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Referrals, intergenerational mobility and human capital accumulation☆

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ABSTRACT

The aim of this paper is to investigate the interaction between two channels of intergenerational transmission of inequalities: parental income and networks. For this purpose, job referrals are introduced in an overlapping generations model of human capital accumulation with borrowing constraints. Although the exploitation of workers' networks through referrals can decrease the costs borne by firms and workers in the matching process, they also widen the opportunity gap between workers having parents with different educational levels. It is shown that when market inequalities are high, segregation effects may overcome the gains provided in the labour market by referrals. Even though referrals are exploited only in the educated segment of the labour market, the reduction of frictional costs may coexist with an overall negative effect on human capital accumulation.

1. Introduction

The literature on intergenerational mobility has considered many channels through which parents affect their child's future income. An important distinction is between direct economic channels such as bequests or investments in a child's education, and more indirect channels that affect their opportunities and outcomes. The latter include locational choices, family ties and other aspects of parental-based networks. When assessing the economic effects of intergenerational transmission of inequalities, most theoretical studies focus on the first kind of channels. Indeed, the standard framework is based on overlapping generation (OLG) models where the accumulation of human capital is constrained by parental transfer because of binding borrowing constraints. This article's aim is to study the channel of family networks along with the standard parental income channel. In particular, we concentrate on referrals, which are intended as options exploited by firms and workers to reduce the different kinds of frictional costs in the labour markets. When workers tend to refer workers of the same type, the networks on which referrals are based have an *inbreeding* bias (Montgomery, 1991). In an overlapping generation framework, such bias may involve access to referral that depends on parental economic and social conditions. This would add an extra source of persistence in the transmission of social status that originates from the job matching process. In Fig. 1, we report a cross country evidence to support such hypothesis. We plot the share of job matches obtained through informal channels with intergenerational income elasticities for selected EU Countries: social mobility (the inverse of the intergenerational elasticity) is lower where the degree of informality of labour market institutions is higher.

Therefore, the main contribution of this paper consists in filling a gap in the economic theoretical literature related to the evaluation of the role of job referrals and more generally, labour market networks as a source of persistence in the transmission of social status.

We connect the literature assessing the relationship between growth and intergenerational mobility and the literature on the impact of referrals in imperfect labour markets. Here, we sketch out the main features of the effects of referrals in theoretical (Montgomery, 1991; Finneran and Kelly, 2003; Kugler, 2003) and empirical literature (Macmillan et al., 2015; Brown et al., 2016; Dustmann et al., 2016) and introduce them with a reduced form in a model of human capital accumulation with borrowing constraints, in the specification of Maoz and Moav (1999). In this class of models, the accumulation of human capital, i.e. the overall investments in education, is the result of the workers' choice between two segments of the labour market: the segment for educated workers and the other for uneducated ones. We introduce the additional cost that workers bear and that affects their income, which differs between the two segments of the labour market. For each worker,

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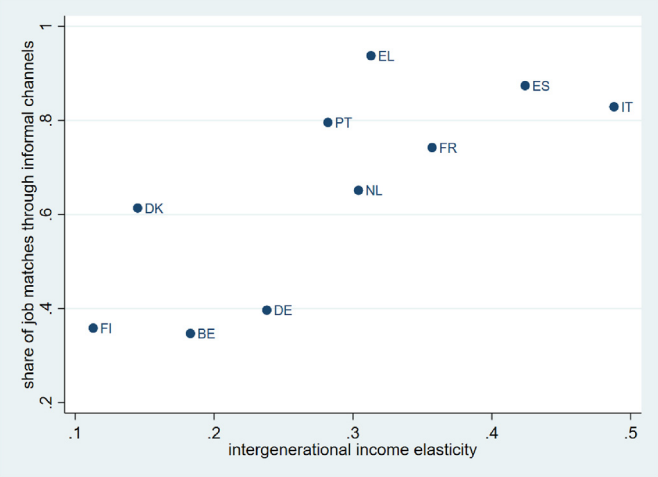

Fig. 1. Intergenerational income elasticities (Equal Chances database) and informal labour market institutions by EU Countries (EU-LFS, 2013).

these costs depend on their parent type. Consequently, the first finding of the paper is that an increase in the strength of networks in one segment reduces such costs but rises the opportunity gap between movers (workers coming from parents in the other segment) and stayers (workers coming from parents in the same segment).

Many kinds of institutions aimed at solving underlying market inefficiencies have regressive side effects. This is the case of formal institutions, including regulation (Thomas, 2019; Bailey et al., 2019) but it is also the case of informal institutions exploiting the socially embedded nature of the economic process (Granovetter, 1985), such as social status (Granovetter, 2010) and networks (Finneran and Kelly, 2003; Kugler, 2003). When such regressive effects are displayed in a framework of intergenerational transmission of inequalities, they widen the economic effects of inequality of opportunities in terms of lower accumulation of human capital. As a result, the efficiency gains provided in a specific market by social embedded institutions may not correspond to an improvement of the overall economic performance.

A similar effect has been found by Arnott and Stiglitz (1991) in the study of informal insurance markets, where the exploitation of informal channels to solve market incompleteness negatively affects the overall insurance market outcome. This reversed impact of informal channels of information holds in a context of migration in Banerjee and Newman (1998). In their two-sector model, a decline in information asymmetries in the traditional sector, by facilitating consumption loans, hampers the transition to the modern sector. In both cases, the disclosure of information only concerns the weak side of the dual economy at stake, the informal insurance, and the traditional sector respectively. The second finding of the paper is that the perverse effect holds even if the exploitation of informal channels only concerns the higher productive part of the labour market. Indeed, we show that a decrease in the path of human capital accumulation may hold also if the exploitation of informal channels concerns the educated segment of the labour market. From a theoretical point of view, this happens because two imperfections in two different markets (labour and credit) coexist. As they interact, an institution delivering a first best option in one market (labour) could negatively affect the general equilibrium results by worsening the impact of the other market (credit) imperfections.

This paper is structured as follows: in Section 2 we analyse the different strands of literature. Then, in Section 3, we sketch the baseline model of human capital accumulation and intergenerational inequality as found in Maoz and Moav (1999). Next, in Section 4 we set up the referral mechanism according to the main features in the literature and introduce it into the baseline model. In Section 5, we assess the impact of referrals by providing three propositions that characterise equilibrium dynamics. Finally, we propose concluding remarks.

2. Related literature

The theoretical literature on intergenerational mobility is vast and comprehensive. The seminal papers by Becker and Tomes (1979), Loury (1981) and Solon (2004), analyse the relationship between mobility and market inequality. Galor and Zeira (1993) and Banerjee and Newman (1993) concentrate instead on the relationship between inequality and economic growth. The papers by Owen and Weil (1998), Maoz and Moav (1999) and Hassler et al. (2007) combine the two previous approaches and study the dynamic relationship between mobility, inequality, and economic growth. Intergenerational persistence is explained by the role that income and wealth play as compensating factors when imperfect capital markets do not give access to the liquidity necessary for financing both the direct costs of education and the opportunity costs of foregone wages during the educational period, which tends to constrain human capital investment. However, as argued by Bowles and Gintis (2002), the intergenerational transmission of economic status is accounted for by a heterogeneous collection of mechanisms. In particular, in this paper, we consider the parental network along with the standard parental income channel.

The peculiarity of networks in the labour market is that they may affect both the probability of finding a job and determining which kind of jobs are available for one individual. The empirical literature on the role of networks and referrals concentrates on the comparative effectiveness of different search methods: formal or informal channels. In particular, attention has been devoted to the various effects on finding a job (or the job arrival rate), unemployment duration or persistence, and wage distribution. Analysing labour markets in European countries, Pellizzari (2010) finds evidence that the premiums and penalties of finding jobs through personal contacts are equally frequent and similar in terms of relevance. The wage effect of finding jobs through personal contacts is higher in countries with more labour market intermediaries. Brown et al. (2016) study the effect of networks over time and conclude that referred candidates are more likely to be hired and experience an initial wage advantage, which dissipates over time. According to Dustmann et al. (2016), job search networks help reduce informational deficiencies in the labour market and lead to productivity gains for workers and firms. Cappellari and Tatsiramos (2010) find evidence of higher wages and employment stability for those with more employed friends, which is consistent with networks acting as an information transmission mechanism. Macmillan et al. (2015) suggest that the use of networks provides an additional advantage to new-entrants in the labour market, and this varies by the type of occupation.

Regarding the theoretical analysis of the network literature (especially in the sociological field), numerous reasons are presented to

explain why networks are important in job markets. The explanations range from assortative matching (employers can find workers with similar characteristics by searching through certain networks), to information asymmetries (in hiring models with adverse selection) and simple insurance reasons (to help deal with the uncertainty in labour market turnover). The theoretical literature on job networking has benefited significantly from the contribution of Montgomery (1991). In his two-period model, firms do not have information on the productivity of job candidates, but the presence of a positive correlation in productivity between friends is assumed, which is defined as the inbreeding bias. Given this correlation, firms, having observed the employees' types, offer higher wages to the friends of productive employees. Montgomery's results provide support for the intuitive notion that social connections may be associated with better job matching performance, both for individuals and firms.

More recent contributions on the subject of referrals are those by Krauth (2003) and Calvo-Armengol and Jackson (2004). The first paper explores an economy in which personal connections facilitate the job search; its main emphasis is on the debate of weak vs. strong ties, and the findings are that networks with weaker ties are associated with smaller inequality in the distribution of employed friends and thus have a higher overall employment rate. The paper by Calvo-Armengol and Jackson (2004) extends Montgomery's framework by analysing the long-run dynamics of job networking. It allows referred workers to more effectively sample a given wage distribution. In these models, an increase in the worker's endowment of contacts implies a net improvement in wage possibilities; hence, they predict that jobs found through contacts should pay higher wages.

Other papers, as the ones by Fontaine (2008) as well as Bentolila et al. (2010), contribute to the contradictory evidence, even in theoretical terms, on the role of networks in the labour market. These papers study the effect of the presence of job referrals in the context of a standard equilibrium search model à la Pissarides.[1] Fontaine (2008) showed that a larger overall endowment of contacts may lead to a rise in the equilibrium unemployment. Bentolila et al. (2010) find that jobs found through contacts are obtained more quickly but also pay lower wages.

This contradictory evidence may rely on a composition effect; indeed, Kugler (2003) studies the referral mechanism in labour markets, where referrals impact both the probability of finding a job as well as the determination of which kinds of jobs are available to whom. In other words, the individuals are divided depending on their contacts; the matching process induces segmentation in the labour market: referrals match high-paying jobs to well-connected workers, while formal methods match less attractive jobs to less-connected workers. Finneran and Kelly (2003) provide an interesting description of why labour market networks exist. They analyse an economy where all hiring occurs through anonymous matching and then use those results as a benchmark to determine the advantages of referred matches. Hiring referred workers has three potential advantages for the firm when compared with anonymous matching: better information about the true qualifications of the employee, reduced recruiting and training costs and lower monitoring costs. We later refer to this composite effect as a reduction of frictional costs. The main result of their paper is that there is a transition from low inequality to severe inequality as the network moves below a critical level of density. In particular, there is the emergence of what the authors define as an underclass of workers who are low in the hierarchy.[2]

To clarify the network concept, it is important to specify that we refer to three types of contacts: family, friends and acquaintances. As originally proposed by Granovetter (1974, 1995), the family is deemed as an example of strong tie, whereas acquaintances are typically weak ties. Strong ties cannot only help with a direct referral but can also help in indirect ways such as advice in the use of formal channels and so on. Therefore, the network is not just an informal source of information exploited by firms when they decide who to hire; in the intergenerational context, it can be seen as an additional source of persistence in the transmission of social status. One of the novelties of this paper is studying, in theoretical terms, the importance of parents as network members. As explained by Magruder (2010), parents may endow children with references, job information or social connections that provide an advantage in the labour market as much as inherited wealth can. Kramarz and Skans (2014) conclude that family ties are indeed important for the transition from school to work, in particular for low-educated males who tend to follow their fathers in their profession. Another related strand of literature is the one about nepotism (Aina and Nicoletti, 2014; Raitano and Vona, 2018), which is deemed to hurt performance by limiting the scope of labour market competition.

The idea that social segregation is crucial in the transmission of group inequality across generations dates back to Loury (1977). Segregation is usually interpreted on a spatial dimension. For instance, the seminal works by Loury concentrate on neighborhood externalities in schooling. In Durlauf's work (1996), the economic stratification of neighborhoods creates a link between cross-sectional and intertemporal inequality. His model describes the process by which heterogeneous urban communities can be transformed into ghettos as wealthier families move to suburbs. Such endogenous stratification has consequences on the long-run behaviour of the economy because it implies that different agents experience different environments of interaction.

As proposed by the social isolation theory by Wilson (1987), poor access to job networks plays an essential role in explaining high unemployment rates among low-income African-Americans. This hypothesis is supported by the empirical work from Holzer (1987), who finds that black youth have a lower success rate than white youth in obtaining job offers through networking, despite a similar rate of success in more formal means. The more recent empirical study by Corak and Piraino (2010) finds that the parental network's strength surges with the social position of the family.

This paper is a theoretical contribution to the three different broad strands of literatures above: the one about intergenerational mobility, the one about networks in the labour market and the one about stratification or segregation. Anderberg and Anderson (2007) analyse the three topics jointly as well. However, they analyse the neighborhood as the relevant network dimension by focusing on locational choices. Instead in our model, we focus on the role of referrals in the labour market and their interaction with the human capital accumulation process in the presence of endogenous stratification and borrowing constraints.

3. The baseline model

To analyse the effect of referrals in an intergenerational mobility model, we start from the standard model of human capital accumulation and intergenerational mobility with imperfect credit markets, as in the specification from Maoz and Moav (1999).

In this model, individuals live two periods: in the first period, they receive a monetary transfer from parents and do not work but can be involved in education. In the second period they work and make a transfer to their child. The utility of individual i is given by:

$$u_t^i = \ln(c_t^i) + \ln(c_{t+1}^i) + \ln(x_{t+1}^i), \tag{1}$$

where c is consumption and the last term, x, represents the parental utility provided by the transfer to the child.

Credit market imperfection is modeled in the extreme version of no borrowing (nor lending). It is not possible to borrow to acquire education for those who have not enough resources to cover education costs. As a result, the individual budget constraint depends on the parental

[1] See also Galenianos (2014). For a complete review of the literature on the use of search models in the labour market theory, see Rogerson et al. (2005).

[2] As stated by Finneran and Kelly (2003) pp.289: *The referral network represents an unambiguous Pareto improvement over anonymous matching. For a referral network to be of interest it must be hierarchical: some individuals are better situated to be referred than others.*

transfer, which is the mechanism underlying the imperfect mobility which involves the intergenerational correlation of incomes. The two-period budget constraints of an individual acquiring an education are:

$$c_t^i + h_t^i = x_t^i \qquad c_{t+1}^i + x_{t+1}^i = w_{t+1}^E, \tag{2}$$

where h is the cost of becoming educated and w^E is the wage of educated workers.

The budget constraints of an individual not acquiring education are:

$$c_t^i = x_t^i \qquad c_{t+1}^i + x_{t+1}^i = w_{t+1}^U, \tag{3}$$

where w^U is the wage of uneducated workers.

Technology is modeled as a Cobb Douglas production function, with wages set at the productivity levels:

$$Y_t = AE_t^{1-\alpha}U_t^{\alpha}, \tag{4}$$

$$w_t^E = (1-\alpha)A(U_t/E_t)^{\alpha} \qquad w_t^U = \alpha A(U_t/E_t)^{\alpha-1}.$$

The overall labour supply is normalised to 1, and thus, $U_t = 1 - E_t$.

The individual choice consists in whether to acquire education or not. The solution of the individual maximization problem[3] defines an upper threshold of education costs $\widetilde{h}_t^i$ for each of the two possible parental conditions, uneducated (U) and educated (E):

$$\widetilde{h}_t^U = \frac{w_t^U}{2}\left[1 - \left(\frac{w_{t+1}^U}{w_{t+1}^E}\right)^2\right] = \frac{1-\alpha}{1-E_t}\frac{\overline{w}_t}{2}\left[1 - \left(\frac{1-\alpha}{\alpha}\frac{E_{t+1}}{1-E_{t+1}}\right)^2\right], \tag{5}$$

$$\widetilde{h}_t^E = \frac{w_t^E}{2}\left[1 - \left(\frac{w_{t+1}^U}{w_{t+1}^E}\right)^2\right] = \frac{\alpha}{E_t}\frac{\overline{w}_t}{2}\left[1 - \left(\frac{1-\alpha}{\alpha}\frac{E_{t+1}}{1-E_{t+1}}\right)^2\right]. \tag{6}$$

Education costs depend on an idiosyncratic component that is equally distributed among workers (independently of the worker's parents) and that embodies the individual's talent in attaining education. Considering an individual parameter θ^i uniformly distributed on an interval $[\underline{\theta};\ \overline{\theta}]$ that proxies the inverse of individual talent, education costs are:

$$h_t^i = \theta^i(a + b\overline{w}_t)\ , \tag{7}$$

where $\overline{w}_t$ is the average wage in t and $(a + b\overline{w}_t)$ is a scale factor, a and b are positive.[4]

As a result, the two education thresholds $\widetilde{h}_t^E$ and $\widetilde{h}_t^U$ correspond to thresholds of the idiosyncratic parameters $\widetilde{\theta}_t^E$ and $\widetilde{\theta}_t^U$.

The dynamics of the model can be expressed by the following implicit equation:

$$E_{t+1} = F(\widetilde{\theta}_t^E)E_t + F(\widetilde{\theta}_t^U)(1 - E_t), \tag{8}$$

where F is the cumulative distribution function of the idiosyncratic component, and hence, $F(\widetilde{\theta}_t^i)$ is the share of workers with parent type i that choose to invest in education, that is, the cumulative distribution function of the idiosyncratic component:

$$F(\theta) = \frac{\theta - \underline{\theta}}{\overline{\theta} - \underline{\theta}}. \tag{9}$$

To exclude trivial and corner solutions, the following assumption must hold:

$$\underline{\theta} < \frac{w(\widehat{E})}{2[a + bw(\widehat{E})]}, \tag{10}$$

where $\widehat{E} = 1 - \alpha$ is the level of E such that $w^U = w^E = w(\widehat{E})$ and $w(\widehat{E}) = Y_t$ because the number of workers is normalised to 1. This assumption implies that there is always some worker choosing education ($E_{t+1} > 0 \forall E_t \in (0,1)$) since $x(w^E) > \widetilde{h}^E$ for any $E \in \left(0, \widehat{E}\right]$ and $x(w^U) > \widetilde{h}^E$ for any $E \in [\widehat{E}, 1]$. This corresponds at assuming that at the level of education maximizing production (at least) some upward mobility exists.

For any $E_t \in (0,1)$, the maximization problem has a unique solution E_{t+1}, where the upper threshold of costs is higher for workers with educated parents ($h_t^E > h_t^U$). This is the source of inequalities in education rates among parental types. Accordingly, there would be some workers with non educated parents choosing not to invest in education even though they have the potential to be better than some workers of the other group that choose to invest in education. Thus, the correspondent gap $\widetilde{\theta}_t^E - \widetilde{\theta}_t^U$ expresses both the inequality of opportunity and the inefficient allocation of talents induced by the borrowing constraint hypothesis.

The model has a steady state equilibrium E^*, where downward mobility equals upward mobility:

$$\{1 - F[\widetilde{\theta}^E(E^*)]\}E^* = F[\widetilde{\theta}^U(E^*)](1 - E^*). \tag{11}$$

Starting from a lower level of E, the system monotonically converges to the steady state equilibrium.

In the original paper by Maoz and Moav (1999), the authors extend the model to show the inefficiency of redistributive taxation. Although redistribution through reducing income inequality reduces the inequality of opportunity by narrowing the threshold gap ($\widetilde{\theta}_t^E - \widetilde{\theta}_t^U$), it negatively affects investment in education. In Section 4 and 5, we modify this model to analyse how referrals, exploited to improve labour market efficiency, might impact on the accumulation of human capital.

4. Referrals and parental networks

To model the effect of referrals, we adopt a reduced form framework. Without modeling the matching process specifically, we make general assumptions about how the outcome of the referral process can be introduced in the baseline model of human capital accumulation pictured in Section 3. Then, the hypotheses about how these outcomes are produced, and their relationship with the referral mechanism is taken to be coherent with the wide range of cases for referrals studied in the literature. According to the literature outlined in Section 2, we move in a theoretical framework where referrals are informal channels exploited by workers and/or firms to reduce frictional costs in the labour market. From the firm's perspective, such costs can be related to the time needed to fill a vacancy, to screening and selection costs or, in case of asymmetric information, to the implicit costs of wrong matches. These costs include the loss of productivity and possible firing costs and further costs of opening a new vacancy. From the workers' perspective, three symmetric channels apply: the costs of unemployment spells, costs related to the fact that searching for a job is a job in itself, and the costs of wrong matches. In either case, if the costs are exogenously given or if they are a result of a strategic interaction, workers' overall payoffs are affected. Furthermore, since we have not assumed imperfections in the final goods market, a firm's efficient solution always involves wages to be set at labour marginal productivity, hence the costs of the process are fully shifted to workers and firms' first order conditions are instead not affected. In our human capital accumulation framework, these costs directly and only affect workers' educational choices. In particular, this happens as long as individual costs differ between the two segments of the labour market. Thus, without loss of generality, we can introduce

[3] See the Appendix for the stepwise PROOF of the baseline model.

[4] As noted by Nakamura and Murayama (2011), the assumption $a > 0$ has an important role in determining the path of convergence to the steady state equilibrium. For the sake of simplicity, we maintain this original hypothesis.

such effects in the definition of h_t^i in eq. (7) as[5]:

$$h_t^i = (\theta^i + \nu^i)(a + b\overline{w}_t)\ , \qquad \nu^i = c_E^i - c_U^i; \tag{12}$$

where ν^i is the difference between the additional costs that worker i would bear in the matching process in the E sector c_E^i and the additional costs that they would bear in the U sector c_U^i and thus may be interpreted as the opportunity costs (or net costs) of choosing the segment E. As a result, these costs enter in the budget constraint (eq. (3)) in the maximization problem of eq. (1) and thus, as we will discuss below, affect the talent thresholds $\widetilde{\theta}_t^i$ that characterise the dynamics of the model in eq. (8). In this setting, the main issue is to discuss how referrals impact on c_j^i and their relationship with the workers' parent type.

Firms are usually supposed to obtain referrals through their employees. Therefore, firms' networks correspond to the overlap of its employee networks, while new workers exploit their connections with employed workers. The workers that are employed in one firm may refer one friend, a relative or acquaintance, in other words, one member of the network who is unemployed, helping in the job search process. More connected workers are those with more connections with employed workers. Asymmetry in worker connections implies that in each labour segment (educated and uneducated jobs) the workers who have parents with the same educational choice (stayers), have a stronger network. With this asymmetry we account for the concepts of inbreeding bias by Montgomery (1991) as well as the hierarchical concept by Finneran and Kelly (2003).

We assume that the costs c_j^i borne by a worker i in each $j \in (E;U)$ segment only depend on their parent type ($c_j^i = c_j^E$ if $i \in E$; $c_j^i = c_j^U$ if $i \in U$ and hence also $\nu^i = \nu^E$ if $i \in E$; $\nu^i = \nu^U$ if $i \in U$) and that the costs for workers having parents in the same segment (stayers) are lower than the costs borne by workers having parents in the other segment (movers), that is:

$$c_j^j < c_j^l, \qquad j \neq l \qquad j,l \in (E,U); \tag{13}$$

where c_j^j and c_j^l are respectively the costs of stayers and movers in the segment j.

Note that taking the condition in eq. (13) together with the definition of ν^i in eq. (12) involves:

$$\nu^U > \nu^E\ . \tag{14}$$

This is because the costs of workers with U-type parents are, if compared to the E-type ones, higher in the E segment and lower in the U segment.

In the theoretical models of referrals, where the allocation of referrals is non-uniformly distributed, an increase in the strength of networks for a worker has two effects: a direct positive effect on its payoff and a negative externality on other workers. This is the case in the seminal paper by Montgomery (1991), where workers having no search costs exploit a rent through a bargaining power emerging in the strategic matching process, increasing their wages at the expense of firms and other workers' wages. This negative externality emerges both in strategic settings with asymmetric information as well as with perfect information when the frictional costs consist in the probability of finding an appropriate vacancy. In this case, as in Kugler (2003), a rise in one worker's probability of finding a job inversely affects other workers' chances. More generally, as long as the individual costs affect the employability of workers competing in the same labour market segment, the externality emerges.

To clarify the main features of such a stylized referral set up, let's deal with a simplified framework of matching concerning workers with same educational level, that is, in the same segment E or alternatively U in terms of our general model. Although workers have the same educational level, there are different types of jobs available to the worker. As an example, in the E sector we could examine the several graduation fields (Engineering, Law, Economics, etc.), or a distinction between the required soft skills and capabilities (leadership, team working, flexibility, etc.). A similar distinction could be made within the U sector between different jobs such as salesmen, waiters or drivers or between other specific requirements for less skilled jobs (even physical strengths or skills), but with different kinds of jobs requiring such educational level. Each worker may be employed only in one of the different jobs. Matching occurs throughout interviews where firms verify whether the attending workers are suited for the job, i.e. verify their type. The type corresponding to each vacancy is known, but ex-ante workers have no information about their type until they participate in their first interviews and get to know whether they are of the correspondent vacancy's type. Furthermore, although the labour market will be at equilibrium ex-post, not all vacancies open simultaneously, and the number of right type candidates can be higher than the number of vacancies opened in each interview. As a result, the firms randomly choose a subset of workers among those who resulted of the right type and the other workers have to participate in further interviews, even if their type was the right one. With each interview the worker bears a cost. The referral mechanism implies that a subset of workers (subgroup R) has a positive probability of having publicly known type and therefore of being hired in advance, without attending the interview. Thus, the direct effect of referrals is to decrease the overall costs borne by workers of the subgroup R, and also the total costs since the overall number of interviews declines as well. The indirect effect is a "queue" effect on the rest of the workers: the available vacancies at the earlier interviews reduce, hence their overall average costs of search increase. In Appendix B we provide a formal specific version of this matching process. In what follows we take the main implications of such model of referrals in a more general version: the direct effect on the overall costs and the indirect effects on net costs. The probability of people belonging to the group with referrals of having a public type is what we use to represent the strength of the network (μ).

As an example, a rise in the strength of networks in the educated segment μ_E reduces costs for workers having parents from this segment but increases the same costs for the other parent-type workers. The opposite happens when the rise concerns the strength of networks in the other segment μ_U. Formally:

$$\frac{\partial c_j^j}{\partial \mu_j} \leq 0 \qquad \frac{\partial c_j^l}{\partial \mu_j} \geq 0 \qquad \forall\, j, l = (E;U)\ ; l \neq j. \tag{15}$$

Analysing the effect on the net costs ν^i in eq. (13) and the indirect effect found in the simplified version of the matching process, we can write the following:

$$\frac{\partial \nu^E}{\partial \mu_j} \leq 0 \qquad \frac{\partial \nu^U}{\partial \mu_j} \geq 0 \qquad \forall\, j = (E;U)\ . \tag{16}$$

Since net costs affect investments in education, a surge in the strength of networks (μ_j) in any of the two segments involves a polarization effect. Given the individual costs c_j^l and the number of workers in each sector j of type l, we define as C_j^l the sum of all the costs borne

[5] With this formulation we implicitly assume frictional costs to impact on the first rather than the second period budget constraint. This feature is more appropriate when these costs affect workers' payoff before the employer-employee match because they consist of the risk of unemployment spells or job-seeking costs, as in Kugler (2003). In other cases, workers' payoffs are affected after the match, mostly in terms of wage penalties or wage premia. In such cases, there would be different wages for workers with the same productivity, but there would be different net wages because of different frictional costs. However, since the implicit discount rate in the model is null, assuming that the correspondent wage gap is paid just before starting work is a straightforward approximation. Furthermore, in the simplified two-period framework, it is coherent with the empirical micro evidence on the wage gaps related to referrals, which is significant, especially in the initial period of the job relationship, as shown empirically by Kramarz and Skans (2007) and Brown et al. (2016).

by such workers. Since we are deeming referrals as options to reduce overall frictional costs, the overall decrease in stayers' costs (C_E^E or C_U^U) has always to outweigh the increase in movers' costs (C_E^U or C_U^E). Thus, we have to consider the assumption that:

$$\frac{\partial C_E^E}{\partial \mu_E} = -\frac{\partial \nu^E}{\partial \mu_E} F_t^E E_t > \frac{\partial \nu^U}{\partial \mu_E} F_t^U (1 - E_t) = \frac{\partial C_E^U}{\partial \mu_E}\ , \tag{17}$$

$$\frac{\partial C_U^U}{\partial \mu_U} = \frac{\partial \nu^U}{\partial \mu_U}(1 - F_t^U)(1 - E_t) > -\frac{\partial \nu^E}{\partial \mu_U}(1 - F_t^E)E_t = \frac{\partial C_U^E}{\partial \mu_U}\ , \tag{18}$$

where $F^U(1 - E)$ and $F^E E$ are the number of workers choosing education, having respectively parents of the U and E type (movers and stayers of sector E) and $(1 - F^U)(1 - E)$ and $(1 - F^E)E$ are the number of workers not choosing education, having respectively parents of the U and E type (stayers and movers of sector U).

Since the increase in the strength of networks has a positive impact on the overall costs borne by workers choosing the segment where such increase occurs, at a first sight, this should rise the number of workers choosing that segment. Accordingly, an increase in the strength of networks in the segment E should boost human capital accumulation. On the contrary, a surge in the strength of networks in segment U, here lowering the frictional costs in this segment, should rise the supply of uneducated labour and negatively affect the accumulation of human capital. However, we show in Section 5 that such intuitive effects do not always hold. Indeed, both by directly increasing stayers' incentives and indirectly decreasing movers' incentives, referrals produce a segregation effect that adds to the borrowing constraints by decreasing social mobility, and this has significant economic repercussions.

5. Equilibrium

This Section contains the main findings of the paper, that are captured by three propositions. To analyse the properties of equilibrium dynamics, in the first PROPOSITION we consider ν^E and ν^U as given. Thereafter in the remaining propositions, we study the impact of a change in the strength of networks to assess the impact of referrals.

First, we take the equivalent of the assumption in eq. (10), as follows:

$$\underline{\theta} + \nu^U < \frac{w(\widehat{E})}{2[a + bw(\widehat{E})]}. \tag{19}$$

This assumption implies that there is always at least one worker choosing education ($E_{t+1} > 0 \forall\ E_t \in (0,1)$) because $x(w^E) > \widetilde{h}^E$ for any $E \in \left(0, \widehat{E}\right]$ and $x(w^U) > \widetilde{h}^E$ for any $E \in [\widehat{E}, 1]$. This is the equivalent of the assumption made for the benchmark model, which actually avoids imposing minimal thresholds to the initial condition of E_0, below which the system has finite solutions.

Including the definition of the thresholds $\widetilde{h}^i$ in eqs. (5) and (6) and the definition of costs h^i in eq. (12), given the additional costs ν^i, we can rearrange the two thresholds of education costs $\widetilde{h}^i$ into the two thresholds of the idiosyncratic education individual parameters $\widetilde{\theta}^i$:

$$\widetilde{\theta}_t^E = \frac{\widetilde{h}_t^E}{(a + b\overline{w}_t)} - \nu^E = \frac{\alpha}{E_t}\frac{\overline{w}_t}{2(a + b\overline{w}_t)}\left\{1 - \left[\frac{(1-\alpha)E_{t+1}}{\alpha(1 - E_{t+1})}\right]^2\right\} - \nu^E, \tag{20}$$

$$\widetilde{\theta}_t^U = \frac{\widetilde{h}_t^U}{(a + b\overline{w}_t)} - \nu^U = \frac{1-\alpha}{1-E_t}\frac{\overline{w}_t}{2(a + b\overline{w}_t)}\left\{1 - \left[\frac{(1 - \alpha E_{t+1})}{\alpha(1 - E_{t+1})}\right]^2\right\} - \nu^U. \tag{21}$$

From eq. (8) and taking into account that the distribution function of θ^i is uniform in $(\overline{\theta}, \underline{\theta})$, we study the dynamics of the model to have the following implicit equation:

$$E_{t+1} = E_t \frac{\widetilde{\theta}^E - \underline{\theta}_t}{\overline{\theta}_t - \underline{\theta}_t} + (1 - E_t)\frac{\widetilde{\theta}^U - \underline{\theta}_t}{\overline{\theta}_t - \underline{\theta}_t}. \tag{22}$$

Considering eqs. (20) and (21), we can rearrange the following:

$$E_{t+1} = \frac{\frac{\overline{w}_t}{a + b\overline{w}_t}\left[1 - \left(\frac{1-\alpha}{\alpha}\frac{E_{t+1}}{1-E_{t+1}}\right)^2\right] + (\nu^U - \nu^E)E_t - \nu^U - \underline{\theta}}{\overline{\theta} - \underline{\theta}}. \tag{23}$$

To simplify notations, much like Nakamura and Murayama (2011) for the baseline model, we define two auxiliary functions H and f to break up the first term on the right-hand side of the equation:

$$H(E_t) = \frac{\frac{\overline{w}_t}{a + b\overline{w}_t}}{\overline{\theta} - \underline{\theta}}, \tag{24}$$

$$f(E_{t+1}) = \left[1 - \left(\frac{1-\alpha}{\alpha}\frac{E_{t+1}}{1 - E_{t+1}}\right)^2\right]. \tag{25}$$

Since the density function of θ^i is uniform, using eqs. (20) and (21) into eq. (8), we can express the law of motion of the economy in eq. (22) as follows:

$$E_{t+1} = H(E_t)f(E_{t+1}) - \frac{E_t\nu^E + (1 - E_t)\nu^U + \underline{\theta}}{\overline{\theta} - \underline{\theta}}. \tag{26}$$

All the functions are continuous, and hence, this relationship defines an implicit function $E_{t+1} = \varphi(E_t)$. By using the properties of implicit functions, we can obtain the derivative of the function:

$$\frac{dE_{t+1}}{dE_t} = \frac{\frac{\nu^U - \nu^E}{\overline{\theta} - \underline{\theta}} + f(E_{t+1})\frac{dH(E_t)}{dE_t}}{1 - H(E_t)\frac{df(E_{t+1})}{dE_{t+1}}}, \tag{27}$$

where the denominator is positive because eqs. (24) and (25) imply that $\frac{df(E_{t+1})}{dE_{t+1}}$ is negative, $H(E_t)$ positive, and the numerator is positive if the initial level of education is lower than $\widehat{E}$ (i.e., for $w^E \geq w^U$). Thus, the implicit function φ is continuous and strictly monotonic in $(0, \widehat{E})$: starting from a low level of capital accumulation, the share of workers choosing education rises. Furthermore, it is straightforward to show from eqs. (20) and (21) that the thresholds $\widetilde{\theta}^U$ and $\widetilde{\theta}^E$ are, respectively, increasing and decreasing in $(0, \widehat{E})$: along the process of human capital accumulation, upper and downward mobility both increase. The dynamic features of the model are the same as in the benchmark model; this still holds for the properties of the steady state equilibrium. Therefore, the following PROPOSITION may be stated.

PROPOSITION 1. *A stable steady state equilibrium of the model exists, and the equilibrium value of human capital is the same as the baseline model with $\nu^E = \nu^U = 0$ with the interval of variation of the idiosyncratic component modified by adding ν^U to the lower bound and ν^E to the upper one.*

PROOF. In the steady state equilibrium, we have from eq. (26) the following:

$$E^* = H(E^*)f(E^*) - \frac{E^*\nu^E + (1 - E^*)\nu^U + \underline{\theta}}{\overline{\theta} - \underline{\theta}}. \tag{28}$$

Rearranging and using the definitions of H and f, we have the following:

$$E^* = \frac{1}{\left(1 - \frac{\nu^U - \nu^E}{\overline{\theta} - \underline{\theta}}\right)(\overline{\theta} - \underline{\theta})} \times \left\{\frac{\overline{w}(E^*)}{a + b\overline{w}(E^*)}\left[1 - \left(\frac{1-\alpha}{\alpha}\frac{E^*}{1 - E^*}\right)^2\right] - \nu^U - \underline{\theta}\right\}. \tag{29}$$

If we define $\underline{\theta}^0 = \underline{\theta} + \nu^U$ as the lower bound and $\overline{\theta}^0 = \overline{\theta} + \nu^E$ as the upper bound, we have

$$E^* = \frac{1}{\overline{\theta}^0 - \underline{\theta}^0}\left\{\frac{\overline{w}(E^*)}{a + b\overline{w}(E^*)}\left[1 - \left(\frac{1-\alpha}{\alpha}\frac{E^*}{1-E^*}\right)^2\right] - \underline{\theta}^0\right\}; \quad (30)$$

which is the equivalent of eq. (23) in the benchmark case. As a result, the stable equilibrium has the same properties of existence and uniqueness of a model without the additional costs with the interval of variation of the idiosyncratic component modified by adding ν^U to the lower bound and ν^E to the upper one.

In the previous Section, we have considered how the net costs to become educated for the two parent-types, ν^E and ν^U, change in response to the change in the strength of networks in the labour market, or at least in one of its two segments. Since stayers' costs decrease and movers' costs rise, any positive change in one of the two network parameters μ_E and μ_U widens the opportunity gap between workers having parents with different educational levels by decreasing ν^E and increasing ν^U as expressed in eq. (13). We can now assess the role of referrals by analysing the effect of an increase in the strength of networks.

PROPOSITION 2. *The increase in the strength of networks negatively impacts the steady state equilibrium level of human capital if and only if:*

$$-\frac{\frac{\partial \nu^E}{\partial \mu_j}}{\frac{\partial \nu^U}{\partial \mu_j}} < \frac{1-E}{E}. \quad (31)$$

PROOF. Take the differential of eq. (26) at equilibrium ($E_{t+1} = E_t = E^*$) in E^*, ν^E and ν^U[6]:

$$\partial E^* = \frac{(E-1)\partial \nu^U - E\partial \nu^E}{(\overline{\theta} - \underline{\theta})\left[(1 - H'f) - \left(f'H + \frac{\nu^U - \nu^E}{\overline{\theta} - \underline{\theta}}\right)\right]}. \quad (32)$$

The stability of E^* implies that the denominator of this ratio is positive. Indeed, taking into account eq. (27), the stability of E^* implies that $\frac{\partial E_{t+1}}{\partial E_t}$ at equilibrium has to be lower than one and the same holds for the right-hand side of the equation. Hence, once considering the variation in μ_j affecting the (net) costs ν^U and ν^E, we have the following:

$$\frac{\partial E}{\partial \mu_j} < 0 \Longleftrightarrow E^*\frac{\partial \nu^E}{\partial \mu_j} + (1 - E^*)\frac{\partial \nu^U}{\partial \mu_j} > 0. \quad (33)$$

By taking eq. (16) and rearranging, we have eq. (31).

This PROPOSITION implies that referrals, though positively affecting the labour market, may negatively impact on the accumulation of human capital through their segregation effects. The left-hand side of the inequality in eq. (32) is the share between, respectively, the decrease in the opportunity costs of being a stayer in sector E and the opportunity costs of being a stayer in sector U. Indeed, segregation effects have two aspects: a decline in the opportunity costs in downward mobility (ν^E) and the reduction in the opportunity costs in upward mobility ($-\nu^U$). When the former prevails, the range for negative aggregate effects narrows, and the opposite occurs when the overall effect is mainly a decrease in upward mobility opportunities. The right-hand side is the ratio between the number of the two worker types. Considering eq. (4), such ratio is a positive function of the ratio between the two worker types' wages $\frac{w^E}{w^U}$, that is, a measure of inequality. Thus, the degree of market inequality worsens the negative effects.

An alternative way of interpreting PROPOSITION 2 is the following: consider that $(1 - E) = U$ is the mass of workers with non educated parents, that $dh^E = \frac{\partial \nu^E}{\partial \mu_j} d\mu_j$ is the variation of the opportunity costs for education of a worker having educated parents induced by the surge of the strength of networks $d\mu_E$, and $dh^U = \frac{\partial \nu^U}{\partial \mu_j}$ is the variation of the opportunity costs for education of a worker having non-educated parents, then we rewrite the condition in eq. (31) by rearranging it as:

$$-dh^E E < dh^U U. \quad (34)$$

The left-hand side of the equation corresponds to the decline in the total opportunity costs of workers having educated parents and the right-hand side is the surge in the total opportunity costs of workers having uneducated parents. Therefore, we can reformulate PROPOSITION 2 as:

PROPOSITION 2a. *The increase in the strength of networks negatively impacts the steady state equilibrium level of human capital if and only if the resulting decrease in total opportunity costs of education for workers with educated parents is lower than the rise in the total opportunity costs of education for workers with uneducated parents*

It is important to show that this condition is not directly related to the condition for referrals to reduce overall search costs. Indeed, this last condition is related to the costs that are actually borne by workers with type E or U parents choosing education and not to the potential costs that they would face by choosing all education, which corresponds to the case of the statement in PROPOSITION 2.

To show that a referral mechanism can be detrimental to growth although decreasing actual search costs, the condition described in PROPOSITION 1 (eq. (31)) must hold together with the conditions in eqs. (17) and (18), as we discuss in the following PROPOSITION 3.

PROPOSITION 3. *The negative effects on the final equilibrium do not depend on which segment exploits the rise in the strength of networks and can hold even if the direct impact of referrals is a decrease in search costs.*

PROOF. Any increase in the network strength, μ_j, implies variations in both the parameters ν^E and ν^U. The sign of the variations is the opposite since a stronger network impacts on the stayers' costs as well as on the movers' costs, through the external effect. We now need to verify that the variation of the net costs, ν^i, complies with the condition set on the use of referrals, that is in each sector overall frictional costs decreases and therefore, referrals are efficient. We can rewrite eqs. (17) and (18) as:

$$\frac{\frac{-\partial \nu^E}{\partial \mu_U}}{\frac{\partial \nu^U}{\partial \mu_U}} < \frac{1-E}{E}\frac{1-F^U}{1-F^E} \quad ; \quad \frac{\frac{-\partial \nu^E}{\partial \mu_E}}{\frac{\partial \nu^U}{\partial \mu_E}} > \frac{1-E}{E}\frac{F^U}{F^E}.$$

Since imperfect mobility implies $F^U < F^E$, the values in the right-hand side of these two inequalities are respectively higher and lower than the right-hand side of eq. (31) in PROPOSITION 2. As a result, the constraint for efficiency of referrals in each labour market segments does not exclude the negative effects on the steady state equilibrium level of human capital.

While it is not surprising that an increase in the strength of networks that reduces the search costs in the uneducated sector might also decrease the accumulation of human capital, it is less intuitive that such a negative effect could happen in case of a decline in the search costs in the educated sector. This last PROPOSITION implies that the reduction in the accumulation of human capital may occur even if networks are exploited only in the educated sector of the labour market. This is because while the effect of referrals on search costs in the educated sector concerns only the group of workers actually choosing education, the effect on opportunity costs concerns all workers, and the share of workers having a benefit in the first group is higher than their share in overall employment. Finally, if the strengthening of networks concerns symmetrically both segments of the labour market, that is $-dh^E = dh^U$,

[6] We have: $\partial E^* = (H'f + f'H + \frac{\nu^U - \nu^E}{\overline{\theta} - \underline{\theta}})\partial E^* + \frac{E-1}{\overline{\theta} - \underline{\theta}}\partial \nu^U - \frac{E}{\overline{\theta} - \underline{\theta}}\partial \nu^E$

since $E < U$, the condition for a negative impact on the accumulation of human capital in eq. (34) always holds.

6. Conclusions

By introducing jointly two market imperfections, in the credit and in the labour markets, we have set up a theoretical model assessing two different channels of intergenerational transmission of inequalities: parental investment in education and their networks in the labour market. This allows us to connect two different branches of the labour economics literature. On one hand, the branch on the negative effects of inequality of opportunity on the accumulation of human capital, from which we draw the basic OLG model in the version by Maoz and Moav (1999). On the other hand, the branch on the use of referrals in the labour market to reduce the frictions in the matching process.

We have shown that the interaction between the two sources of imperfect mobility can determine counterintuitive results. In fact, the use of informal mechanisms in labour market intermediation, despite being an efficient solution for the partial equilibrium on the labour market, generates segregation effects exacerbating the intergenerational transmission of inequalities and therefore also its negative effects on the accumulation of human capital. Accordingly, a trade-off between partial and general equilibrium efficiency emerges. Even if referrals are exploited only in the most educated segment of the labour market, by reducing the overall costs of creating a skilled labour force, the overall effect on the process of human capital accumulation may be negative. Thus, our results are stronger than the results in existing literature on the reversal impact of informal channels. Indeed, in models such as Banerjee and Newman (1998) and Arnott and Stiglitz (1991), the disclosure of informality concerns the weak side of the dual economy at stake. As a result, information disclosure implicitly benefits the weak side of the economy at the expenses of the strong (more productive) side. Instead, in our case the reversal effect occurs also when the use of referrals concerns only the more productive side of the economy.

The segregation effect of referrals consists in the reduction of both upward and downward mobility incentives. The negative effect is more likely to happen when the decline in upward mobility prevails on the decrease in downward mobility. However, when wages inequality is already high, a worsening of the long run equilibrium occurs even when the segregation effect is constituted mostly of a reduction in downward mobility.

The use of informal channels in the labour market is an example of exploitation of the socially embedded character of economic relationships (Granovetter, 1995). We provide theoretical evidence that, in a context of intergenerational transmission of inequalities, the economic exploitation of social embedding worsens the consequences of inequality of opportunity, involving an overall perverse effect. This provides a further argument in favor of policies promoting equality of opportunities in the access to education by adding some specific concerns. Such policies usually consist in facilitating loans and providing grants for higher education to solve the misallocation of talents induced by credit constraints. However, when in the labour market informal channels of job searching and matching are exploited, strongly progressive tax schemes with subsidies at the bottom are more suited to correcting the opposite biases in the incentives to investing in human capital involved at the bottom and at the top of the distribution of parental income.

Declaration of competing interest

None.

Appendix A

Following Maoz and Moav's (1999) model, the individual maximization is solved backwards in two steps. In the first step, the individual decides how to allocate between consumption and transfers to the child, and in the second step, the individual decides whether to acquire an education or not.

In equation terms, the second period maximization problem is formulated as follows:

$$z(w^i_{t+1}) \equiv \max(\log c^i_{t+1} + \log x^i_{t+1}),$$

$$\text{subject to}: c^i_{t+1} + x^i_{t+1} = w^i_{t+1}.$$

The maximization gives the optimal allocations, in which the intergenerational transfer is an increasing function of the parent's wage:

$$x^i_{t+1} = w^i_{t+1}/2.$$

Then, the individual chooses to invest in human capital and hence to educate if the following inequality holds:

$$\log(x^i_t - h^i_t) + z(w^E_{t+1}) \geq \log x^i_t + z(w^U_{t+1}).$$

Let $\widetilde{h}^i$ denote the threshold (or critical value) of the cost of education such that the individual invests if and only if $h^i_t \leq \widetilde{h}^i_t$ and vice versa. The threshold is a function of future wages and of the transfer received:

$$\widetilde{h}^i_t = x^i_t \left[1 - \left(\frac{w^U_{t+1}}{w^E_{t+1}}\right)^2\right].$$

The function is continuous and differentiable with respect to x^i_t, w^U_{t+1} and w^E_{t+1}, with the following derivative signs: $\partial\widetilde{h}^i_t/x^i_t > 0$, $\partial\widetilde{h}^i_t/w^E_{t+1} > 0$ and $\partial\widetilde{h}^i_t/w^U_{t+1} < 0$.

Appendix B

In what follows we sketch a simple model of referrals in a labour market with workers of same education level but different types that discover their type throughout interviews or referrals. Let's account for the case of continuum L workers equally distributed in J types. The overall vacancies correspond to the number and type of job seeking workers, but they open sequentially. At each round there is an interview session for each type hiring a maximum share J of each type among the workers that have passed the interview (overall, in each round L/J can be hired). When workers hold interviews for their type, they get to know their type and then, if they have not been already hired, they only take part to interviews for the right type. Otherwise, they choose the type of vacancies for which to hold an interview randomly. Note that in this set up, including the

hypothesis of continuum of workers, in the absence of referrals at any interview there is always exactly the right number of candidates to hire, and the number of interviews rounds after which all workers are hired is exactly J (after $J-1$ rounds the L/J workers that are still on the job market know their type).

Without referrals, at the first round all workers randomly choose to which interview to participate, in this way for each type of vacancies there is L/J candidates for a total of L workers bearing the individual interview cost $\underline{c}$. In each interview a share J of all workers is hired ($\frac{L}{J^2}$ workers for each of the J types), therefore realized matches are $\frac{L}{J}$. At the subsequent round the number of interview will be $L-\frac{L}{J}$, the hired workers will be again $\frac{L}{J}$ and so on up to round J. The total search costs C are:

$$C=\underline{c}\left[\left(L-\frac{L}{J}\right)+\left(L-2\frac{L}{J}\right)+\left(L-3\frac{L}{J}\right)+\cdots+L-(J-1)\frac{L}{J}\right]=$$

$$=\underline{c}\sum_{J}\left[L-(j-1)\frac{L}{J}\right]=\underline{c}\left[JL-\frac{L}{J}\sum_{J}(j-1)\right]=\underline{c}\left[JL-\frac{L(J-1)}{2}\right]=$$

$$\underline{c}\left[\frac{L(J+1)}{2}\right]$$

The average search costs for workers $\hat{c}$ are:

$$\hat{c}=\underline{c}\left[\frac{(J+1)}{2}\right]$$

Including referrals corresponds to assuming that in a subgroup R (corresponding to a share $R<1$ of total employment L) there is a probability of having public type (μ) and thus, of being hired at the first round.[7] As a result, μRL less interviews are held and so the overall costs decrease and correspond to:

$$C_R=\underline{c}\left[\frac{L(J+1)}{2}-\mu RL\right]$$

Since workers with a public type do not bear any interview cost, this cost are borne by all $(1-R)L$ workers not in the group R and by the remaining $(1-\mu)RL$ in the group R. Therefore, the average search costs for workers without referrals are:

$$\hat{c}_N=\frac{C_R}{(1-R)L+(1-\mu)RL}=\frac{\underline{c}\left[\frac{L(J+1)}{2}-\mu L\right]}{(1-R)L+(1-\mu)RL}=\frac{\underline{c}\left[\frac{(J+1)}{2}-\mu R\right]}{(1-\mu R)}=\underline{c}\left[\frac{\frac{(J-1)}{2}}{(1-\mu R)}+1\right]$$

Note that $\hat{c}_N$ is increasing in μ and corresponds to $\hat{c}$ when $\mu=0$. As a result, when some workers have public type, the costs borne by the other workers rise since the average number of interviews they have to hold increases. Hence, the average costs for each worker not in the R group are equal to $\hat{c}^N$, increasing in μ. As to the overall effect in the R group we have:

$$\hat{c}_R=(1-\mu)\hat{c}_N=(\hat{c}-\underline{c}\mu R)\frac{1-\mu}{1-\mu R}$$

which is decreasing in μ.

In the main text the average costs $\hat{c}$ that have been substituted by actual costs c since this would have complicated the notation and the exposition of the model by adding a variety of parents, although it would not have affected the impact of such costs in the optimization process since it is already expressed in an expected utility framework. Leaving aside this exception, all the other hypotheses on the relationship between the strength of network, μ, and then search costs correspond. First, the overall costs decrease in μ as in eq. (17) and eq. (18). Second, the strength of networks reduces the costs borne by workers in the R sector and those outside this group. When we consider the effect of network in the matching process in the E segment, the R group corresponds to the group of workers having parents in the E group, while when we consider the referrals process in the U segment, the workers in the R group are the ones with parents in the U sector. This matches the other hypotheses of the referral mechanism in eq. (15).

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[7] Coherently with the discussion above, we are taking the case where the search costs are borne directly by workers, an infinitesimal cost for the employer would be enough to justify the assumption of the earlier hiring of referred workers.

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