con…rming by and large the behavior of the system in BGP:

1. The city with the most intense externality exhibits larger experience premium, and after the shock its advantage will increase.

2. The wages of young workers in the two cities are di¤erent. The real wage is lower in the high externality city, but the nominal wage could be higher, to equate the consumption wage. On the other side it must be true that the wage of old workers is higher in the high externality city. The shock increases this dispersion of wages for workers in the same age group and in di¤erent cities, although this is stronger beginning from the second period after the shock.

3. Workers, after the shock, tend to move to the "high-externality city" that has become more attractive due to new technologies that have increased local learning and therefore future earning possibilities.

[14] This is in line with the empirical …nding that, while the experience premium has been rising since the 70's there is no sign of the technological revolution in the factor productivity data untill the 90's.

With these implications in mind as stylized facts, emerging from the model presented, we now turn to some empirical results, that consider US cities in 1990. This analysis is suggestive that experience premia in the 90's vary considerably across cities and we will argue that they may be related to city-wise characteristics a¤ecting the intensity of local externalities.

4 Some Empirical Evidence on Experience Premia in Cities

4.1 Descriptive statistics

The present section describes some empirical evidence, obtained from data on American Statistical Metropolitan Areas . The sources of the data is the 5%, Census Public Use Microdata Samples for the year 1990 . The units of analysis for the aggregation of the data are 236 SMSA. The geographic distribution of the Cities is rather uniform over the national territory. The East and the South are a bit denser than the West but the sample covers rather uniformly most of the inhabited lands of the US. I have considered non-agricultural non self-employed civilian workers in cities, younger than 70, to calculate averages for each city. The PUMS sample includes, on average, 5358 observations per city in 1990 which means that the average SMSA considered includes around one hundred thousands employed people. The …ve largest SMSA included in our sample are Los Angeles, New York, Chicago, Washington and Philadelphia while the …ve smallest are Columbia (MO), Waterbury (CT), Manchester (NH), Billings (MT) and Jacksonville (NC).

The measure of wage considered is hourly wages in current US $. This value is calculated as the total yearly salary and wage income reported, divided by the hours worked in the year, calculated as hours worked in the week times weeks worked in the year. As can be observed from Table 2 the simple average wage across cities in 1990 is 11.58 $. We report, as summary statistics, the average values across cities of wages for the group of workers 20 to 40 years old and of workers 40 to 60 years old. The di¤erence of wages between the two age-groups gives an idea of the magnitude of the experience premia .

Considering the experience premia in more detail, Table 2 shows also the premia for more narrowly de…ned age groups and for education groups. The …rst three premia reported are calculated subtracting the average wage for the 10-year groups of age from the average of the immediately older group and dividing by the average wage of the …rst group. The last premium is the "overall premium" calculated using the 20-40 and the 40-60 years old groups. We can see that most of the gains in wage due to experience emerge in passing from the 20-30 year group to the 30-40. The experience premium seems to mirror a process of accumulation of useful skills, that is very intense early in the working life of a person, and then, following a learning curve, declines. Moreover we also see how the experience premium increases with the level of education.

Variable	Mean across cities	Std. Dev. across cities
Average Wage	11.58	1.56
Std. Dev. of wages	14.01	1.6
Average Wage	10.48	1.42
(20-40yrs old)		
Average Wage	14.19	1.96
(40-60yrs old)		
[wage(30-40)-wage(20-30)]/ /wage(20-30)	0.39	0.08
[wage(40-50)-wage(30-40)]/ /wage(30-40)	0.15	0.05
[wage(50-60)-wage(40-50)]/ /wage(40-50)	0.03	0.06
[wage(60-40)-wage(20-40)]/ /wage(20-40)	0.35	0.08
[wage(60-40)-wage(20-40)]/ /wage(20-40), "some high school"	0.28	0.17
[wage(60-40)-wage(20-40)]/ /wage(20-40), "high school"	0.27	0.08
[wage(60-40)-wage(20-40)]/ /wage(20-40), "college"	0.39	0.12

A further comment is granted just looking at the geographical dispersion of the experience premia across cities. The standard deviation of the premia, across city is about 8% of their value. The di¤erence between the top quartile and the bottom quartile of the distribution of premia across cities is around 16%. The di¤erence between the maximum and the minimum average city experience premium is 51% in 1990. We can say that the amount of variation of experience premia shown by the geographical cross section is, by all means, remarkable.

4.2 Controlling for individual characteristics

The model (equation 16) suggests that the dispersion of experience premia may be due to a dispersion in unobservable skills cumulated by the workers in different local conditions. The empirical analysis of this section, far from being a rigorous test of the model, aim to identify empirically what are the city-characteristics (k_i in the model) relevant to determine skill accumulation.

I will exploit the cross sectional variation of experience premia across cities to show that only 27% of this variation is explained by observables personal characteristics, while the remaining 73% depends on unobservables and city-wise factors. Local externalities due to the concentration of educated people, to the local industrial composition, to the ethnic composition and to the "learning environment" matter in determining the experience premium in a city. In particular, identifying few factors that may, in our opinion, a¤ect the intensity of local externalities, we are able to explain 20-30% of the remaining variability of the premia across cities. Di¤erences in experience premia across cities may therefore depend on di¤erences in the "amount" of skills accumulated by observationally identical workers exposed to di¤erent local environments.

As we have information on individual characteristics in our sample, the first regression considers the single individuals as units of observation. The universe of our analysis are non-agricultural workers, between twenty and sixty years of age, working in 236 SMSAs in the US. From the 5% PUMS sample, for reasons of disk-space, we have extracted a random sub-sample whose size is half of the original one. This leaves us with a total number of observation equal to 1,552,380 . These observations are used to estimate the following basic wage equation:

$$\begin{aligned} \log(W_{i,j}) &= X_{i,j}\beta + X_{i,j}(Experience)_{i,j}\delta + \\ &\quad \sum_{i=1}^{236} \phi_i D_i + \sum_{i=1}^{236} \gamma_i D_i (Experience)_{i,j} + \varepsilon_{i,j} \end{aligned} \tag{27}$$

This equation is estimated by OLS on the individual observations and is a "preliminary one", that allows us to identify the city-specific experience premia. W_{ij} is the nominal hour wage for individual i in city j. The matrix $X_{i,j}$ includes dummies to control for individual characteristics. In particular their sex, education, race and the industry they work in are included as controls . Appendix A lists the dummies included in the regression. They are one sex group, five racial groups, four educational groups, and thirty-one sectors[15]. These control dummies are included by themselves and also interacted with the experience variable, which is measured as (age-education-6), the commonly used value for potential experience. This procedure allows us to control for the effect of all the observables on the experience premium. Then we also include a dummy (D_i) for each city, and an interaction of the dummy with the experience. The coefficients ϕ_i captures city "i" fixed effect on wages, while the coefficient γ_i captures the city-specific component of the experience premium[16] , after we have controlled for the characteristics of the workers and their industry affiliation. In short γ_i captures the city-wise effect on yearly percentage increase in wage of an average person in city i; after we have "cleaned" this effect from observable differences in worker's characteristics and industrial affiliation.

As first step, toward understanding inter-city variability of experience premia, we measure what fraction of the variability of average experience premia across cities is explained by personal characteristics of the workers. To perform this task we compare the OLS estimate of γ_i from the basic wage equation 27 specified above (we will call these coefficients "cleaned" experience premia) with OLS estimates of γ_i from a similar equation, but with no control terms in $X_{i,j}$ (we will call these coefficient "simple" experience premia). The last regression simply captures average experience premia, by city, allowing also for different fixed city effects on wage levels. Then we consider an OLS regression of the "simple" city experience premia, on the "cleaned" experience premia. The R^2

[15] We also included in one specification 4 occupational categories (managerial, administrative, service, craft). The results do not change in any significant way.

[16] I am using a linear specification for the experience premium, for different specifications see sections below.

of the regression says that 73% of the variability of the simple city-premia is explained by the "cleaned" city-premia and therefore is not due to individual characteristics. Therefore only about 27% of the cross-city variability of experience premia is accounted for by worker's characteristics .

Another interesting statistic is the correlation coe¢cient between the estimates of $Á_i$ and $°_i$ in regression . This number shows that, as predicted by our model, there is negative correlation between the experience premium and the initial wage in a city, after controlling for the observable characteristics of workers. The estimated coe¢cient is -0.44 and is signi…cant at the 1% level, implying that in cities where the experience premium is unusually low the initial wage is unusually large and vice-versa.

In the following section we focus on some characteristics of the local environment that, in our opinion, should a¤ect the intensity and the quality of local interactions. If they are factors in‡uencing k_i then we should …nd that they have a signi…cant e¤ect on the city-speci…c component of the experience premia.

4.3 Local Externalities a¤ecting Experience Premia

Characteristics of the cities that are likely to a¤ect the intensity of information ‡ows and the "learning" environment of a city are its economic, cultural and ethnic composition. Some previous evidence suggested that high average education in the city may increase the human capital externalities (see Rauch [17]). The presence of an "high-tech" manufacturing sector may create a local advantage in the di¤usion of information and learning, compared to the presence of more traditional manufacturing sectors . Among services, the presence of more educational oriented and information intensive sectors may induce a more dynamic local environment. Finally the "ethnic" composition of a city may a¤ect the intensity of communication. Possibly a city that is ethnically homogeneous has more widespread communication ‡ows if we assume that communication may ‡ow more easily within rather than across ethno-linguistic groups. On the other side a more "diverse" city may promote more productive interactions.

In the present section we analyze the e¤ect of these local characteristics on the "cleaned" experience premia, to verify if they play the expected role in the accumulation of skills and if they are signi…cant. We consider the e¤ect of the share of workers in high-tech manufacturing[17] , expecting a positive sign and the share of workers in traditional manufacturing, mining and construction , expecting a negative sign. The idea is that traditional sectors generate less ‡ow of information and spillovers than advanced, highly technological ones. The share of teachers, in the employment of a city is taken as an indicator of the intensity of communication and of how "culturally active" is the local environment. Its e¤ect is also expected to be positive. The average level of education is also considered as a potential determinant of the intensity of the externality in the city . Finally an index of ethnic homogeneity is considered,

[17] The sectors included in high tech, following Katz and Murphy [14] are: Chemicals, Petroleum, Equipment, Machinery and instruments.

calculated by adding the squared shares of the six ethnic groups reported in Appendix A. Its effect is expected to be positive, if communication flows more intensely within ethnic groups than across them but negative if cultural diversity promotes more fruitful interactions.

I estimate the following equation:

$$\gamma_i = \alpha + Z_i \beta + u_i \tag{28}$$

Where γ_i are the 236 "cleaned" experience premia, estimated in regression 27, Z_i are the city-specific characteristics mentioned above and u_i are uncorrelated city-specific disturbances. The equation is estimated using OLS and WLS, where the weights are the inverse of the estimated standard errors of γ_i in the wage equation, to correct for heteroskedasticity across cities.

Table 3a reports the estimated coefficients on the average years of schooling, sector composition , density of teachers and ethnic homogeneity, including them separately and together. The coefficient estimates show that the sector variables have always the expected sign and are very often significant. The high-tech sector has a positive effect and the traditional, construction and mining sectors have negative effects. The presence of teachers has a positive effect which is very significant, and the average level of schooling has a significant positive effect when included by itself and looses some significance when included with the other variables. This can be an indication that the sector composition of a city may actually be more important than the level of education in determining useful and skill-improving contacts. Finally the ethnic homogeneity variable has not a very significant effect (possibly for the coexistence of the two opposite effects).

Notice that the R^2 of the regressions that includes all the variables together is 0.36. The local factors analyzed explain about one third of the variability of the "cleaned" experience premia across cities. Part of the cross-city variability of premia is certainly due to measurement errors and idiosyncratic factors. Nevertheless we consider remarkable that in the 90's local city-wise factors potentially affecting the intensity of externalities may explain about the same variability that is explained by observable individual characteristics .

The local characteristics considered are very persistent over time and they could be regarded as "exogenous" in determining the city-specific experience premia. In order to reinforce the exogeneity of the right hand side variables we have re-run a regression (not reported) including those variables measured in 1980 rather than in 1990. All the signs of the coefficients are the same as in the regressions of Table 3a. The share of high-tech manufacturing and the share of teachers have positive and significant coefficient, the share of mining, construction and traditional manufacturing have negative coefficients. The average years of schooling have positive coefficient and the variable is more significant when industry composition is not included. Finally the ethnic homogeneity does not have a significant coefficient.

Variable	OLS				WLS			
	1a	2a	3a	4a	5a	6a	7a	8a
Average years of education	0.15***			0.07**	0.14***			0.06**
	(0.02)			(0.02)	(0.02)			(0.02)
Construction		-5.75***		- 2***		-4.2***		-2.4***
		(0.97)		(0.95)		(0.85)		(0.86)
Mining		-0.8		-0.17		-0.34		-0.58
		(0.9)		(0.90)		(1.1)		(1.02)
Manufacture, High-tech		0.21		0.67**		0.56***		0.77***
		(0.20)		(0.26)		(0.24)		(0.23)
Manufacture, Traditional		-1.2***		-0.38		-1.0***		-0.33
		(0.26)		(0.29)		(0.28)		(0.32)
Teachers			4***	2.8***			2***	2.7***
			(0.43)	(0.44)			(0.51)	(0.49)
Ethnic Homogeneity				-0.08				-0.08
				(0.14)				(0.14)
R^2	0.18	0.18	0.20	0.37	0.08	0.17	0.20	0.36

In Table 3b we report the results of the same regressions run on a sub-group of people, namely those that are reported not having moved in the last …ve years previous to 1990. The local characteristics considered should a¤ect human capital accumulation, promoting a more fertile environment for communication and exchange. Therefore people who have not moved are those that have been exposed to the local environment for longer. This is, basically, a …rst attempt to address the problem of selection bias. The local characteristics that we consider may simply attract people who have cumulated more skills and this will induce a correlation between those characteristics and the experience premium. Considering the non-movers we try to eliminate this bias. Clearly this is an imperfect way of controlling for movements in population as it only consider the …ve years previous to 1990. Moreover the variable only signals a change of residence, which does not necessarily mean a change of city[18] .

The results, reported in Table 3b, though, con…rms what we found using the whole population, particularly for the positive e¤ect of the "high-tech" industries and the negative e¤ects of the traditional industries and for the positive e¤ect of the share of teachers. Although the R^2 in these regressions are smaller than those in table 3a, possibly indicating that part of the overall correlation observed is due to selection bias, it is still true that almost 15% of the variability of experience premia is still explained by the local factors.

[18] Reassuringly, 70% of the workers aged between 40 and 60 are non movers.

Variable	OLS				WLS			
	1b	2b	3b	4b	5b	6b	7b	8b
Average years of education	0.07*** (0.02)			0.01 (0.03)	0.07*** (0.02)			0.02 (0.02)
Construction		- 6*** (1.0)		- 2.0*** (1.1)		- 2*** (0.89)		-2.7*** (0.96)
Mining		-0.22 (1.0)		-0.09 (1.0)		-0.26 (1.1)		-0.14 (1.2)
Manufacture, High-tech		0.53** (0.28)		0.77*** (0.30)		0.86*** (0.24)		1.02*** (0.26)
Manufacture, Traditional		-0.92*** (0.27)		-0.68** (0.35)		-1.03*** (0.28)		-0.76** (0.37)
Teachers			1.44** (0.47)	1.01** (0.50)			1.44** (0.47)	1.05** (0.56)
Ethnic Homogeneity				0.18 (0.17)				0.12 (0.15)
R^2	0.04	0.12	0.04	0.14	0.04	0.11	0.03	0.14

Table 3b: Dependent Variable: (°$_i$*100) estimated on non-movers only

4.4 Some Robustness checks

The impact of local externalities may be di¤erent on di¤erent workers. In particular, the level of education of the workers may determine the extent to which local characteristics a¤ect their accumulation of skills. Considering workers with di¤erent education as di¤erent groups we address this speci…c issue.

We divide workers in "less educated" (some high school and high school) and more educated (some college, college and graduate). Then we estimate the basic wage equation 27 separately on more educated and less educated, including all the controls except for the level of education. The estimates of the city-speci…c experience premia for each group are then used to estimate, as before, the e¤ect of the local characteristics on skills accumulation (Regression 28).

The simple correlation between the "cleaned" city-speci…c experience premia for more educated and for less educated is 0.50. This denotes the existence of a relevant local common e¤ect on the accumulation of skills. The results for the two education groups, including all the variables are reported in Table 4. All the coe¢cients have the same sign in the two regression.

Variable	More Educated		Less Educated	
	OLS	WLS	OLS	WLS
Average years of education	0.04	0.03	0.13***	0.07**
	(0.04)	(0.04)	(0.04)	(0.03)
Construction	-4.4***	-4.9***	-2.1*	-1.03
	(1.0)	(-1.2)	(1.2)	(1.1)
Mining	-0.11	-1.1	-1.4	-2.3
	(1.0)	(1.6)	(1.2)	(1.4)
Manufacture,	0.86**	0.45*	0.71**	1.38***
High-tech	(0.40)	(0.29)	(0.36)	(0.33)
Manufacture, Traditional	-0.18	-0.34	-0.68*	-0.95**
	(0.47)	(0.54)	(0.39)	(0.45)
Teachers	5.8***	5.2***	0.48	0.31
	(0.67)	(0.68)	(0.60)	(0.76)
Ethnic Homogeneity	0.075	-0.15	0.25	0.28
	(0.23)	(0.22)	(0.21)	(0.19)
R^2	0.38	0.37	0.20	0.16

Table 4: Separate regression for more and less Educated

Local characteristics, as density of high-tech industries and density of teachers have a positive effect on the accumulation of skills of more and less educated. The density of traditional and low tech industries has negative impact. The average years of schooling affect positively the accumulation of skills of both groups but only significantly for the more educated workers. This may be a sign that there is a local effect of "learning from the more educated". Finally ethnic homogeneity, although not very significant, seems to affect positively the accumulation of skills of the less educated, while more educated seem to have mild benefits from ethnic diversity. This makes sense as probably the inter-cultural barriers to communication are stronger for less educated.

As a further control, to see if the local supply of workers affects the experience premium, we have also included the ratio of old (20-40 years of experience) to young (0-20 years of experience) workers. This variable is not significant when added to regression 4 in Table 4, and moreover its coefficient is positive (0.20). This denotes that there is no "supply effect" at all in the experience premium.

Similarly if we introduce the "size" of the city, measured as the number of workers in it, this has no significant effect (t-stat = 0.21). Larger cities do not have an advantage on the small ones in terms of the intensity of the externalities to human capital.

As a final check, I report in table 5 the results of regression 28 where the γ'_is are calculated in different ways, keeping into account the non-linearity of the experience profile, but still considering a single value as summary statistic for a city. In regression 1 of Table 6 the dependent variable is the average yearly experience premium calculated by introducing a quadratic, city specific terms in equation 27 and using the linear and quadratic coe¢cient to calculate the average experience premium in 40 years of experience. In regression 2, the dependent variable is the city-speci…c coe¢cient on the dummy for 30-40 years of experience, estimated from a regression like 27 where we included four experience dummies (0-10, 10-20, 20-30 and 30-40 years of experience). The results we found are robust across speci…cations in that all the coe¢cients in Table 5 have the same sign and signi…cance level as those in the regression of table 3a. The R^2 are a little smaller than those in the regression of table 3a but still in the 0.25-0.30 range.

Variable	yearly exp. premium*100	exp.premium for 30-40 years of experience
	Linear-Quadratic	Dummy 30-40
Average years of education	0.09***	0.02***
	(0.02)	(0.009)
Construction	- 2***	-0.95***
	(0.98)	(0.31)
Mining	-0.14	-0.72
	(0.93)	(0.30)
Manufacture, High-tech	0.50**	0.13*
	(0.25)	(0.76)
Manufacture, Traditional	-0.69**	-0.12***
	(0.31)	(0.09)
Teachers	1.5***	0.57***
	(0.45)	(0.14)
Ethnic Homogeneity	0.24	0.07
	(0.15)	(0.05)
R^2	0.31	0.26

In conclusion we can summarize the evidence saying that local characteristics such as the industrial composition, the average years of schooling and the local learning environment have an important external e¤ect in explaining city experience premia. These local characteristics may generate accumulation of skills via local externalities and are able to explain up to 30% of the cross-city variability of experience premia.

4.5 Conclusions

The present paper develops an overlapping generations model in which "learning by doing" externalities are enhanced by some local characteristics so that the accumulation of skills and the increase in productivity of workers is di¤erent depending on the local environment. We have solved for the balanced growth path of the model and simulated the adjustment after a technological shock.

Notably, a robust prediction is that, those local characteristics a¤ecting the intensity of "learning" externalities will positively a¤ect the experience premium of the city. This result gives an interesting way of measuring the intensity of local dynamic externalities that a¤ect the process of learning by doing (or by "imitating"). If these externalities are important, as Lucas [16] claims arguing about the growth of East Asian countries, this study provides a new way of capturing and measuring their e¤ect and applies it preliminarly to the US cities. We have then conveyed a novel model describing the consequences and some evidence identifying the local sources of skills' accumulation in US cities in the recent past. The high percentage of educated workers, high density of technologically intensive sectors and high density of schooling institutions help the process of accumulation of skills. If these local characteristics are really promoting faster accumulation of skills via better learning by doing it may be the case that local authority could increase local productivity by attracting these industries and educated workers.

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5 Appendix A

Individual Controls in the Wage equation:

Dummies Included in the Wage Equation			
sex: Male, Female	**Education:** Some High School*, High School, Some College, College, Graduate	**race**: White*, Hispanic, Black, Native, Asian, Pacific	**sector**: Public Sector*, Construction, Mining, Food Processing, Textiles, Paper, Chemicals, Petroleum, Rubber, Leather, Lumber, Stone, Metal, Machinery, Electric Machinery, Equipment, Precision Instruments, Other Manufacturing, Utilities, Wholesale Trade, Retail Trade, FIRE, Repair Services, Personal Services, Entertainment Services, Health services, Legal Services, Teaching, Social Services, Other services