Matching and Sorting across Regions

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Abstract

I measure the effects of workers' mobility across regions of different productivity through the lens of a search and matching model with heterogeneous workers and firms estimated with administrative data. In an application to Italy, I find that reallocation of workers to the most productive region boosts productivity at the country level but amplifies differentials across regions. Employment rates decline as migrants foster job competition, and inequality between workers doubles in less productive areas since displacement is particularly severe for low-skill workers. Migration does affect mismatch: mobility favors co-location of agents with similar productivity but within-region rank correlation declines in the most productive region. I show that worker-firm complementarities in production account for 33% of the productivity gains. Place-based programs directed to firms, like incentives for hiring unemployed or creating high productivity jobs, raise employment rates and reduce the gaps in productivity across regions. In contrast, subsidies to attract high-skill workers in the South have limited effects.

Keywords: cross-regional mobility, mismatch, search-matching, sorting, productivity differentials.

JEL codes: J61, J64, R13.

1 Introduction

Most countries experience large productivity differentials across regions. In OECD countries, the most productive region is on average twice as productive as the least productive region (OECD Regional Statistics 2018). Productivity differentials between regions might be even more significant than those between countries. For example, the average real GDP per worker in the United States

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is about 59 percent higher than in Turkey. In comparison, the per-worker GDP in the state of New York is 72 percent higher than in Mississippi.

One of the biggest challenges of disadvantaged regions is emigration. When some locations feature a productivity premium, this creates the scope for agglomeration economies: workers relocate to the most productive regions attracted by jobs that pay higher wages. On the one hand, this relocation of workers to high productivity regions increases aggregate productivity. On the other hand, it might deepen inequalities across regions. There is a growing sense that it is essential to support left-behind regions, and many countries implement place-based policies aimed at transferring resources towards areas experiencing poor economic performance and high unemployment.[1] In order to evaluate specific policies, we need a better understanding of the effects of cross-regional migration.

This paper investigates the effect of workers' mobility across two regions with different productivity levels. As internal migration reshapes the regional distribution of workers' skills, I measure how this affects employment and productivity in each region and at the country level. Workers' reallocation changes the job competition faced by workers in each region, but, at the same time, firms might react to the new composition of the labor force by offering a different number of jobs. The result of job creation and job competition depends on the differences in workers and firms across regions and requires a quantitative assessment. Native workers can be substituted by migrants but also by other natives of different skills. Who gains and who loses from the redistribution across skills induced by migration? Reallocation might affect heterogeneous workers differently and increase or decrease inequality within the region and within the country. Finally, which policies are effective in reducing cross-region inequalities and helping disadvantaged regions in terms of employment and productivity?

To address these questions, I introduce a search and matching model of the labor market with two regions and heterogeneous workers and firms. Regions differ in both location-specific productivity and the distribution of firm and worker unobserved productivities. Workers search randomly within and across regions. I present an application to Italy, characterized by large and persistent cross-regional productivity gaps and large net migration from the disadvantaged Southern regions to the high-performing Northern regions. After calibrating the model using administrative data, I assess the impact of internal migration by comparing the stationary equilibrium under worker relocation and the counterfactual equilibrium if workers cannot migrate. The model predicts the equilibrium labor market outcomes at the worker and firm type level, quantifying heterogeneous effects along the skill and technology distribution. Then, I use the model to evaluate the effectiveness of alternative place-based policies. More specifically, I compare the change in mobility and workers' outcomes in the presence of a policy with the baseline migration equilibrium reflecting the one

[1] In the US, federal and state governments spend around 95 USD billion on spatially targeted economic development programs each year (Kline and Moretti, 2014). In the European Union, regional policy is implemented through the European Structural and Investment Funds, allocating a budget of 278 billion euro in the period 2007-2013.

observed in the data. I evaluate the effects of two major policies implemented in Italy in the last decades to help disadvantaged regions: subsidies to hire unemployed workers differentiated by regional productivity and subsidies to create highly productive jobs in the South. I also measure the potential implications of subsidies to attract high-skill workers in the South, along the lines of a national program implemented towards high-qualified migrants from other countries.

I find that workers' mobility across regions fosters country-level productivity by relocating more workers to the high-productivity region. However, productivity differentials across regions widen: in the North, output per employee rises by more than 5%, in contrast it drops by more than 13% in the South. Native workers in both regions face higher competition from migrant workers, and their employment rate declines. While the number of low-technology jobs in the North declines, job creation in the South is not large enough to compensate for the higher demand for low-technology jobs. The employment rate of all workers declines at the regional level as well as at the country level. In particular, reallocation fosters the substitution between high and low skill workers. As high-skill workers face higher competition in the North, to enjoy the higher regional productivity premium, they accept low-technology jobs that without mobility would not have accepted. Then, low-skill workers in the North face higher displacement, and their unemployment rate increases. As a result, country-level inequality measured by the interquartile difference in the worker present value increases. At the regional level, inequality decreases in the North since workers of the lowest skill prefer to migrate, conversely it doubles in the South.

By incorporating complementarities in production between workers and firms, I show that migration does affect mismatch. The correlation between worker and firm ranks rises at the country level and converges across regions: it increases in the South and decreases in the North. I also show that in the absence of worker-firm complementarities the effect of migration would change substantially: the net share of workers moving to the South would be higher while the rise in aggregate productivity would be 33% lower, and, coherently, inequality would be lower.

As countries invest large shares of the government budget in programs aimed at improving labor market conditions in disadvantaged regions, I use the model to evaluate two programs designed to reduce regional gaps: the introduction of region-specific subsidies to hire unemployed workers (law 407/90, in force between 1990 and 2014), and incentives aimed at fostering the creation of high technology firms in the South (law 488/1992). By comparing the stationary equilibrium in the presence and absence of each subsidy, I show that these policies have similar effects: they increase employment rates in both regions and reduce productivity differentials. In addition, I measure what would be the impact of a tax reduction program aimed at attracting workers in the top 4% skill percentile by tax reductions, similar to the one implemented at the country-level to contain brain drain. As it is directed to a small and privileged fraction of the population, this policy has reduced size and only mildly increases employment rates and productivity in the South,

In contrast to an extensive empirical literature on the effects of regional migration and spatially targeted programs, the theoretical literature usually relies on neoclassical models with no unemployment (for a review, see Dustmann et al., 2008). More recently, some authors started to use the search and matching framework (Mortensen and Pissarides, 1994) to analyze labor markets in the presence of migration (Ortega, 2000; Epifani and Gancia, 2005; Chassamboulli and Peri, 2015; Schmutz and Sidibe, 2019; Iftikhar and Zaharieva, 2019). While accounting for frictions and departing from the competitive paradigm, these models do not allow to dig deeper into the diverse effect of migration on different groups in the population and the resulting implications on inequality, since they distinguish at most between two groups of workers (skilled and unskilled).[2] The main obstacle relies on the difficulty of obtaining analytical results when more than two groups are involved. To this aim, this paper extends the empirical search and matching model in Lise et al. (2016), which studies labor allocations by specifying the entire worker and firm distributions.

Being able to trace heterogeneous workers and firms allows evaluating mismatch jointly. The model explicitly allows for sorting, and I estimate the complementarities from administrative data. This feature reveals a novel angle: internal migration can induce sorting. Whereas a broad literature has studied the effects of worker-firm complementarities in production on wage inequalities (Abowd et al., 1999; Hagedorn et al., 2017 among others), their impact on the reallocation through migration have been overlooked. Two recent papers move a step towards enlightening the relationship between migration and sorting. Dauth et al. (2018) study assortative matching between and within German cities and document a strong relation between sorting and regional inequality. They find that wages are higher in larger cities both because larger cities have more high-quality workers and because workers are more likely to be matched with plants of similar quality within each city. By using French matched employer-employee Orefice and Peri (2020) document that sorting in a local labor market increases with the inflow of skilled immigrant workers, and this is associated with a rise in average productivity and firm profits. This paper offers a theoretical framework to make sense of the underlying dynamics while obtaining results consistent with their findings.

Finally, the model is a flexible framework for policy evaluation. It allows evaluating the effects of programs even in the absence of exogenous variation. Also, it is handy for the ex-ante evaluation of the expected consequences of a policy. While being consistent with the findings by reduced-form evaluations (Bronzini and de Blasio, 2006; Ciani et al., 2019), the assessment of policies through a general equilibrium model allows to qualify the impact of a policy along several dimensions and to evaluate the redistributive implications.

The rest of the paper is organized as follows. Section 2 presents the model and section 3 details the model parametrization. Section 4 introduces the data and describes the estimation procedure. Section 5 reports the results and section 6 concludes.

[2] A notable exception is Piyapromdee (2021).

2 Model

I specify a search and matching model with two regions, heterogeneous workers and firms, and production complementarities at the match level. Heterogeneity is introduced by following Lise et al. (2016). The main innovation is that workers can search across regions in addition to within regions. I define a migrant as a worker located in a region different than her region of birth. The mobility opportunity arises from a successful job search in a region different from the one where the worker is located. This paper aims to investigate how the mobility opportunity alters the labor market equilibrium disregarding the determinants of higher or lower propensity to migrate. The exogenous cost of moving is captured by a higher search intensity ($\mu > \frac{1}{2}$) in the region of the worker's location and $(1 - \mu)$ in the other region. This difference captures mobility costs and is symmetric across regions, which implicitly assumes away cross-regional differences in the propensity to move linked to factors external to the labor market (e.g., housing costs that alter the expected value of working abroad or cultural differences).

As emphasized by the migration literature, the possibility of sorting across jobs after migration might be an important component of the expected value of moving.[3] To account for that, I include on-the-job search à la Cahuc et al. (2006). When a vacant job meets an employed worker, the incumbent and poaching jobs engage in a Bertrand competition that can lead to the transition of the worker to the poaching job or to wage renegotiation.

The distribution of jobs is endogenous both in the mobility choice of workers and the recruiting choice of firms. The number of job opportunities posted reacts to the number and skills of job seekers in the region. In the model's description, I denote the region where the job is located with e, the other region with $-e$, and the region where the worker/firm is located when she receives/makes an offer with c.

2.1 Workers, firms and matches

Time is continuous. There is a fixed measure of infinitely lived individuals L. Each individual is characterized by a skill level $x \in [\underline{x}, \overline{x}]$. Differences in skill are exogenous, permanent, and perfectly observable by all agents.[4] Workers are unemployed or assigned to a firm. Each firm is characterized by a technology $y \in [\underline{y}, \overline{y}]$, which is exogenous, permanent and perfectly observable. Let $u^e(x)$ denote the number of unemployed workers of skill x in region e, $v^e(y)$ the number of vacant jobs of technology y, and $h^e(x, y)$ the jobs of technology y filled by a worker of skill x. The number of

[3] This is reflected in the wage dynamics. Among others, D'Amuri and Peri (2014) show that earnings of the migrants are initially significantly lower than earnings of the natives, even conditional on skills, but this gap narrows over time.

[4] Hendricks (2001) presents a model of migration and positive assortative matching where worker ability is only imperfectly observable by firms. Since firms use origin as an indicator for a worker's ability, the worker's earning and incentives for human capital accumulation depend on the average ability level of her ethnic group.

workers of skill x in region e is

$$L^e(x) = \int h^e(x,y)\,\mathrm{d}y + u^e(x), \tag{1}$$

and the total population is $L(x) = \sum_{e=1}^{2} \int L^e(x)\,\mathrm{d}x$. The number of jobs of technology y in region e is

$$N^e(y) = \int h^e(x,y)\,\mathrm{d}x + v^e(y), \tag{2}$$

and the total number of jobs is $N = \sum_{e=1}^{2} \int N^e(y)\,\mathrm{d}y$. The total number of unemployed workers and vacancies in each region are indicated by U^e and V^e, respectively.

Transition across regions only happens upon a job offer. Employed workers search for a job with intensity s with respect to the unemployed search intensity (normalized to 1). The total number of job seekers in each region is $JS^e = \mu U^e + \mu s(L^e - U^e) + (1-\mu)U^{-e} + (1-\mu)s(L^{-e} - U^{-e})$. Job seekers and vacancies meet according to a standard constant return to scale matching function $M(\cdot,\cdot)$. The market tightness in each region is summarized by

$$\kappa^e \equiv \frac{M(JS^e, V^e)}{JS^e \cdot V^e} \ . \tag{3}$$

This tightness parameter allows computing the meeting rates for each worker across the two regions. A vacancy meets an unemployed worker of type x in the same region e at rate $\kappa^e JS^e \cdot \frac{\mu u^e(x)}{JS^e} = \mu\kappa^e u^e(x)$ and an unemployed in the other region at rate $\mu\kappa^e u^{-e}(x)$. The meeting rate of a vacancy with an employed worker is $s\mu\kappa^e h^e(x,y)$ in e and $s\mu\kappa^e h^{-e}(x,y)$ in $-e$. An unemployed worker in e meets a vacancy of productivity y with probability $\mu\kappa^e v^e(y)$ in her region and with probability $(1-\mu)\kappa^{-e}v^{-e}(y)$ in the other region.

A match produces a flow output, $f^e(x,y)$, that depends on the worker and firm type and the region-specific productivity. Exogenous match destruction occurs at rate ξ^e. Matches can also end endogenously when the worker accepts an offer from another firm. A match is realized and maintained only if the surplus is positive. Define $W_0^c(x)$ as the present value of unemployment of a worker x in region $c = \{e, \text{-}e\}$; and $W_1^c(w(c), x, y)$ as the present value of a wage contract w for a worker x employed in a job y in c. Also, let $\Pi_0^e(y)$ be the present value of a vacancy for a job of productivity y in e; and $\Pi_1^e(w(c), x, y)$ the present value of a wage contract $w(c)$ for a job y employing a worker x in e.

The surplus of a match between a worker x from region c and a firm y in region e is

$$S^e(x,y,c) = \Pi_1^e(w(c),x,y) - \Pi_0^e(y) + W_1^c(w(c),x,y) - W_0^c(x). \tag{4}$$

Notice that at the time that the job meets the worker, the option value of not accepting the job depends on the region of origin of the job seeker. This reflects the fact that the worker's value of being unemployed changes as she moves between regions. Therefore, the workers' choice of accepting the job and moving hinges on the difference in the value of being unemployed in the region of destination and origin, $W_0^e(x) - W_0^c(x)$. Since wage bargaining happens before the worker moves, the cross-regional difference in the value of being unemployed generates wage differentials between workers hired in the same region or the other. If $W_0^c(x) < W_0^e(x)$, the new match is stable only if $\Pi_1^e(w(c), x, y) - \Pi_0^e(y) + W_1^c(w(c), x, y) > W_0^e(x)$. Otherwise, the match is disrupted just after the worker's transition. In this case, the worker only takes advantage of the job offer to enjoy a higher value of unemployment in the other region.

2.2 Wage setting and job-to-job transitions

The wage for a worker transiting from unemployment, w^U, is set to split the surplus according to Nash bargaining

$$W_1^e(w^U(c), x, y) - W_0^c(x) = \beta S^e(x, y, c), \tag{5}$$

where $\beta > 0$ is a bargaining coefficient independent on the characteristics of the worker and the job.

Employed workers might receive an offer from vacant jobs and the incumbent job reacts to alternative offers. The incumbent and the poaching firm engage a negotiation game as described in Dey and Flinn (2005) and Cahuc et al. (2006). Denote with y' and c' respectively the productivity and the region of the alternative job. Not all the outside offers lead to a move or a wage renegotiation. If the surplus of the alternative job is smaller than the current worker's surplus, $S^{c'}(x, y', e) \leq W_1^e(w(c), x, y) - W_0^e(x)$, the worker cannot make a credible threat to leave, and the current match is not disrupted, nor the wage changes. On the contrary, if the surplus of the alternative job is higher than the current surplus, $S^{c'}(x, y', e) > S^e(x, y, e)$, the new firm can always pay a higher wage than the current one, and the worker accepts the outside offer. When the employed worker joins the poaching firm, the surplus of the previous job is the outside option in bargaining her wage w^E,

$$W_1^e(w^E(c), x, y) - W_0^e(x) = S^{c'}(x, y', e) + \beta\Big(S^e(x, y, e) - S^{c'}(x, y', e)\Big). \tag{6}$$

Alternatively, assume that the surplus in the alternative job is lower than the surplus in the current job but higher than the portion of surplus that the worker currently receives, $W_1^e(w, x, y) - W_0^e(x) < S^{c'}e(x, y', e) < S^e(x, y, e)$. In this case, the worker uses the outside offer to negotiate up her wage. The incumbent firm raises the wage, such that the worker receives the total surplus at the poaching firm and a share β of the surplus differential between the two jobs. This renegotiation mechanism implies that the offers from a region with different productivity not resulting in new matches increase the average wages of workers in the disadvantaged region and lower the average wages in the more productive region.

2.3 Worker's value functions

Unemployed workers do not receive benefits. The present value of being unemployed is the expected return of finding a job in the current or in the other region,

$$rW_0^e(x) = \mu\kappa^e\beta\int S^e(x,y,e)^+\upsilon^e(y)\,\mathrm{d}y + (1-\mu)\kappa^{-e}\beta\int S^{-e}(x,y,e)^+\upsilon^{-e}(y)\,\mathrm{d}y, \tag{7}$$

where r is the discount rate and the superscript '+' indicates that only positive surplus enters the integral (i.e., it is equivalent to $\max\{S^c(x,y,e),0\}$).

In each period, an employed worker enjoys the wage, and discounts the possibility of losing her job exogenously or receiving job offers from other firms.

Define $\mathcal{A}^e$ the set of jobs in e that can lead to moving or a wage renegotiation, $\mathcal{A}^e \equiv \{y' : W_1^e(w,x,y) - W_0^e(x) < S^{c'}(x,y',e)\}$, and $\upsilon^e(\mathcal{A}^e) = \int_{\mathcal{A}^e}\upsilon^e(y)\,\mathrm{d}y$ the total number of vacancies for any set $\mathcal{A}^e$. The present value of being employed in a match (x,y,e) at a wage w results from the following equation,

$$\begin{aligned}
&\Big(r{+}\xi^e + s\mu\kappa^e\upsilon^e(\mathcal{A}^e) + s(1\text{-}\mu)\kappa^{\text{-}e}\upsilon^{\text{-}e}(\mathcal{A}^{\text{-}e})\Big)\Big(W_1^e(w,x,y)\text{-}W_0^e(x)\Big) = w - W_0^e(x)\\
&\quad + s\mu\kappa^e\int_{\mathcal{A}^e}\Big(\min\{S^e(x,y,e),S^e(x,y',e)\} + \beta[S^e(x,y',e) - S^e(x,y,e)]^+\Big)\upsilon^e(y')\,\mathrm{d}y'\\
&\quad + s(1\text{-}\mu)\kappa^{\text{-}e}\int_{\mathcal{A}^{\text{-}e}}\Big(\min\{S^e(x,y,e),S^{\text{-}e}(x,y',e)\} + \beta[S^{\text{-}e}(x,y',e) - S^e(x,y,e)]^+\Big)\upsilon^{\text{-}e}(y')\,\mathrm{d}y'
\end{aligned} \tag{8}$$

The continuation value on the right-hand side sums the wage net of the flow value of unemployment and the expected excess value following an alternative offer in the same or the other region, both in case the worker moves or renegotiates the wage in the current match.

2.4 Vacancy creation

Each period firms post vacancies by paying a cost which is independent of the firm's technology and increasing and convex in the number of vacancies posted, $p(\upsilon) \geq 0$.[5] Similarly to Lise and Robin (2017), the number of vacancies posted in equilibrium is the one that equalizes the marginal cost to the expected value of a vacancy (i.e., the probability that the firm meets a feasible match times the expected value of a filled vacancy),

$$\frac{\partial p(\upsilon^e(y))}{\partial \upsilon} = \kappa^e J S^e \mathbb{E}_x\Big(\Pi_1^e(w,x,y)\Big). \tag{9}$$

By the definition of equilibrium surplus (equation 4) and the assumptions on wage setting (equations 5 and 6), the present value of profits for a vacancy meeting an unemployed worker of skill x from

[5] The convexity of the cost function guarantees that the equilibrium distribution of vacancies is non-degenerate.

region c is

$$\Pi_1^e(w^U(c), x, y) - \Pi_0^e(y) = (1-\beta)S^e(x, y, c), \tag{10}$$

and the present value of profits for a vacancy meeting a worker of skill x employed in a match with lower surplus in c is

$$\Pi_1^e(w^E(c), x, y) - \Pi_0^e(y) = (1-\beta)\Big(S^e(x, y, c) - S^{c'}(x, y', c)\Big). \tag{11}$$

The present value of a vacancy of productivity y in the region e is

$$\begin{aligned} r\Pi_0^e(y) = -p(\upsilon^e(y)) + (1\text{-}\beta)\Bigg(&\mu\kappa^e \int S^e(x, y, e)^+ u^e(x)\,\mathrm{d}x + (1-\mu)\kappa^e \int S^e(x, y, \text{-}e)^+ u^{\text{-}e}(x)\,\mathrm{d}x \\ &+ s\mu\kappa^e \int\int [S^e(x, y, e) - S^e(x, y', e)]^+ h^e(x, y')\,\mathrm{d}x\,\mathrm{d}y \\ &+ s(1-\mu)\kappa^e \int\int [S^e(x, y, \text{-}e) - S^{\text{-}e}(x, y', \text{-}e)]^+ h^{\text{-}e}(x, y')\,\mathrm{d}x\,\mathrm{d}y\Bigg). \end{aligned} \tag{12}$$

The second term of the RHS resumes the expected gain from filling the vacancy. This can happen by meeting an unemployed of skill x such that the match yields a positive surplus, or by meeting an employed worker of skill x such that the the match yields a surplus higher than the one with the incumbent firm.

2.5 Surplus of a match

Appendix A provides the derivation of the joint value of a match and the surplus equation. The match surplus does not depend on the wage contract, and the fixed point in the equation below defines it:

$$\begin{aligned} &(r + \xi^e)\ S^e(x, y) = f^e(x, y) - rW_0^e(x) - r\Pi_0^e(y) \\ &\quad + s\mu^e\kappa^e\beta \int \left[S^e(x, y') - S^e(x, y)\right]^+ \upsilon^e(y')\,\mathrm{d}y' + s(1\text{-}\mu)\kappa^{-e}\beta \int \left[S^{-e}(x, y') - S^e(x, y)\right]^+ \upsilon^{-e}(y')\,\mathrm{d}y'. \end{aligned} \tag{13}$$

2.6 Steady-state equilibrium

The regions differ in the number and skill distribution of workers at birth and the distribution of technologies. Moreover, they differ in the exogenous job destruction rate ξ^e and in the production function $f^e(x, y)$. The discount rate r, the search intensity at home μ, the search intensity when employed s, the bargaining power β, as well as the matching function and the cost function, are exogenous and equal across regions. The total population in the country is also fixed.

The equilibrium is fully characterized by the knowledge in each region of the tightness parameter κ^e, the distribution of workers of each type $L^e(x)$, the number of jobs and vacancies of each type, $N^e(y)$ and $\upsilon^e(y)$ respectively, the number of (x, y) matches $h^e(x, y)$ and their surplus $S^e(x, y)$.

The zero-profit condition, by equating the marginal cost of posting an additional vacancy to the marginal value of the vacancy (equation 19), pins down the number of jobs posted by each technology type. From equation 2, the total number of jobs of type y in each region is the sum of the filled and vacant jobs posted by y-firms.

In order to determine the number of matches and the number of unemployed workers in each region, consider that in a stationary equilibrium, the inflows of new matches of each type (x, y) should be equal to the outflows. Define $\bar{\mathcal{B}}^e(x, y)$ as the set of poaching jobs with surplus higher than the incumbent job in region e: $\bar{\mathcal{B}}^e(x, y) \equiv \{y' : \ S^{c'}(x, y') \geq S^e(x, y)\}$. Symmetrically, define $\mathcal{B}^e(x, y)$ as the set of poaching jobs that do not imply an improvement of the match surplus for the worker of ability x: $\bar{\mathcal{B}}^e(x, y) \equiv \{y' : \ 0 \leq S^{c'}(x, y') < S^e(x, y)\}$. Matches terminate exogenously, or in case of poaching by a job with higher surplus, with rate $s\mu\kappa^e\upsilon^e(\bar{\mathcal{B}}^e(x, y))$ if the alternative firm is in the same region and with rate $s(1\text{-}\mu)\kappa^{-e}\upsilon^{-e}(\bar{\mathcal{B}}^{-e}(x, y))$ if it is in the other region. A new match (x, y) is created when a vacancy of technology y is filled by an unemployed or an employed worker of type x.

The number of matches $h^e(x, y)$ in region e is determined by the equation:

$$\begin{aligned}\Big(\xi^e + s\mu\kappa^e\upsilon^e(\bar{\mathcal{B}}^e(x, y)) + s(1\text{-}\mu)\kappa^{-e}\upsilon^{-e}(\bar{\mathcal{B}}^{-e}(x, y))\Big)h^e(x, y) \\ = \ \mu\kappa^e u^e(x) + (1\text{-}\mu)\kappa^e u^{-e}(x) + s\mu\kappa^e h^e(x, \mathcal{B}^{-e}) + s(1\text{-}\mu)\kappa^e h^{-e}(x, \mathcal{B}^{-e}).\end{aligned} \tag{14}$$

In stationary equilibrium, mobility across regions obeys the condition that the inflows of workers of skill x in each region equal the outflows. Workers move from the other region if they employed and successfully poached by a domestic firm, or if they meet a job leading to a positive surplus when unemployed with probability $(1 - \mu)\kappa^e\upsilon^e(\bar{\mathcal{C}}^e(y))$, where $\bar{\mathcal{C}}^c(y) \equiv \{y : \ S^c(x, y) > 0\}$. The outflows from a region include the unemployed workers meeting a feasible match in the other region and the employed workers poached by a firm with positive surplus. The following law of motion of movers holds in each region,

$$\begin{aligned}\kappa^e\upsilon^e(\bar{\mathcal{C}}^e(y))u^{-e}(x) + s\kappa^e\upsilon^e \int \upsilon(\bar{\mathcal{B}}^e(x, y))h^{-e}(x, y)\,\mathrm{d}y = \\ \kappa^{-e}\upsilon^{-e}(\bar{\mathcal{C}}^{-e}(y))u^e(x) + s\kappa^{-e}\upsilon^{-e} \int \upsilon(\bar{\mathcal{B}}^{-e}(x, y))h^e(x, y)\,\mathrm{d}y.\end{aligned} \tag{15}$$

where $(1 - \mu)$ is omitted since it multiplies both sides of the equation. Once combined with the accounting equation 1 of the population in each region, this equation yields the distribution of unemployed in each region.

Finally, the surplus equation 13 pins down the surplus of each (x, y) match.[6] The equilibrium is computed using the iterative algorithm detailed in Appendix B.

3 Model specification

In this section, I complete the model's description by defining the parametric specification of the production function, the distribution of skills and technologies, the cost function, and the matching function. As shown by the literature on assortative matching (Shimer and Smith, 2000), the allocation of workers depends on the worker-firm complementarities in production. Therefore, a major ingredient of a model that analyzes workers' reallocation across and within regions is a production function that allows for the existence of such complementarities. I assume that match output is produced according to a production function with constant elasticity of substitution (CES) in the worker skill and the firm technology,

$$f^e(x, y) = A^e\Big(\lambda x^\rho + (1-\lambda)y^\rho\Big)^{\frac{1}{\rho}}. \tag{16}$$

The parameter ρ in the production function governs the substitutability between different workers and jobs. When ρ has a value lower than 1, a worker produces more output when she is employed by a firm of technology level similar to her skill level (positive assortative matching arises). In that case, aggregate output is higher if firms of higher technology employ workers of higher skill, and firms of lower technology employ workers of lower skill. On the contrary, when ρ has value 1, a worker has the same marginal productivity independently of the technology of the employer firm, and alternative worker-firm assignments produce the same aggregate output. The factor A^e is a multiplier common to all jobs in the region e, capturing the location premium and contributing directly to cross-regional differences in productivity. The parameter λ defines the relative importance of skill to technology in production. In section 4.2, I describe in detail how I identify the production function parameters jointly with the ranks of workers according to their skill and the ranks of firms according to their technologies, by using the information on workers' wages and transitions across firms and regions, and the value added per worker at the firm level.

An additional important element of the model is the matching function, which disciplines the relation between the number of vacancies and job seekers in a region. I assume the standard functional form used by the literature,

$$M^e(JS^e, V^e) = \eta^e\sqrt{JS^eV^e}, \tag{17}$$

[6] See Appendix A for the full specification.

where I set the matching elasticity to 0.5 following Petrongolo and Pissarides (2001), and I estimate the region-specific matching efficiency η^e from the data.

Finally, following Lise and Robin (2017), the cost function is increasing and convex in the number of vacancies posted, which guarantees a non-degenerate distribution of vacancies,

$$p(\upsilon) = \frac{p_0 \upsilon^{1+p_1}}{1+p_1}. \tag{18}$$

From equilibrium condition 9, each firm of technology y in equilibrium creates a number of vacancies equal to

$$\upsilon^e(y) = \Big(\frac{1}{p_0}\kappa^e JS^e \mathbb{E}_x\Big(\Pi_1^e(w,x,y)\Big)\Big)^{\frac{1}{p_1}}. \tag{19}$$

To account for differences in the region-specific firm distribution, I weight the number of new vacancies for the share of firms in each technology bin.

4 From the South to the North: migration within Italy

In what follows, I apply the model to the case of migration between North and South Italy. I define the North of Italy as the NUTS 1 regions of North West and North East, while the South of Italy includes the Central regions, the South of Italy, and the Islands. I estimate the model by using administrative records of workers' job spells, jointly with some statistics computed using the Italian Labor Force Survey. Data are presented in section 4.1. The calibration approach is mixed. The distribution of skills and technology and the relative productivity of the South relative to the North are estimated in a preliminary step coherently with the model assumptions but are taken as exogenous in the model, as described in section 4.2. Few parameters are set by following the standard values in the literature. Finally, I identify the main model parameters by a simulated method of moments (section 4.3).

4.1 Data

I use the INPS-INVIND matched employer-employee data for the years 1991-1997. The data is based on the Survey on the Industrial Firms (INVIND) maintained by the Bank of Italy and representative of manufacturing firms with more than 50 workers. For each firm, the working history of all workers starting from 1980 has been extracted from Social Security administrative data (INPS). This panel has been featured by several studies on Italian wage inequality, like Iranzo et al. (2008) and Daruich et al. (2020). The panel includes information on annual wages, the number of weeks worked, province of the job, and employer identifier for each job spell observed in a given year. Importantly, information on the birthplace of each worker is available, as well as information on her gender and age. Moreover, the data includes firms' financial statements, allowing to compute a measure of the value added per worker.

Table A1 in the Appendix reports descriptive statistics. I estimate skills using around 19 million records starting in 1980, for more than 1.3 million workers. To achieve identification, it is necessary to observe enough mobility in the data: workers are observed by on average 13 years, 98% of them has a spell in at least two different years, and 5% of workers in the North and 13% in the South have job records in both regions. In the North, 23% of the spells are by workers born in the South, while in the South 5% of the spells are by workers born in the North.The INVIND sample includes 6,195 firms, 78% of these firms have at least a plant in the North. Firms usually appear in multiple years (on average four years), and a large fraction has plants in both regions.

4.2 Ranking skills and technologies

The skills of the workers, the technologies of the firms, and the production function parameters are directly estimated from the linked employer-employee data, following the approach proposed in Lacava (2020). The estimation builds on the CES production function specified in equation 16. I assume that the firm output is the sum of the individual output produced by each worker employed at the firm. Also, I assume that, within a plant, the wage is monotonically strictly increasing in the worker's skill.

The first step consists in retrieving the skills of the workers. I recover a global ranking of workers by applying the non-parametric algorithm proposed by Hagedorn et al. (2017). The latter uses wages to compare workers within firms and regions, and then exploits workers' transitions to compare workers across different firms. More specifically, to compare workers while controlling for factors that might mechanically affect their wage independently of their skill, I estimate a weekly real log wage regression on gender, a quadratic specification of experience and tenure, fixed effects for years, and the number of weeks worked.[7] The gender control allows for the possible presence of systematic wage differences related to gender. For each worker, I average the residual wage estimated after the regression at the plant level, with the plant being defined as a firm-region pair. Then, I use the average estimated rank of each worker in a plant to rank all the workers within the plant. With this procedure, I obtain for workers who move across firms and regions a within-plant ranking in each plant where they transited. The partial ranking of a worker in a plant allows comparing the skills of co-workers in the firm of origin with the skills of co-workers in the firm of destination. When there are sufficient transitions of workers across plants, it is possible to compute a global ranking of workers. While this is a computationally complex problem, Hagedorn et al. (2017) provide a feasible algorithm to solve the rank aggregation problem.

As a second step, I estimate region-specific productivity by looking at how the value added per worker of a specific firm changes with the within-firm variation in the workforce's allocation across regions over time -while controlling for the level of the workforce's skills. For each plant, I

[7] Wages are deflated using the 1995 CPI index.

compute the average share of workers in each decile of the global ranking of workers to approximate the distribution of workers' skills. Then, by focusing on the sample of firms with plants in both regions, I estimate a regression of the value added per worker of the firm on the share of workers in each region, on the distribution of workers in each rank decile and firm fixed effect. I also control for time fixed effects to account for possible aggregate variation in productivity over time which is unrelated to the regional productivity.

Finally, I jointly estimate the global ranking of firms and the parameters of the production function (i.e., the relative importance of the worker skill relative to the firm technology, λ, and the parameter governing the elasticity of substitution between skill and technology, ρ), by minimizing the distance between the predicted and observed value added per worker at the firm level.

After estimating the distribution of worker and firm ranks, I impose some working assumptions to map the rank of each worker and firm to their skill x and technology y entering as inputs in the production function. I approximate the continuous heterogeneity of skills and technologies by a grid of linearly spaced points, respectively $x_1, \ldots, x_N$ on (0,1) and $y_1, \ldots, y_N$ on (0,1). More specifically, after grouping the workers in 25 bins of equal size, I fix the support of skill x to be bounded between 0 and 1. Then, I assume that the difference in the skill value of workers of consecutive ranks is equal for all ranks, which means setting for each worker of rank r a skill higher by 1/25 relative to a worker of rank $r-1$. The same applies to technologies.

Estimating the distributions of skill and technology by using the information in the job records allows to classify workers and firms in bins of similar skill and technology, with the preferred degree of detail, without relying on proxy variables like the information on the education level, which is broader and imperfectly reflects the true worker's skill.[8]

Figure 1 displays the distribution of estimated ranks of workers at birth by region. Ranks of workers are similar across regions, with a slightly higher density of low-rank workers in the South. This result might seem at odds with other studies looking at differences in the population's schooling level but reflects the considered sample, including all workers with at least one employment spell in the manufacturing industry. While being motivated by the specific data used, the model aims to study the labor market allocations with a focus on workers in employment and unemployment, thus excluding workers not participating in the labor force. The distribution of firm ranks in figure 2 exhibits differences in technologies across regions: low-rank firms are more frequent in the South than in the North.

Table 1 summarizes the estimates of the production function parameters. The relative regional productivity of the South of Italy with respect to the North is 0.879. There are complementarities

[8]Other papers estimate the distributions of types and the production function parameters within the model after introducing some additional parametrization. For example, Lamadon et al. (2014) propose an identification strategy that uses matched employer-employee data, or Lise et al. (2016) use longitudinal data on wages and determine the elasticity of substitution between skill and technology in the production function by exploiting information on the wage growth profile and its variance both on-the-job and at job change.

in production between worker and firm: the elasticity of substitution between skill and technology is 0.459. In each match, the skill contributes to the output match by a share of 0.7 (a value consistent with the estimates of the labor share provided by the literature).

The remaining parameters reported in Table 1 are set following the literature. The length of each period is one year, and the annual discount rate is five percent. As mentioned above, the matching function has a standard constant return to scale specification, and the elasticity is set to 0.5, following Petrongolo and Pissarides (2001). The bargaining power of the workers is fixed to 0.188, which is the estimate obtained by Lise et al. (2016) for the group of workers with high school license or lower education in the US. They set the value of β in order to target wage growth at job change. Finally, since I cannot observe data for the variation of vacancies over the period of interest, I set the exponential parameter of the cost function to the value estimated by Lise and Robin (2017), $p_1 = 0.007$.

4.3 Choice of moments and estimation

I estimate the remaining set of model parameters $\theta \equiv \{\eta^e, \xi^e, \forall e; s, \mu, p_0\}$ by Simulated Methods of Moments (McFadden, 1989; Pakes and Pollard, 1989). I use the model to simulate a panel of workers given a parameter vector θ. I specify for each worker his rank, region of birth, employment status, region of job, the rank of the employer, and the worker's present value. Then, I use the simulated careers to compute some moments, $\hat{m}_S(\theta)$, e.g., the share of employed workers over the workers located in a region. Then, I compute the same moments using the longitudinal data, $\hat{m}_D$, and I choose the vector of parameters that minimizes the squared differences between the simulated and the data moments, i.e., the optimal vector of parameters solves the minimization problem

$$\min_{\theta} \quad (\hat{m}_D - \hat{m}_S(\theta))^\top \mathbb{I}(\hat{m}_D - \hat{m}_S(\theta)), \tag{20}$$

where $\mathbb{I}$ is the identity matrix and implies equal weight to each moment. Identification is ensured by choosing moments that are sensitive to the parameters of interest. Table 2 summarizes the selected moments. The employment rates in the North and in the South pin down the matching efficiency parameters, η^N and η^S, respectively. The exogenous job destruction rates, ξ^N and ξ^S, govern the transitions from employment to unemployment, while the parameter s disciplines the relative search intensities of employed workers. The employment rates and the transitions between jobs jointly inform the value of the cost function parameter, p_0. Finally, the search intensity in the region of origin, μ is estimated by matching the fraction of migrants in the population.

Using the simulated panel, I compute the employment rate in each region as the ratio of employed workers over the sum of employed and unemployed workers. The job-finding rate in a given year is defined as the fraction of employed workers in a region who were unemployed in the previous year out of the total number of workers in that region unemployed in the previous year. Symmetrically, the job-separation rate is the fraction of unemployed workers in a region who were employed in the previous year out of all the workers in that region employed in the previous year. I compare these statistics with those computed following the same definition (i.e., excluding individuals out of the labor force) by using the Italian Labor Force Survey collected by the National Institute of Statistics (ISTAT) for the period 1992q4-1997q4, considering individuals of age 15 and older.

Then, I compute the job-to-job transition rate in a region as the number of workers employed by a different firm in the previous year out of all the workers employed in the region. Finally, a migrant is defined as a worker located in a region different from her birth region. A region's migration rate is the fraction of workers located in one region and born in the other region. The net migration rate refers to the difference between the migration rate from the South to the North and the migration rate from the North to the South. I use the same definition to obtain these statistics using simulated data and INPS-INVIND matched employer-employee data. I implement a simulated annealing algorithm to solve the global minimization problem. Table 3 reports the fit of the model.

4.4 Sensitivity analysis

To measure how elastic the moments are to changes in the value of the parameters, I solve the steady-state equilibrium by assigning a different value to each parameter while leaving all the others set to the calibrated value. More specifically, I assign to each parameter 100 random values lying in a reasonable interval, and I compute the equilibrium moments. Then I run a linear regression of the vector of moments on the vector of parameters. Table 4 reports the estimated coefficients. Increasing the matching efficiency boosts the transitions to employment and across jobs in both regions, and lowers job separations in the North, while increasing them in the South. The separation rates correlate positively with an increase in the job separation rates and negatively with the employment rates in the same region. The relative search intensity of employed workers mainly affects the job-to-job transition rates. Employment rates change slightly depending on the search intensity in the same region, while the migration of employed workers and the migration rate are elastic to the related parameter μ. Finally, the moments which are more sensitive to changes in the linear parameter of the cost function p_0 are the employment rates and the job-to-job transition rates.

In panel B, I assess the elasticity of moments to the parameters set before the model estimation. All moments except the separation rate in the South are positively related to increases in the convexity parameter of the cost function, while the only moments negatively related to the worker's bargaining power are the job separation rate in the South and the job-to-job transition rate in the North. The regional productivity of the South relative to the North is crucial for the assessment of the equilibrium moments. As differentials in the region-specific productivity narrows, migration declines, and both employment rate and job-to-job transitions increase in the South and decrease in the North. Also, job separation rates decline in both regions. Finally, the CES elasticity parameter value is orthogonal to the job separation rates and it has a mild positive effect on employment, on-the-job change, and migration rate since it increases the output produced by worker-firm couples, proportionally their type similarity.

5 Results

5.1 The labor market impact of migration

The presented model characterizes the steady-state equilibrium in two regions when the workers can search for a job across regions. A natural exercise to assess the effects of workers' cross-regional mobility in the labor market is to compare the observed equilibrium with the counterfactual equilibrium when workers can only search in the region where they are born. To this aim, I estimate the equilibrium by forcing μ equal to 1. This exercise allows comparing how the distribution of matches, unemployed workers, and their productivity would change at each skill level without mobility across regions.

Table 5 reports averages of key moments of the stationary equilibrium in the presence and absence of regional migration. The model predicts a net migration rate of workers of low ranks to the South and workers of high ranks to the North. In line with the large elasticity of migration to productivity differentials, the main force driving this polarization in workers' skills is the difference in the region-specific productivity. The surplus of matches in the North is systematically higher than that of matches in the South, which encourages especially the migration of workers of high skill to the North. Job competition for workers of low skill in the North increases since firms prefer waiting for a better worker rather than hiring a low skill worker. Indeed, the surplus of workers in the lowest quantiles becomes negative in the North, and workers migrate to the South.

Employment rates decline in both regions by slightly more than 1%, and globally. There are two forces at work. On the one hand, as the regional population increases, workers face higher job competition, whose intensity varies depending on the substitutability across native and migrant workers, but also between the substitutability across different skills. This latter channel seems to be relevant and would motivate the monotonic change in employment rates of increasing skills rate due to migration, as displayed in figure 3, panel A. On the other hand, if additional workers with a lower outside option than natives are searching for a job, firms might post more vacancies. Job creation can counterbalance job competition driving the employment rate up.[9]

Panel C of figure 3 shows the percentage change in vacancies posted under migration with respect to the closed region scenario. In the North, vacancy creation of high technology jobs increases since the expected return of a match with a worker of higher skill is higher. That limits the congestion effect for workers of higher quantile, while destruction of low-technology jobs amplifies the reduction in the employment rate for low skill workers. Conversely, workers in higher skill quantiles in the

[9] Albert (2021) shows analytically the competing effects of job creation and job competition in the context of a search and matching model with documented and undocumented immigration.

South face lower job competition due to the decrease in population. Therefore, they do not suffer a negative change in the employment rate, notwithstanding job destruction.

Workers in the lower skill quantiles do face higher competition, which results in lower employment rates, but at the same time, vacancies posted by low-technology firms slightly mitigate congestion. Indeed, market tightness, as measured by the ratio between vacancies and unemployed, increases in the North and declines only mildly in the South. In both regions, natives are those most affected by the decline in the employment rate, but the relative change across natives of different skills is similar to that of non-native workers (figure 3, panel B). The employment rate gap across regions slightly increases. This result is consistent with the model of two-regions search model in Epifani and Gancia (2005), where frictions generate congestion externalities that counterbalance the gain for further agglomeration, and long run unemployment differences across regions are amplified by mobility.[10]

Then, I compute labor productivity as the total output of the production function of the filled jobs divided by the number of employed workers. Thanks to the reallocation of workers in the most productive region, global output increases by around 2%. Global productivity also increases, resulting from a 5.5% increase in the North and a 13.5% decline in the South. That is due to the increase in the number of matches by firms of higher technology in the North and low technology in the South. Indeed, in the South, around 27% of the matches are between workers and firms in the bottom three quantiles of skill and technology type (roughly equivalent to the bottom decile). In the South, high competition among workers in the lower quantiles decreases their option value. Consequently, firms of higher technology match more frequently with workers of lower skill, which decreases the average productivity (figure 3, panel D).

Figure 4 reports the joint distribution of matches in each region with and without migration. The interesting pattern that emerges from the figure is that matches align over the diagonal, indicating that workers' allocation exploits the positive worker-firm complementarities in production. Under migration, the rank correlation between the worker and the firm type rises due to workers of lower skill reallocating to the low productivity region. There is convergence in within-region sorting that declines in the North and increases in the South. The evidence of co-location of high type workers and firms is consistent with the empirical findings of Dauth et al. (2018), who document reallocation patterns of German workers across cities over time. However, they also find an increasing rank correlation of workers within the local labor market. The different finding in this application might depend on the absence of between-workers complementarity in production, an assumption required for tractability. That suggests a substantial role in complementarities across workers for sorting within local labor markets.

Finally, the model allows evaluating how inequality changes with workers' reallocation. As a

[10] A similar result arises in the search model in Ortega (2000), generated by the assumption of structurally different labor markets of the two economies, and by that of higher search cost for migrants rather than for natives.

measure of inequality, I compute the interquartile difference in the present value of workers in each region. Inequality slightly increases globally, decreases by 28% in the North and almost doubles in the South. Higher sorting is associated with higher inequality, and this positive relation emerges both across and within regions.

5.2 The role of worker-firm complementarity

In recent years, a broad literature originated by the seminal contribution of Shimer and Smith (2000) has investigated the role of the worker-firm complementarity in production for the allocation of workers within an economy. However, limited attention has been devoted to how this complementarity might also impact the reallocation through migration across economies. Under complementarities, the output produced by a worker-firm match increases in the similarity between the worker's skill and the firm's technology. Therefore, with zero complementarities, any allocation of workers to firms and across economies leads to the same aggregate output. Instead, in the presence of complementarities, the allocation of high-skill workers to high-technology firms and low-skill workers to low-technology firms (positive assortative matching) yields higher aggregate output.

I provide a quantitative assessment of the role of such complementarities within the presented model. I compare the stationary equilibrium under the estimated elasticity of substitution, $\rho = -1.178$, and the counterfactual equilibrium in the absence of complementarity, i.e., setting $\rho = 1$, to evaluate how complementarities affect migration, employment rate, and productivity. Table 6 shows the results. When there is no gain of being matched with a similar partner, the region-specific productivity differential pulls migration even more. Indeed, the share of the population migrating to the North almost doubles. However, as the option value of waiting for a partner of a similar type fades, this eliminates some frictions. More vacancies are posted in the North, leading to a mild decline in the employment rate due to migration. At the same time, congestion collapses in the South as the population shrinks and the employment rate rises. Globally, the employment rate rises, reverting the finding under positive complementarities among workers.

The effects of cross-regional mobility are also different with respect to productivity. In the presence of complementarities, worker reallocation substantially raises productivity in the North. Under random matching, the positive change in productivity is more contained. Also, in the South, the decline in productivity is lower. The global gain in productivity due to migration is 33% lower when there are no complementarities, meaning that sorting plays a quantitatively relevant role. Sorting substantially affects inequality between workers in the same region: under random matching, the change in inequality would be close to zero in the North and around -0.6% in the South.

5.3 Evaluating policy interventions

The presented model is a suitable framework for measuring the distributional implications of alternative policies because it is flexible to introducing taxes and subsidies directed only at specific groups of workers and firms. In this section, I analyze the effects of two policies introduced in the past decades to improve labor market outcomes in the South of Italy. In particular, I study the introduction of (i) a differentiated subsidy in hiring unemployed workers and (ii) incentives to high-technology jobs in the South. In addition, by adapting to the regional framework a policy implemented at the country level, I consider the effect of incentives to attract high-skill workers to the most disadvantaged region. A proportional tax on match output funds the total cost of each program. The tax, τ, is set such that the total taxes collected equal the sum of subsidies distributed, $\tau = \sum_{e=1}^{2} \int \int f^e(x,y) h^e(x,y)\, \mathrm{d}x\, \mathrm{d}y$.

5.3.1 Subsidies to hire unemployed workers

One of the primary measures targeting regional differentials in the Italian labor market over the past thirty years is a subsidy to hire unemployed workers introduced by law 407/90 (art. 8, par. 9), in force until the end of 2014.[11] This program applied to firms hiring through a permanent contract a worker being in unemployment for at least 24 months or a worker being under the national work-compensation scheme. It consisted of the exemption from social security contributions for 36 months for unemployed workers hired in the Southern regions and a 50% waiver for unemployed workers hired in the Northern regions. I simulate this policy by introducing a permanent increase in the firm surplus for hires of unemployed workers. This subsidy enters the present value of a vacant job in equation 12. The average contribution rate for a non-manager worker in manufacturing between 1991 and 1997 was 47.4%, each year. Then, a firm would gain on average a 32.1% extra surplus for each match with a worker hired from unemployment.[12] Assuming an average working life of 40 years, I fix the total increase in yearly surplus due to the subsidy to 2.4% in the South and 1.2% in the North. I estimate that this would require a 1.9% tax on output match.

Panel A in Table 7 presents the average effects of this hiring subsidy. The program effectively raises the employment rate in both regions since, with the subsidy, some previously infeasible matches yield a positive surplus and the number of matches increases. That is consistent with findings by Ciani et al. (2019), who analyze the effects of law 407/90 in a triple difference framework exploiting the variation in the subsidy across regions, workers' unemployment length, and over time. They document that eligible workers have a higher probability of finding a permanent job.

[11] A similar program was reintroduced in 2019, under the name of *Incentivo Occupazione Sviluppo Sud* for hires from unemployment in the Southern regions.

[12] This figure is computed using the contribution rate tables of contribution rates for manufacturing firms with more than 50 employees published by the Italian Social Security Institute (INPS). The average contribution rate for 1991-1997 is 48% for blue collars, and 45.8% for white collars, and around 71% of non-managerial jobs are blue-collar jobs.

Notwithstanding that the surplus in the North is only half the size of that in the South, migration to the North rises (an additional 6% of the total population moves), and the gaps in employment rates across regions do not shrink.

A possible drawback of the subsidy could be that it only leads to a substitution among hired workers instead of fostering job creation. Untargeted workers might face stronger competition from the unemployed workers. Indeed, as reported in figure A1 this policy has a re-distributive effect in favor of the low skilled workers, which are the group otherwise characterized by the highest unemployment rate. The marginal return of meeting a worker increases, and firms in the North post more vacancies. In both regions, the tightness rises, but in the South, the decline in the population mechanically implies a lower number of vacancies.

Because, on average, unemployed workers are less productive, the productivity of high y-type matches declines (see panel D in figure A1). There are mixed effects on productivity. In the North, the productivity of employed workers decreases by almost 1.5%, while in the South, it increases by around 2.4% because the average match involves firms of higher type. Overall this yields a rise in productivity by 1.5%. Since the subsidy targets unemployed workers, independently of their skill or the technology of the hiring firm, rank correlation declines. Inequality lowers in the North, while rises in the South inequality due to an increase in job heterogeneity: without the program, matches are concentrated in the lowest bin of workers and firm type, while in the presence of the subsidy jobs by higher technology firms become feasible.

5.3.2 Incentives to create high technology jobs

Another major policy instrument aimed at reducing regional differentials in Italy under the last decades was the introduction of tax credit for the creation or expansion of firms in the South.[13] In particular, law 488/1992 introduced project-related capital grants for manufacturing and extractive firms to create, expand, modernize, or restructure firms based in disadvantaged areas. Bronzini and de Blasio (2006) provide a detailed description of the program design. The program distributed around 16 billion euros between 1996 and 2003 to 27,846 projects, primarily located in Southern regions. I mimic this policy introducing in the model a 50% reduction of cost of posting a vacancy for firms in the upper quartile of the technology distribution in the South. The policy is financed by a 0.9% tax on output match.

I report estimated effects in panel B of Table 7. The program positively affects the employment rate in both regions, and native workers enjoy a higher increase. The incentive to vacancy posting is equivalent to a subsidy to hiring any worker, notwithstanding the previous employment status and skills. Higher skill workers in the South have more incentives to wait for a job without migrating

[13]Incentives sometimes take the form of tax credits. Bronzini et al. (2008) evaluate the effects of the Investment Tax Credit program implemented between 2000 and 2002 (law 388/2000). In 2015, law 208 introduced tax credits for purchasing new capital goods before the end of 2022, and in 2019, law 160 established tax credits covering up to 45% of the investments in research and development undertaken before 2022.

to the North, and the average rank of a migrant from the South declines. The subsidy to high technology firms has redistributive implications on the distribution of jobs. Creation of jobs that are not subsidized declines in the South and, at the same time, increases in the North. Thanks to a decrease in the number of low-technology jobs, output per employee increases substantially in the South. The program reduces differentials in productivity across regions while raising aggregate productivity at the country level. Accordingly, sorting decreases within each region and at the country level. However, the change in the interquartile differential is negative in the North and globally but positive in the South.

5.3.3 Brain remittance subsidies

Finally, I consider the introduction of a policy for brain remittance in the South. This measure is inspired by a national policy in place starting from 2003, targeted at attracting high-qualified workers from abroad.[14] I model the policy as an increase in the worker's share of surplus for workers in the highest skill bin (i.e., top 4%) in the North hired by firms in the South, either unemployed or employed. In Italy, incomes above 55,000 euros are subject to a 41% tax rate (43% above 75,000 euros). The existing program entails a maximum 90% reduction on income tax for five years. Then, I model the subsidy as a 47% increase in the worker's surplus share for the years of the program, which considering a working life of 40 years is equivalent to a 5.9% increase in the surplus share of workers moving from the North.

As shown in panel C of Table 7 and figure A3, being addressed to a small and relatively wealthy fraction of the workforce, brain remittance subsidies have effects of small magnitude in comparison to the other subsidies. However, they discourage the migration of low-skill workers from the North to the South and reduce the net migration rate to the South. Migration of high-skill workers born in the South persists since it is optimal for the workers to migrate in the first instance to be eligible for the subsidy later. The employment rate rises in the South and declines in the North, but the magnitude and the resulting gap reduction are almost negligible. The most important effect of the program is the rise in productivity in the South by almost 1%, due to firms with technology above the median hiring workers of higher skill. Rank correlation is almost unaffected. Since the policy targets a very limited number of workers its cost is negligible (below 0.01% tax on output match).

6 Conclusion

This paper frames internal migration across regions of different productivity as a job search problem to measure how the mobility of workers reshapes employment, output, and inequality across and within regions. In an application to Italy, I find that migration from the South to the more productive

[14]See for example law 269/2003, law 147/2015, and law 232/2016. These programs usually target high skilled workers in research or management roles. In other cases, the benefit expands to graduate workers employed abroad.

North exacerbates differences across regions: high-skill workers concentrate in the most productive region, and productivity gaps increase sharply. I identify workers' skills and firms' technologies using matched employer-employee data. I show that the impact is diverse across workers. Low-skill workers are exposed to higher job competition due to both migrants and natives of higher skill levels and experience the highest increase in the unemployment rate. As a result, within-region inequality doubles in the most disadvantaged region.

All around the world, the urgency to help left-behind regions results in the adoption of place-based policies, which often absorb a large part of the public budget. I use this framework to enlighten the effects of alternative policies aimed at improving the labor market outcomes in the South of Italy. I find that introducing both differentiated incentives to hiring unemployed workers and incentives to firms in the top quartile of the technology distribution increases net migration further, but at the same time, redistributes resources across workers. Employment rates increase, and cross-regional differences in productivity decline. I also simulate a program targeted to attract top 4% high-skill workers in the least productive region, and I estimate that it would have negligible impact.

Finally, I show that migration affects sorting. By considering explicitly worker-firm complementarities in production, I measure that regional mobility fosters rank correlation at the country level, but rank correlation declines in the most productive region as low-skill workers move there attracted by a regional premium on output. In addition, I show that in the thought experiment of the absence of worker firm complementarities, net migration would be much higher in equilibrium. However, at the same time, the productivity gains would be 33% lower. These findings complement recent contributions by Dauth et al. (2018) and Orefice and Peri (2020) and call for further research on the role of sorting for migration outcomes.

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A Derivations

Value of a job match

Let $P^e(x,y)$ be the value of joint production of a match between a worker x and a firm y in region e. A match produces a flow output according to the production function. If it is disrupted at rate ξ^e, both agents obtain their outside option, or another firm might approach the worker with a job offer which might yield a higher surplus. Recall from equation 4 that the surplus is $S^e(x,y,c) = P^e(x,y) - W_0^c(x) - \Pi_0^e(y)$. Since starting from period two the outside option of the worker depends on the region of the job and the region of origin only matters in how the surplus is shared between worker and firm, with a slight abuse of notation, I omit the index for the region of the worker when the region is e. Then,

$$\begin{aligned}
rP^e(x,y) &= f^e(x,y) + \xi^e\Bigg(W_0^e(x) + \Pi_0^e(y)\text{-}P^e(x,y)\Bigg) \\
&+ s\mu\kappa^e \int \Big[\max\Big\{P^e(x,y),\ \Pi_0^e(y) + W_0^e(x) + S^e(x,y) + \beta\big(S^e(x,y') - S^e(x,y)\big)\Big\} - P^e(x,y)\Big]\upsilon^e(y')\,\mathrm{d}y' \\
&+ s(1\text{-}\mu)\kappa^{-e} \int \Big[\max\Big\{P^{-e}(x,y,),\ \Pi_0^{-e}(y) + W_0^{-e}(x) + S^{-e}(x,y) + \beta\big(S^{-e}(x,y') - S^e(x,y)\big)\Big\} - P^{-e}(x,y)\Big]\upsilon^{-e}(y')\,\mathrm{d}y'
\end{aligned}$$

$$\begin{aligned}
&= f^e(x,y) - \xi^e S^e(x,y) + s\mu^e\kappa^e \int \max\Big\{0,\ \beta\big(S^e(x,y') - S^e(x,y)\big)\Big\}\upsilon^e(y')\,\mathrm{d}y \\
&+ s(1\text{-}\mu)\kappa^{-e} \int \max\Big\{0,\ \beta\big(S^{-e}(x,y') - S^e(x,y)\big)\Big\}\upsilon^{-e}(y')\,\mathrm{d}y'
\end{aligned}$$

$$= f^e(x,y) - \xi^e S^e(x,y) + s\mu^e\kappa^e\beta \int \big[S^e(x,y') - S^e(x,y)\big]^+\upsilon^e(y')\,\mathrm{d}y' + s(1\text{-}\mu)\kappa^{-e}\beta \int \big[S^{-e}(x,y') - S^e(x,y)\big]^+\upsilon^{-e}(y')\,\mathrm{d}y'. \tag{21}$$

The second equality uses the definition of surplus, and the third just rearranges the last term.

Surplus equation
Surplus function is obtained by substituting out $rW_0^e(x)$ and $r\Pi_0^e(y)$,

$$\begin{aligned}
(r+\xi^e)\; S^e(x,y) &= f^e(x,y) + p(\upsilon^e(y)) - \mu\kappa^e\beta \int S^e(x,y')^+ \upsilon^e(y')\,\mathrm{d}y' - (1-\mu)\kappa^{-e}\beta \int S^{-e}(x,y')^+ \upsilon^{-e}(y')\,\mathrm{d}y' \\
&- \mu\kappa^e(1\text{-}\beta) \int S^e(x',y)^+ u^e(x')\,\mathrm{d}x' - (1\text{-}\mu)\kappa^e(1\text{-}\beta) \int S^e(x',y,\text{-}e)^+ u^{-e}(x')\,\mathrm{d}x' \\
&- s\mu\kappa^e(1\text{-}\beta) \int\int \left[S^e(x',y) - S^e(x',y')\right]^+ h^e(x',y')\,\mathrm{d}x'\,\mathrm{d}y' \qquad (22) \\
&- s(1\text{-}\mu)\kappa^e(1\text{-}\beta) \int\int \left[S^e(x',y,\text{-}e) - S^{-e}(x',y',\text{-}e)\right]^+ h^{-e}(x',y')\,\mathrm{d}x'\,\mathrm{d}y' \\
&+ s\mu^e\kappa^e\beta \int \left[S^e(x,y') - S^e(x,y)\right]^+ \upsilon^e(y')\,\mathrm{d}y' + s(1\text{-}\mu)\kappa^{-e}\beta \int \left[S^{-e}(x,y') - S^e(x,y)\right]^+ \upsilon^{-e}(y')\,\mathrm{d}y'.
\end{aligned}$$

Recall that $\bar{\mathcal{B}}^e(x,y)$ is the set of poaching jobs with surplus higher than the incumbent job in region e: $\bar{\mathcal{B}}^e(x,y) \equiv \{y' :\; S^{c'}(x,y') \geq S^e(x,y)\}$. The first derivative of the surplus function with respect to the job productivity y takes the form

$$\left(r + \xi^e + s\mu\kappa^e\upsilon(\bar{\mathcal{B}}^e(x,y)) + s(1\text{-}\mu)\kappa^{-e}\upsilon(\bar{\mathcal{B}}^{-e}(x,y))\right)\frac{\partial S^e(x,y)}{\partial y} = \frac{\partial f^e(x,y)}{\partial y} - r\frac{\partial \Pi_0^e(y,)}{\partial y}.$$

Consequently, the set of y-s maximizing the surplus $S^e(x,y)$ is the set of y-s maximizing $f^e(x,y) - r\Pi_0^e(y)$.

B Algorithm

The equilibrium is characterized by the vector $\{\kappa^e, L^e(x), u^e(x), h^e(x,y), N^e(y), \upsilon^e(y), S^e(x,y); \forall e, x, y\}$, collecting the tightness parameter, the number of distribution of workers and unemployed of each skill, the joint distribution of matches, the distribution of jobs and vacancies of each type, and the surplus function in each region. The steady-state equilibrium cannot be determined analytically; neither existence and uniqueness can be proven. The steady-state solution is computed by the fixed point iterative algorithm described below.

Guess initial values of $L^e(x), h^e(x,y), N^e(y), \upsilon^e(y), S^e(x,y), \forall e, x, y$. Then,

1. compute in each region the total number of job seekers and vacancies and update the tightness parameter κ^e by using equation 3;
2. update the values of the surplus for each (x,y) match in each region by using equation 22;
3. update the number of vacancies posted by each firm $\upsilon^e(y)$ using equation 19;
4. update the distributions of matches by using equation 14;

5. compute the distributions of unemployed workers in each region $u^e(x)$ rearranging equation 15. Define $H(x) \equiv \int (h^e(x,y) + h^{-e}(x,y))\, \mathrm{d}y$ as the sum of employed workers of skill x in the country. Given equation 1 and the total population of skill x being the sum of the population in the two regions, $u^{-e}(x) = L(x)\text{-}H(x) - u^e(x)$. Then,

$$u^e(x) \leftarrow \frac{(L(x)\text{-}H(x))\kappa^{-e}\upsilon^{-e}(\bar{\mathcal{C}}^{-e}(y))\text{-}s\kappa^e\upsilon^e \int \upsilon(\bar{\mathcal{B}}^e(x,y))h^{-e}(x,y)\, \mathrm{d}y + s\kappa^{-e}\upsilon^{-e} \int \upsilon(\bar{\mathcal{B}}^{-e}(x,y))h^e(x,y)\, \mathrm{d}y}{\kappa^{-e}\upsilon^{-e}(\bar{\mathcal{C}}^{-e}(y)) + \kappa^e\upsilon^e(\bar{\mathcal{C}}^e(y))}, \tag{23}$$

6. update the regional distributions of workers using the population accounting equation 1.

Figures

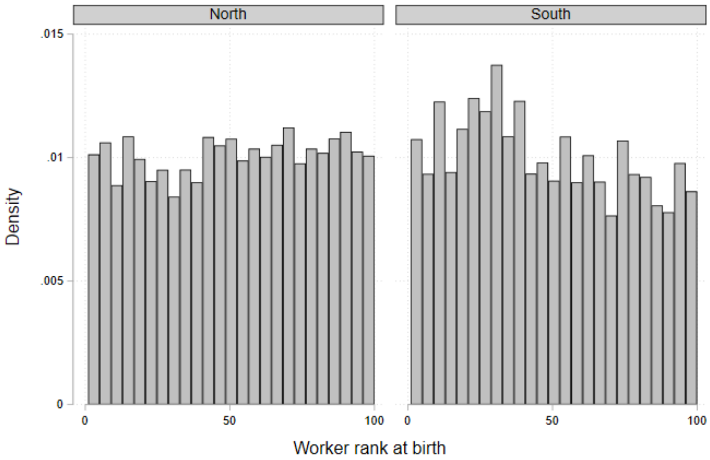
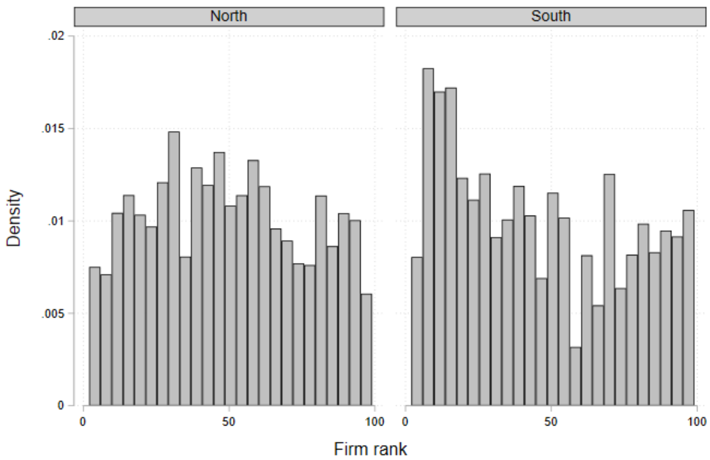
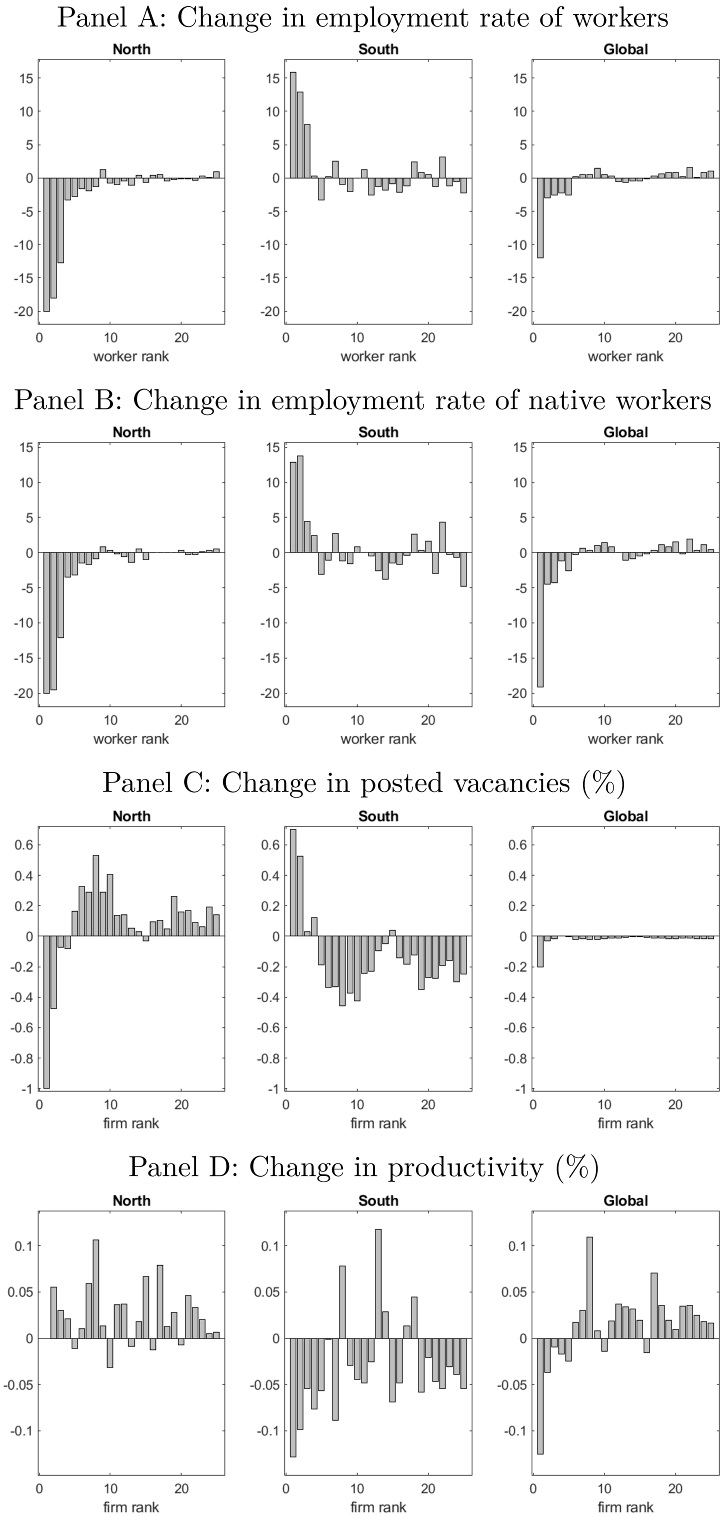


Figure 1: Distributions of worker ranks by region of birth



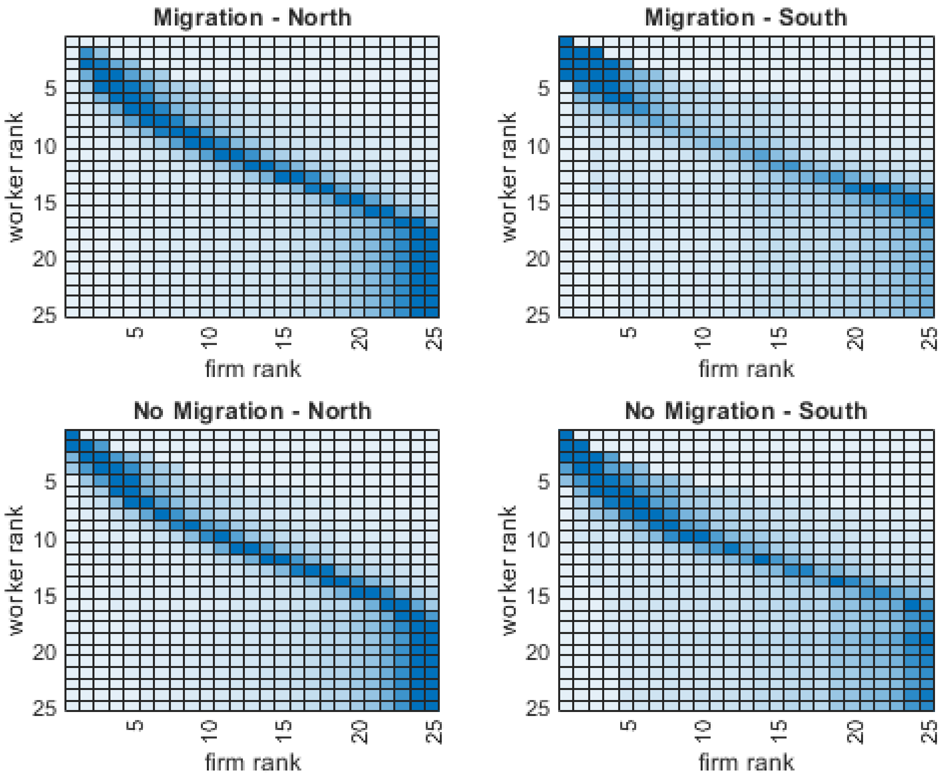
Notes. Distribution of the estimated ranks of firms.

Figure 2: Distributions of firm ranks by region



Notes. Panels A and B display the difference between the employment rates for all and native workers in the migration equilibrium and the closed region equilibrium. In both panels, the value for the first skill bin in the North was -56.2% but is winsorized to -20% for figure legibility. Panels C and D display the growth rate in vacancies and productivity, respectively, in the migration equilibrium with respect to the closed region equilibrium.

Figure 3: The heterogeneous effects of migration



Notes. Density of matches by skill of the worker and technology of the firm in stationary equilibrium. The intensity of the color increases with higher density. The first row displays the allocation under the migration scenario and the second row under the closed region scenario.

Figure 4: Joint regional distribution of matches by skill and technology

Tables

Table 1: Parameters fixed outside the model

Parameter		Value	Source
Panel A. Production function			
Relative match productivity in the South	A_S/A_N	0.879	
Labor share	λ	0.700	estimated using INPS-INVIND data
Elasticity of substitution	$(1-\rho)^{-1}$	0.459	
	ρ	-1.178	
Panel B. Labor market			
Discount rate	r	0.050	annual rate
Matching function elasticity	γ	0.500	Petrongolo and Pissarides (2001)
Worker bargaining power	β	0.188	Lise et al. (2016)
Cost function (exponential term)	p_1	0.007	Lise and Robin (2017)

Notes. The production function parameters in panel A are estimated using administrative data by following the procedure described in section 4.2. The labor market parameters listed in panel B are set according to the estimates by the literature.

Table 2: Calibrated parameters and moments used in estimation

Parameter		Moment	Value
Matching efficiency - North	η^N	Employment rate in the North	0.548
Matching efficiency - South	η^S	Employment rate in the South	0.440
Exogenous job destruction - North	ξ^N	Employment to Unemployment transitions in the North	0.021
Exogenous job destruction - South	ξ^S	Employment to Unemployment transitions in the South	0.033
Employed search intensity	s	Job-to-Job transitions in the North	0.335
Cost function (linear term)	p_0	Job-to-Job transitions in the South	0.006
Search intensity in the same region	μ	Net migrants from South to North over the population	0.826

Notes. Yearly frequency, except for the last parameter using the average moment over the period 1991-1997. A worker's transition is defined as a change of labor market status or firm relative to the previous year, independently of the worker's region in the previous year.

Table 3: Model fit

	Model	Data
Employment rate - North	91.763	93.637
Employment rate - South	85.286	84.766
Job separation rate - North	2.134	1.438
Job separation rate - South	3.340	2.153
Job-to-job transition - North	2.461	1.468
Job-to-job transition - South	2.390	1.054
Net migration rate	11.051	10.502

Notes. Data figures of employment rate and job separation rate are estimated using the Italian Labor Force Survey for the years 1992-1997. Data figures of job changing rate and share of workers born in the other region are estimated from the INPS-INVIND sample. As the model does not allow for firms with multiple plants, transitions of workers to a plant of the same firm in a different region is counted as a transition to a different firm. The net migration rate is computed as the difference in the fraction of workers from the South to the North and from the North to the South over the population.

Table 4: Elasticity of moments with respect to parameters

Panel A. Calibrated parameters

Moment	η_N	η_S	ξ_N	ξ_S	s	μ	p_0
	[.3,.8]	[.3,.8]	[.0001,.4]	[.0001,.4]	[0,1]	[.5,1]	[.001,.5]
Employment rate - North	0.057	0.017	-0.357	0.008	0.029	0.004	0.01
Employment rate - South	0.032	0.09	0.019	-0.394	0.016	0.046	0.032
Job separation rate - North	-0.014	0.010	0.98	0.002	-0.005	-0.053	-0.001
Job separation rate - South	-0.062	0.028	-0.005	0.978	-0.035	0.095	-0.027
Job-to-job transition rate - North	0.231	0.099	0.134	0.016	0.608	0.373	0.054
Job-to-job transition rate - South	0.359	0.165	0.021	0.016	0.770	-0.642	0.131
Net migration rate	0.346	-0.225	0.450	0.398	0.683	0.090	-0.034

Panel B. Exogenous parameters

Moment	p_1	β	A^S/A^N	ρ
	[0,1]	[0,1]	[.2,1]	[-4,4]
Employment rate - North	0.004	0.009	-0.014	0.001
Employment rate - South	0.011	0.024	0.005	0.001
Job separation rate - North	0.003	0.001	-0.001	0
Job separation rate - South	-0.017	-0.011	-0.044	0
Job-to-job transition rate - North	0.057	-0.038	-0.051	0.002
Job-to-job transition rate - South	0.072	0.035	0.243	0.005
Net migration rate	0.006	0.086	-0.729	0.009

Notes. Estimated coefficients of linear regressions of model moments indicated in the rows on the parameter indicated in the column headline. For each parameter, 100 random values are extracted in the interval indicated in square parentheses. Then, the model is re-estimated using the random parameter, and the model moments are computed.

Table 5: The labor market effects of migration

	North		South		Global	
	Migration	Closed	Migration	Closed	Migration	Closed
Population (%)	69.324	58.290	30.676	41.710	100	100
Employment rate	91.763	92.949	85.286	86.735	89.776	90.357
Natives' employment rate	90.554	92.949	84.260	86.735	88.787	90.357
Tightness (V/U)	6.043	5.417	3.226	3.261	4.471	4.195
Output	78.616	63.481	21.384	34.198	100	97.679
Output per employee	110.949	105.189	73.377	84.864	100	97.051
Output per worker	113.405	108.906	69.707	81.989	100	97.679
Rank correlation	0.814	0.830	0.812	0.770	0.813	0.805
Interquartile difference in WPV^e	2.098	2.912	11.410	5.762	3.525	3.503

Notes. Steady-state equilibrium moments for each region (columns 1-4) and the country (columns 5-6). Even columns report the steady state equilibrium moments under migration, while odd columns report the counterfactual moments under the assumption of no mobility across regions. All output measures (rows 5-7) are reported as a percentage of the global value under migration in column 5. The interquartile difference in the worker's present value is computed as $\frac{WPV^e_{75} - WPV^e_{25}}{WPV^e_{25}}$, where 25 and 75 indicate the respective percentiles.

Table 6: The role of worker-firm complementarity

Difference in selected moments	North		South		Global	
under migration and closed scenario	$\rho < 1$	$\rho = 1$	$\rho < 1$	$\rho = 1$	$\rho < 1$	$\rho = 1$
Population (%)	11.034	21.324	-11.034	-21.324	0	0
Employment rate	-1.186	-0.261	-1.449	3.844	-0.581	2.233
Natives' employment rate	-2.395	-0.259	-2.475	3.718	-1.570	2.266
Tightness (V/U)	0.626	-1.126	-0.035	4.659	0.276	2.642
Output	15.135	22.600	-12.814	-18.329	2.321	4.271
Output per employee	5.760	0.161	-11.487	-9.281	2.949	1.963
Output per worker	4.499	-0.129	-12.282	-5.471	2.321	4.271
Rank correlation	-0.016	-0.001	0.042	0.015	0.008	0.029
Interquartile difference in WPV^e	-0.814	0.020	5.648	-0.576	0.022	-0.362

Notes. The table reports the difference between the moments of the steady-state equilibrium in the migration scenario and the moments of the stationary equilibrium in the closed scenario. Even columns report the difference computed under the presence of worker-firm complementarity in production as reported in Table 1. Odd columns report the difference computed when assuming no worker-firm complementarity.

Table 7: The effects of policy interventions

Difference in selected moments under different policies	A. Hiring subsidies to unemployed			B. Incentive to high y-s jobs			C. Brain remittance subsidies		
	North	South	Global	North	South	Global	North	South	Global
Population (%)	5.748	-5.748	0	5.194	-5.194	0	-0.090	0.090	0
Employment rate	1.247	0.985	1.553	1.187	1.369	1.569	-0.005	0.014	-0.005
Natives' employment rate	1.464	1.481	1.768	1.396	1.745	1.750	-0.002	0.026	0.001
Tightness (V/U)	0.398	0.523	0.666	0.430	0.517	0.667	0.001	-0.002	-0.001
Output	6.533	-3.229	3.304	6.08	-2.838	3.242	-0.111	0.088	-0.022
Output per employee	-1.468	2.411	1.548	-1.172	2.028	1.469	-0.006	0.078	-0.016
Output per worker	0.019	3.121	3.304	0.253	3.076	3.242	-0.013	0.085	-0.022
Rank correlation	-0.057	-0.050	-0.060	-0.060	-0.053	-0.063	0	-0.001	0
Interquartile diff. in WPV^e	-0.261	0.749	-0.967	-0.264	0.65	-0.985	0.008	-0.048	-0.002

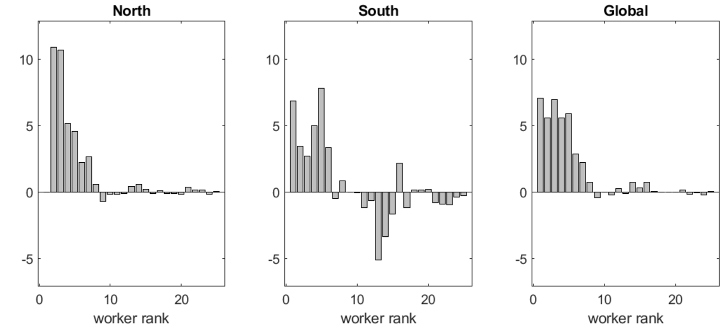
Notes. The table reports the difference between the moments of the stationary equilibrium with cross-regional migration in the presence and absence of the policy indicated in the first row.

ONLINE APPENDIX

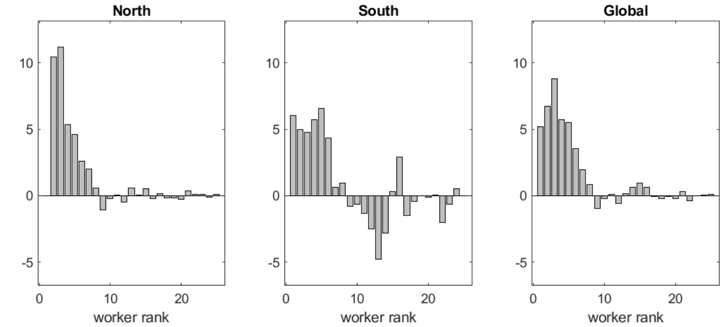
Table A1: Descriptive statistics

	Italy	North	South
Workers: INPS (1980-1997)			
Employment spells	18,806,792	12,869,770	5,934,079
Share of spells		0.68	0.32
Workers	1,335,161	972,993	475,022
Share of workers		0.73	0.36
Share of women	0.23	0.24	0.18
Share of spells by migrants	0.17	0.23	0.05
Share of workers observed in:			
- more than one year	0.98	0.98	0.98
- more than one firm	0.77	0.79	0.76
- both regions	0.09	0.05	0.13
Mean n. years	12.65	12.60	12.76
Mean n. firms	2.93	3.04	2.71
Workers: INPS–INVIND (1991–1997)			
Employment spells	3,188,743	2,201,454	987,289
Share of spells		0.69	0.31
Workers	884,427	594,792	297,007
Share of workers		0.67	0.34
Share of women	0.23	0.26	0.18
Share of spells by migrants	0.16	0.21	0.06
Share of workers observed in:			
- more than one year	0.74	0.75	0.72
- more than one firm	0.06	0.07	0.03
- both regions	0.01	0.01	0.02
Mean n. years	3.35	3.46	3.17
Mean n. firms	1.06	1.07	1.03
Mean log real weekly wage	5.84	5.85	5.80
Std.dev. log real weekly wage	0.42	0.42	0.43
Firms: INPS–INVIND (1991–1997)			
Observations	6,195	5,668	1,552
Share of observations		0.78	0.45
Firms	1,464	1,137	714
Share of firms		0.78	0.49
- more than one year	0.86	0.87	0.86
- both regions	0.26	0.34	0.54
Mean n. years	4.23	4.31	4.12

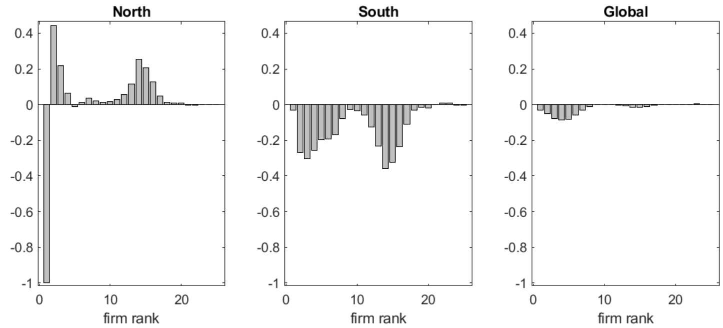
Panel A: Change in employment rate of workers



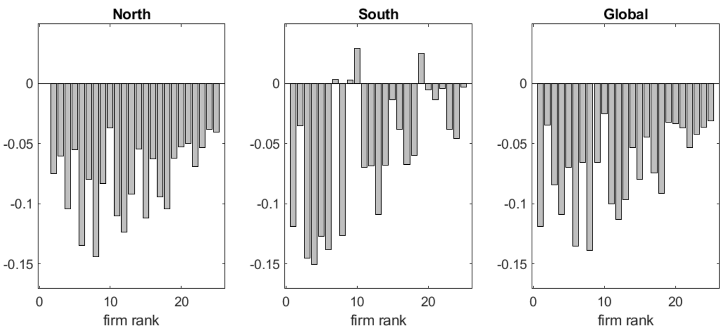
Panel B: Change in employment rate of native workers



Panel C: Change in posted vacancies (%)

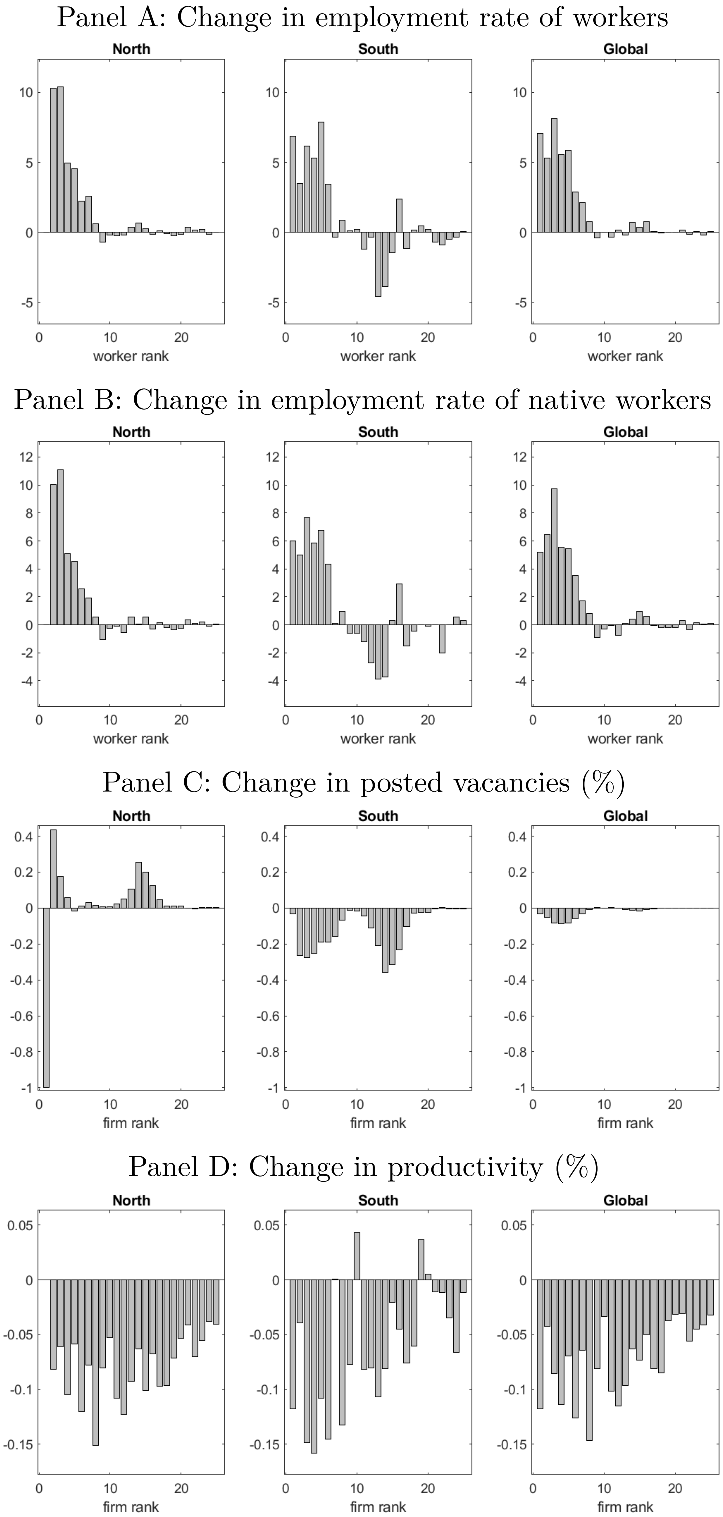


Panel D: Change in productivity (%)



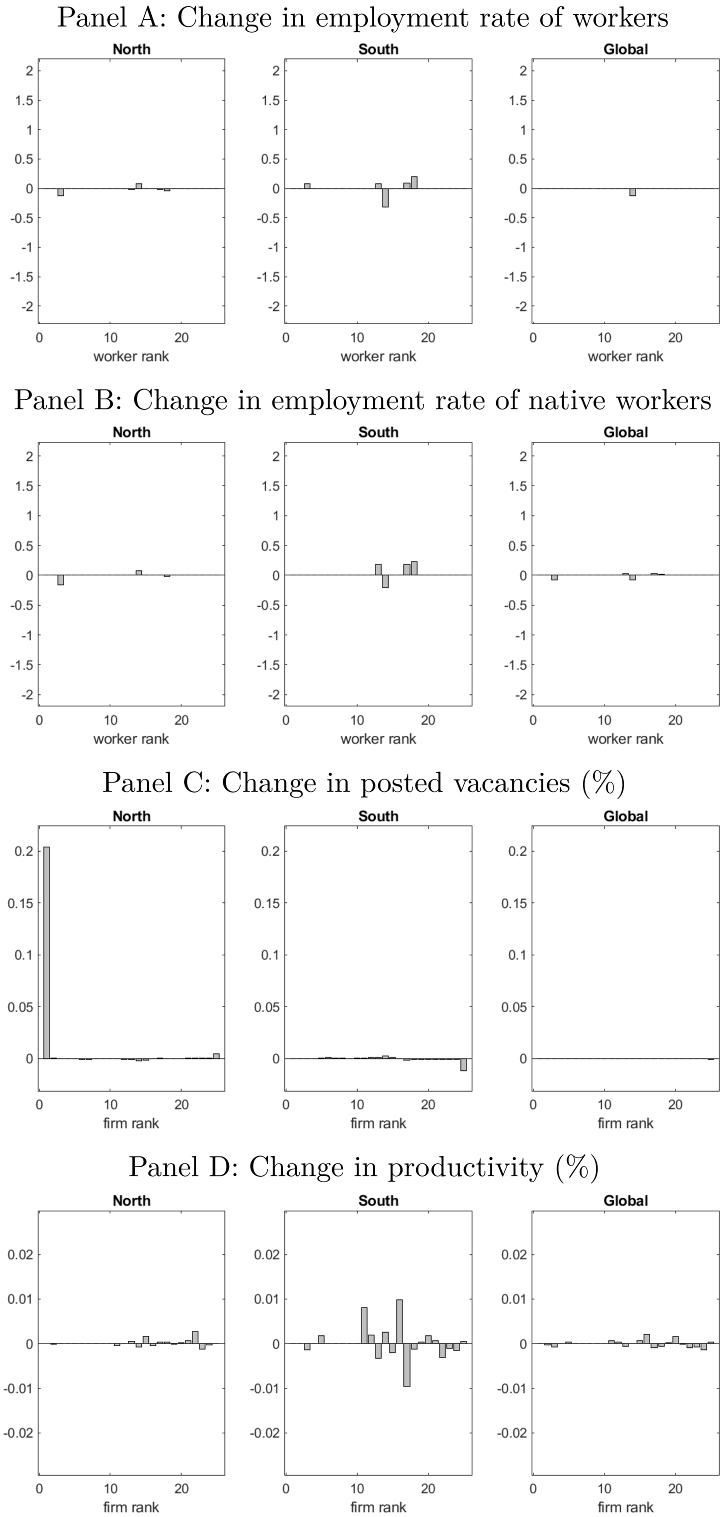
Notes. Panels A and B display the difference in employment rates for all and native workers in the equilibrium with and without investment incentives to high technology jobs. Panels C and D display the growth rate in vacancies and productivity, respectively, between the equilibrium with and without investment incentives to high technology jobs.

Figure A1: The heterogeneous effects of hiring subsidies to unemployed workers



Notes. Panels A and B display the difference in employment rates for all and native workers in the equilibrium with and without investment incentives to high technology jobs. Panels C and D display the growth rate in vacancies and productivity, respectively, between the equilibrium with and without investment incentives to high technology jobs.

Figure A2: The heterogeneous effects of investment incentives to high technology jobs in the South



Notes. Panels A and B display the difference in employment rates for all and native workers in the equilibrium with and without brain remittance subsidies. Panels C and D display the growth rate in vacancies and productivity, respectively, between the equilibrium with and without brain remittance subsidies.

Figure A3: The heterogeneous effects of brain remittance subsidies in the South