Where Do Human Capital Externalities End Up To?

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Abstract: Recent literature has aimed at evaluating human capital externalities by estimating the effect of human capital on wages at urban level. We argue that this methodology might not identify properly human capital spillovers. We consider a general equilibrium model based on Roback (1982) where both wages and rents are simultaneously determined at the local level. We show that human capital externalities cannot be identified unless the joint effect of local human capital on both wages and rents is considered. Empirically, we study the effects of local human capital on household-level rents and individual-level wages for a sample of Italian local labor markets. Our results show a positive and robust effect of local human capital on rents. This unambiguously demonstrates that the concentration of human capital at the local level generates positive externalities. As for the relative importance of consumption and production externalities, our results suggest that the two effects have a similar impact on wages.

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1. INTRODUCTION

Even though there are many good reasons to argue in favor of schooling externalities, cross-country evidence on human capital and growth has proved to be surprisingly mixed (see, for example, Mankiw et al., 1992, and Bils and Klenow, 2000). More recently, some literature has followed Lucas' (1988) suggestion that the ideal field for empirical research on human capital externalities should be local labor markets, like Metropolitan Areas. Following this suggestion, Rauch (1993), Acemoglu and Angrist (2000), Moretti (2004), Ciccone and Peri (2003) have estimated Mincerian wage-equations, augmented with an average human capital term meant to capture the productivity externalities generated by schooling. But again, overall results do not provide strong evidence in favor of social effects from human capital.

The conclusion that social returns from human capital are negligible, however, may be flawed. With the exception of Rauch (1993), all the recent "Mincerian" evidence concentrates only on production externalities. However, human capital can generate social benefits that go well beyond those on productivity: see, e.g., Weisbrod (1962) and Haveman and Wolfe (1984). Recently, Lochner and Moretti (2004) have shown that a relevant part of the social returns to education comes from crime reduction.[1] Moreover, Glaeser, Kolko, and Saiz (2001) have suggested that high local levels of education are associated with a wide array of local amenities, ranging from consumer goods (such as restaurants and theaters) to good public services (such as good schools) and low crime. These findings suggest the presence of several mechanisms that may relate the local level of human capital to the quality of life.

As showed by Roback (1982), and emphasized by Rauch (1993), when human capital generates relevant consumption externalities, it will have an impact on the price of locally fixed factors, such as land. Not only. Local wages will not only depend on production externalities, but also on consumption externalities. By developing a simple Roback-Rauch model we show that, when firms and workers are mobile across areas and local human capital has positive externalities on both production and utility, average

schooling will always have a *positive* effect on rents, while having an *ambiguous* effect on local wages.[2] The reason is that local productivity and local utility have opposing effects on local wages. On the one hand, human capital spillovers raise local wages by increasing local productivity. But on the other hand, local wages tend to fall when human capital has positive spillovers on utility. This result is central for the main point of our paper. In fact, by looking only at wage equations, human capital spillovers cannot be properly identified. In particular, the Mincerian literature mentioned above understates systematically the role of human capital externalities on productivity.

We study the effects of local human capital on household-level rents and individual-level wages for a sample of Italian local labor markets. We find a positive effect of local human capital on rents. This effect is robust when controlling for a number of potential covariates at the individual/household and territorial level, and to instrumental variable strategies. In our estimates, a unit increase in the local average level of years of schooling increases local rents from 6 to 24 percent. As from the theoretical model, the positive impact of local schooling on rents shows that the concentration of human capital generates positive spillovers. On the other hand, the effect of local schooling on wages is less robust. In most cases, we find that it ranges from 2 to 3 percent and, in some specifications, the impact of the local schooling is statistically not different from zero. As for the relative importance of consumption and production externalities, our results suggest that these two forces offset each other in local wage determination.

Section 2 presents the Roback-type model, following the special version proposed by Ottaviano and Peri (2004). Section 3 provides the evidence, and Section 4 concludes.

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[1] See also Lochner (2004).

[2] The main issue of our paper is closely related to Shaphiro (2003). Shapiro develops a dynamic version of Roback's model to analyze the effects of human capital on city growth. His evidence suggests that, while most of the literature have emphasised the impact of human capital on productive externalities, consumption externalities can be important as well. Shapiro's strategy is further developed by Glaeser and Saiz (2003), who find that human capital increases consumption amenities within metropolitan areas.

2. A SIMPLE ROBACK TYPE MODEL

In what follows, we sketch a simple model to identify the effects of local human capital. The basic framework builds on Roback (1982), Rauch (1993) and Ottaviano and Peri (2004), and it postulates that both local firms' productivity and consumption amenities depend on a specific type of site characteristics, the local average level of human capital. The economy is partitioned in *C* non-overlapping areas, indexed by *c*=1,2,..*C*. Each individual possesses an education level h_i, works in the same area where he lives, and supplies inelastically one unit of labour. Moreover, workers and firms are assumed to be perfectly mobile across locations (which is, their cost of changing location is zero), while the supply of land, L_c, is fixed in each area. Land is used in both production and consumption, and landowners do not live in the economy we consider.[3]

The utility of an individual *i* who lives and works in area *c* has the following form:

$$U_{ic} = A_U(H_c) \cdot L_{ic}^{1-\mu} \cdot Y_{ic}^{\mu} \qquad (1)$$

and is maximized under the budget constraint $h_i \cdot w_c = r_c \cdot L_{ic} + p_c \cdot Y_{ic}$, with $\mu \in (0,1)$. L_{ic} denotes worker *i*'s consumption of land, and Y_{ic} denotes his consumption of a freely-tradable homogeneous good. The local price of land is r_c, while w_c denotes the local wage as measured in per-education units. The price of the good is taken as the numeraire: p_c=1. The shifter $A_U(H_c)$ picks the effect of local average human capital H_c on utility. In particular, if $\frac{dA_U(H_c)}{dH_c} > 0$, a higher local level of education will increase the welfare of residents.[4] By solving problem (1), one obtains the indirect utility function expressed in education units:

$$v_{ic} = \eta \cdot A_U(H_c) \cdot \frac{w_c}{r_c^{1-\mu}} \qquad (2)$$

[3] See Rauch (1993, p.383).
[4] For example, if higher average schooling reduces criminality, the welfare of residents will be larger.

where $\eta = (1-\mu)^{1-\mu}\mu^{\mu}$. "Free-mobility" of workers implies that worker *i* must receive the same utility (per unit of individual education) across locations, which is:

$$v_{ic} = v_{ic'} = v, \quad for\ any \quad (c,c') = 1,2,..,C \tag{3}$$

Firms are competitive and produce good *Y* by using both land and labour with a constant-returns technology. The production function of firm *j* in area *c* is:

$$Y_{jc} = A_Y(H_c) \cdot L_{jc}^{\ 1-\alpha} \cdot (h_j N_{jc})^{\alpha} \tag{4}$$

where $\alpha \in (0,1)$ and $(h_j N_{jc})$ denotes the labor input of firm *j* expressed in efficiency units.[5] The term $A_Y(H_c)$ captures the effect of human capital spillovers on productivity in area *c*. Profit maximization implies that $Y_{jc} = \frac{r_c L_{jc}}{1-\alpha} = \frac{w_c(h_j N_{jc})}{\alpha}$, so that expression (4) can be re-written as:

$$1 = \xi \cdot \frac{A_Y(H_c)}{r_c^{\ 1-\alpha} w_c^{\ \alpha}} \tag{5}$$

where $\xi = (1-\alpha)^{1-\alpha}\alpha^{\alpha}$. With p_c=1, condition (5) implies that price equals marginal cost. Because of constant returns to scale, firms make zero profit in equilibrium and expression (5) can be interpreted as a "free-entry condition" in the product market.

By combining expressions (2) and (3) and exploiting expression (5), we obtain a system of two equations in (w_c, r_c) such that, given the level of local human capital H_c across locations, no firm and no worker will have an incentive to migrate. By log-linearizing and solving the system, we obtain the following equilibrium expressions for (the log of) local rents and wages:

$$\log r_c = \frac{\log\xi + \alpha\log\eta - \alpha\log v}{1-\alpha\mu} + \frac{\log A_Y(H_c) + \alpha\log A_U(H_c)}{1-\alpha\mu} \tag{6}$$

[5] The production function implies that that workers of different education are perfectly substitutable. In this case, the "composition" problem emphasized by Ciccone and Peri (2003) would not arise.

$$\log w_c = \frac{(1-\mu)\log\xi - (1-\alpha)\log\eta + (1-\alpha)\log v}{1-\alpha\mu} + \frac{(1-\mu)\log A_Y(H_c) - (1-\alpha)\log A_U(H_c)}{1-\alpha\mu} \quad (7)$$

Expressions (6) and (7) allow us to identify the effects of human capital externalities on local factor prices.

Under the assumption that human capital has non-negative effects on productivity and utility, that is, $A_Y'(H_c) \geq 0$ and $A_U'(H_c) \geq 0$, equation (6) implies that human capital spillovers have an unambiguous positive effect on rents. Households and firms will be willing to pay higher rents to locate in areas rich in human capital.

By contrast, equation (7) implies that the effect of human capital on wages is ambiguous. Human capital drives local wages up by increasing productivity, since $A_Y'(H_c) \geq 0$. However, households are willing to accept lower wages (and pay higher rents) to live in areas where human capital boosts local utility, since $A_U'(H_c) \geq 0$.

The main predictions of the model are summarized by the following:

Remark. (I) When $A_Y'(H_c) \geq 0$ *and* $A_U'(H_c) \geq 0$ *, it must hold that* $\frac{d\log r_c}{dH_c} > \frac{d\log w_c}{dH_c}$*. Moreover,*

(II) The relative effects of production and consumption externalities generated by local human capital are identified as follows:

(i) If the production externality $A_Y'(H_c) \geq 0$ *dominates, then* $\frac{d\log r_c}{dH_c} > 0$ *and* $\frac{d\log w_c}{dH_c} > 0$.

(ii) If the consumption externality $A_U'(H_c) \geq 0$ *dominates, then* $\frac{d\log r_c}{dH_c} > 0$ *and* $\frac{d\log w_c}{dH_c} < 0$.

Thus, estimation of equations (6) and (7) can assess the net impact of production and consumption externalities.

3. EMPIRICAL FINDINGS

In this section, we study the effects of local human capital on household rents and individual wages for a sample of Italian local labor markets. We start by estimating baseline rent and wage equations: see Sect. 3.1. Then, we adopt three strategies to substantiate our results. First, in Sect. 3.2, we check the robustness of the baseline estimates by including additional household/individual controls. Second, we test whether the estimated effects of local schooling are robust to the inclusion of additional territorial variables that, in principle, may represent factors omitted from the baseline equations (see Sect. 3.3). Finally, in Sect. 3.4, we tackle omitted variable and endogeneity problems by instrumenting local schooling.

3.1 Baseline Regressions

Our main data source is the Survey of Household Income and Wealth (SHIW). This survey is conduced every two years by the Bank of Italy on a representative sample of about 8,000 households: see Brandolini and Cannari (1994) for details. The SHIW collects detailed information on Italian households. For each member of the family, it gathers data on demographic features and economic behavior including wage, age, sex, marital status, work status, schooling, work experience, and employer's branch of activity. Moreover, at the household level, the survey collects data on dwellings, including both the main family's house of residence (be it owned or rented) and other property owned. For each dwelling, the SHIW collects several characteristics: rent and house price, surface, location, year of construction, and additional information such as number of bathrooms and presence of a heating system. Since from 1993 the survey has maintained the same structure, we pool data from the last four waves (1993, 1995, 1998, and 2000). The details of the variables used in the paper are reported in the Appendix.

Our dataset includes 27,931 dwelling's observations and 23,371 worker's observations (the sample is restricted to workers of age between 15 and 65). Dwellings and workers are distributed over 238 LLMs. All regressions below are based on appropriate weighted data.[6]

The confidential version of the SHIW we use here reports each individual's area of residence. This allows us to augment our regressions, based on individual observations, with variables defined at territorial level. The main territorial variable we use is an indicator of local human capital, as measured by average years of schooling of the population residing in the local labor market. This measure is obtained from the 1991 Population Census by the National Institute of Statistics (ISTAT). It averages 9.88 years of schooling and exhibits a standard deviation of .73.

Column 1 of Table 2 reports the baseline results on the effects of local human capital on house rents. The dependent variable is the log of annual rent.[7] The regression includes a number of standard controls: see, for example, Berger at al. (2003) and Gyourko et al. (1999): the surface area and the age of the dwelling, and dummies for the presence of two bathrooms and heating system. The regression also includes a set of dummies for the location of the dwelling within the local labor market (LLM). The SHIW classifies location by six categories: isolated area, countryside; town outskirts, between outskirts and town center, town center, other, hamlet. Finally, we include a dummy for families residing in the south of Italy.

Our results show that local human capital significantly affects rents: a unit increase in the local average level of schooling years increases the local rents by 17.2 percent. The effects of the other variables on rents are quite obvious: rents are higher for larger and newer houses and for dwellings endowed with more than one bathroom and heating system. Location dummies enter with high significance: compared with

[6] Our coefficient estimates however are not sensitive to weighting or not weighting the regressions.
[7] The interviewed can be either the property owner or the tenant. In the first case, the SHIW collects the rent the owner charges (or, if the dwelling is not rented or it is the family residence, her best estimate for the rent she could charge) and the price that could be set for the dwelling. In the second case, the tenant reports both the actual rent and her best estimate of the dwelling's price. For the sake of brevity, we report in the text only the results for the rents. House prices provide remarkably similar results.

dwellings located in the countryside, rents for the houses in the town center are 27 percent higher (point estimates not reported in Tables).

As well known, the south of Italy differs from the center-northern counterparts in a number of respects: the south is generally poorer and less endowed with infrastructures. The south has also lower quality of local institutions and property right protection. To make sure that local human capital is not just picking up differences between center-north and south of Italy, we control for the southern location of the dwellings. This dummy is associated with a 15 percent discount on rents. In Column 2, we re-estimate our baseline regression using a finer partition of the territory in 20 regions: the results confirm the previous findings. Finally, Column 3 exploits a finer partition that uses 103 province dummies. This amounts to identifying the effects of local human capital on wages through the variation across LLM within each province. It represents an extremely conservative specification, since the LLMs within the same province are quite similar and we are probably eliminating a lot of the LLM variation needed to identify the results. Remarkably, the positive effect of local human capital still persists, and its point estimates are similar to those of previous specifications.

Column 1 of Table 3 provides the baseline results of the effects of local human capital on wages. Individual log earnings (hourly wage rate) are the dependent variable. The baseline specification includes the standard Mincerian set of individual characteristics: labor market experience, its squared value, number of years of schooling, and two dummies for sex and marital status. As for the rents, the baseline specification includes a dummy for workers residing in the south. The results are in line with previous studies based on the SHIW: see Cannari and D'Alessio (1995) and Colussi (1997). We find that each individual year of schooling increases hourly wages by 6.0 percent.[8] Experience increases wages up to approximately 42 years of experience. Wages of women are 8.6 percent lower than men's wages. Married workers enjoy an 8.2 percent

[8] We also estimate a model in which private returns to education are non-linear in the years of schooling. For this purpose, we replace individual human capital with dummies for the highest educational attainment obtained by the individual. This has negligible effects on the estimates of local human capital returns.

premium.[9] Southern workers suffer from a 6.4 percent discount. Local human capital enters the earning equation with a positive and statistically significant coefficient. A unit increase in LLM average education is associated with a 2.3 percent increase in local wages. This result is robust to specifications where the south dummy is replaced with region and province dummies.

According to the theoretical model in Sect. 2, when there are positive spillovers from education, equation (6) implies that the semi-elasticity of rents to human capital must be positive. Thus, our results from estimation of the rent equation provide significant evidence on the existence of schooling externalities. Moreover, equation (7) implies that the semi-elasticity of wages to human capital has an ambiguous sign, depending on which source of externality prevails. Since we find that local schooling has a positive and significant effect on wages, production externalities seem to dominate consumption externalities in wage determination: see the Remark. In what follows, we check the robustness of these conclusions.

3.2 Robustness: Additional Household and Individual Controls

Table 4 reports estimates of rent and wage regressions with additional controls on both dwellings and individuals.[10]

As for rents, we add two subjective ratings of the dwelling. In the SHIW, the interviewed is asked to provide her own evaluation regarding the quality of both the house and its location. In the first case, she has to answer to the question “How do you rate this dwelling” by picking one of the following answers: luxury, upscale, mid-range, modest, low-income, very-low income. In the second case, the question is “How do you rate the area in which this dwelling is located?” and the potential answers are recorded respectively as: upscale, run-down, neither upscale or run-down, other. The two subjective measures are clearly correlated with the observable characteristics of the houses and their location, which represent our standard controls in Table 2. This implies

[9] A wage premium on marriage status is common in the labor literature. For some alternative explanations of this finding see, for example, Korenman and Neumark (1991) and Loh (1996).
[10] The inclusion of these additional controls reduces the rent and wage samples respectively to 27,904 and 23,252 observations. As we checked, these reductions are not relevant for the results obtained before.

that their inclusion will reduce the coefficients on the observables. However, the two individual ratings are also likely to be correlated with unobservable house and location characteristics. For instance, richer LLMs might display higher house quality even after controlling for surface, age, bathrooms and heating. Similarly, richer LLMs might have suburbs of superior quality. Thus, the inclusion of the two subjective ratings can provide a robustness check for the effect of local human capital with respects to these unobservable features. As shown in the first column of Table 4, adding the two subjective ratings increases the explanatory power of the regression from 37% to 48%. As expected, the two ratings are highly significant and their inclusion reduces the estimated effects of the observables. More important, the change in the coefficient of local human capital is very small.

Turning to wages, we add three additional sets of individual controls. We include seven industry dummies for eight branches of activity (agriculture; manufacturing; building and construction; wholesale and retail trade, lodging and catering services; transport and communications; services of credit and insurance institutions; real estate and renting services, other professional, business activities; general government and other private and public services). We also add six dummies for seven classes of employer's size (up to 4; from 5 to 19; from 20 to 49; from 50 to 99; from 100 to 499; 500 or more; not applicable - public-sector employee). Finally, we include three dummies for the individual job qualification (for the following four categories: blue-collar worker or similar; office worker or school teacher; junior manager cadre; manager, senior official). Again, it is debatable whether to include or not these controls. Duranton and Monastiriotis (2002) argue that - to the extent that the additional controls are likely to be determined simultaneously with the labor market outcome - their inclusion can lead to an underestimation of the true differences between areas characterized by different levels of local human capital. We find that controlling for industries, firm sizes, and job qualifications[11] reduces the coefficient of local human capital from 2.3% to 1.3%, making it non-significant even at the 10% level.

[11] In Table 3, all additional controls are introduced simultaneously. The introduction of only (i) industry, (ii) firm-size, (iii) job qualification controls reduce the coefficient of local human capital respectively to (i) 1.8% (ii) 2.1%, and (iii) 1.5%.

In sum, our robustness checks with respect to additional controls for dwelling and individuals confirm the evidence in favor of the presence of human capital spillovers. As for the relative importance of consumption and production externalities, these results suggest that the two forces tend to offset each other.

3.3 Additional Territorial Controls

Next, we check the robustness of our findings when additional territorial variables are included. Table 5 presents the results for the coefficient of local human capital when the regressions (2.1) and (3.1) include additional territorial variables that, in principle, could affect the concentration of human capital, as well as local rents and wages. Consistently with the theoretical model of Sect. 2, we control for potential omitted variables concerning both local productivity and local amenities. The additional territorial variables refer to the beginning of the '90s (see the Appendix for details).

We start (Table 5, line 2) by augmenting the individual and household-level regressions with a measure of economic development, measured by GDP per capita in the province. It averages 14,370 thousand lira and exhibits wide variations (standard deviation 3,980 thousand lira). The inclusion of this control might underestimate the effect of human capital. If human capital is a precondition, rather than a consequence, of economic development, then some of the effects of human capital will be reflected by income per capita. GDP per capita enters positively and with high significance in both rent and wage equations.[12] Consistently with this interpretation, the impact of human capital becomes smaller when GDP per capita is included. Its coefficient goes down to 14.4% for rents, and to 1.2% for wages. Crucially, the impact of local schooling on wages becomes not statistically different from zero.

The correlation of education with both rents and earnings might also be affected by the distribution of unemployment across LLMs. If better-educated individuals are less likely to be unemployed, then average human capital might pick up the effect of the unemployment rate. When the ISTAT LLM-specific unemployment rate is considered (line 3), however, the local human capital coefficient remains essentially unchanged.

Local unemployment enters (with a negative sign and high significance) only in the wage equation.

We then consider physical capital. Due to capital-skill complementarities,[13] local human capital might pick up the contribution of physical capital. We include an index of physical capital in the private sector, calculated as the ratio between stock of capital (valued at the replacement price) and value added in each LLM. This variable is taken from the Cannari-Signorini dataset.[14] The index of physical capital never enters significantly and the estimates of local human capital remain unchanged (line 4). Next, we control for the local level of infrastructures. This variable is measured as the ratio between kilometers of roads and LLM's surface in squared kilometers. Our results show that the infrastructure index enters with a positive (negative) sign in the rent (wage) regression. More important, the coefficient associated with local human capital is unaffected (line 5).

The effects of local human capital on rents and wages could also reflect agglomeration effects: see Ciccone and Hall (1996). Suppose first that agglomeration effects are adequately captured by the size of the local population. If the density of economic activity makes workers more productive, as in Glaeser and Maré (1999), one should expect that controlling for population reduces the impact of average human capital on wages. At the same time, population might be a consumption disamenity: see Rauch (1993) and Adamson et al. (2004). In this case, one should expect that controlling for population increases the impact of local schooling on rents. Our results do not support these predictions. The coefficient of (log of) population is significant and positive in the rent equation, while non-significant in the wage equation. As for our variable of interest, controlling for population halves the effect of local human capital on rents, while increasing the effect on wages by 1/3.[15] On the other hand, the number of inhabitants may be a poor proxy for agglomeration effects. Henderson (2003) argues

[12] For the sake of brevity, point estimates for the control variables are not reported in the tables.
[13] See, for example, Goldin and Katz (1998).
[14] The Cannari-Signorini dataset is derived from a variety of sources (Census; Company Account Data Service; ISTAT's Surveys on Export, Value added, Labor Force, Capital Stock): see Cannari and Signorini (2000) for details.
[15] Replacing (log)population with (log)employment or population density produces similar results.

that external effects derive from the number of plants, rather than from population, in a given territory. Thus, we include a measure of plant intensity (number of plants over squared kilometers in a LLM) from the Cannari-Signorini dataset. This variable makes local human capital not significantly different from zero in the wage equation, while it remains highly significant in the rent equation.[16]

Next, we include all the controls considered above (from line 2 to line 7) simultaneously. We find that the effect of local schooling on rents remains significant while that on wages is not statistically different from zero.

Local human capital may also be correlated with omitted variables that have amenity value and determine the local quality of life. Such a correlation would bias upwards (downwards) the estimate coefficient on local education in the rent (wage) equation. An obvious candidate for an amenity that is correlated with local human capital is cultural facilities. We include two additional variables, which are taken from the ISTAT DAVOS dataset[17]: the province-level ratios of (i) number of theater exhibitions, and (ii) number of cinema halls over resident population. These two variables enter significantly with positive signs in the rent equation, while only the cinema density enters significantly (and positively) the wage equation. Our estimates are consistent with the presumption that cultural facilities are important determinants of a locational equilibrium (line 10): the effect of local schooling on rents goes down to 15.8%, and the effect on wages goes up to 2.7%.

Another variable that could be correlated with local education is the crime rate. As suggested by Lochner (2004), human capital increases the opportunity cost of crime for foregone work and expected costs associated with incarceration. The ISTAT DEMOS province-level crime rate enters with a positive sign in the rent equation and a negative

[16] We report here only a subset of robustness checks that have been performed. Following de Blasio and Nuzzo (2003), we also controlled for the local endowments of social capital. In the tradition of Glaeser, Kallal, Scheinkman and Shleifer (1992), we controlled for local competition, as measured by the ratio between average firm-size in the LLM and the average size at national level. Moreover, we controlled for indexes of the LLM sector composition of economic activity. Results were only marginally different from those of the baseline case.

sign in the wage equation. Its inclusion reduces the estimated coefficient for local education on the rents while increasing its impact on wages (raw 11). Since crime is supposed to be bad for both production and consumption, these results can hardly be justified. One potential explanation for these findings is given by the fact that the crime rate is based on crimes reported to the police. In cases where crime is high and police-effectiveness low, citizens may have few incentives to report a crime to the police. If this is the case, then the local crime rate could be a proxy for the efficiency of the local police (and judiciary) rather than a measure of the local number of crimes.[18]

According to Downes and Zabel (1999), local school characteristics explain a good deal of the variation in U.S. house prices: all else equal, houses in better school districts are more expensive. Differently from the U.S. where the education system is mostly financed at the local level, the Italian schooling system is very centralized and egalitarian, with low variability in the quality of education across areas. This, however, does not apply to nurseries for infants of 0-3 of age, which are funded by local authorities or private. The local availability of nurseries may be correlated with local schooling. For instance, skilled workers might care more for the local availability of nursery schools either because skilled parents might be both working (Costa and Kahn (2001)) or because educated parents care more about getting better education for their sons. Ideally, we would like to control for an index of availability of nurseries for infants from 0 to 3. Unfortunately, this information is not available. Therefore, we use the number of public nurseries for children aged 0-5 over local population of the corresponding age group from the ISTAT DEMOS source. This index never enters significantly in our equations. The effect of average human capital (line 12) remains unchanged for wages and goes moderately up for rents.[19]

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[17] The ISTAT DEMOS dataset provides an array of demographic and socio-economic variables for the Italian territories. Since information from this source is not available at the LLM-level, the ISTAT DEMOS indicators that we use in the paper refer to the province-level.

[18] This potential explanation receives some empirical support. If we control for an index of judicial efficiency at the local level, then the crime rate does not enter significantly either in the rent or wage equation. Moreover, its inclusion does not alter the coefficient of local schooling. We thank Armanda Carmignani for providing us with the data on the judicial efficiency at the local level.

[19] We also used proxies for the quality of local nurseries (such as, the existence of playgrounds, school buses, and availability of extra-hours), without implications for our results.

The local health system represents another key factor for the quality of life. In Italy local (regional) authorities manage the public health system, and big differences arise in the effectiveness of health services provision. We proxy the quality of local health system with two variables: (i) the number of doctors, and (ii) hospital beds in public hospitals over local population. The two indexes enter with high significance and the expected signs, that is, positive for rents and negative for wages. As far as local education is concerned, the inclusion of these variables (line 13) does not alter our results.[20]

We then include all the "quality of life" controls together. As a result, the estimated coefficient for local human capital falls to 16.2% in the rent equation, while it rises to 3.4% in the wage equation. Finally, line 15 includes all the additional territorial controls at the same time (controls from line 2 to 7 and from line 10 to 13). We find that the effect of local schooling remains positive and significant in the rent equation. By contrast, local schooling has no significant impact on wages.

All in all, the results in this section allow us to conclude that human capital spillovers do exist. As for the relative importance of consumption versus production externalities, the results are not definitive. In most of the cases, production externalities seem to dominate, since there is a positive impact of local schooling on wages. However, this result is not robust to all sensitivity checks. [21]

[20] Again, only a subset of robustness checks accomplished has been reported. We also controlled for natural amenities, such as climate variables (average temperature and average raining days). Moreover, we controlled for cancer and cardiovascular mortality rates, which proxy for environmental quality. Compared with the baseline of raw 9, results were only marginally affected.

[21] The results reported in the text have also been checked by using Seemingly Unrelated Regression (SUR) techniques. In the theoretical model of section 2, wages and rents are simultaneously determined. This implies that there might be correlation between unobservable shocks to wages and rents. In this case, SUR estimates are more efficient, while OLS are still consistent and unbiased. SUR estimates (not reported) confirm previous findings. For instance, in the benchmark case of line 1, the estimated coefficient for local human capital rises to 18.2 percent in the rent equation, and 2.4 in the wage equation. As for the robustness checks with additional household/individual or territorial controls, in all cases SUR estimates are very similar to the OLS results reported in the text.

3.4 IV Estimates

The correlation of local human capital with rents and wages cannot be interpreted as a causal relation running from local schooling to local prices. There might still be some omitted determinants of rents and wages that are correlated with local human capital. Moreover, areas characterized by high rents and wages might be able to afford or prefer higher human capital. In this case, there will be a reverse causality problem.[22] As argued in Moretti (2003), these problems can be tackled when we have an instrument for local human capital. Such an instrument must account for the observed variation in local human capital, but not be correlated with rents and wages. We propose two instruments which are likely satisfy this property, so to check the robustness of our previous conclusions.

We first use the LLM lagged demographic structure as an instrument.[23] Because of the compulsory schooling system, 1981's local demographic structure is strongly related to 1991's local education but, at the same time, it is unlikely to be correlated with real estate and labor market local shocks in 1991.

LLMs with a larger share of residents who where younger than 5 in 1981 experienced, in 1991, an increase in the share of residents who completed the elementary school (5 years of schooling, starting from age six) and a -less pronounced- increase in the share of residents who completed the middle school (additional three years of schooling, starting from age 11). Since average schooling in 1991 was above 8 years, a larger share of residents under the age of five in 1981 will tend to reduce the 1991's local human capital level.

On the other hand, LLMs which exhibited a large share of population between the age of five and the age of ten in 1981 experienced, later in 1991, an increase in the share of residents who: (i) completed the middle school, and (ii) completed high school

[22] Further, measurement error problems might be present as well: see Krueger and Lindahl (2001).
[23] Demographic instruments are very popular in the literature on human capital externalities: see Moretti (2004) and Ciccone and Peri (2002).

(additional 5 years of schooling, which are fulfilled by the age of 18). Thus, these LLMs experienced an increase in their local human capital.

Table 6, Panel A, shows the results of the 2SLS estimates that exploit the LLM 1981's age 0-5 share, and the 1981's age 5-10 share of the population as instruments for local human capital. As expected, these two shares are highly correlated with local human capital. The first-stage *R*-squared is equal to 51 and 54 percent, respectively for rents and wages. The two instruments are highly jointly significant[24], and they exhibit the expected signs. The IV estimates of the effects of local education are higher than the corresponding OLS estimates (reported for convenience at the top of Panel A). In the rent equation, the coefficient goes up from 17.2% to 24.3%, while in the wage equation it raises from 2.3% to 3.0%.

Still, it is very difficult to take these estimates as conclusive. As emphasized in Angrist and Krueger (2001), a problem with interpreting IV estimates is that, in general, instruments do not affect observations in the same way. In case of heterogeneous responses, this technique provides an estimate that is mostly related to the specific group of people whose behavior is sensitive to the instrument itself: see also Imbens and Angrist (1994). In our context, the demographic instrument is particularly relevant to those who are likely to quit school early, with little or no effect on those who are likely to go on to college. With regard to people who decide whether to attain college education, cost-benefit comparisons are likely to matter most. Thus, we would like to check the robustness of the 2SLS estimates by using an alternative instrument which is likely to be relevant to a different group of people. As suggested by Arkes (2003), the lagged youth unemployment rate is a reasonable instrument for those who decide whether to go beyond compulsory schooling. Past local unemployment affects one's education attainment both through income and substitution effects. The income effect is such that, when unemployment is high, household's income is lower. Thus, some families may push their teenage children to quit school to help support the family. Also, low family income can make college unaffordable. On the other hand, the substitution effect implies

that high unemployment rates are associated with low wages and few job opportunities for teenagers. Poor labor market conditions reduce the opportunity costs of attending school and, thus, increase educational attainment. It turns out that, in our data, the substitution effect dominates. This is consistent with the evidence provided by Rossi (1997) who finds that, also because of low fees, a large fraction of Italian college students is made up of youngsters who were not able to get job opportunities. We use the LLM-level youth unemployment rate as an instrument. This variable is measured by the number of first-job seekers within the 15-24 age group. As for the demographic instruments used above, this variable refers to 1981.[25] Thus, we exploit the fact that youngsters who lived in areas characterized by high youth unemployment in 1981 were more likely to enroll in higher education.

Table 6, Panel B, reports the results.[26] The first stage shows that past youth unemployment rate is highly correlated with local education (the *R*-squared is equal to 39 (40) percent in the rent (wage) equation, and the *p*-value of the *F*-statistic is always zero in the first four decimals). The estimates of the effects of local schooling are, however, quite different from the previous ones. While the estimated coefficient remains highly significant and positive in the rent equation, the estimated coefficient in the wage equation turns out to be not significantly different form zero.

Finally, in Table 6, Panel C, we use at the same time both the demographic shares and past youth unemployment as instruments. The results confirm that human capital is not significant in the wage equation.

Overall, our results show that different instruments for local human capital generate different conclusions about wages. On the other hand, the positive effect on rents is always confirmed. We interpret this finding as evidence that schooling generates

[24] The *p*-value of the *F*-statistic is always zero at the first four decimals.
[25] Alberto Baffigi reconstructed first-job seekers at the province level in 1981. We thank Andrea Brandolini for providing us these data. The 15-21 age group was obtained from ISTAT 1981 Census.
[26] A main concern when using 1981 youth unemployment as an instrument is that this variable is very likely to be correlated with 1991 unemployment and, hence, correlated also with wages and rents. Similarly to Cameron and Taber (2004), we deal with this problem by controlling for the local 1991 unemployment in the rent and wage equation. Under this specification, the crucial assumption justifying

important consumption externalities. In particular, consumption externalities have an impact on local wages that is similar to that generated by production externalities.

4. CONCLUSIONS

Where do human capital externalities end up to? Since local average schooling is non-significant in augmented wage equations, much literature has concluded that human capital does not generate production externalities. As we argued here, this conclusion is far from granted, if human capital also generates relevant consumption externalities. Indeed, according to the simple Roback-type model we developed, one should conclude that human capital produces no spillover only if average schooling were non-significant in the *rent* equation. On the contrary, we do find that human capital has always a positive and significant effect on rents. This finding is robust to several alternative specifications and persists under instrumental variable strategies. Thus, human capital spillovers matter. For what it concerns the sources of spillovers, wage equation estimates suggest that the impact of productivity externalities is similar to the impact of consumption externalities. This finding implies that human capital generates relevant externalities on firms' productivity.

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the instrument is that, conditional on current labor market conditions, 1981 youth unemployment is unrelated to the error term.

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TABLE 1
SUMMARY STATISTICS

	Mean	Std. Dev.	Obs.
(Log) Rents	8.712	.709	27,931
(Log) Wages	2.464	.406	23,371
Local human capital	9.877	.727	27,931
Surface area	103.721	52.144	27,931
Age of the house	50.206	74.662	27,931
Bathrooms	.350	.484	27,931
Heating system	.816	.387	27,931
South	.349	.477	27,931
Individual human capital	10.875	3.888	23,371
Experience	21.538	11.442	23,371
Per capita GDP	14,369.53	3,979.989	27,931
LLM unemployment rate	.103	.058	27,931
LLM physical capital	170.914	10.283	27,931
LLM infrastructures	116.640	42.994	27,931
LLM (log) population	12.191	1.415	27,931
LLM plant intensity	.056	.069	27,931
Theater	195.337	103.205	27,413
Cinema	6.359	2.916	27,413
Crime	4004.174	1767.987	27,413
Nurseries	943.078	70.494	27,413
Doctors	108.378	80.703	27,413
Hospital beds	.506	.143	27,413
1981 share of population 0-5	.056	.016	27,931
1981 share of population 5-10	.074	.014	27,931
1981 youth unemployment rate	.311	.144	27,413

Notes.- The description of the variables is in the Appendix. To save space, the table does not report summary statistics for the following categorical variables: House location, Subjective house rating, Subjective location rating, Job qualification, Industries, and Firm size.

TABLE 2

RENTS: VARYING TERRITORIAL FIXED EFFECTS

Local Human Capital	.172 (.022)	.223 (.024)	.186 (.019)
Surface area in m2 (X100)	.410 (.022)	.408 (.022)	.416 (.021)
Age of the house (X100)	-.059 (.010)	-.063 (.008)	-.062 (.008)
Dummy for two bathrooms	.218 (.017)	.218 (.016)	.214 (.015)
Dummy for heating system	.361 (.020)	.363 (.017)	.364 (.016)
P-value for house's location	[0.0000]	[0.0000]	[0.0000]
Dummy for south	-.155 (.022)	-	-
Dummies for regions	-	YES	-
Dummies for provinces	-	-	YES
Time dummies	YES	YES	YES
Intercept	5.947 (.232)	5.312 (.255)	5.713 (.206)
R2 (%)	.37	.40	.51
N. Obs.	27,931	27,931	27,931

Note.-The White robust standard errors reported in parentheses are corrected for the potential clustering of the residual at the local labor market level. Regressions are weighted to population proportions.

TABLE 3
WAGES: VARYING TERRITORIAL FIXED EFFECTS

Local Human Capital	.023 (.010)	.018 (.007)	.027 (.010)
Individual Human Capital	.060 (.002)	.061 (.002)	.061 (.002)
Experience	.031 (.001)	.031 (.001)	.031 (.001)
Experience squared (X100)	-.037 (.003)	-.037 (.003)	-.037 (.003)
Dummy if female	-.086 (.008)	-.087 (.009)	-.089 (.009)
Dummy if married	.082 (.008)	.083 (.008)	.082 (.008)
Dummy for south	-.064 (.014)	-	-
Dummies for regions	-	YES	-
Dummies for provinces	-	-	YES
Time dummies	YES	YES	YES
Intercept	1.088 (.105)	1.126 (.077)	1.029 (.105)
R2 (%)	.40	.41	.41
N. Obs.	23,371	23,371	23,371

Note.-The White robust standard errors reported in parentheses are corrected for the potential clustering of the residual at the local labor market level. Regressions are weighted to population proportions.

TABLE 4
RENTS AND WAGES: ADDITIONAL HOUSEHOLD/INDIVIDUAL CONTROLS

	Rents	Wages
Local human capital	.168 (.022)	.013 (.008)
Surface area in m2 (X100)	.306 (.017)	-
Age of the house (X100)	-.035 (.008)	-
Dummy for two bathrooms	.157 (.013)	-
Dummy for heating system	.212 (.019)	-
P-value for house's location	[0.0000]	-
P-value for subjective house rating	[0.0000]	-
P-value for subjective location rating	[0.0000]	-
Individual human capital	-	.037 (.002)
Experience	-	.024 (.001)
Experience squared (X100)	-	-.030 (.002)
Dummy if female	-	-.085 (.007)
Dummy if married	-	.067 (.007)
P-value for job qualification		[0.0000]
P-value for industries	-	[0.0000]
P-value for firm size	-	[0.0000]
	-	
Dummy for south	-.136 (.039)	-.076 (.012)
Time dummies	YES	YES
Intercept	6.436 (.232)	1.252 (.083)
R2 (%)	.48	.48
N. Obs.	27,904	23,252

Note.-The White robust standard errors reported in parentheses are corrected for the potential clustering of the residual at the local labor market level. Regressions are weighted to population proportions.

TABLE 5
RENTS AND WAGES: ADDITIONAL TERRITORIAL CONTROLS

	Rents	Wages
(1) Basic	.172 (.022)	.023 (.010)
(N. obs = 27,931 for Rents and 23,371 for Wages)		
(2) Including provincial GDP per capita	.144 (.023)	.012 (.009)
(3) Including LLM unemployment rate	.173 (.022)	.024 (.009)
(4) Including LLM physical capital	.173 (.023)	.022 (.010)
(5) Including LLM infrastructures	.172 (.022)	.023 (.010)
(6) Including LLM (log of) population	.088 (.029)	.032 (.013)
(7) Including LLM plant intensity	.142 (.024)	.018 (.011)
(8) Including from (2) to (7)	.059 (.030)	.013 (.012)
(9) Basic	.170 (.022)	.022 (.010)
(N. obs = 27,413 for Rents and 22,977 for Wages)		
(10) Including provincial culture variables	.158 (.023)	.027 (.009)
(11) Including provincial crime index	.123 (.023)	.032 (.011)
(12) Including provincial nursery variables	.193 (.024)	.021 (.009)
(13) Including provincial health system indexes	.172 (.021)	.023 (.009)
(14) Including from (10) to (13)	.162 (.024)	.034 (.010)
(15) Including from (2) to (7) and from (10) to (13)	.078 (.028)	.015 (.014)

Notes.- Each entry represents the coefficient on the local human capital. The White robust standard errors reported in parentheses are corrected for the potential clustering of the residual at the local labor market level (however, the correction for the clustering of the residual at the province level will no make any difference). Regressions are weighted to population proportions.

TABLE 6
RENTS AND WAGES: 2SLS ESTIMATES

	Rents	Wages
Panel A: Past Demographic Shares as Instruments		
OLS results		
Local human capital	.172 (.022)	.023 (.010)
2SLS results		
Local human capital	.243 (.042)	.030 (.015)
First stage for local human capital		
1981 share of population 0-5	-77.773 (.869)	-98.841 (1.016)
1981 share of population 5-10	87.859 (.828)	102.584 (.957)
N. Obs.	27,931	23,371
Panel B: Past Youth Unemployment as Instrument		
OLS results		
Local human capital	.170 (.021)	.025 (.008)
2SLS results		
Local human capital	.186 (.089)	-.012 (.024)
First stage for local human capital		
1981 youth unemployment rate	.021 (.001)	.030 (.001)
N. Obs.	27,413	22,977
Panel C: Past Demographic Shares and Past Youth Unemployment as Instruments		
OLS results		
Local human capital	.170 (.021)	.025 (.008)
2SLS results		
Local human capital	.237 (.039)	.022 (.014)
First stage for local human capital		
1981 share of population 0-5	-74.756 (.850)	-91.896 (.987)
1981 share of population 5-10	84.632 (.818)	94.835 (.945)
1981 youth unemployment rate	.016 (.000)	0.022 (.003)
N. Obs.	27,413	22,977

Notes.- The White robust standard errors reported in parentheses are corrected for the potential clustering of the residual at the local labor market (however, the correction for the clustering of the residual at the *province* level will not make any difference). Regressions are weighted to population proportions.

APPENDIX

Description of the variables

Variable	Description	Source
Rents	Log of the annual rent. For each household, the interviewed can be either the property owner or the tenant. In the first case, the SHIW collects the rent the owner charges (or, if the dwelling is not rented or it is the family residence, her best estimate for the rent she could charge). In the second case, the tenant reports the actual rent paid.	SHIW
Wages	Log of hourly wages. Hourly wages are calculated by dividing the annual earnings (from any activity as employee, including fringe benefits, net of taxes and social security contributions) by the total amount of hours worked in a year (Average Hours Worked per Week × Months Worked × 4.3333). The sample is trimmed at the 1st and 99th and percentile of the distribution of earnings.	SHIW
Local human capital	Average years of schooling (1991) in the LLM where the dwelling is located or the individual resides.	ISTAT
Surface area	Area in square meters.	SHIW
Age of the house	Calculated as the difference between the year of the survey and the year the house was constructed, which is a data available from the SHIW.	SHIW
Bathrooms	Indicator variable equal to one if two or more bathrooms are available in the dwelling.	SHIW
Heating system	Indicator variable equal to one if an heating system is available in the dwelling.	SHIW
House's location	Series of dummies for the location of the dwelling (isolated area, countryside; town outskirts; between outskirts and town center; town center; other; hamlet).	SHIW
South	Indicator variable equal to one for the following Italian regions: Abruzzi, Molise, Campania, Puglia, Basilicata, Calabria, Sicilia, and Sardegna.	SHIW
Individual human capital	Number of years of studies required to achieve the highest qualification earned by the individual. We derived the length of education by assigning: 2 years to no qualification; 5 years to elementary school; 8 years to middle school; 11 years to professional secondary school diploma; 13 years to high school; 16 years to an associate degree or other short course university degree; 18 years to a bachelor's degree; and 20 years to a postgraduate qualification.	SHIW
Experience	Calculated as the difference between worker's age at the survey date and the age at first job held, which is a data available from the SHIW.	SHIW

Subjective house rating	Series of dummies for the subjective (the survey asks “How do you rate this dwelling’”) rating of the dwelling (luxury; highly desirable; mid-range; modest; low-income; very low-income; rural; other).	SHIW
Subjective location rating	Series of dummies for the subjective (the survey asks “How would you rate the location where the dwelling is located?”) rating of the dwelling’s location (highly desirable; run-down; neither highly desirable nor run-down).	SHIW
Job qualification	Series of dummies for the employment work status (blue collar worker or similar; office worker or school teacher; junior manager, cadre; manager, senior official).	SHIW
Industries	Series of dummies for the sector of activity of the firm in which the individual works (agriculture; manufacturing; building and construction; wholesale and retail trade, lodging and catering services; transport and communications; services of credit and insurance institutions; real estate and renting services, other professional, business activities; general government and other private and public services).	SHIW
Firm size	Series of dummies for the size of the firm in which the individual works (up to 4; from 5 to 19; from 20 to 49; from 50 to 99; from 100 to 499; 500 or more; not applicable, public-sector employee).	SHIW
Per capita GDP	Per capita net disposable income in the province in thousand lira.	ISTAT
LLM unemployment rate	LLM 1993 unemployment rate.	ISTAT
LLM physical capital	Ratio between stock of capital (valued at the replacement price) and value added in each LLM.	Cannari-Signorini
LLM infrastructures	Ratio between kilometers of roads and LLM’s surface in squared kilometers.	Cannari-Signorini
LLM population	Log of the LLM population.	ISTAT
LLM plant intensity	Ratio between the number of plants and the LLM’s surface in squared kilometers.	Cannari-Signorini
Theater	Theater exhibitions over the population residing in the province	ISTAT DAVOS
Cinema	Cinema halls over the population residing in the province	ISTAT DAVOS

Crime	First degree murders, robberies and blackmail divided by the population residing in the province.	ISTAT DAVOS
Nurseries	Public nurseries for children aged 0-5 over the corresponding age group for the population residing in the province.	ISTAT DAVOS
Doctors	Doctors in public hospitals over the population residing in the province.	ISTAT DAVOS
Hospital beds	Beds in public hospitals over the population residing in the province.	ISTAT DAVOS
1981 share of population 0-5	Share of the LLM population between the age of zero and five in 1981	ISTAT
1981 share of population 5-10	Share of the LLM population between the age of five and ten in 1981	ISTAT
1981 youth unemployment rate	Youth unemployment rate in the province in 1981.	Baffigi