

# City of dreams

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**ABSTRACT:** Higher ability workers benefit more from bigger cities while housing costs there are higher for everyone, and yet there is little sorting on ability. A possible explanation is that young individuals have an imperfect assessment of their ability, and, when they learn about it, early decisions have had a lasting impact and reduce their incentives to move. We formalize this idea through an overlapping generations model of urban sorting by workers with heterogenous ability and self-confidence, with the latter defined as individuals' assessment of their own ability. We then test the location patterns predicted by the model over the life cycle on panel data from the National Longitudinal Survey of Youth 1979. We find that the city-size choices of individuals at different stages vary with ability and self-confidence in a way that closely matches our theoretical predictions.

**Key words:** cities, agglomeration, sorting, self-confidence, ability, learning

**JEL classification:** R10, R23

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## 1. Introduction

Bigger cities are associated both with higher individual earnings and with higher housing costs. Higher earnings take partly the form of a static city-size premium that individuals obtain when they are working in a bigger city and partly the form of a dynamic gain due to faster accumulation of more valuable experience in bigger cities (Glaeser and Maré, 2001, Yankow, 2006, Baum-Snow and Pavan, 2012, De la Roca and Puga, 2012). These big-city benefits are not very different by level of education or by broad occupation type, but they appear to be significantly larger for workers with higher ability within broad education or occupation categories (De la Roca and Puga, 2012, Baum-Snow and Pavan, 2012). Since higher ability workers benefit more from bigger cities, while housing costs there are higher for everyone regardless of ability, one would expect more able workers to locate disproportionately in bigger cities. And yet, this is not the case.

Several studies find that more educated workers or those with certain occupations are more likely to locate in bigger cities (Berry and Glaeser, 2005, Moretti, 2012, Davis and Dingel, 2013).<sup>1</sup> However, within broad occupation or education groups, there appears to be little sorting on ability, whether this is measured through cognitive test results (Bacolod, Blum, and Strange, 2009), individual fixed-effects in a wage regression (De la Roca and Puga, 2012), measures of ability derived from a finite-mixture model in a structural estimation setting (Baum-Snow and Pavan, 2012), or individual residuals from a spatial equilibrium condition (Eeckhout, Pinheiro, and Schmidheiny, 2014).

A partial explanation for little sorting on ability is simply that many people are not mobile. In the United States, 55% of people live at age 40 in the same city or town where they were at age 14. Even for college-educated workers, the figure is 40%.<sup>2</sup> However, given that many people do move, one would expect them to take into account how they would fare in different cities depending on their ability. Our starting point in this paper is that it is not all that easy for individuals to make such a calculation. When young individuals choose a location, they have a very imperfect assessment of their own ability and, by the time they learn enough about it, early decisions have had a lasting impact and reduce their incentives to move.

A large literature in psychology documents that individuals' assessment of their own ability generally has little resemblance to their actual ability (see Dunning, Heath, and Suls, 2004, for a survey). Correlation between people's views of their intelligence and their performance on intelligence tests and other academic tasks is typically between 0.2 and 0.3 (Hansford and Hattie, 1982). In the workplace, the correlation between how people expect to perform complex tasks and how they actually perform them is around 0.2 (Stajkovic and Luthans, 1998). Several complementary explanations of the pervasiveness of flawed self-assessment have been put forth. Not only assessing ability is inherently complex, but also assessing skills accurately often requires the same skills one is trying to assess (e.g., knowing whether one is good at maths requires sufficient mathematical knowledge). In addition, comparative assessments are very self-centred, relying largely on some loose perception of whether one is able to do something and not so much on how

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<sup>1</sup>This could reflect sorting by education, but also the fact that cities with more educated workers experience faster employment growth (Shapiro, 2006).

<sup>2</sup>These percentages are calculated from our panel data, described below.

many others can do it substantially better. Even when people have information that would lead them to more accurate self-assessments, they tend to neglect this information, which leads them to worse assessments than they are capable of (Benabou and Tirole, 2002).

We formalize the idea that flawed self-assessment can help explain limited sorting across cities of different sizes through an overlapping generations model of urban sorting by workers with heterogeneous ability and self-confidence, where the latter is defined as individuals' assessment of their own ability. Big cities allow junior workers to gain more valuable experience and provide senior workers with better opportunities to apply their accumulated experience than small cities. Both advantages are stronger for high-ability workers. However, big cities also involve higher living costs. Junior workers choose their location based on the benefits and costs of big cities and on their self-confidence, which may or may not correspond to their actual ability. They then accumulate experience depending on their chosen location, ability and luck. In the process they also learn their own ability. Based on accumulated experience and ability, as well as on the opportunities and costs of big and small cities, senior workers choose whether to relocate or not.

The model predicts various patterns of bilateral sorting between big and small cities along workers' life-cycles. Location decisions by junior workers are mostly driven by self-confidence. For senior workers, ability plays a stronger role in determining location, but the lasting impact of their earlier choices dampens their incentives to move and reduces the aggregate extent of sorting. Nevertheless, workers who seriously underestimated their own ability may relocate from a small to a big city once their labour market experience provides them with better information of their true capabilities. Workers who try their luck in a big city and fail tend to relocate to smaller cities. Even some senior workers who had an accurate assessment of their own ability may relocate: some senior workers at the high end of the ability distribution in small cities relocate to big cities when this provides them with sufficiently greater opportunities to apply their accumulated experience; senior workers at the lower end of the ability distribution in big cities relocate to small cities when instead the main advantage of big cities consists of facilitating the accumulation of valuable experience.

We test these predictions on panel data from the National Longitudinal Survey of Youth 1979 (NLSY79), which allows us to track individuals' location and labour market activities as well as a rich set of personal characteristics. Our primary measure of ability is the individual's percentile score in the Armed Forces Qualification Test (AFQT), a cognitive ability test that was administered to respondents when their median age was 19. In our model, we use the term self-confidence to refer to individuals' perception of their own ability. Prior to being provided their results on the AFQT, respondents in the NLSY79 were subject to a self-evaluation test devised by Rosenberg (1965), which has been found to measure well individuals' perception of their own ability to perform in a wide variety of tasks, in particular those that are job-related (Judge, Erez, and Bono, 1998, Chen, Gully, and Eden, 2001).

When we examine the raw relationship between the location choices of individuals in their junior and senior periods and their levels of self-confidence and ability, we find that the data closely match our theoretical predictions. We then estimate logit models to look at the determinants of locating in a small or a big city either when junior or senior, while controlling for other drivers

of mobility. Our findings confirm that individuals with higher levels of self-confidence are more likely to locate in a big city upon entering the job market. Instead, high-ability young individuals are not significantly more likely to locate initially in a big city. When examining senior period relocations, we find that self-confidence no longer influences the decision to relocate from small to big cities while the level of ability is a significant determinant. Moreover, relocations from big to small cities appear to be driven instead by lack of success in the big city rather than by corrections to flawed self-assessment.

Our findings contribute to the urban economics literature on learning and sorting in cities. The model we develop has several elements in common with the model of learning in cities by Glaeser (1999). Both are overlapping generations models with cities of different sizes where bigger cities facilitate learning. The main difference is that the workers in Glaeser's (1999) model are homogeneous whereas workers in our model are heterogeneous in self-confidence and ability. This allows us to examine sorting patterns over the life-cycle and the consequences of flawed self-assessment. Eeckhout, Pinheiro, and Schmidheiny (2014) and Davis and Dingel (2012) develop static models of sorting. In Eeckhout, Pinheiro, and Schmidheiny (2014) sorting is based on complementarities that are stronger between workers with more different skills. They predict no sorting on average but a greater variance of skills in bigger cities. In Davis and Dingel (2012) there is perfect sorting driven by supermodularity. Behrens, Duranton, and Robert-Nicoud (2014) combine sorting, agglomeration and selection into a common theoretical framework. To keep the model manageable, they assume workers make an irreversible location choice, and obtain perfect sorting by heterogeneous ability, although variations in ex-post luck lead to heterogeneity in the productivity distribution. In contrast, in our model workers can choose their location in each of their two periods, and the incentives to relocate as a result of the interplay between self-confidence, ability and luck are one of our main issues of interest.

On the empirical side, few papers have looked at the impact of personality traits on urban sorting. An exception is Bacolod, Blum, and Strange (2009), who study the prevalence of a variety of skills and personality traits in cities of different sizes. However, they do not examine sorting based on different traits, such as self-confidence and ability, at different stages of a worker's life-cycle.

Our findings also contribute to the literature on personality psychology and economics recently systematized by Almlund, Duckworth, Heckman, and Kautz (2011), who document the power of personality traits both as predictors and as causes of academic and economic success, health, and criminal activity. For many outcomes, personality measures are just as predictive as cognitive measures derived from IQ and achievement tests, even after controlling for family background and cognition. Standard measures of cognition are also heavily influenced by personality traits which vary over the life cycle and can be altered by experience and investment. Intervention studies, along with studies in biology and neuroscience, establish a causal basis for the observed effect of personality traits on economic and social outcomes. Building on a large multi-disciplinary set of studies, Almlund, Duckworth, Heckman, and Kautz (2011) conclude that, as personality traits are more malleable over the life cycle compared to cognition (which rank stabilizes around age 10), interventions that change personality are promising avenues for addressing poverty and disad-

vantage. These findings challenge the (extreme version of the) ‘situationist view’ of personality, which argues that there are no stable personality traits or preference parameters that individuals carry across different situations, and thus, claims that personality psychology has little relevance for economics.

The rest of the paper is organized in five sections. Section 2 presents the model of sorting and learning in cities of different sizes. Section 3 solves for individual location choices taking relative city sizes as given. Section 4 solves for the general equilibrium endogenizing relative city sizes. Section 5 describes the data set that is used to obtain the empirical results presented in section 6. Section 7 concludes.

## 2. The model

Each worker lives for two periods. We refer to workers in the first period of their life as junior workers and to workers in the second period of their life as senior workers. In each of these two periods, each worker chooses whether to locate in a big city or in a small city. We use subscript  $B$  to denote big city variables and subscript  $S$  to denote small city variables. The sizes of cities are derived as an equilibrium outcome of the location decisions of all agents in section 4.

Workers have heterogeneous ability. All junior workers are engaged in a simple task and a worker’s ability, denoted by  $\alpha$ , is her actual probability of successfully completing this simple task. However, junior workers may have an inaccurate assessment of their own ability. We denote by  $\sigma$  self-confidence, defined as a junior worker’s assessment of her own ability (i.e., her belief about  $\alpha$ ). While trying to complete their simple task workers learn about their true ability, so all senior workers know their  $\alpha$  accurately.<sup>3</sup>

Junior workers who fail to complete their simple task get a low return, normalized to 0. Those who instead succeed at completing this simple task, get a high return  $\pi_1 > 0$ . In addition to a higher return, junior workers who successfully complete their simple task also gain experience that will be valuable when senior. The key advantage of locating in the big city for junior workers is that it allows them to accumulate more valuable experience, as suggested by Glaeser and Maré (2001), and consistent with the evidence presented in De la Roca and Puga (2012) and Baum-Snow and Pavan (2012). Successful junior workers in the big city gain experience  $e_B$  while successful junior workers in the small city gain experience  $e_S$ , where  $0 < e_S < e_B < 1$ . Junior workers who fail at completing their simple task gain zero experience.

Senior workers, at the very least, engage in a simple task. In addition, some senior workers are presented with an opportunity to also engage in a more complex task. Regarding the simple task, senior workers who already succeeded at this simple task as junior workers, can replicate what they did and complete their simple task with certainty. Senior workers who failed as junior workers can try again and succeed at their simple task when senior with probability given by

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<sup>3</sup>For simplicity, in the main text we derive results under the assumption that a junior worker is totally convinced that her ability is  $\sigma$  until she updates this belief to the actual value  $\alpha$  in the process of completing the simple task. In appendix C we re-derive results allowing for uncertainty, so that junior workers realize their self-assessment may be inaccurate. Each worker receives an initial signal, on the basis of which she takes her ability to be  $\sigma$  in expectation, with variance  $\theta$ . Under this alternative assumption, the specific thresholds determining the location strategies of junior workers change but all our results remain qualitatively unchanged.

their ability  $\alpha$ . The simple tasks yields a return  $\pi_1$  if successful and zero return if unsuccessful. Regarding the complex task, to complete this a senior worker must be faced with a relevant opportunity and also have prior experience from completing a simple task as a junior worker. The key advantage of locating in the big city for senior workers is that this offers them greater opportunities to exploit their previously acquired experience. Opportunities for engaging in a complex task arise with probability  $\Omega_B$  in big cities compared with probability  $\Omega_S$  in small cities, where  $0 < \Omega_S < \Omega_B < 1$ . If faced with a complex task, a senior worker's probability of success is  $\alpha e$ , the product of her innate ability  $\alpha$  and the experience acquired as a junior worker  $e$ , where  $e = e_B$  if she completed a simple task in the big city,  $e = e_S$  if she completed a simple task in the small city, and  $e = 0$  if she failed to complete a simple task whatever her location was. Note that this implies a positive interaction between ability and the more valuable experience provided by big cities, again consistent with the evidence presented in De la Roca and Puga (2012).<sup>4</sup> Restated, the higher the ability of an experienced worker the more she benefits from the greater opportunities provided by the big city. Successfully completing a complex task yields an extra return  $\pi_2$  on top of  $\pi_1$ .

The disadvantage of locating in the big city for both junior and senior workers is that it involves higher costs for housing and commuting, which we refer to as urban costs.<sup>5</sup> These urban costs are  $\gamma_B$  in the big city and  $\gamma_S$  in the small city, with  $0 < \gamma_S < \gamma_B$ .<sup>6</sup> Since each individual agent chooses her own location in each period taking city sizes as given, we initially treat  $\gamma_B$  and  $\gamma_S$  as parameters. In section 4 we go one step further by explicitly introducing commuting costs and a spatial housing market in a simple monocentric city model, which makes  $\gamma_B$  and  $\gamma_S$  a function of the (endogenous) population size of each city.

Anyone who failed to complete a simple task as a junior worker will choose to locate in the small city as a senior worker. This is because such a worker cannot benefit from the greater opportunities present in big cities ( $\Omega_B > \Omega_S$ ), since tackling a complex task requires success at a simple task first. For such a worker there is also no point in locating in the big city to acquire greater experience ( $e_B > e_S$ ), since this would only be valuable in the future, and senior workers are in their final period. At the same time, the big city has the disadvantage of its higher urban costs ( $\gamma_B > \gamma_S$ ).

Given that senior workers who were unsuccessful in their junior period locate in the small city, the expected utility attained by locating in city  $i$  as a junior worker and, conditional on earlier success, locating in city  $j$  as a senior worker is:

$$U_{ij}(\alpha) = -\gamma_i + (1 - \alpha)(-\gamma_S + \alpha \pi_1) + \alpha(2\pi_1 - \gamma_j + \Omega_j \alpha e_i \pi_2), \quad i, j \in \{B, S\}. \quad (1)$$

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<sup>4</sup>An alternative interpretation of the interaction  $\alpha e$  is that the probability of success at completing a complex task equals the worker's experience independently of her ability, but the experience a junior worker acquires depends not only on her location but also on her ability, so that a worker with ability  $\alpha$  accumulates experience  $\alpha e_B$  when successful in the big city and experience  $\alpha e_S$  when successful in the small city.

<sup>5</sup>The higher cost of living in big cities, mostly because of the higher costs of housing, is widely documented. Combes, Duranton, and Gobillon (2012) estimate an elasticity of urban costs with respect to population of about 0.04 using data for all individual land transactions in France.

<sup>6</sup>Note that in the absence of any difference in urban cost ( $\gamma_B = \gamma_S$ ), nobody would ever locate in  $S$ . Analogously, with no difference in the value of experience ( $e_B = e_S$ ), nobody would locate in  $B$  when junior, while with no difference in opportunities ( $\Omega_B = \Omega_S$ ), nobody would locate in  $B$  when senior.

Someone who locates in city  $i \in \{B, S\}$  as a junior worker incurs an urban cost  $\gamma_i$ . With probability  $1 - \alpha$  she fails at completing a simple task and gets no return as a junior worker. Having failed, she then locates in  $S$  as a senior worker, incurring urban cost  $\gamma_S$ . With probability  $\alpha$  she succeeds at completing the simple task in her senior period and obtains a return  $\pi_1$  while with probability  $1 - \alpha$  she fails again and gets no return. With probability  $\alpha$  she instead succeeds at completing a simple task as a junior worker, and then obtains a return  $\pi_1$  in her junior period and is also guaranteed  $\pi_1$  in her senior period. If, having succeeded, she locates in city  $j \in \{B, S\}$  as a senior worker, she incurs an urban cost  $\gamma_j$ . Then, with probability  $\Omega_j$  she faces the opportunity to also engage in a more complex task. She successfully completes this complex task, yielding an additional return  $\pi_2$ , with probability  $\alpha e_i$  that depends on her ability and the experience  $e_i$  she acquired as a junior worker in city  $i$ . We can now use this equation to compare the possible location choices for each worker.

### 3. Equilibrium location choices

A worker's location choice when junior will affect her location choice when senior. Thus, we must first examine the optimal location choice of senior workers conditional on their location when junior. Only then can we examine the optimal location choice of junior workers.

#### *Senior period location*

Consider a worker who locates in  $B$  when junior. She prefers to also locate in  $B$  when senior (conditional of earlier success) if and only if

$$U_{BB}(\alpha) - U_{BS}(\alpha) = \alpha [\alpha(\Omega_B - \Omega_S)e_B \pi_2 - (\gamma_B - \gamma_S)] > 0, \quad (2)$$

or, equivalently, if and only if

$$\alpha > \alpha_{BB \succ BS} \equiv \frac{\Delta\gamma}{e_B \pi_2 \Delta\Omega}, \quad (3)$$

where

$$\Delta\gamma \equiv \gamma_B - \gamma_S, \quad (4)$$

$$\Delta\Omega \equiv \Omega_B - \Omega_S. \quad (5)$$

The ability threshold defined by equation (3),  $\alpha_{BB \succ BS}$ , is such that anyone with ability above this threshold gets higher utility by locating in  $B$  as a junior worker and, conditional on success, also locating in  $B$  as a senior worker than by locating in  $B$  as a junior worker and relocating to  $S$  as a senior worker (hence the subscript  $BB \succ BS$ ). We use this same notation for all thresholds that follow. Thus, junior workers who locate in the big city and successfully complete a simple task sort by ability when senior: those with high ability ( $\alpha > \alpha_{BB \succ BS}$ ) stay in  $B$ , while those with low ability ( $\alpha \leq \alpha_{BB \succ BS}$ ) relocate to  $S$ . Ability matters in the location choice of senior workers because they are willing to incur the high urban costs of the big city only in the hope of successfully completing a complex project and, other things equal, this is more likely the higher their ability. The ability threshold  $\alpha_{BB \succ BS}$  is higher (fewer senior workers locate in  $B$ ) the higher the urban cost gap between

$B$  and  $S$  ( $\Delta\gamma$ ), the lower the difference in opportunities to engage in a complex task ( $\Delta\Omega$ ), the lower the value of experience acquired as a successful junior worker in the big city ( $e_B$ ), and the lower the extra return from completing a complex task ( $\pi_2$ ).

Consider a worker who instead locates in  $S$  when junior. She prefers to relocate to  $B$  when senior (conditional of earlier success) if and only if

$$U_{SB}(\alpha) - U_{SS}(\alpha) = \alpha [\alpha(\Omega_B - \Omega_S)e_S \pi_2 - (\gamma_B - \gamma_S)] > 0, \quad (6)$$

or, equivalently, if and only if

$$\alpha > \alpha_{SB>SS} \equiv \frac{\Delta\gamma}{e_S \pi_2 \Delta\Omega}. \quad (7)$$

Thus, junior workers who locate in the small city and successfully complete a simple task also sort by ability when senior: those with high ability ( $\alpha > \alpha_{SB>SS}$ ) relocate to  $B$ , while those with low ability ( $\alpha \leq \alpha_{SB>SS}$ ) stay in  $S$ . The comparative statics for this threshold  $\alpha_{SB>SS}$  are the same as for  $\alpha_{BB>BS}$  except that, since we are now looking at the senior period decision of a worker who located in  $S$  in her junior period, it is  $e_S$  rather than  $e_B$  that appears in the threshold.

Note that the location choice as a junior worker affects the ability threshold above which a senior worker prefers to locate in the big city. A successful junior worker who locates in  $B$  acquires more valuable experience than one who locates in  $S$  ( $e_B > e_S$ ), so has a lower ability threshold above which location in  $B$  when senior is worthwhile:

$$\alpha_{BB>BS} \equiv \frac{\Delta\gamma}{e_B \pi_2 \Delta\Omega} < \frac{\Delta\gamma}{e_S \pi_2 \Delta\Omega} \equiv \alpha_{SB>SS}. \quad (8)$$

Note also that the probability of not completing a simple task  $1 - \alpha$  falls with ability but is nevertheless positive for everyone. Thus, even some very high-ability junior workers fail and locate in the small city in their senior period. This is a first reason why sorting by ability will always be imperfect: ability is important but luck also plays a role.<sup>7</sup>

Gathering all of the above, location decisions in the senior period follow the rules in the following Lemma.

**Lemma 1.** A worker who fails at the simple task when junior, locates in  $S$  when senior.

A worker with  $\alpha \leq \alpha_{BB>BS}$  locates in  $S$  when senior.

A worker with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$  locates in  $B$  when senior if and only if she located in  $B$  when junior and succeeded at the simple task.

A worker with  $\alpha_{SB>SS} < \alpha$  locates in  $B$  when senior unless she fails at the simple task when junior.

### *Junior period location when self-confidence accurately reflects ability*

Having characterized the senior period location choice conditional on junior period location and success or failure at a simple task, we now turn to the junior period location choice. We begin with a simple case in which an individual's self-confidence while junior accurately reflects her ability ( $\sigma = \alpha$ ). Afterwards, we will examine the more general case where an individual's self-confidence

<sup>7</sup>In the model of Behrens, Duranton, and Robert-Nicoud (2014) luck also prevents complete sorting.

while junior may not reflect her actual ability ( $\sigma \neq \alpha$ ); only after working in a first task does a worker learn her actual ability.

In Lemma 1 we have shown that senior-period location depends on the value of ability relative to two thresholds,  $\alpha_{BB>BS}$  and  $\alpha_{SB>SS}$ , where  $\alpha_{BB>BS} < \alpha_{SB>SS}$ . Thus, in studying junior-period location, we will need to consider three ranges of ability:  $\alpha \leq \alpha_{BB>BS}$ ,  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$ , and  $\alpha_{SB>SS} < \alpha$ .

For a worker with low ability  $\alpha \leq \alpha_{BB>BS}$  locating in  $B$  when senior is never worthwhile regardless of her junior period location. However, even knowing she will locate in  $S$  when senior, such a worker may nevertheless locate in  $B$  when junior to acquire more valuable experience. In particular, she locates in  $B$  in her junior period if and only if

$$U_{BS}(\alpha) - U_{SS}(\alpha) = \alpha^2 \Omega_S (e_B - e_S) \pi_2 - (\gamma_B - \gamma_S) > 0, \quad (9)$$

or, equivalently, if and only if

$$\alpha > \alpha_{BS>SS} \equiv \sqrt{\frac{\Delta\gamma}{\Omega_S \pi_2 \Delta e}}, \quad (10)$$

where

$$\Delta e \equiv e_B - e_S. \quad (11)$$

Ability matters in the location choice of junior workers for two reasons (hence the exponent of  $\alpha$  in equation 9 and the square root in equation 10). First, because more able workers are more likely to complete a simple task and attain experience, which is more valuable if acquired in the big city. Second, because that experience helps complete a complex task once the worker reaches her senior period and success at that is also more likely the greater her ability. A worker with  $\alpha \leq \alpha_{BB>BS}$ , who always locates in  $S$  when senior, may be willing to incur the higher urban costs of  $B$  when junior in order to acquire additional experience, which could be valuable if an opportunity to use that experience in  $S$  when senior were to arise. The ability threshold  $\alpha_{BS>SS}$  above which location in  $B$  when junior is worthwhile for such a worker is higher (fewer junior workers locate in  $B$ ) the higher the urban cost gap between  $B$  and  $S$ ,  $\Delta\gamma$ , the lower the difference in the experience acquired by successful junior workers in  $B$  and  $S$ ,  $\Delta e$ , the smaller the opportunities to engage in a complex task as a senior worker in the small city,  $\Omega_S$ , and the lower the extra return from completing a complex task,  $\pi_2$ . Note that these comparative statics are the same as for the ability thresholds that determine the location of senior workers, except that in the junior period it is the difference in experience,  $\Delta e$ , instead of the difference in opportunities,  $\Delta\Omega$ , that matters.

For a worker with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$  locating in  $B$  when senior is worthwhile if she located in  $B$  when junior and successfully completed her simple task. Knowing this, she locates in  $B$  in her junior period if and only if

$$U_{BB}(\alpha) - U_{SS}(\alpha) = \alpha^2 (\Omega_B e_B - \Omega_S e_S) \pi_2 - (1 + \alpha)(\gamma_B - \gamma_S) > 0, \quad (12)$$

or, equivalently, if and only if

$$\alpha > \alpha_{BB>SS} \equiv \frac{1}{2} \left( \tilde{\alpha} + \sqrt{\tilde{\alpha}^2 + 4\tilde{\alpha}} \right), \quad \text{where} \quad \tilde{\alpha} \equiv \frac{\Delta\gamma}{(\Omega_B e_B - \Omega_S e_S) \pi_2}. \quad (13)$$

Note that the more complex functional form for this threshold  $\alpha_{BB \succ SS}$  occurs because for workers with intermediate ability ( $\alpha_{BB \succ BS} < \alpha \leq \alpha_{SB \succ SS}$ ) their junior period location affects their senior period location. Thus, in the utility comparison of equation (12) there is a difference in urban costs both for the junior period and, conditional on success, also for the senior period. In contrast, workers with low ability ( $\alpha < \alpha_{BB \succ BS}$ ) chose their junior period location knowing they will locate in  $S$  when senior regardless. The comparative statics on this threshold  $\alpha_{BB \succ SS}$  are nevertheless the same as for the threshold  $\alpha_{BS \succ SS}$ , except that for workers with intermediate ability the differences in opportunities combine with the differences in experience to determine junior location.

For a worker with high ability  $\alpha_{SB \succ SS} < \alpha$  locating in  $B$  when senior (conditional on junior period success) is always worthwhile regardless of her junior period location. Knowing she will locate in  $B$  when senior if successful, she locates in  $B$  in her junior period if and only if

$$U_{BB}(\alpha) - U_{SB}(\alpha) = \alpha^2 \Omega_B (e_B - e_S) \pi_2 - (\gamma_B - \gamma_S) > 0, \quad (14)$$

or, equivalently, if and only if

$$\alpha > \alpha_{BB \succ SB} \equiv \sqrt{\frac{\Delta \gamma}{\Omega_B \pi_2 \Delta e}}. \quad (15)$$

The comparative statics for this threshold  $\alpha_{BB \succ SB}$  are the same as for  $\alpha_{BS \succ SS}$  except that, since we are now looking at the junior period decision of a worker who will locate in  $B$  instead of in  $S$  when senior, it is  $\Omega_B$  rather than  $\Omega_S$  that appears in the threshold.

Gathering all of the above, location decisions in the two periods follow the rules in the following Lemma.

**Lemma 2.** A worker who fails at the simple task when junior, locates in  $S$  when senior.

A worker with  $\alpha \leq \alpha_{BB \succ BS}$  locates in  $S$  when senior; if  $\alpha \leq \alpha_{BS \succ SS}$  she also locates in  $S$  when junior while if instead  $\alpha_{BS \succ SS} < \alpha$  she locates in  $B$  when junior.

A worker with  $\alpha_{BB \succ BS} < \alpha \leq \alpha_{SB \succ SS}$  locates in  $S$  in both periods if  $\alpha \leq \alpha_{BB \succ SS}$ ; if instead  $\alpha_{BB \succ SS} < \alpha$ , she locates in  $B$  when junior and, if she succeeds at the simple task, also locates in  $B$  when senior.

A worker with  $\alpha_{SB \succ SS} < \alpha$  locates in  $B$  when senior unless she fails at the simple task when junior; if  $\alpha_{BB \succ SB} < \alpha$  she also locates in  $B$  when junior while if instead  $\alpha \leq \alpha_{BB \succ SB}$  she locates in  $S$  when junior.

With this, we now have all the information required to characterize location as a function of ability when workers' self-confidence while junior accurately reflects their ability ( $\sigma = \alpha$ ).

### *Equilibrium location when self-confidence accurately reflects ability*

At first glance the positive interaction between workers' ability and the more valuable experience and greater opportunities that the big city provides would suggest a straightforward 'assortative matching' result with low-ability workers locating in  $S$  both periods and high-ability workers locating in  $B$  both periods, with the exception of those high-ability workers who, having failed at the simple task in  $B$  when junior, move to  $S$  when senior. The previous lemmas, however, hint

at additional relocation trajectories. For instance, workers may decide to locate in  $S$  when junior to save on urban costs but then, if they are successful and acquire some experience, relocate to  $B$  when senior to take advantage of greater opportunities to put that experience to use. Alternatively, workers may decide to gain additional experience by locating in  $B$  when junior but then, even if they have been successful, relocate to  $S$  when senior and use their big-city experience there thus saving on urban costs. The existence of these trajectories clearly depends on whether the differences in experience or in opportunities between  $S$  and  $B$  dominate the tradeoffs that workers face given their ability.

The following proposition characterizes the exact conditions under which relocations may or may not take place in equilibrium.

**Proposition 1.** When workers' self-confidence while junior accurately reflects their ability ( $\sigma = \alpha$ ), location and relocation patterns fall in one of three cases.

Case 1. If  $\frac{\Delta e}{\Delta \Omega^2} < \frac{\pi_2 e_S^2}{\Omega_B \Delta \gamma}$ :

- Workers with  $\alpha \leq \alpha_{SB \succ SS}$  locate in  $S$  in both periods.
- Workers with  $\alpha_{SB \succ SS} < \alpha \leq \alpha_{BB \succ SB}$  locate in  $S$  when junior and, if and only if successful, relocate to  $B$  when senior.
- Workers with  $\alpha_{BB \succ SB} < \alpha$  locate in  $B$  in both periods unless they fail at the simple task when junior, in which case they relocate to  $S$  when senior.

Case 2. If  $\frac{\pi_2 e_S^2}{\Omega_B \Delta \gamma} \leq \frac{\Delta e}{\Delta \Omega^2} \leq \frac{\pi_2 e_B^2}{\Omega_S \Delta \gamma}$ :

- Workers with  $\alpha \leq \max(\alpha_{BB \succ BS}, \min(\alpha_{SB \succ SS}, \alpha_{BB \succ SS}))$  locate in  $S$  in both periods.
- Workers with  $\max(\alpha_{BB \succ BS}, \min(\alpha_{SB \succ SS}, \alpha_{BB \succ SS})) < \alpha$  locate in  $B$  in both periods unless they fail at the simple task when junior, in which case they relocate to  $S$  when senior.

Case 3. If  $\frac{\pi_2 e_B^2}{\Omega_S \Delta \gamma} < \frac{\Delta e}{\Delta \Omega^2}$ :

- Workers with  $\alpha \leq \alpha_{BS \succ SS}$  locate in  $S$  in both periods.
- Workers with  $\alpha_{BS \succ SS} < \alpha \leq \alpha_{BB \succ BS}$  locate in  $B$  when junior and relocate to  $S$  when senior.
- Workers with  $\alpha_{BB \succ BS} < \alpha$  locate in  $B$  in both periods unless they fail at the simple task when junior, in which case they relocate to  $S$  when senior.

*Proof* See appendix A. □

Intuitively, in all three cases described by the proposition, workers with high ability locate in  $B$  in both periods (provided they are successful at the simple task when junior) whereas workers with low ability locate in  $S$  in both periods. This is explained by the positive interaction between

workers' ability and the more valuable experience and opportunities provided by  $B$ . What differs across cases is, instead, the location of workers with intermediate ability.

In case 1, the difference between  $B$  and  $S$  in the value of experience acquired when junior is dwarfed by the difference in opportunities to use that experience when senior. Restated in terms of parameters,  $\Delta e$  is small relative to  $\Delta\Omega$ . This makes it worthwhile for workers of intermediate ability to locate in  $S$  when junior and in  $B$  when senior if successful at the simple task when junior. In this way, they avoid the higher urban costs of  $B$  when junior that, due to their moderate ability, is not compensated by a higher enough expected benefit in terms of differential experience. And yet, they relocate to  $B$  when senior since this provides sufficiently larger expected opportunities to offset the higher urban costs of  $B$  when senior.

In case 3, the situation is reversed: the difference between  $B$  and  $S$  in the value of experience acquired when junior dwarfs the difference in opportunities to use that experience when senior. Restated in terms of parameters,  $\Delta e$  is large relative to  $\Delta\Omega$ . This makes it worthwhile for workers of intermediate ability to locate in  $B$  when junior and in  $S$  when senior no matter whether they are successful or not at the simple task when junior. In this way they enjoy the more valuable experience associated with working in  $B$  when junior but avoid a higher urban cost when senior that, due to their moderate ability, is not compensated by a higher enough benefit in terms of differential opportunities.

In the intermediate case 2 neither the greater experience nor the greater opportunities of  $B$  dominate and changing location is not worthwhile irrespective of ability, even for workers who succeed at completing the first simple task when junior.

The three cases are respectively described in panels (a), (b) and (c) of figure 1 along the 45-degree line. The diagram in each panel represents self-confidence ( $\sigma$ ) on the horizontal axis and ability ( $\alpha$ ) on the vertical axis. Proposition 1 concerns the case where self-confidence accurately reflects ability ( $\sigma = \alpha$ ), which corresponds to the diagonal. For instance, in panel (a) (for case 1) the segment of the diagonal in the bottom-left of the diagram ( $\alpha \leq \alpha_{SB>SS}$ ) lies in an area marked  $SS$ , meaning that workers with low ability locate in  $S$  in both periods; the intermediate segment of the diagonal ( $\alpha_{SB>SS} < \alpha \leq \alpha_{BB>SB}$ ) lies in an area marked  $SB$ , meaning that workers with intermediate ability locate in  $S$  when junior and, if successful, relocate to  $B$  when senior; the top-right segment of the diagonal ( $\alpha_{BB>SB} < \alpha$ ) lies in an area marked  $BB$ , meaning that workers with high ability locate in  $B$  in both periods unless they fail at the simple task when junior, in which case they relocate to  $S$  when senior. The area off the diagonal corresponds to cases where a worker's self-confidence when junior may not accurately reflect her actual ability, to which we turn next.

### ***Equilibrium location when self-confidence does not reflect ability accurately***

We now consider the situation in which a worker's self-confidence when junior may not accurately reflect her actual ability ( $\sigma \neq \alpha$ ). Only after trying to complete a simple task for the first time does a worker realize her actual ability. To remain as general as possible, we do not make any specific assumption on the correlation between self-confidence and ability, characterizing instead the equilibrium location of workers for all possible combinations of  $\sigma$  and  $\alpha$ .

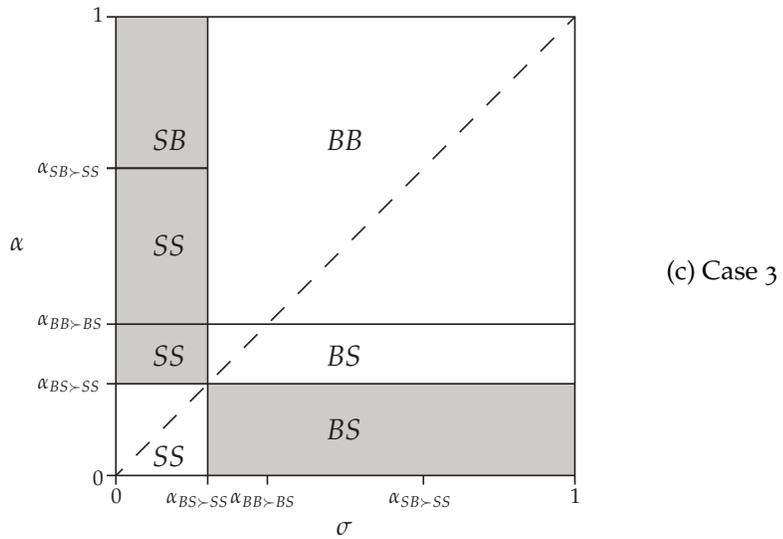
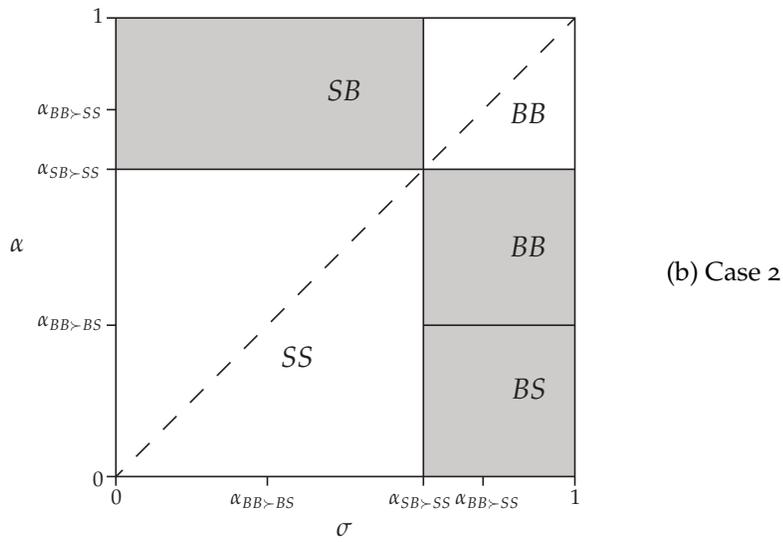
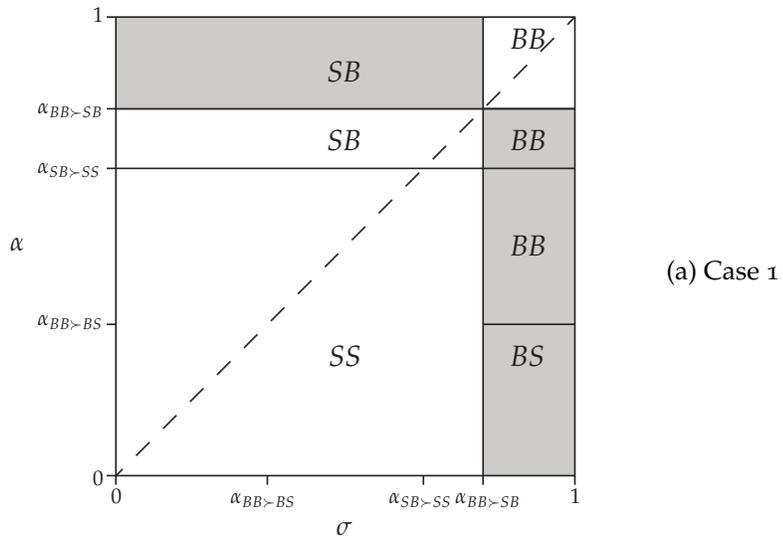


Figure 1: Equilibrium location choices by self-confidence and ability

When self-confidence in the junior period does not accurately reflect a worker's ability, both junior and senior location decisions change. The junior decision is still driven by the same tradeoffs as before but it is now based on the individual's self-confidence  $\sigma$  (i.e., her prior about her ability) rather than her ability  $\alpha$ . The senior decision is also affected. While  $\alpha$  is known to the senior worker, her junior period decision affects her experience, which in turn affects the relative incentives to locate in  $B$  or  $S$  when senior.

The main implication is that workers whose self-confidence is very different from their ability may end up making decisions they would not have made if they had known their actual ability to start with. The resulting patterns of self-deceit are summarized in the following proposition.

**Proposition 2.** When workers' self-confidence while junior does not reflect ability accurately ( $\sigma \neq \alpha$ ), location and relocation patterns fall in one of three cases.

Case 1. If  $\frac{\Delta e}{\Delta \Omega^2} < \frac{\pi_2 e_S^2}{\Omega_B \Delta \gamma}$ :

- During their junior period
  - Workers with  $\sigma \leq \alpha_{BB>SB}$  locate in  $S$ .
  - Workers with  $\alpha_{BB>SB} < \sigma$  locate in  $B$ .
- During their senior period
  - Workers with  $\alpha \leq \alpha_{BB>BS}$  locate in  $S$ .
  - Workers with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$  locate in  $B$  if  $\alpha_{BB>SB} < \sigma$  and they succeed at the simple task when junior; they locate in  $S$  otherwise.
  - Workers with  $\alpha_{SB>SS} < \alpha$  locate in  $B$  if they succeed at the simple task when junior; they locate in  $S$  otherwise.

Case 2. If  $\frac{\pi_2 e_S^2}{\Omega_B \Delta \gamma} \leq \frac{\Delta e}{\Delta \Omega^2} \leq \frac{\pi_2 e_B^2}{\Omega_S \Delta \gamma}$ :

- During their junior period
  - Workers with  $\sigma \leq \max(\alpha_{BB>BS}, \min(\alpha_{SB>SS}, \alpha_{BB>SS}))$  locate in  $S$ .
  - Workers with  $\max(\alpha_{BB>BS}, \min(\alpha_{SB>SS}, \alpha_{BB>SS})) < \sigma$  locate in  $B$ .
- During their senior period
  - Workers with  $\alpha \leq \alpha_{BB>BS}$  locate in  $S$ .
  - Workers with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$  locate in  $B$  if they succeed at the simple task when junior and  $\max(\alpha_{BB>BS}, \min(\alpha_{SB>SS}, \alpha_{BB>SS})) < \sigma$ ; they locate in  $S$  otherwise.
  - Workers with  $\alpha_{SB>SS} < \alpha$  locate in  $B$  if they succeed at the simple task when junior; they locate in  $S$  otherwise.

Case 3. If  $\frac{\pi_2 e_B^2}{\Omega_S \Delta \gamma} < \frac{\Delta e}{\Delta \Omega^2}$ :

- During their junior period

- Workers with  $\sigma \leq \alpha_{BS>SS}$  locate in  $S$ .
- Workers with  $\alpha_{BS>SS} < \sigma$  locate in  $B$ .
- During their senior period
  - Workers with  $\alpha \leq \alpha_{BB>BS}$  locate in  $S$ .
  - Workers with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$  locate in  $B$  if  $\alpha_{BS>SS} < \sigma$  and they succeed at the simple task when junior; they locate in  $S$  otherwise.
  - Workers with  $\alpha_{SB>SS} < \alpha$  locate in  $B$  if they succeed at the simple task when junior; they locate in  $S$  otherwise.

**Proof** Location decisions when junior follow directly from Proposition 1, but with ability  $\alpha$  replaced by self-confidence  $\sigma$ .

Locations decisions when senior depend on the value of  $\alpha$  relative to the thresholds  $\alpha_{BB>BS}$  and  $\alpha_{SB>SS}$ .

Starting from the lowest ability, consider first workers with  $\alpha \leq \alpha_{BB>BS}$ . By Lemma 1, such workers always locate in  $S$  when senior.

Consider next workers with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$ . By Lemma 1, workers with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$  locate in  $B$  when senior if and only if they locate in  $B$  when junior and succeed at the simple task. We now need to distinguish the same three cases as in Proposition 1. In case 1, by Proposition 1 (with  $\alpha$  replaced by  $\sigma$ ), workers with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$  locate in  $B$  when junior (and thus also when senior if successful at the simple task) if and only if  $\alpha_{BB>SB} < \sigma$ . In case 2, by Proposition 1 (with  $\alpha$  replaced by  $\sigma$ ), workers with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$  locate in  $B$  when junior (and thus also when senior if successful at the simple task) if and only if  $\max(\alpha_{BB>BS}, \min(\alpha_{SB>SS}, \alpha_{BB>SS})) < \sigma$ . In case 3, by Proposition 1 (with  $\alpha$  replaced by  $\sigma$ ), workers with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$  locate in  $B$  when junior (and thus also when senior if successful at the simple task) if and only if  $\alpha_{BS>SS} < \sigma$ .

Turning finally to workers with  $\alpha_{SB>SS} < \alpha$ , by Lemma 1, such workers always locate in  $B$  when senior if they succeed at the simple task when junior; they locate in  $S$  otherwise.  $\square$

The three cases are again described in the three panels of figure 1, the focus being now on the area away from the 45-degree line where self-confidence and ability do not coincide ( $\sigma \neq \alpha$ ). The intuition behind the existence of these three cases is the same as before: in the first case the difference in opportunities between  $B$  and  $S$  dominates; in the second case neither the difference in experience nor the difference in opportunities prevails; in the third case it is the difference in experience that dominates. The novelty is the presence of new trajectories that did not arise before and correspond to the shaded areas in the three figures.

In panel (a) of figure 1, for case 1, where the difference in opportunities between  $B$  and  $S$  dominates, most new trajectories arise for workers who locate in  $B$  when junior due to their overconfidence ( $\alpha < \sigma$ ). Believing it is worthwhile for them to incur the higher cost of  $B$ , they locate in  $B$  when junior while, had they accurately assessed their ability when young, they would have located in  $S$  instead. What happens to them depends on how high their ability turns out to be.

A first group consists of overconfident workers with high-enough ability to locate in  $B$  when senior no matter where they have completed the simple task when junior ( $\alpha_{SB>SS} < \alpha < \alpha_{BB>SB}$ ). Their ability, however, would not be high enough to justify location in  $B$  when junior if correctly assessed. Yet, their overconfidence brings them to  $B$  when junior and there they remain if they are lucky enough to complete the simple task. These are the workers whose  $\sigma$  and  $\alpha$  fall in the top right shaded rectangle labelled  $BB$ .

A second group consists of workers with intermediate ability ( $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$ ) who also locate in  $B$  when junior due to overconfidence (and are lucky enough to gain experience  $e_B$ ). These are the workers whose  $\sigma$  and  $\alpha$  fall in the middle right shaded rectangle labelled  $BB$ . Going horizontally from this rectangle to the diagonal, we see that these workers, had they accurately assessed their ability when junior, would have located in  $S$  in both periods. However, given that they located in  $B$  when junior driven by their overconfidence and gained some valuable experience, and in light of their intermediate ability, now it is worthwhile for them to stay in  $B$  when senior.

A third group consists of workers who decide to locate in  $B$  when junior unaware of their very low ability ( $\alpha \leq \alpha_{BB>BS}$ ). Some of them are lucky: they succeed at the simple task and gain higher experience  $e_B$ . However, while completing the simple task, they realize that their ability is too low to stand a good enough chance of exploiting higher opportunities  $\Omega_B$  by remaining in  $B$ , so they relocate to  $S$  when senior. This holds for all workers whose  $\sigma$  and  $\alpha$  fall in the bottom right shaded rectangle labelled  $BS$ . Going horizontally from this rectangle to the diagonal, we see that these workers, had they accurately assessed their ability when young, would have instead located in  $S$  both periods.

In addition to the three new trajectories for overconfident workers, in panel (a) there is also one new trajectory due to underconfident workers. Underconfident workers with very high ability locate in  $S$  when junior and, if successful as junior, move to  $B$  when senior once they realize that their ability is high enough to exploit better opportunities there. These are the workers whose  $\sigma$  and  $\alpha$  fall in the top left shaded rectangle labelled  $SB$ .

Panel (b) of figure 1 corresponds to case 2, where neither the difference in opportunities nor the difference in the value of experience between  $B$  and  $S$  dominate. The inaccurate assessment of ability when junior makes a difference for overconfident workers with low ability, who would locate in both periods in  $S$  if correctly informed, and for underconfident workers with high ability, who would locate in both periods in  $B$  if correctly informed.

Overconfident workers with very low ability locate in  $B$  when junior and, even if successful as junior, relocate to  $S$  when senior once they realize that their ability is too low to benefit from better opportunities in  $B$ . These are the workers whose  $\sigma$  and  $\alpha$  fall in the bottom right shaded rectangle labelled  $BS$ . Then there are other overconfident workers of higher ability who when junior are brought to  $B$  by their overconfidence and are lucky enough to succeed at the simple task. Thanks to the higher experience gained and their higher ability, it is beneficial for them to stay in  $B$  also when senior. These are the workers whose  $\sigma$  and  $\alpha$  fall in the middle right shaded rectangle labelled  $BB$ .

Conversely, underconfident workers with very high ability locate in  $S$  when junior and, if successful as junior, move to  $B$  when senior once they realize that their ability is high enough to

exploit better opportunities there. These are the workers whose  $\sigma$  and  $\alpha$  fall in the top left shaded rectangle labelled  $SB$ .<sup>8</sup>

Panel (c) at the bottom of figure 1 corresponds to case 3, where the difference in the value of experience between  $B$  and  $S$  dominates. In this case, most new trajectories are driven by workers who locate in  $S$  when junior due to their underconfidence ( $\sigma < \alpha$ ). Believing it is not worthwhile for them to incur the higher cost of  $B$ , they locate in  $S$  when junior while, had they accurately assessed their ability when young, they would have located in  $B$  instead. What happens to them depends on how high their ability turns out to be.

Underconfident workers with very high ability ( $\alpha_{SB>SS} < \alpha$ ), as long as they succeed at completing the simple task when junior, find it worthwhile moving to  $B$  when senior. Thus, their senior location is not affected, although, having gained less experience by locating in  $S$  when junior, they are nevertheless less likely to succeed at the complex task than if they had located in  $B$ . These are the workers whose  $\sigma$  and  $\alpha$  fall in the top left shaded rectangle labelled  $SB$ .

For those among underconfident workers with intermediate ability ( $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$ ) locating in  $S$  when junior affects their senior location choice. Had they accurately assessed their ability when young, they would have located both periods in  $B$ . Having instead located in  $S$  when junior due to underconfidence, they gain less valuable experience even if successful and now do not find it worthwhile to locate in  $B$  when senior given that the difference in opportunities between  $B$  and  $S$  is limited. These are the workers whose  $\sigma$  and  $\alpha$  fall in the higher of the two left shaded rectangles labelled  $SS$ .

Underconfident workers with lower ability ( $\alpha_{BS>SS} < \alpha \leq \alpha_{BB>BS}$ ) would not have located in  $B$  when senior regardless. Their underconfidence merely leads them to locate in  $S$  instead of  $B$  when junior. These are the workers whose  $\sigma$  and  $\alpha$  fall in the lower of the two left shaded rectangles labelled  $SS$ .

Finally, some overconfident workers with very low ability ( $\alpha \leq \alpha_{BS>SS} < \sigma$ ) follow the same pattern as in case 1. Driven by their overconfidence, they locate in  $B$  when junior. Then, realizing that their ability is too low, they move to  $S$  when senior even if successful at the simple task. Had they correctly anticipated their low ability, they would have located in  $S$  both periods. This holds for all workers whose  $\sigma$  and  $\alpha$  fall in the bottom left shaded rectangle labelled  $BS$ .

#### 4. Endogenizing urban structure

We now endogenize the urban structure and solve for the general equilibrium of our model. Suppose each of the two cities  $B$  and  $S$  is linear and monocentric.<sup>9</sup> Land covered by each city is endogenously determined and can be represented by a segment on the positive real line. All workers in a city perform their job at a single point  $x = 0$ , the Central Business District (CBD).

<sup>8</sup>The aspect of panel (b) will vary slightly depending on where  $\alpha_{BB>SS}$  lies relative to  $\alpha_{BB>BS}$  and  $\alpha_{SB>SS}$ . The panel is represented for  $\alpha_{SB>SS} < \alpha_{BB>SS}$  so that  $\max(\alpha_{BB>BS}, \min(\alpha_{SB>SS}, \alpha_{BB>SS})) = \alpha_{SB>SS}$ , but conclusions are very similar regardless. The only difference is that as we let  $\alpha_{BB>SS}$  fall in value, a new shaded area marked  $SS$  appears in the middle left while the shaded area marked  $BB$  in the middle right shrinks in size until it ends up disappearing.

<sup>9</sup>We develop a highly simplified version of the monocentric city model (Alonso, 1964, Mills, 1967, Muth, 1969). For an exposition of more general versions of the monocentric city model, see Brueckner (1987) and Duranton and Puga (2015).

Workers consume housing and a freely tradable numéraire good. For simplicity, let us assume that all residences have the same size, are built under perfect competition with a constant capital to land ratio, and are owned by absentee landlords.<sup>10</sup> Thus, every individual consumes one unit of floorspace built on one unit of land with a fixed amount of capital. The price of capital is constant throughout the economy while the price of land varies. Commuting costs increase linearly with distance to the CBD, so that a worker living at distance  $x$  incurs a commuting cost  $\tau x$ . The total urban costs for a worker located in a residence at a distance  $x$  from the CBD of city  $i$  are the sum of her commuting costs  $\tau x$  and her housing costs  $P_i(x)$ :

$$\gamma_i(x) = \tau x + P_i(x), \quad i, j \in \{B, S\}. \quad (16)$$

As a result, any resident in a city is willing to bid  $\tau x$  more for a house that is  $x$  closer to the CBD.<sup>11</sup> Equilibrium house prices are then such that the increase in commuting costs incurred as one relocates towards the CBD is exactly offset by an increase in house prices.

Using  $N_i$  to denote the equilibrium population in city  $i$ , house prices in city  $i$  can then be expressed as

$$P_i(x) = \tau(N_i - x) + \bar{r}, \quad i, j \in \{B, S\}, \quad (17)$$

where the constant  $\bar{r}$  is the sum of the rental cost of the fixed amount of capital used in every residence and the rental price of land in the best non-urban use (e.g., agriculture). A worker living at the edge of a city has to commute a distance equal to the population of the city, thus incurring a commuting cost  $\tau N_i$ , but only pays  $\bar{r}$  for housing. A worker living at the CBD has no cost of commuting but pays an additional  $\tau N_i$  for her house. Substituting equation (17) into (16) yields urban cost in city  $i$ :

$$\gamma_i = \tau N_i + \bar{r}, \quad i, j \in \{B, S\}. \quad (18)$$

In order to allow for the coexistence of junior and senior workers in a city, let us assume that there are overlapping generations of workers. Each generation is made up of a continuum of workers of measure 1 and lives for two periods. Thus, workers coexist when junior with senior workers of the previous generation and coexist when senior with junior workers of the next generation. Since our focus is on the steady state, we avoid using a time subscript for our variables.

The total population of city  $i$ ,  $N_i$ , is the sum of junior and senior workers in the city. Let us denote by  $n$  the difference in population between the big and the small city:

$$n \equiv N_B - N_S. \quad (19)$$

Note that  $0 \leq n \leq 2$  since, by definition, the big city has a larger population and since the total population in the economy at any point in time is made up of two living generations with unit population mass each. Combining equations (18) and (19), we can then express the difference in urban costs between  $B$  and  $S$ ,  $\Delta\gamma \equiv \gamma_B - \gamma_S$ , as

$$\Delta\gamma = \tau n. \quad (20)$$

<sup>10</sup>Having instead common ownership of the housing stock by local residents yields essentially the same results. One simply gets  $\gamma_i = \frac{1}{2}\tau N_i$  instead of  $\gamma_i = \tau N_i$  in equation (18) below.

<sup>11</sup>Note that the assumptions of homogenous commuting costs and fixed housing consumption imply a common bid-rent schedule for all workers, allowing us to abstract from within-city sorting.

Taking  $n$  as given, each worker can calculate  $\Delta\gamma$  as per equation (20). She can then substitute this into equation (3) to calculate  $\alpha_{BB>BS}$ , into (7) to calculate  $\alpha_{SB>SS}$ , into (10) to calculate  $\alpha_{BS>SS}$ , into (13) to calculate  $\alpha_{BB>SS}$ , and into (15) to calculate  $\alpha_{BB>SB}$ . Given all these thresholds, each worker chooses her optimal location as per proposition 2. If we then add up how many workers choose to locate in each city, an equilibrium arises when this yields a difference in population between the two cities equal to  $n$ .

Adding  $N_B + N_S = 2$  to equation (19) and solving for  $N_B$ , we can express population in  $B$  in terms of  $n$ :

$$N_B = 1 + \frac{n}{2}. \quad (21)$$

In equilibrium this must equal the total number of junior and senior workers choosing to reside in  $B$ , which we will denote by  $b(n)$ . To obtain an expression for  $b(n)$ , we must refer back to proposition 2. Proposition 2 distinguishes three cases depending on the value of  $\Delta\gamma = \tau n$ . Expressing the corresponding conditions in terms of  $n$ , case 1 arises for  $0 \leq n < \underline{n}$ , where  $\underline{n} \equiv \frac{\pi_2 e_S^2 \Delta \Omega^2}{\tau \Omega_B \Delta e}$ ; case 2 arises for  $\underline{n} \leq n \leq \bar{n}$ , where  $\bar{n} \equiv \frac{\pi_2 e_B^2 \Delta \Omega^2}{\tau \Omega_S \Delta e}$ ; and case 3 arises for  $\bar{n} < n \leq 2$ . Let us denote by  $f(\sigma, \alpha)$  the probability density function for the bivariate distribution of ability and self-confidence for individual workers in the population. Hence, we can write:

$$b(n) = \begin{cases} \int_{\alpha_{BB>SB}(n)}^1 \int_0^1 f(\sigma, \alpha) d\alpha d\sigma + \int_{\alpha_{BB>SB}(n)}^1 \int_{\alpha_{BB>BS}(n)}^{\alpha_{SB>SS}(n)} \alpha f(\sigma, \alpha) d\alpha d\sigma + \int_0^1 \int_{\alpha_{SB>SS}(n)}^1 \alpha f(\sigma, \alpha) d\alpha d\sigma & \text{if } 0 \leq n < \underline{n} \\ \int_{\alpha_{\max \min}(n)}^1 \int_0^1 f(\sigma, \alpha) d\alpha d\sigma + \int_{\alpha_{\max \min}(n)}^1 \int_{\alpha_{BB>BS}(n)}^{\alpha_{SB>SS}(n)} \alpha f(\sigma, \alpha) d\alpha d\sigma + \int_0^1 \int_{\alpha_{SB>SS}(n)}^1 \alpha f(\sigma, \alpha) d\alpha d\sigma & \text{if } \underline{n} \leq n \leq \bar{n} \\ \int_{\alpha_{BS>SS}(n)}^1 \int_0^1 f(\sigma, \alpha) d\alpha d\sigma + \int_{\alpha_{BS>SS}(n)}^1 \int_{\alpha_{BB>BS}(n)}^{\alpha_{SB>SS}(n)} \alpha f(\sigma, \alpha) d\alpha d\sigma + \int_0^1 \int_{\alpha_{SB>SS}(n)}^1 \alpha f(\sigma, \alpha) d\alpha d\sigma & \text{if } \bar{n} < n \leq 2 \end{cases} \quad (22)$$

with  $\alpha_{\max \min}(n) \equiv \max(\alpha_{BB>BS}(n), \min(\alpha_{SB>SS}(n), \alpha_{BB>SS}(n)))$ .

Equation (22) can be readily understood by referring back to proposition 2. For example, the first case (for  $0 \leq n < \underline{n}$ ) has three types of workers choosing to locate in  $B$  (each type captured by one of the three double integrals for this first case): junior workers with high self-confidence  $\alpha_{BB>SB} < \sigma$ ; senior workers with intermediate ability  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$  who in their junior period located in  $B$  due to high-self-confidence  $\alpha_{BB>SB} < \sigma$  and succeeded at the simple task (probability  $\alpha$ ); and senior workers with high ability  $\alpha_{SB>SS} < \alpha$ , regardless of their self confidence, provided they succeeded at the simple task when junior (probability  $\alpha$ ).

We can also interpret equation (22) in terms of figure 1. Given the unit population mass of each generation of workers, the number of junior workers who decide to reside in  $B$  is given by the fraction of them with self-confidence and ability in rectangles  $BB$  or  $BS$ . The number of senior workers who decide to reside in  $B$  is given by the fraction of them with self-confidence and ability

in rectangles  $BB$  or  $SB$  weighted by the probability  $\alpha$  that they successfully completed the simple task when junior.

Any equilibrium value of  $n$  has to satisfy  $b(n) = 1 + \frac{n}{2}$  for  $0 \leq n \leq 2$ . Under the assumption that  $f(\sigma, \alpha)$  is continuous and differentiable in  $\alpha \in [0, 1]$  and  $\sigma \in [0, 1]$ , the following result holds.

**Proposition 3.** There exists a unique equilibrium allocation of population across cities. In equilibrium, both the big and small cities are populated. The difference  $n$  in population between the big and small cities decreases with the common commuting cost per unit of distance  $\tau$ , and increases with the additional opportunities  $\Delta\Omega$  and the additional experience  $\Delta e$  provided by the bigger city.

*Proof* See appendix B. □

When deciding whether to locate in  $B$ , junior workers trade off the greater experience they are likely to acquire by locating there against the higher urban costs they need to incur. Senior workers trade off the greater opportunities  $B$  provides to use their previously-acquired experience against its higher urban costs. In equilibrium, some workers strictly prefer to locate in  $B$  and others strictly prefer to locate in  $S$ . Individual choices depend on self-confidence, ability and luck, all of which vary across workers, on common parameters capturing the magnitude of the advantages and disadvantages of locating in the big city, and on the choices of other workers.

In equilibrium, the difference in population  $n$  between  $B$  and  $S$  is such that the difference between the mass of workers who prefer to locate in  $B$  and the mass of workers who prefer to locate in  $S$  in light of that difference  $n$  aggregates up to precisely  $n$ . Off-equilibrium, the mass of workers who given  $n$  prefer  $B$  to  $S$  may aggregate up to more than  $n$ , but as more workers locate in  $B$  and fewer in  $S$  commuting and housing costs increase in  $B$  relative to  $S$  until an equilibrium is restored. And conversely if the mass of workers who given  $n$  prefer  $B$  to  $S$  aggregates up to less than  $n$ .

The higher the common cost of commuting per unit of distance,  $\tau$ , the greater the difference in urban costs for any given difference in population between  $B$  and  $S$ , and hence the smaller is  $n$  in equilibrium. The greater the additional opportunities  $\Delta\Omega$  and the additional experience  $\Delta e$  provided by  $B$ , the greater its attractiveness relative to  $S$  so a higher difference in population  $n$  (which results in a higher difference in urban costs) is needed to balance things out in equilibrium.

## 5. Data

We use panel data from the “cross-sectional sample” of the National Longitudinal Survey of Youth 1979 (NLSY79). The survey, conducted by the US Department of Labor’s Bureau of Labor Statistics, follows a nationally representative sample of 6,111 men and women who were 14–22 years old when they were first surveyed in 1979. These individuals were interviewed annually through 1994 and are currently interviewed on a biennial basis. The NLSY79 contains information on a rich set of personal characteristics and tracks individuals’ labour market activities.

## *Locations*

The confidential geocoded portion of the NLSY79 gathers information on the location of each respondent at multiple points in time. Specifically, for each respondent we know the county and state where they are located at birth, at age 14, and at each interview date since 1979. We use this location information to link the counties of location of each respondent to Core Based Statistical Areas (CBSA) as defined in 2008. A CBSA or metropolitan area is a collection of counties that delimits a local labour market.<sup>12</sup> We classify individuals as located in a big city if they are within a CBSA with a population over two million in 2010. By this definition, 44 CBSA metropolitan areas are classified as big (from Kansas City with a population of just over 2 million to New York with almost 19 million). This is in line with other papers dealing with urban sorting, which typically classify cities as big when their population is above a threshold of between 1.5 million (Baum-Snow and Pavan, 2012) and 2.5 million (Eeckhout, Pinheiro, and Schmidheiny, 2014). Our results are robust to using these alternative definitions.

## *Ability*

Importantly for us, the NLSY79 contains test results that aim to capture cognitive ability as well as self-evaluation. Our basic measure of ability is the individual's percentile score in the Armed Forces Qualification Test (AFQT), a cognitive ability test that was administered to NLSY79 respondents in 1980, when their median age was 19.

For some additional results, we also construct an alternative measure of skills following Eeckhout, Pinheiro, and Schmidheiny (2014). They argue that, in a spatial equilibrium model with worker mobility and Cobb-Douglas preferences, any differences in real wages across individuals reflect differences in their skills. To construct this price-theoretic measure of skills, we first identify the last wave in NLSY79 where an individual reports a wage, which corresponds to 2010 for the majority of the sample. Davis and Ortalo-Magné (2011) show that in the United States housing expenditure shares are, to a large extent, constant across metropolitan areas despite large differences in average income levels (hence the Cobb-Douglas assumption). Thus, like Eeckhout, Pinheiro, and Schmidheiny (2014), we adjust nominal wages for housing cost differences across cities using the median housing expenditure share of 0.24. Housing costs are measured through mean rental price indices for the individual's metropolitan areas of residence, calculated from the 2009 American Community Survey.<sup>13</sup> If  $w$  is the individual's log nominal wage and  $h$  the log rental price index for the individual's metropolitan area of residence, the Eeckhout, Pinheiro, and Schmidheiny (2014) price-theoretic measure of skills is  $w - 0.24h$ .

The moderate correlation between the two measures of ability we use, 0.42, suggests that they capture different dimensions of skills. While the AFQT score approximates cognitive ability, the

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<sup>12</sup>Core Based Statistical Areas (CBSA) are defined by the Office of Management and Budget. These CBSA metropolitan areas have replaced the metropolitan areas that were defined based on the 1990 census.

<sup>13</sup>Most workers report a wage in 2010 (72%). For the small share of workers who report their last wage in the 2008 wave (9%), we also use 2009 metropolitan area rental price indices to construct their measure of skills. For workers who report their last wage in 2004 or 2006 (7%), we calculate rental price indices using data from the 2005 American Community Survey. Last, for workers who report their last wage in 1998, 2000 or 2002 (12%), we calculate rental price indices using data from the 2000 Decennial Census.

Eeckhout, Pinheiro, and Schmidheiny (2014) price-theoretic measure of skills reflects not just cognitive ability but also other traits that may be valuable in the job market and, importantly, the consequences of earlier individual decisions, including location, training and job choices.

### *Self-confidence*

In our model, we use the term self-confidence to refer to individuals' perception of their own ability. Psychologists often use the term 'general self-efficacy' to capture this aspect of self-evaluation. This is defined as "individuals' perception of their ability to perform across a variety of different situations" (Judge, Erez, and Bono, 1998, p. 170). While the NLSY79 does not measure general self-efficacy per se, it does measure self-esteem, which is strongly related to it. Self-esteem is defined as "the overall value one places on oneself as a person" (Harter, 1990, p. 67). Conceptually, general self-efficacy and self-esteem are somewhat different aspects of self-evaluation in that self-esteem is a broader concept. However, there is a very strong empirical association between them. Respondents of the NLSY79 were subject in 1980 to a test to measure their self-esteem using Rosenberg's (1965) self-esteem scale. Summarising extant results on the relationship between Rosenberg's measure and general self-efficacy, Chen, Gully, and Eden (2001, p. 67) note that "the standard general self-efficacy scale is correlated highly with the Rosenberg (1965) self-esteem scale ( $r = .75$  to  $.91$ )" and conclude that general self-efficacy "does not capture a construct distinct from self-esteem." Judge, Erez, and Bono (1998) argue that both concepts are strongly related to individuals' assessment of their own ability to perform on the job.

The Rosenberg (1965) measure is based on a ten-item questionnaire that assesses the self-evaluation of respondents through their expressed agreement or disagreement with various statements (e.g., "I am able to do things as well as most other people"). Five of the items have positively-worded statements and are assigned a score between 0 and 3 based on increasing agreement with the statement (strongly disagree, disagree, agree, strongly agree). Five of the items have negatively-worded statements and are assigned a score between 0 and 3 based on increasing disagreement with the statement. The Rosenberg measure is calculated by adding up the scores for all ten items. We convert the measure into a percentile score and use that as our measure of self-confidence. For us, it is important that this measure predates labour market experience since labour market outcomes could feed back into self-confidence (see the discussion in section 8 of Almlund, Duckworth, Heckman, and Kautz, 2011). It is also worth noting that respondents were subject to the Rosenberg test before they were given their results on the AFQT test of cognitive ability. The low correlation between the AFQT and Rosenberg scores, 0.3, reflects the pervasiveness of flawed self-evaluation and is in line with that reported in psychology studies such as the aforementioned Hansford and Hattie (1982).

### *Periods*

To test the implications of our model, we need to define two periods (junior and senior) and relate respondents' location trajectories to their levels of ability and self-confidence. To match our model, we would like to use as the junior period for each individual the time immediately prior to entering

the labour market and to use as the senior period a time that is late enough that he or she has accumulated significant labour market experience.

The NLSY79 records detailed information on the educational attainment of respondents over time, so that in each wave, we know their highest grade completed and their schooling enrolment status. We set the junior period for all respondents at the year after the highest level of education is completed.<sup>14</sup> The average age of individuals in their junior period is 20.4 for high school graduates and 24.1 for college graduates. We then determine whether each individual was located in a big metropolitan area or not in this junior period.<sup>15</sup>

Next, we set the senior period for all respondents by adding ten years to their junior period. The average age of individuals in their senior period is 30.2 for high school graduates and 33.3 for college graduates. Again, we determine whether each individual was located in a big metropolitan area or not in this senior period.

Our starting sample is made of 6,111 individuals. We exclude individuals for whom the AFQT or the Rosenberg self-esteem scores are missing, which reduces the sample to 5,622 individuals. We are able to determine the junior period location of 5,402 individuals. Availability of the demographic controls we use further reduces our sample to 5,244.<sup>16</sup>

## 6. Empirical evidence

### *Observed location choices by self-confidence and ability*

We begin by examining how the location choices of individuals in their junior and senior periods vary with self-confidence and ability. To better illustrate location choices graphically and to relate these choices to the theoretical predictions depicted in figure 1, we first divide both the self-confidence and the ability measures into terciles. This yields nine possible combinations of self-confidence and ability. Figure 2 plots in a grid each of those nine combinations of self-confidence and ability, with self-confidence on the horizontal axis and ability on the vertical axis. If individuals chose a location strategy independently of their ability and self-confidence, the prevalence of each location strategy in each of these nine cells should be the same regardless of ability and self-confidence. Instead, different location strategies turn out to be more or less

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<sup>14</sup>We exclude educational periods that take place after a spell of more than two years away from any educational institution. For example, if an individual completes an undergraduate university degree, works for three or more years, and then goes back to university to pursue postgraduate studies, we take the year after completing the undergraduate degree as this individual's junior period, not the year after completing the postgraduate degree.

<sup>15</sup>Using information on current enrolment status in each wave, for 4,002 respondents we can identify the year in which they completed their highest level of education (excluding enrolments after spells away from education longer than two years). We use the following year as their junior period. The majority of the remaining respondents who never report any spell of educational enrolment are high-school graduates who were older than 18 in 1979, so we use 1979 as their junior period.

<sup>16</sup>Since the NLSY79 became biennial after 1994, for some individuals there is no interview ten years after their junior period and we must use the preceding or subsequent year.

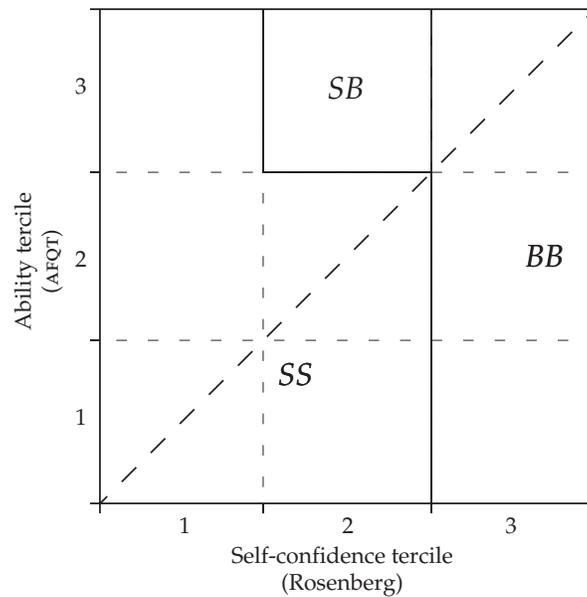


Figure 2: Observed location choices (compared to average location choice)

prevalent depending on the values of ability and self-confidence.<sup>17</sup> Using the same notation as in figure 1, in figure 2 we assign to each grid cell the most prevalent location trajectory observed in the data for that combination of self-confidence and ability.

Looking first at the three cells along diagonal of figure 2 (representing individuals whose self-confidence and ability are well aligned), we see that individuals with low and intermediate values of both self-confidence and ability tend to locate in small cities when junior and to remain there. Similarly, individuals with high values of both self-confidence and ability tend to locate in big cities when junior and to remain there. This assortative matching between cities and workers with an accurate self-assessment matches well with our theoretical predictions. Looking back at the three cases in figure 1, we can see that while all three have *SS* at the bottom left corner and *BB* at the top right corner, the complete coverage of the diagonal with *SS* and *BB* best matches case 2.

Turning to individuals whose self-assessment is less accurate, consider next individuals with intermediate values of self-confidence but whose ability is not intermediate but either high or low. It is worth noting that such combinations of self-confidence and ability are very common in practice. In fact, in our data individuals in the middle tercile of self-confidence are almost equally likely to be in the top, middle and bottom terciles of ability.<sup>18</sup> Looking at figure 2, we see that individuals with intermediate self-confidence and low ability (bottom middle cell) tend to locate in small cities when junior and remain there. According to our model, by not having high self-confidence these individuals choose to locate in a small city when junior and, if they

<sup>17</sup>As usual when measuring localisation, the relevant benchmark is not a uniform distribution but the distribution that would arise under random location choices (see e.g. Ellison and Glaeser, 1997, Duranton and Overman, 2005). Thus, we measure the prevalence of each location trajectory relative to a random-location benchmark in which each individual followed each location strategy with the same probability as the share of that strategy in the aggregate population regardless of ability and self-confidence.

<sup>18</sup>The percentage of individuals in each of the three cells in the middle tercile of self-confidence is 11.2% for those in the top tercile of ability, 12.2% for those in the middle tercile of ability, and 11.8% for those in the bottom tercile of ability. Not only are these percentiles similar, but they are also not far from the 11.1% that would correspond to a uniform bivariate distribution of self-confidence and ability.

subsequently realize their ability is low, they have no reason to alter this initial location choice. Individuals who instead have intermediate self-confidence and high ability (top middle cell) tend to locate in small cities when junior but to then relocate to big cities. Our model suggests that, finding that they unexpectedly have high ability, these individuals move away from small cities where their under-confidence led them to locate initially. Thus, both these empirical outcomes match well again with our theoretical predictions, particularly with cases 1 and 2.

The only two cells in figure 2 that do not match with panel (b) of figure 1 are those for opposite terciles of self-confidence and ability. Individuals in the highest tercile of self-confidence and the lowest tercile of ability tend to locate in big cities in both periods, as indicated by *BB* in the bottom right cell of figure 2. In panel (b) of figure 1, this bottom right range is marked *BS* instead. And yet this difference between the theoretical predictions and the empirical findings will disappear if  $\alpha_{BB>BS} \equiv \frac{\Delta\gamma}{e_B \pi_2 \Delta\Omega}$  is quite low, which will tend to increase the prevalence of *BB* relative to *BS* in the bottom right part of the figure. Intuitively, this happens if  $e_B$  and  $\Delta\Omega$  are quite large. Then, workers with low ability who are driven to the big city when junior due to overconfidence and get lucky in solving the simple task are able to accumulate significant experience  $e_B$ . Despite their low ability, given their valuable big city experience and the much greater opportunities that big cities provide,  $\Delta\Omega$ , they choose to remain there. Our regression results below provide additional support for this interpretation.

Individuals in the lowest tercile of self-confidence and the highest tercile of ability tend to locate in small cities in both periods, as indicated by *SS* in the top left cell of figure 2. In panel (b) of figure 1, this range is marked *SB* instead. This empirical outcome is not as easy to reconcile with the model. One possible explanation is that, while in the model junior workers only make a location decision based on self-confidence, in practice they make additional decisions. For instance, workers who have very little confidence in their ability, in addition to locating in a small city, may engage in less training, not work as hard, etc. If they then realize their ability is much higher than they thought, it may be too late to make up for the lack of investment in building up their capabilities when junior, and they end up staying in the small city when senior even if they are very able. A second explanation is that data for this range are quite noisy. Workers with self-confidence in the lowest tercile and ability in the highest tercile are relatively uncommon and tend to have a different type of low self-confidence: they tend to be simultaneously aware of their abilities and quite critical of themselves (Kohn and Schooler, 1969, Rosenberg, Schooler, Schoenbach, and Rosenberg, 1995). Kohn and Schooler (1969) suggest taking answers to a subset of the questions used to compute Rosenberg's self-esteem measure as a way to separate self-confidence from self-deprecation in such cases. When we replace the measure of self-confidence with this alternative measure, the dominant strategy in this top left cell in figure 2 switches to *SB* as in the theoretical predictions of panel (b) of figure 1 while all other cells remain unchanged. However, we still do not wish to put much emphasis on this result, since the alternative measure, being computed out of fewer questions, has much less variability and there are few individuals in this range in any case.

Overall, we find that the location choices of individuals in their junior and senior periods vary with self-confidence and ability in a way that closely matches our theoretical predictions. However,

this is based on raw data without taking into account other characteristics and experiences of individuals. We next turn to incorporating these.

### *Determinants of location in big and small cities*

We now test key implications of our model by examining whether self-confidence and ability affect the location decisions of individuals across cities of different sizes in their junior and senior periods, while controlling for other drivers of location and mobility. Specifically, we estimate logit models to look at the determinants of locating in a small or a big city either when junior or senior. In table 1 we report exponentiated coefficients (odd ratios), so coefficients above one indicate a positive effect and coefficients below one indicate a negative effect. Standard errors are clustered at the metropolitan area level and \*\*\*, \*\*, and \* indicate that a coefficient is significantly different from one at the 1, 5, and 10 percent levels.

A first implication of our model is that junior workers sort on self-confidence instead of on ability, so that we should expect more confident workers to have a higher probability of locating in big cities initially. In column (1) of table 1 we estimate a logit model where the dependent variable takes value one if the individual lives in a big city during his or her junior period. Results show that individuals with higher levels of self-confidence are more likely to locate in a big city when junior. The corresponding coefficient reveals that an increase of one standard deviation in the self-confidence percentile (28.7 points) raises the probability of locating in a big city by 15%. Instead, individuals with higher levels of ability are not significantly more likely to locate initially in a big city.

We include a set of conventional demographic controls. Results reveal that having college education increases the probability of locating in a big city when junior by around 100% relative to having at most primary education. Hispanics are also more likely to live in a big city during their junior period. Since many people are closely attached to the place where they grew up, we include as a control an indicator variable that takes value one if the individual was living in a small city at age 14. This turns out to be a crucial determinant of location decisions, greatly decreasing the probability of locating in a big city upon completing education and (as we shall see below) greatly increasing the probability of moving back home for those that do locate in a big city when junior. However, our results regarding ability and self-confidence are very similar whether we control for location at age 14 or not.

Turning to the senior period, our model implies that ability—revealed after some years of labour market experience—should matter more for the location of senior workers, although sorting on ability can still be quite imperfect. Moreover, some successful high-ability workers should relocate from small to big cities while some unsuccessful low-ability workers should relocate from big to small cities. To test these implications, we estimate two logit models in which the dependent variable captures a relocation across cities of different sizes between the junior and senior periods.

In column (2) of table 1 we focus exclusively on workers who located in a small city upon completing education (hence the smaller number of observations relative to column 1) and study whether they move subsequently. The dependent variable takes value one if the individual has relocated to a big city when observed in his or her senior period and value zero if the individual

Table 1: Logit estimation of the determinants of location in big and small cities

	Probability of living in big city upon completing education	For individuals living in small city upon completing education, probability of having moved to big city 10 years later	For individuals living in big city upon completing education, probability of having moved to small city 10 years later
	(1)	(2)	(3)
Self-confidence percentile	1.005 (0.002)***	1.003 (0.002)	0.997 (0.002)
Cognitive ability percentile	1.003 (0.003)	1.010 (0.004)***	1.001 (0.003)
Male	0.881 (0.082)	0.914 (0.108)	0.964 (0.131)
Hispanic	2.044 (0.529)***	1.250 (0.563)	0.575 (0.221)
Black	1.331 (0.342)	1.369 (0.389)	0.500 (0.149)**
High-school graduate	0.879 (0.116)	0.737 (0.153)	0.779 (0.282)
Some college	1.169 (0.180)	1.070 (0.306)	0.820 (0.331)
College graduate	2.031 (0.477)***	1.343 (0.373)	0.941 (0.416)
Never married	1.293 (0.255)	1.005 (0.227)	0.597 (0.132)**
Number of children	0.958 (0.035)	0.886 (0.059)*	1.128 (0.061)**
Working spouse	0.823 (0.171)	0.711 (0.107)**	0.988 (0.141)
Living in small city at age 14	0.020 (0.005)***	0.234 (0.054)***	3.056 (0.730)***
% working life unemployed		0.995 (0.009)	1.027 (0.009)***
Relative wage		1.190 (0.201)	0.706 (0.109)**
N	5,244	2,868	1,806
Pseudo $R^2$	0.449	0.081	0.070

*Notes:* All specifications include a constant and birth-year indicators. Odd ratios (exponentiated coefficients) are reported, with coefficients above one indicating a positive effect and coefficients below one indicating a negative effect. Standard errors in parentheses are clustered at the metropolitan area level. \*\*\*, \*\*, and \* indicate significance at the 1, 5, and 10 percent levels. A 'big city' is defined as a Core Based Statistical Area (CBSA) with a population greater than 2,000,000 in 2010. White, female, ever married and high-school dropouts are the omitted categories. Relative wage is the actual pre-migration wage of the individual relative to the wage predicted for the same individual by a regression including all the variables in column (1), plus experience in each city-size class and its square, firm tenure and its square, and a city-size class fixed-effect.

remains in a small city. Therefore, we examine the determinants of relocating from a small to a big city between periods. Results show that the level of self-confidence no longer influences the decision to relocate while the level of ability is a crucial relocation driver from small to big cities. The estimated coefficient implies that a one standard deviation increase in the ability percentile (28.5 points) raises the probability of moving to a big city by 28%. Thus, not only ability matters more for the location of senior workers than for the location of junior workers, but also, among the set of residents in small cities, it is the most able who move to a big city when senior. Other determinants show that having children, a working spouse or having lived in a small city at age 14 deter individuals from moving to a big city in their senior period.

In column (3) of table 1 we focus exclusively on workers who located in a big city during their junior period and study whether they move subsequently.<sup>19</sup> The dependent variable takes value one if the individual relocates to a small city when observed in his or her senior period and value zero if the individual remains in a big city. Therefore, we examine the determinants of relocating from a big to a small city between periods. Results reveal that neither self-confidence nor ability are key determinants of the relocation decision of senior workers from big to small cities. This is consistent with one of our conclusions from figure 2: if workers locate in a big city when junior and are fortunate enough to have a positive experience there, they tend to stay even if their ability is low.

Although low-ability workers who initially locate in big cities do not tend to relocate to small cities in general, results also reveal that such relocations from big to small cities can in part be driven by a negative experience of the worker in a big city. This negative experience can be the result of luck or the worker being unable to benefit from the larger set of opportunities in big cities. We proxy these possibilities with two variables: the fraction of the time the individual spent unemployed in the big city since his or her junior period, and the residual of his or her wage that cannot be explained by observable wage determinants. Our findings show that the time spent unemployed in a big city affects the likelihood of moving to a small city. The coefficient implies that a one standard deviation increase in the share of time spent unemployed (7.9%) increases the probability of moving to a small city by 22%. Moreover, a higher relative wage (i.e., a larger wage component that can not be explained by usual wage determinants) decreases the likelihood of relocating to a small city. Thus, our findings hint that unsuccessful workers in big cities tend to move to small cities, yet, they are not necessarily the least able workers among the pool of workers in big cities. The coefficients on the demographic controls show that blacks and individuals who remain unmarried are less likely to move from a big to a small city when senior, while those who have more children or grew up in a small city are more likely to move.

We measure ability through individuals' score in the AFQT test. However, there is growing evidence that ability is multi-dimensional and aspects beyond cognitive ability matter for labour market outcomes (Almlund, Duckworth, Heckman, and Kautz, 2011). We have partly addressed this by including wages relative to those of individuals with comparable observable characteristics

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<sup>19</sup>The number of observations in columns (2) and (3) add up to the number of workers for whom we observe their senior period location, 4,674. This is lower than the number of observations in column (1) due to sample attrition over the ten-year period that separates both periods.

when looking at the probability of relocating (where these relative wages reflect some combination of skills other than cognitive ability and also luck). As an additional robustness check, we have re-estimated our logistic regressions including the Eeckhout, Pinheiro, and Schmidheiny (2014) price-theoretic measure of skills. Results (shown in appendix D) are essentially unchanged. While the price-theoretic skill measure is not a statistically significant determinant of location decisions, the estimated coefficients point in the direction that high long-term skills are associated with having been initially in a big city and with not having subsequently relocated to a small city.

## 7. Conclusions

Flawed self-assessment of own ability can help explain the limited sorting of workers across cities of different sizes, even though bigger cities provide higher-ability workers with disproportionately better learning experience and richer opportunities to exploit such experience. The reason is that workers whose self-confidence at an early stage of their career is not aligned with their ability may make location decisions they would not have made if they had known their actual ability to start with. By the time they learn enough about their actual ability, those early decisions have had a lasting impact, reducing their incentives to move and affecting their lifetime earnings. We have formalized this argument using an overlapping generations model with sorting across cities by workers who differ in self-confidence and ability, derived location and relocation patterns by self-confidence and ability from the model, and shown that they are empirically relevant using data for the United States.

In particular, self-perceived ability is more important than actual ability for the location decisions of young workers. For older workers, ability plays a stronger role in determining location, but the lasting impact of their earlier choices limits the scope for relocation. Thus, some overconfident young workers start their career in a big city, while they would have chosen a small one had they correctly self-assessed their actual ability. If they nevertheless are fortunate enough to gain valuable experience, they tend to find that they can fully exploit this only by remaining in the big city also when older. Their initial misjudged decision thus becomes self-validating. Analogously, some underconfident young workers end up spending their whole life in a small city, even though a correct initial assessment of their ability would have made them self-select into a big city instead. Workers who seriously underestimate their own ability may nevertheless relocate from a small to a big city once their labour market experience provides them with better information of their true capabilities. Relocations from big to small cities appear to be driven instead by lack of success in the big city rather than by corrections to flawed self-assessment. Young workers who are confident enough of their own abilities locate in bigger cities to pursue their dreams, but those dreams do not come true for everyone.

Besides helping explain limited urban sorting, these findings also confirm the power of personality traits as predictors and as causes of economic success, even after controlling for education, experience and cognition.

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## Appendix A. Proof of Proposition 1

First, note that the three cases are mutually exclusive. Since  $e_S < e_B$  and  $\Omega_S < \Omega_B$  it follows that  $\frac{\pi_2 e_S^2}{\Omega_B \Delta \gamma} < \frac{\pi_2 e_B^2}{\Omega_S \Delta \gamma}$ . Hence the condition for case 1,  $\frac{\Delta e}{\Delta \Omega^2} < \frac{\pi_2 e_S^2}{\Omega_B \Delta \gamma}$ , and the condition for case 3,  $\frac{\pi_2 e_B^2}{\Omega_S \Delta \gamma} < \frac{\Delta e}{\Delta \Omega^2}$ , cannot hold simultaneously. The condition for case 2,  $\frac{\pi_2 e_S^2}{\Omega_B \Delta \gamma} \leq \frac{\Delta e}{\Delta \Omega^2} \leq \frac{\pi_2 e_B^2}{\Omega_S \Delta \gamma}$ , is precisely that neither the condition for case 1 nor the condition for case 3 hold.

Case 1 arises when  $\alpha_{SB} > \alpha_{SS} < \alpha_{BB} > \alpha_{SB}$ . Substituting equations (7) and (15) into this inequality and rearranging leads to the condition  $\frac{\Delta e}{\Delta \Omega^2} < \frac{\pi_2 e_S^2}{\Omega_B \Delta \gamma}$ .

Starting from the lowest ability, consider first workers with  $\alpha \leq \alpha_{BB>BS}$ . By Lemma 2, such workers always locate in  $S$  when senior, while they also locates in  $S$  when junior if and only if  $\alpha \leq \alpha_{BS>SS}$ . Since  $e_S < e_B$ , it is always true that  $\alpha_{BB>BS} < \alpha_{SB>SS}$  so that  $\alpha \leq \alpha_{BB>BS}$  implies  $\alpha < \alpha_{SB>SS}$ . The parameter condition defining case 1 is  $\alpha_{SB>SS} < \alpha_{BB>SB}$ . And since  $\Omega_S < \Omega_B$ , it is always true that  $\alpha_{BB>SB} < \alpha_{BS>SS}$ . Thus, in case 1,  $\alpha \leq \alpha_{BB>BS}$  also implies  $\alpha < \alpha_{BS>SS}$  so that workers with  $\alpha \leq \alpha_{BB>BS}$  locate in  $S$  both periods.

Consider next workers with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$ . The condition  $\alpha \leq \alpha_{SB>SS}$  is equivalent to  $U_{SB} - U_{SS} \leq 0$ . The parameter condition defining case 1 is  $\alpha_{SB>SS} < \alpha_{BB>SB}$ , so that  $\alpha \leq \alpha_{SB>SS}$  also implies  $\alpha < \alpha_{BB>SB}$ , equivalent to  $U_{BB} - U_{SB} < 0$ . Adding these two inequalities on utility levels yields  $U_{BB} - U_{SS} < 0$ , which is equivalent to  $\alpha < \alpha_{BB>SS}$ . By Lemma 2, workers with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$  locate in  $S$  both periods if and only if  $\alpha \leq \alpha_{BB>SS}$ . Since in case 1 both workers with  $\alpha \leq \alpha_{BB>BS}$  and workers with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$  locate in  $S$  both periods, we can pool them together stating that workers with  $\alpha \leq \alpha_{SB>SS}$  locate in  $S$  in both periods.

Moving up to intermediate ability, consider workers with  $\alpha_{SB>SS} < \alpha \leq \alpha_{BB>SB}$ . By Lemma 2, workers with  $\alpha_{SB>SS} < \alpha$  locate in  $B$  when senior unless they fail at the simple task when junior, while they locate in  $S$  when junior if and only if  $\alpha \leq \alpha_{BB>SB}$ . Thus, workers with  $\alpha_{SB>SS} < \alpha \leq \alpha_{BB>SB}$  locate in  $S$  when junior and, if and only if successful, relocate to  $B$  when senior.

To conclude case 1, consider workers with  $\alpha_{BB>SB} < \alpha$ . The parameter condition defining case 1 is  $\alpha_{SB>SS} < \alpha_{BB>SB}$ , so that  $\alpha_{BB>SB} < \alpha$  also implies  $\alpha_{SB>SS} < \alpha$ . By Lemma 2, workers with  $\alpha_{SB>SS} < \alpha$  locate in  $B$  when senior unless they fail at the simple task when junior, while they also locate in  $B$  when junior if and only if  $\alpha_{BB>SB} < \alpha$ . Hence, workers with  $\alpha_{BB>SB} < \alpha$  locate in  $B$  in both periods unless they fail at the simple task when junior, in which case they relocate to  $S$  when senior.

Case 2 arises when  $\alpha_{BB>SB} \leq \alpha_{SB>SS}$  and  $\alpha_{BB>BS} \leq \alpha_{BS>SS}$  simultaneously. Substituting equations (3), (7), (10) and (15) into this inequality and rearranging leads to the condition  $\frac{\pi_2 e_S^2}{\Omega_B \Delta \gamma} \leq \frac{\Delta e}{\Delta \Omega^2} \leq \frac{\pi_2 e_B^2}{\Omega_S \Delta \gamma}$ .

Starting from the lowest ability, consider first workers with  $\alpha \leq \alpha_{BB>BS}$ . By Lemma 2, such workers always locate in  $S$  when senior, while they also locates in  $S$  when junior if and only if  $\alpha \leq \alpha_{BS>SS}$ . One of the parameter conditions for case 2 is  $\alpha_{BB>BS} \leq \alpha_{BS>SS}$ , so that  $\alpha \leq \alpha_{BB>BS}$  also implies  $\alpha \leq \alpha_{BS>SS}$ . Thus, workers with  $\alpha \leq \alpha_{BB>BS}$  locate in  $S$  both periods.

Moving up to intermediate ability, consider workers with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$ . By Lemma 2, if  $\alpha \leq \alpha_{BB>SS}$  such workers locate in  $S$  both periods, while if  $\alpha_{BB>SS} < \alpha$ , they locate in  $B$  in both periods unless they fail at the simple task when junior; if they do fail, then they relocate to  $S$  when senior. Thus, if  $\alpha_{SB>SS} \leq \alpha_{BB>SS}$  then all workers with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$  also have  $\alpha \leq \alpha_{BB>SS}$  and locate in  $S$  in both periods. If  $\alpha_{BB>SS} < \alpha_{BB>BS}$  then all workers with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$  also have  $\alpha_{BB>SS} < \alpha$  and locate in  $B$  in both periods unless they fail at the simple task when junior; if they do fail, then they relocate to  $S$  when senior. If  $\alpha_{BB>BS} \leq \alpha_{BB>SS} < \alpha_{SB>SS}$  then workers with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$  fall in two subcategories: those with  $\alpha_{BB>BS} < \alpha \leq \alpha_{BB>SS}$  locate in  $S$  in both periods; while those with  $\alpha_{BB>SS} < \alpha < \alpha_{SB>SS}$  locate in  $B$  in both periods unless they fail at the simple task when junior, in which case they relocate to  $S$  when senior.

To conclude case 2, consider workers with  $\alpha_{SB>SS} < \alpha$ . By Lemma 2, such workers locate in

$B$  when senior unless they fail at the simple task when junior, while they also locate in  $B$  when junior if and only if  $\alpha_{BB>SB} < \alpha$ . One of the parameter conditions for case 2 is  $\alpha_{BB>SB} \leq \alpha_{SB>SS}$ , so that  $\alpha_{SB>SS} < \alpha$  also implies  $\alpha_{BB>SB} < \alpha$ . Thus, workers with  $\alpha_{SB>SS} < \alpha$  locate in  $B$  both periods unless they fail at the simple task when junior, in which case they relocate to  $S$  when senior.

Case 2 can be summarized based on the magnitude of  $\alpha_{BB>SS}$  relative to  $\alpha_{BB>BS}$  and  $\alpha_{SB>SS}$ . Workers with  $\alpha \leq \max(\alpha_{BB>BS}, \min(\alpha_{SB>SS}, \alpha_{BB>SS}))$  locate in  $S$  in both periods. Workers with  $\max(\alpha_{BB>BS}, \min(\alpha_{SB>SS}, \alpha_{BB>SS})) < \alpha$  locate in  $B$  in both periods unless they fail at the simple task when junior, in which case they relocate to  $S$  when senior.

Case 3 arises when  $\alpha_{BS>SS} < \alpha_{BB>BS}$ . Substituting equations (3) and (10) into this inequality and rearranging leads to the condition  $\frac{\pi_2 e_B^2}{\Omega_S \Delta \gamma} < \frac{\Delta e}{\Delta \Omega^2}$ .

Starting from the lowest ability, consider first workers with  $\alpha \leq \alpha_{BS>SS}$ . The parameter condition defining case 3 is  $\alpha_{BS>SS} < \alpha_{BB>BS}$ , so that  $\alpha \leq \alpha_{BS>SS}$  also implies  $\alpha < \alpha_{BB>BS}$ . By Lemma 2, workers with  $\alpha \leq \alpha_{BB>BS}$  locate in  $S$  when senior, while they also locate in  $S$  when junior if and only if  $\alpha < \alpha_{BS>SS}$ . Thus, in case 3, workers with  $\alpha \leq \alpha_{BS>SS}$  locate in  $S$  in both periods.

Moving up to intermediate ability, consider workers with  $\alpha_{BS>SS} < \alpha \leq \alpha_{BB>BS}$ . By Lemma 2, workers with  $\alpha \leq \alpha_{BB>BS}$  locate in  $S$  when senior, while they locate in  $B$  when junior if and only if  $\alpha_{BS>SS} < \alpha$ . Thus, workers with  $\alpha_{BS>SS} < \alpha \leq \alpha_{BB>BS}$  locate in  $B$  when junior and relocate to  $S$  when senior.

Consider next workers with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$ . The condition  $\alpha_{BB>BS} < \alpha$  is equivalent to  $U_{BB} - U_{BS} > 0$ . The parameter condition defining case 3 is  $\alpha_{BS>SS} < \alpha_{BB>BS}$ , so that  $\alpha_{BB>BS} < \alpha$  also implies  $\alpha_{BS>SS} < \alpha$ , equivalent to  $U_{BS} - U_{SS} > 0$ . Adding these two inequalities on utility levels yields  $U_{BB} - U_{SS} > 0$ , which is equivalent to  $\alpha_{BB>SS} < \alpha$ . By Lemma 2, workers with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$  locate in  $B$  both periods if  $\alpha_{BB>SS} < \alpha$ , unless they fail at the simple task when junior, in which case they relocate to  $S$  when senior.

To conclude case 3, consider workers with  $\alpha_{SB>SS} < \alpha$ . By Lemma 2, such workers locate in  $B$  when senior unless they fail at the simple task when junior, in which case they locate in  $S$  when senior. Also by Lemma 2, such workers locate in  $B$  when junior if and only if  $\alpha_{BB>SB} < \alpha$ . Since  $e_S < e_B$ , it is always the case that  $\alpha_{BB>BS} < \alpha_{SB>SS}$  so that  $\alpha_{SB>SS} < \alpha$  implies  $\alpha_{BB>BS} < \alpha$ . The parameter condition defining case 3 is  $\alpha_{BS>SS} < \alpha_{BB>BS}$ . Since  $\Omega_S < \Omega_B$ , it is always the case that  $\alpha_{BB>SB} < \alpha_{BS>SS}$ . Thus, in case 3,  $\alpha_{SB>SS} < \alpha$  also implies  $\alpha_{BB>SB} < \alpha$ , so that workers with  $\alpha_{SB>SS} < \alpha$  locate in  $B$  both periods if  $\alpha_{BB>SS} < \alpha$ , unless they fail at the simple task when junior, in which case they relocate to  $S$  when senior. Since in case 3 both workers with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$  and workers with  $\alpha_{SB>SS} < \alpha$  choose the same locations, we can pool them together stating that workers with  $\alpha_{BB>BS} < \alpha$  locate in  $B$  in both periods unless they fail at the simple task when junior, in which case they relocate to  $S$  when senior.

□

## Appendix B. Proof of Proposition 3

Define the auxiliary function

$$\tilde{b}(n) = 1 + \frac{n}{2} - b(n). \quad (\text{B.1})$$

This is the difference between the population of  $B$ ,  $1 + \frac{n}{2}$ , and the number of workers who wish to locate in  $B$  given that population,  $b(n)$ . Existence and uniqueness of the urban equilibrium can be proven by showing that  $\tilde{b}(n)$  has a single root in the feasible interval  $0 \leq n \leq 2$ .

We begin by showing that  $b(n)$  is a continuous decreasing function of  $n$  over the interval  $[0,2]$ . First,  $b(n)$  is a continuous and decreasing function of  $n$  in each of the three open or half-open intervals  $[0, \underline{n})$ ,  $(\underline{n}, \bar{n})$ , and  $(\bar{n}, 2]$ . Consider  $b(n)$  for  $n \in [0, \underline{n})$ . In this interval  $b(n)$  is continuous in  $n$ : by the fundamental theorem of calculus, it is a continuous function of  $\alpha_{BB \succ SB}(n)$ ,  $\alpha_{BB \succ BS}(n)$ , and  $\alpha_{SB \succ SS}(n)$ , which are in turn continuous functions of  $n$ . From equation (22), by the fundamental theorem of calculus and the chain rule of derivation, its derivative with respect to  $n$  can be written

$$\begin{aligned}
b'(n) \Big|_{0 \leq n < \underline{n}} &= -\alpha'_{BB \succ SB}(n) \int_0^1 f(\alpha_{BB \succ SB}(n), \alpha) d\alpha - \alpha'_{BB \succ BS}(n) \int_{\alpha_{BB \succ BS}(n)}^{\alpha_{SB \succ SS}(n)} \alpha f(\alpha_{BB \succ SB}(n), \alpha) d\alpha \\
&\quad - \alpha'_{BB \succ BS}(n) \alpha_{BB \succ BS}(n) \int_{\alpha_{BB \succ SB}(n)}^1 f(\sigma, \alpha_{BB \succ BS}(n)) d\sigma \\
&\quad - \alpha'_{SB \succ SS}(n) \alpha_{SB \succ SS}(n) \int_0^{\alpha_{BB \succ SB}(n)} f(\sigma, \alpha_{SB \succ SS}(n)) d\sigma,
\end{aligned} \tag{B.2}$$

which is negative given that  $\alpha'_{BB \succ SB}(n) > 0$ ,  $\alpha'_{BB \succ BS}(n) > 0$  and  $\alpha'_{SB \succ SS}(n) > 0$ . The continuity of  $b(n)$  over the intervals  $(\underline{n}, \bar{n})$  and  $(\bar{n}, 2]$  can be proven analogously.

Second,  $b(n)$  is continuous in  $n$  also at  $n = \underline{n}$  and  $n = \bar{n}$ . Consider the continuity of  $b(n)$  at  $n = \underline{n}$ . This follows from  $\alpha_{SB \succ SS}(\underline{n}) = \alpha_{BB \succ SS}(\underline{n})$ , the ranking  $\alpha_{SB \succ SS}(n) > \alpha_{BB \succ BS}(n)$  for any  $n$ , and the definition of  $\underline{n}$  such that  $\alpha_{SB \succ SS}(\underline{n}) = \alpha_{BB \succ SB}(\underline{n})$ . These three properties together imply

$$\begin{aligned}
\alpha_{\max \min}(\underline{n}) &= \max(\alpha_{BB \succ BS}(\underline{n}), \min(\alpha_{SB \succ SS}(\underline{n}), \alpha_{BB \succ SS}(\underline{n}))) \\
&= \max(\alpha_{BB \succ BS}(\underline{n}), \alpha_{SB \succ SS}(\underline{n})) \\
&= \alpha_{SB \succ SS}(\underline{n}) \\
&= \alpha_{BB \succ SB}(\underline{n})
\end{aligned} \tag{B.3}$$

In equation (22) we see that the only difference between  $b(n)|_{0 \leq n < \underline{n}}$  and  $b(n)|_{\underline{n} \leq n \leq \bar{n}}$  is that wherever  $\alpha_{BB \succ SB}(n)$  appears in  $b(n)|_{0 \leq n < \underline{n}}$ ,  $\alpha_{\max \min}(n)$  appears instead in  $b(n)|_{\underline{n} \leq n \leq \bar{n}}$ . Since by equation (B.3)  $\alpha_{\max \min}(\underline{n}) = \alpha_{BB \succ SB}(\underline{n})$ , it follows that

$$\lim_{n \rightarrow \underline{n}^-} b(n) = b(\underline{n}) = \lim_{n \rightarrow \underline{n}^+} b(n) \tag{B.4}$$

The continuity of  $b(n)$  at  $n = \bar{n}$  can be proven analogously.

Since  $1 + \frac{n}{2}$  is a continuous increasing function of  $n$  and  $b(n)$  is a continuous decreasing function of  $n$  over the interval  $[0,2]$ , it follows that  $\tilde{b}(n) = 1 + \frac{n}{2} - b(n)$  is a continuous increasing function of  $n$  over this interval.

By equation (20),  $n = 0$  implies  $\Delta\gamma = 0$ ; which in turn, by equations (3), (7), (10), (13), and (15), implies  $\alpha_{BB \succ BS} = \alpha_{SB \succ SS} = \alpha_{BS \succ SS} = \alpha_{BB \succ SS} = \alpha_{BB \succ SB} = 0$ ; and substituting these into equation (22) yields  $b(0) = 2$ ; which, by equation (B.1), implies  $\tilde{b}(0) = -1$ . Moreover, since  $1 + \frac{n}{2}$  takes

value 2 for  $n = 2$ , and since  $b(n)$  is decreasing in  $n$  over the interval  $[0,2]$  starting from the value  $b(0) = 2$ , it follows that  $\tilde{b}(2) > 0$

Since  $\tilde{b}(n)$  is a continuous function of  $n$  over the interval  $[0,2]$ ,  $\tilde{b}(0) < 0$ , and  $\tilde{b}(2) > 0$ , by Bolzano's Theorem there exists at least one value of  $n \in (0,2)$  such that  $\tilde{b}(n) = 0$ . This proves that an urban equilibrium exists. In addition, both the big and small cities are populated in equilibrium (i.e., the equilibrium value of  $n$  satisfies  $0 < n < 2$  with strict inequality). The urban equilibrium is also unique. Suppose on the contrary that there were two or more values of  $n$  in  $(0,2)$  such that  $\tilde{b}(n) = 0$ . Then, by Rolle's Theorem there would have to be some  $n$  in this interval such that  $\tilde{b}'(n) = 0$ , which contradicts our previous result that  $\tilde{b}'(n) > 0$  over the interval  $[0,2]$ .

Turning to comparative statics, totally differentiating the equilibrium condition  $\tilde{b}(n) = 1 + \frac{n}{2} - b(n) = 0$  and solving for  $\frac{dn}{d\tau}$  yields

$$\frac{dn}{d\tau} = \frac{\frac{db(n)}{d\tau}}{\tilde{b}'(n)}. \quad (\text{B.5})$$

Since  $\tau$  and  $n$  always enter  $b(n)$  together as a product (because  $\Delta\gamma$  enters every threshold level of  $\alpha$  and, by equation 20,  $\Delta\gamma = \tau n$ ), it follows that  $\frac{db(n)}{d\tau} = b'(n)$ , and we have already shown that  $b'(n) < 0$ . We have also shown that  $\tilde{b}'(n) > 0$ . Hence, we can sign equation (B.5):  $\frac{dn}{d\tau} < 0$ . The comparative statics  $\frac{dn}{d\Delta\Omega} > 0$  and  $\frac{dn}{d\Delta e} > 0$  can be proven analogously. □

### Appendix C. Introducing uncertainty over junior workers' self-assessment

For simplicity, in the main text we treat the situation in which self-confidence accurately reflects ability as one where each worker knows her ability  $\alpha$  with certainty; and we treat the situation in which self-confidence does not reflect ability accurately as one where each junior workers is certain that her ability is  $\sigma$  (self-confidence) until she updates this belief to the actual value  $\alpha$  while attempting to complete a simple task.

In this appendix, we re-derive results allowing junior workers to realize their self-assessment may be inaccurate. In this alternative formulation, accurate self-assessment does not imply that each junior worker knows her ability  $\alpha$  with certainty. Instead, she receives a signal that allows her to compute an unbiased estimate of her ability, so that she takes her ability to have expected value  $\alpha$  and variance  $\theta$ . The situation in which self-confidence does not reflect ability accurately is modelled in this alternative formulation by having each worker receive a signal that leads her to a possibly biased estimate of her ability. However, she realizes this self-assessment may be inaccurate, and she takes her ability to have expected value  $\sigma \neq \alpha$  and variance  $\theta$ . We still maintain the assumption that while trying to complete their simple task workers learn about their true ability, so all senior workers know their  $\alpha$  accurately.

Since senior workers know their ability, the senior location choice remains exactly as in the main text and follows lemma 1, with the two thresholds on which senior-period location depends,  $\alpha_{BB>BS}$  and  $\alpha_{SB>SS}$ , unchanged.

For the junior location choice, we need to consider the same three ranges of ability as before:  $\alpha \leq \alpha_{BB>BS}$ ,  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$ , and  $\alpha_{SB>SS} < \alpha$ . For a worker with low ability  $\alpha \leq \alpha_{BB>BS}$

locating in  $B$  when senior is never worthwhile regardless of her junior period location. She locates in  $B$  in her junior period if and only if

$$E [U_{BS}(\alpha) - U_{SS}(\alpha)] = (\alpha^2 + \theta)\Omega_S(e_B - e_S) \pi_2 - (\gamma_B - \gamma_S) > 0, \quad (\text{c.1})$$

or, equivalently, if and only if

$$\alpha > \alpha_{BS>SS} \equiv \sqrt{\frac{\Delta\gamma}{\Omega_S \pi_2 \Delta e}} - \theta. \quad (\text{c.2})$$

Compared with the value of  $\alpha_{BS>SS}$  in equation (10), the only difference is the term  $-\theta$ . Uncertainty over ability and convexity lower the (expected) ability threshold above which a junior worker locates in  $B$ .

For a worker with  $\alpha_{BB>BS} < \alpha \leq \alpha_{SB>SS}$  locating in  $B$  when senior is worthwhile if she located in  $B$  when junior and successfully completed her simple task. Knowing this, she locates in  $B$  in her junior period if and only if

$$E [U_{BB}(\alpha) - U_{SS}(\alpha)] = (\alpha^2 + \theta)(\Omega_B e_B - \Omega_S e_S) \pi_2 - (1 + \alpha)(\gamma_B - \gamma_S) > 0, \quad (\text{c.3})$$

or, equivalently, if and only if

$$\alpha > \alpha_{BB>SS} \equiv \frac{1}{2} \left( \tilde{\alpha} + \sqrt{\tilde{\alpha}^2 + 4(\tilde{\alpha} - \theta)} \right), \quad (\text{c.4})$$

where  $\tilde{\alpha}$  is still defined as in equation (12). Compared with the value of  $\alpha_{BB>SS}$  in equation (13), the only difference is the term  $-\theta$ .

For a worker with high ability  $\alpha_{SB>SS} < \alpha$  locating in  $B$  when senior (conditional on junior period success) is always worthwhile regardless of her junior period location. Knowing she will locate in  $B$  when senior if successful, she locates in  $B$  in her junior period if and only if

$$E [U_{BB}(\alpha) - U_{SB}(\alpha)] = (\alpha^2 + \theta)\Omega_B(e_B - e_S) \pi_2 - (\gamma_B - \gamma_S) > 0, \quad (\text{c.5})$$

or, equivalently, if and only if

$$\alpha > \alpha_{BB>SB} \equiv \sqrt{\frac{\Delta\gamma}{\Omega_B \pi_2 \Delta e}} - \theta. \quad (\text{c.6})$$

Compared with the value of  $\alpha_{BB>SB}$  in equation (14), the only difference is the term  $-\theta$ .

Lemma 2 still applies as before, but with the thresholds  $\alpha_{BS>SS}$ ,  $\alpha_{BB>SS}$ , and  $\alpha_{BB>SB}$  now defined by equations (c.2), (c.4), and (c.6) respectively instead of by equations (10), (13), and (15).

The three cases in propositions 1 and 2 need to be redefined using the new values of the thresholds. Case 1 arises when  $\alpha_{SB>SS} < \alpha_{BB>SB}$ . Substituting equations (7) and (c.6) into this inequality and rearranging leads to the updated parameter condition defining case 1:  $\frac{\Delta e}{\Delta \Omega^2} < \frac{\pi_2 e_S^2}{\Omega_B \Delta \gamma} - \frac{\theta e_S^2 \pi_2^2 \Delta e}{\Delta \gamma^2}$ . Case 2 arises when  $\alpha_{BB>SB} \leq \alpha_{SB>SS}$  and  $\alpha_{BB>BS} \leq \alpha_{BS>SS}$  simultaneously. Substituting equations (3), (7), (c.2) and (c.6) into this inequality and rearranging leads to the updated parameter condition defining case 2:  $\frac{\pi_2 e_S^2}{\Omega_B \Delta \gamma} - \frac{\theta e_S^2 \pi_2^2 \Delta e}{\Delta \gamma^2} \leq \frac{\Delta e}{\Delta \Omega^2} \leq \frac{\pi_2 e_B^2}{\Omega_S \Delta \gamma} - \frac{\theta e_B^2 \pi_2^2 \Delta e}{\Delta \gamma^2}$ . Case 3 arises when

$\alpha_{BS>SS} < \alpha_{BB>BS}$ . Substituting equations (3) and (c.2) into this inequality and rearranging leads to the updated parameter condition defining case 3:  $\frac{\pi_2 e_B^2}{\Omega_S \Delta \gamma} - \frac{\theta e_B^2 \pi_2^2 \Delta e}{\Delta \gamma^2} < \frac{\Delta e}{\Delta \Omega^2}$ .

The proof of proposition 1 in appendix A and the proof of proposition 2 in the main text are still valid with the updated values for the thresholds  $\alpha_{BS>SS}$ ,  $\alpha_{BB>SS}$ , and  $\alpha_{BB>SB}$  and the updated parameter conditions for each of the three cases. Thus all of our results are qualitatively unchanged. The difference is that the (perceived) ability thresholds above which junior workers locate in  $B$  are lower with uncertainty since utility is convex in ability (which matters in both periods, creating a positive quadratic term in  $\alpha$ ). Furthermore, we can see from the updated parameter conditions for each of the three cases that uncertainty increases the opportunity cost of foregoing possible better experience in the bigger city (a positive  $\theta$  creates an additional role for  $\Delta e$ ). Thus, the more noisy is the signal young workers receive about their ability, the more likely they are to take the bet of locating in a big city and seeing if it fulfils their dreams.

## Appendix D. Additional empirical evidence

Table D.1: Logit estimation of the determinants of location in big and small cities

	Probability of living in big city upon completing education	For individuals living in small city upon completing education, probability of having moved to big city 10 years later	For individuals living in big city upon completing education, probability of having moved to small city 10 years later
	(1)	(2)	(3)
Self-confidence percentile	1.005 (0.002)***	1.002 (0.002)	0.999 (0.002)
Cognitive ability percentile	1.002 (0.003)	1.009 (0.004)**	1.004 (0.003)
Price-theoretic skill percentile	1.002 (0.002)	1.003 (0.003)	0.996 (0.003)
Male	0.830 (0.097)	0.920 (0.124)	1.033 (0.140)
Hispanic	1.973 (0.453)***	1.229 (0.536)	0.525 (0.192)*
Black	1.270 (0.326)	1.469 (0.429)	0.433 (0.134)***
High-school graduate	0.886 (0.105)	0.681 (0.146)*	0.797 (0.282)
Some college	1.205 (0.192)	1.034 (0.319)	0.866 (0.337)
College graduate	2.043 (0.501)***	1.215 (0.365)	0.950 (0.399)
Never married	1.278 (0.280)	1.030 (0.236)	0.606 (0.135)**
Number of children	0.984 (0.035)	0.915 (0.062)	1.157 (0.064)***
Working spouse	0.799 (0.188)	0.704 (0.107)**	0.935 (0.140)
Living in small city at age 14	0.019 (0.004)***	0.240 (0.059)***	3.144 (0.773)***
% working life unemployed		0.995 (0.010)	1.032 (0.010)***
Relative wage		1.110 (0.199)	0.683 (0.121)**
N	4,616	2,676	1,646
Pseudo $R^2$	0.455	0.079	0.078

*Notes:* All specifications include a constant and birth-year indicators. Odd ratios (exponentiated coefficients) are reported, with coefficients above one indicating a positive effect and coefficients below one indicating a negative effect. Standard errors in parentheses are clustered at the metropolitan area level. \*\*\*, \*\*, and \* indicate significance at the 1, 5, and 10 percent levels. A 'big city' is defined as a Core Based Statistical Area (CBSA) with a population greater than 2,000,000 in 2010. White, female, ever married and high-school dropouts are the omitted categories. Price-theoretic skill follows Eeckhout, Pinheiro, and Schmidheiny (2014) to calculate the difference between the individual's wage and the median expenditure share on housing times the mean rental price index in the metropolitan area (see text for more details). Relative wage is the actual pre-migration wage of the individual relative to the wage predicted for the same individual by a regression including all the variables in column (1), plus experience in each city-size class and its square, firm tenure and its square, and a city-size class fixed-effect.