City of dreams

Jorge De la Roca*¶
University of Southern California

Gianmarco I. P. Ottaviano*‖
Bocconi University

Diego Puga*§
CEMFI

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ABSTRACT: Bigger cities offer more valuable experience and opportunities in exchange for higher housing costs. While higher-ability workers benefit more from bigger cities, they are not more likely to move to one. Our model of urban sorting by workers with heterogeneous self-confidence and ability suggests flawed self-assessment is partly to blame. Analysis of NLSY79 data shows that, consistent with our model, young workers with high self-confidence are more likely to locate in a big city initially. For more experienced workers, ability plays a stronger role in determining location choices, but the lasting impact of earlier choices dampens their incentives to move.

Key words: cities, migration, sorting, agglomeration, self-confidence, ability
JEL classification: R10, R23

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¶Sol Price School of Public Policy, University of Southern California, 650 Childs Way RGL 326, Los Angeles, CA 90089, USA (e-mail: jdelaroc@usc.edu; website: http://jorgedelaroca.name).

‖Bocconi University, Department of Economics, Via Roentgen 1, 20136 Milan, Italy (e-mail: gianmarco.ottaviano@unibocconi.it; website: https://sites.google.com/view/gipottaviano).

§CEMFI, Casado del Alisal 5, 28014 Madrid, Spain (e-mail: diego.puga@cemfi.es; website: http://diegopuga.org).

1. Introduction

Working in a bigger city is associated with higher present and future earnings. Experience is more valuable when accumulated in a bigger city, even when the worker's job is no longer in one. Further, prior experience has a higher return in bigger cities (Glaeser and Maré, 2001; De la Roca and Puga, 2017). In exchange for these advantages, workers in bigger cities incur higher housing and congestion costs (Combes, Duranton, and Gobillon, 2019; Duranton and Puga, 2019).

The benefits of bigger cities are significantly larger for workers with higher ability within broad education or occupation categories (De la Roca and Puga, 2017). Given that housing costs are higher in bigger cities for everyone regardless of ability, one might expect that when workers choose a location, the more talented ones are more likely to move to a big city. Nevertheless, this is not the case.

Bigger cities have more jobs requiring a college degree and more workers holding one (Moretti, 2012; Davis and Dingel, 2013). However, within broad occupational or educational groups, there appears to be little sorting on ability. This finding holds regardless of whether one assesses ability through cognitive test results (Bacolod, Blum, and Strange, 2009), individual fixed-effects in a wage regression (De la Roca and Puga, 2017), measures derived from a structural estimation setting (Baum-Snow and Pavan, 2012), or individual residuals from a spatial equilibrium condition (Eeckhout, Pinheiro, and Schmidheiny, 2014).

Weak sorting on ability is not entirely surprising, given that many people are not mobile. According to our data, 56% of all individuals (and 42% of the college-educated) in the United States live in the same city at ages 14 and 40. However, given that many people do move, one would expect them to consider how they would fare in different cities depending on their ability.

Our starting point is that it is challenging for individuals to assess their ability, and thus also how much they would benefit from working in a big city. An extensive literature in psychology documents that individuals' assessment of their ability generally has little resemblance to their actual ability (see Dunning, Heath, and Suls, 2004, for a survey). Our data show a low correlation of 0.21 between ability and self-confidence (our measure of ability self-assessment). Among college graduates, this correlation falls to 0.02.

In section 2, we formalise the idea that flawed self-assessment can help explain the limited impact of ability on location decisions through a model of urban sorting. Relative to the overlapping generations model of learning in cities in Glaeser (1999), we have heterogeneous workers in self-confidence and ability. Relative to recent models of urban sorting where workers make a single location choice (Behrens, Duranton, and Robert-Nicoud, 2014; Eeckhout, Pinheiro, and Schmidheiny, 2014; Davis and Dingel, 2019), in our framework, workers choose their location in each period. Furthermore, we introduce a role for workers' self-confidence so that the interplay among self-confidence, ability, and experience shapes the incentives to relocate.

The model predicts various patterns of bilateral sorting between big and small cities during workers' life cycles. When young workers choose a location, they may be fooled by an imperfect assessment of their ability. Thus, location decisions by young workers are driven mainly by self-confidence. For senior workers, ability plays a more decisive role in determining location. However, the lasting impact of earlier choices dampens their incentives to move.

We test the main predictions of our model on panel data from the National Longitudinal Survey of Youth 1979 (NLSY79), which contains measures of ability, self-assessment, and individuals' location and job history. Our primary measure of ability is the individual's percentile score in the Armed Forces Qualification Test (AFQT), a general ability test administered to respondents in 1980 when they were between 15 and 23 (with a median age of 19). In our model, we use the term self-confidence to refer to individuals' perception of their ability. Respondents in the NLSY79 were also subjected in 1980 to a self-evaluation test devised by Rosenberg (1965), which has been found to measure well individuals' perception of their ability to perform a wide variety of tasks, particularly job-related ones (Judge, Erez, and Bono, 1998; Chen, Gully, and Eden, 2001).

After describing the data in section 3, in section 4, we examine the raw relationship between the location choices of individuals and their levels of self-confidence and ability upon completing education (corresponding to the junior period of our model) and ten years later (the senior period). We find that the data closely match our theoretical predictions. Workers with accurate self-assessment tend to locate in small cities if they have low ability and in big cities if they have high ability. Workers with a flawed self-assessment instead make initial location choices related to their self-confidence rather than their ability. Initial location choices driven by moderate errors in self-assessment tend to become self-perpetuating, while those driven by large errors are more likely to be corrected.

Of course, ability positively correlates with higher educational attainment. In turn, college-educated workers tend to locate in a big city, likely aware that the balance of benefits and costs favours them. Section 5 extends the model to include an education period when individuals decide to attend college. Ability and self-confidence then matter for location decisions both directly and indirectly through a college enrollment choice. The extended model illustrates the complex interactions of ability and self-confidence with location and education decisions. It highlights why, unless we control for college education in our empirical specifications, we may indirectly capture the effect of personality traits on educational choices rather than the role of self-confidence and ability in determining location choices over the life cycle.

Taking this implication of the extended model into account, in section 6, we estimate a multinomial logit where the choices are all four possible combinations of each individual's junior and senior period locations. We include education and other relevant individual characteristics as controls. We find that, relative to locating in a small city upon completing education and remaining there ten years later, the odds of initially locating in a small city and relocating to a big city increase with individuals' ability. Also, the odds of locating in a big city in both periods are higher for individuals with higher self-confidence and ability. Further, we find that college attainment is a central feature that distinguishes those individuals who initially locate in a big city and relocate to a small city ten years later compared to those who never leave a small city.

We remain close to our theoretical framework by studying location choices in terms of trajectories over a junior and a senior period. However, this strategy constrains our capacity to split the sample further (for example, based on the size of the city where people grew up), and prevents us from entirely exploiting the advantages of our rich panel. Thus, we next estimate logit models that look at the determinants of locating in a small or a big city when junior while controlling for other mobility drivers, particularly education. 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. Importantly, self-assessment of ability relative to people with the same education is so imperfect that there is essentially no correlation between self-confidence and ability among college-educated workers. As a result, conditional on education, ability does not influence the decision to locate in a big city when young. These findings persist when we control for the size of the city where people grew up and when we restrict the sample to only those who have moved since then.

Finally, we estimate multinomial logit models to examine relocations later in life. We find that corrections to flawed self-assessment are an essential driver of relocations from small to big cities, with higher ability rather than self-confidence being the key driver of such moves. At the same time, workers who started in a big city tend to stay there even if their ability is low.

A relevant source of concern is that the early sorting by self-confidence that we observe could be unrelated to an inaccurate assessment of ability. Alternatively, it may reflect an additional intrinsic value of self-confidence in big cities. Urban economics has paid much attention to education and cognitive skills, but less so to other skills and personality traits.[1] While certain personality traits could have higher returns in big cities, we show this is not the case for self-confidence. Instead, self-confidence matters for location decisions because it reflects individuals' perception of their ability.

2. The model

Every worker lives two periods, junior and senior. In each period, each worker chooses whether to locate in a big or small city. Subscript B denotes big city and subscript S small city variables.

Ability differs across workers. During her junior period, each worker engages in a continuum of simple tasks with finite measure 1. A worker's ability, α, is the share of simple tasks she can complete successfully as a junior worker. However, junior workers may

[1] An exception is Bacolod, Blum, and Strange (2009). They show that workers with stronger cognitive and people skills (as inferred from occupations and the skills related to them in the Dictionary of Occupational Titles) are more highly rewarded in bigger cities, while those with greater motor skills and physical strength are not.

have an inaccurate assessment of their own ability. A junior worker's self-confidence, σ, is her assessment of what her ability is (i.e., her belief about α). Looking back at what share of simple tasks she completed while junior, a senior worker knows her actual ability α.

Completing a simple task when junior yields an immediate return and acquired experience that will be valuable when senior. The advantage of locating in a big city for junior workers is that it allows them to accumulate more valuable experience, consistent with the evidence in De la Roca and Puga (2017). Specifically, completing a simple task yields experience e_B in the big city and e_S in the small city, where $0 < e_S < e_B < 1$.

The advantage of locating in a big city for senior workers is the increased opportunities to exploit previously acquired experience, again consistent with De la Roca and Puga (2017). In particular, during her senior period, each worker may be presented with an opportunity to perform a more complex task and obtain an additional return. Such an opportunity arises with probability Ω_B in the big city compared with Ω_S in the small city, where $0 < \Omega_S < \Omega_B < 1$. The probability of completing this complex task when presented with such an opportunity equals the worker's experience acquired during her junior period.

The disadvantage of locating in a big city for both junior and senior workers is the higher costs of housing and commuting, which we refer to as urban costs, a widely-documented fact (Duranton and Puga, 2020). These urban costs are γ_B in the big city and γ_S in the small city, with $0 < \gamma_S < \gamma_B$.[2]

Junior period location

Every worker has four possible lifetime trajectories, each consisting of a junior period location choice i and a senior period location choice j: $(i, j) = \{(S, S), (S, B), (B, S), (B, B)\}$. As a junior worker, she chooses among these trajectories based on her self-assessed ability σ. Afterwards, once her true ability α is revealed, the worker can choose whether to stick to her previously selected trajectory or alter her senior period location choice.

In her junior period, the worker solves the problem

$$\max_{i,j\in\{B,S\}} U_{ij}^{\text{JR}}(\sigma) = -\gamma_i + \sigma\pi_1 - \gamma_j + \Omega_j \sigma e_i \pi_2 \,. \tag{1}$$

$U_{ij}^{\text{JR}}(\sigma)$ denotes the lifetime net return that a junior worker with self-confidence σ expects to obtain from residing in city i when junior and in city j when senior. By locating in city $i \in \{B, S\}$ during her junior period, the worker incurs an urban cost γ_i. She also completes a share of simple tasks equal to her ability, which she believes to be σ, obtaining an expected return $\sigma\pi_1$. By locating in city $j \in \{B, S\}$ as a senior worker, she incurs an urban cost γ_j. She also faces an opportunity to perform a complex task with probability Ω_j. She succeeds with

[2]Here, we treat γ_B and γ_S as parameters. In Appendix A, we model city structure to make γ_B and γ_S a function of the population of each city, with city populations derived in turn as an equilibrium outcome of the location decisions of all agents. We prove equilibrium existence and uniqueness.

probability equal to the experience acquired as a junior worker in city i —an experience that, when making her initial choice, she expects to be σe_i— and then obtains a return π_2.

The key elements of equation (1) are that a big city provides junior workers with both disadvantages (higher urban costs $\gamma_B > \gamma_S$) and advantages (more valuable experience $e_B > e_S$). The advantages are larger for workers with higher ability (which at this point workers believe to be σ). A big city also provides senior workers with both disadvantages (again, higher urban costs) and advantages (more opportunities to use previously acquired experience, $\Omega_B > \Omega_S$). Such advantages are larger for workers with higher ability or more valuable experience ($\sigma e_B > \sigma e_S$).

The big city has an 'absolute advantage' in both experience ($e_B > e_S$) and opportunities ($\Omega_B > \Omega_S$), but to rank location trajectories, we must think of 'comparative advantage.' If $\frac{e_B}{e_S} > \frac{\Omega_B}{\Omega_S}$, the big city has a comparative advantage in experience. From equation (1), when $\frac{e_B}{e_S} > \frac{\Omega_B}{\Omega_S}$, $U_{BS}(\sigma) > U_{SB}(\sigma)$ holds for all values of σ and trajectory (S, B) can be ruled out. While trajectory (B, S) dominates (S, B), it will only be selected if it also dominates the other two trajectories. From equation (1), $U_{BS}(\sigma) > U_{SS}(\sigma)$ and $U_{BS}(\sigma) \geqslant U_{BB}(\sigma)$ jointly hold if and only if[3]

$$\sigma > \alpha_{BS \succ SS} \equiv \frac{\Delta\gamma}{\Delta e\, \Omega_S\, \pi_2} \tag{2}$$

and

$$\sigma \leqslant \alpha_{BB \succ BS} \equiv \frac{\Delta\gamma}{e_B\, \Delta\Omega\, \pi_2} \tag{3}$$

are simultaneously satisfied, where

$$\Delta\gamma \equiv \gamma_B - \gamma_S \;, \tag{4}$$

$$\Delta e \equiv e_B - e_S \;, \tag{5}$$

$$\Delta\Omega \equiv \Omega_B - \Omega_S \;. \tag{6}$$

The ability threshold defined by equation (2), $\alpha_{BS \succ SS}$, is such that anyone with ability above this threshold gets a higher expected return by locating in B as a junior worker and relocating to S as a senior worker than by locating in S in both periods (hence the subscript $BS \succ SS$). We use this same notation for all thresholds that follow. Thus, a junior worker will choose trajectory (B, S) if and only if $\alpha_{BS \succ SS} < \sigma$ and $\sigma \leqslant \alpha_{BB \succ BS}$. These two inequalities can only hold simultaneously if $\alpha_{BS \succ SS} < \alpha_{BB \succ BS}$. Using equations (2) and (3), this requires $\frac{e_B}{\Omega_S} < \frac{\Delta e}{\Delta\Omega}$.

We can rewrite the condition that the big city has a comparative advantage in experience, $\frac{e_B}{e_S} > \frac{\Omega_B}{\Omega_S}$, as $\frac{e_s}{\Omega_S} < \frac{\Delta e}{\Delta\Omega}$. Since $e_S < e_B$, the new condition is more stringent. Thus, for some workers to choose trajectory (B, S), it is not enough that the big city has a comparative advantage in experience; the comparative advantage has to be large enough. Then, when $\frac{e_B}{\Omega_S} < \frac{\Delta e}{\Delta\Omega}$, workers with self-confidence $\alpha_{BS \succ SS} < \sigma < \alpha_{BB \succ BS}$ locate in the big city when junior to acquire valuable experience. They do so, intending to relocate to the small city in their

[3]We arbitrarily break ties between location trajectories in favour of the small city, hence the strong inequality $U_{BS}(\sigma) > U_{SS}(\sigma)$ and the weak inequality $U_{BS}(\sigma) \geqslant U_{BB}(\sigma)$.

senior period since the advantage of the big city in terms of opportunities is comparatively small, and they believe their ability is not high enough to compensate for the additional urban cost. Workers with higher self-confidence, $\alpha_{BB>BS} < \sigma$, also locate in the big city when junior but intend to remain there. Finally, workers with low self-confidence, $\sigma < \alpha_{BS>SS}$, locate in the small city when junior and anticipate to remain there.

If instead $\frac{e_B}{e_S} < \frac{\Omega_B}{\Omega_S}$, the big city has a comparative advantage in opportunities. From equation (1), when $\frac{e_B}{e_S} < \frac{\Omega_B}{\Omega_S}$, $U_{BS}(\sigma) < U_{SB}(\sigma)$ holds for all values of σ and trajectory (B, S) can be ruled out. While trajectory (S, B) dominates (B, S), it will only be selected if it also dominates the other two trajectories. From equation (1), $U_{SB}(\sigma) > U_{SS}(\sigma)$ and $U_{SB}(\sigma) \geqslant U_{BB}(\sigma)$ jointly hold if and only if

$$\sigma > \alpha_{SB>SS} \equiv \frac{\Delta\gamma}{e_S\, \Delta\Omega\, \pi_2} \tag{7}$$

and

$$\sigma \leqslant \alpha_{BB>SB} \equiv \frac{\Delta\gamma}{\Omega_B\, \pi_2\, \Delta e} \tag{8}$$

are simultaneously satisfied. These two inequalities can only hold simultaneously if $\alpha_{SB>SS} < \alpha_{BB>SB}$. Using equations (7) and (8), this requires $\frac{\Delta e}{\Delta\Omega} < \frac{e_S}{\Omega_B}$. This condition is more stringent than $\frac{e_B}{e_S} < \frac{\Omega_B}{\Omega_S}$, so for some workers to choose (S, B), the big city must have a large enough comparative advantage in opportunities. Then, when $\frac{\Delta e}{\Delta\Omega} < \frac{e_S}{\Omega_B}$, workers with self-confidence $\alpha_{SB>SS} < \sigma < \alpha_{BB>SB}$ locate in a small city when junior intending to relocate to the big city in their senior period. The dominant advantage of the big city is now the greater opportunities it provides to use the acquired experience. Workers with low self-confidence $\sigma < \alpha_{SB>SS}$ also locate in a small city when junior and anticipate to remain there. Workers with high self-confidence, $\alpha_{BB>SB} < \sigma$ locate in the big city when junior not planning to relocate either.

We have seen that for any worker to choose trajectory (B, S), we must have $\frac{e_B}{\Omega_S} < \frac{\Delta e}{\Delta\Omega}$. For any worker to choose trajectory (S, B), we must have $\frac{\Delta e}{\Delta\Omega} < \frac{e_S}{\Omega_B}$. Thus, when $\frac{e_S}{\Omega_B} \leqslant \frac{\Delta e}{\Delta\Omega} \leqslant \frac{e_B}{\Omega_S}$, workers only choose trajectories (B, B) and (S, S). From equation (1), a junior worker chooses (B, B) over (S, S) if and only if her self-confidence is high enough:

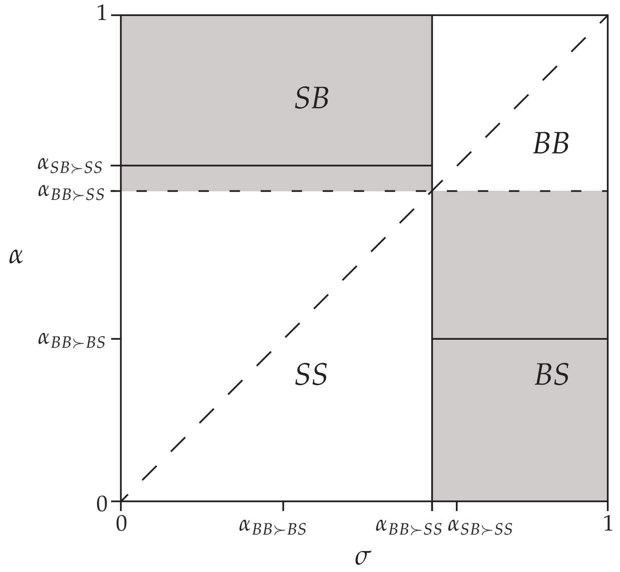
$$\sigma > \alpha_{BB>SS} \equiv \frac{2\Delta\gamma}{(\Omega_B e_B - \Omega_S e_S)\, \pi_2}\ . \tag{9}$$

Senior period location

After her actual ability is revealed by the share of tasks successfully completed when junior, a worker decides whether to stick to her previously planned senior period location or not. If the worker's revealed ability does not match her initial self-assessment ($\alpha \neq \sigma$), the worker will reoptimize by maximizing her senior period utility

$$\max_{j\in\{B,\, S\}} U_{ij}^{\text{SR}}(\alpha) = -\gamma_j + \Omega_j \alpha e_i \pi_2\ , \tag{10}$$

where i has already been determined by her junior choice. This new decision is driven by a combination of the worker's actual ability and her location choice when junior based on her



(Shaded rectangles mark areas where flawed self-assessment alters location choices.)

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

(possibly flawed) self-assessment. In turn, this junior choice has a lasting effect through its impact on experience. Workers whose junior location choice was $i = S$ relocate to B if and only if $U^{\mathrm{SR}}_{SB}(\alpha) > U^{\mathrm{SR}}_{SS}(\alpha)$, i.e., for $\alpha > \alpha_{SB \succ SS}$. Workers whose junior location choice was $i = B$ remain in B if and only if $U^{\mathrm{SR}}_{BB}(\alpha) > U^{\mathrm{SR}}_{BS}(\alpha)$, i.e., for $\alpha > \alpha_{BB \succ BS}$.

The optimal junior and senior location choices as a function of self-confidence σ and ability α are summarised in the following proposition.

Proposition 1. Define low self-confidence as

- $\sigma \leqslant \alpha_{BB \succ SB} \equiv \frac{\Delta\gamma}{\Omega_B\, \pi_2\, \Delta e} \quad \text{if} \quad \frac{\Delta e}{\Delta\Omega} < \frac{e_S}{\Omega_B}$,
- $\sigma \leqslant \alpha_{BB \succ SS} \equiv \frac{2\Delta\gamma}{(\Omega_B e_B - \Omega_S e_S)\, \pi_2} \quad \text{if} \quad \frac{e_S}{\Omega_B} \leqslant \frac{\Delta e}{\Delta\Omega} \leqslant \frac{e_B}{\Omega_S}$,
- $\sigma \leqslant \alpha_{BS \succ SS} \equiv \frac{\Delta\gamma}{\Omega_S\, \Delta e\, \pi_2} \quad \text{if} \quad \frac{e_B}{\Omega_S} < \frac{\Delta e}{\Delta\Omega}$.

Define high self-confidence as the opposite. Define

- low ability as $\alpha \leqslant \alpha_{BB \succ BS} \equiv \frac{\Delta\gamma}{e_B\, \Delta\Omega\, \pi_2}$,
- intermediate ability as $\alpha_{BB \succ BS} < \alpha \leqslant \alpha_{SB \succ SS} \equiv \frac{\Delta\gamma}{e_S\, \Delta\Omega\, \pi_2}$,
- high ability as $\alpha_{SB \succ SS} < \alpha$.

When junior, workers locate in S if they have low self-confidence and B if they have high self-confidence. When senior, workers locate in S if they either have low ability or intermediate ability and low self-confidence; they locate in B if they either have high ability or intermediate ability and high self-confidence.

Figure 1 represents location choices as a function of self-confidence (σ, horizontal axis), and ability (α, vertical axis). The two capital letters in each rectangle denote location choices.

The first represents the junior period location and the second the senior period location for workers with combinations of σ and α falling in that rectangle.

The diagonal of the figure captures situations where self-confidence accurately reflects ability ($\sigma = \alpha$). The figure is plotted for parameter values such that $\frac{e_S}{\Omega_B} \leqslant \frac{\Delta e}{\Delta \Omega} \leqslant \frac{e_B}{\Omega_S}$ so, according to proposition 1, workers with accurate self-assessment locate in the same city in both periods.[4] With $\frac{e_S}{\Omega_B} \leqslant \frac{\Delta e}{\Delta \Omega}$, proposition 1 defines low self-confidence as $\sigma \leqslant \alpha_{BB \succ SS}$. Thus, the vertical line at $\sigma = \alpha_{BB \succ SS}$ has workers with low self-confidence to its left, locating in S when junior, and workers with high self-confidence to its right, locating in B instead.

For the senior period location, we must compare α to $\alpha_{BB \succ BS}$ and $\alpha_{SB \succ SS}$. The horizontal line at $\alpha_{BB \succ BS}$ has workers with low ability below it, who locate in S when senior period regardless of their junior period location. The horizontal line at $\alpha_{SB \succ SS}$ has workers with high ability above it, who locate in B when senior regardless of their junior period location. Workers with intermediate ability $\alpha_{BB \succ BS} < \alpha \leqslant \alpha_{SB \succ SS}$ remain where they located when junior, and this is determined by whether their self-confidence was to the left or right of $\sigma = \alpha_{BB \succ SS}$.

The shaded rectangles in the figure mark areas where workers have sufficiently flawed self-assessment that they behave differently than if they had known their actual ability from the beginning. Overconfident workers with very low ability locate in B when junior and relocate to S when senior once they realise that their ability is too low to benefit from better opportunities in B. These are workers whose σ and α fall in the bottom right shaded rectangle labelled BS.

Next, overconfident works of intermediate ability also locate in B when junior. However, they remain in B when senior, since their intermediate ability lets them take advantage of the higher experience gained when junior better than low-ability workers. These are workers whose σ and α fall in the middle right shaded rectangle labelled BB (each trajectory label refers to the entire rectangle containing it and delimited by a solid line, so the BB label applies to both the white and the shaded portions of this top right rectangle). The proportions of overconfident workers who stick with their initial decision to locate in B and who prefer to relocate to S depend on the magnitude of the threshold $\alpha_{BB \succ BS}$.

Conversely, underconfident workers with very high ability locate in S when junior and move to B when senior once they realise that their ability is high enough to exploit better opportunities there. These are workers whose σ and α fall in the top left shaded rectangle labelled SB.

Finally, underconfident workers of intermediate ability locate in S when junior not realising their true ability. By locating in S, they accumulate less valuable experience than if they had located in B, leading them to remain in S when senior. Had they known their actual ability,

[4]There are only two other possibilities, as per proposition 1. If $\frac{\Delta e}{\Delta \Omega} < \frac{e_S}{\Omega_B}$, even some workers who assess their ability accurately relocate from S to B when senior. If $\frac{e_B}{\Omega_S} < \frac{\Delta e}{\Delta \Omega}$, even some workers who assess their ability accurately relocate from B to S when senior. We show versions of the figure for such parameter values in Appendix B; the degree of comparative advantage in experience or opportunities for big cities is the only key difference between them. We plot figure 1 using $e_B = 0.50$, $e_S = 0.24$, $\Omega_B = 0.70$, $\Omega_S = 0.04$, $\pi_2 = 2.75$, and $\Delta\gamma = 0.30$.

they would have located in B in both periods. These are workers whose σ and α fall in the middle left shaded rectangle labelled SS.

3. Data

We use panel data from the "cross-sectional sample" of the National Longitudinal Survey of Youth 1979 (NLSY79). This survey by the US Department of Labor's Bureau of Labor Statistics (BLS) follows a nationally representative sample of men and women who were 14–22 years old in 1979.
footnoteThe initial NLSY79 sample consisted of a cross-sectional sample of 6,111 respondents selected to represent the non-institutionalized civilian population of the US in 1979 and born between January 1, 1957, and December 31, 1964. The survey included two supplementary samples: one of 5,295 civilian Hispanics, Blacks, and economically-disadvantaged non-Black/non-Hispanic respondents of the same ages, and another one of 1,280 individuals selected to represent the population serving in a branch of the US military who were born between January 1, 1957, and December 31, 1961 (Cooksey, 2018). Both supplemental samples, in addition to lacking the representativeness of the cross-sectional sample, suffered collective attrition events in 1984 and 1990 due to budget constraints that prevent us from tracking individuals in these samples for a long-enough period. We thus restrict our analysis to the cross-sectional sample.

Our measure of ability is the individual's percentile score in the Armed Forces Qualification Test (AFQT). This general ability test was administered in 1980 when NLSY79 respondents were between 15 and 23 (with a median age of 19), regardless of their interest in the military.

In our model, we use the term self-confidence to refer to individuals' perception of their ability. Psychologists often use the term 'general self-efficacy' to capture this aspect of self-evaluation and define it as "individuals' perception of their ability to perform across a variety of different situations" (Judge, Erez, and Bono, 1998, p. 170). Prior to receiving their results on the AFQT, NLSY79 respondents were subject to a test that measured their self-esteem using Rosenberg's (1965) scale. 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 the latter is a broader concept. However, there is a robust empirical association between them. Summarising existing 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 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 level of agreement with various statements

Table 1: Correlation between ability and self-confidence

Age when taking both tests	Level of education	
	At most high school	More than high school
15–17	0.017	0.057
18–19	0.156	0.074
20–21	0.194	0.115
22–23	0.242	0.118

Notes: The ability Armed Forces Qualification Test (AFQT) and the self-confidence Rosenberg test were administered in 1980 to all individuals in our sample.

(e.g., "I am able to do things as well as most other people"). The original scoring method was to use a 1–4 scale for responses to each question ("strongly agree," "agree," "disagree," or "strongly disagree"), reverse coding where appropriate, and then summing over questions. This scoring approach assumes that a response is equally informative about self-assessment for all questions and a unit change in the level of agreement is comparable across all questions. It also produces bunching of scores on a few values. We use the percentile rank computed by the BLS for the Rosenberg test to address these concerns. This measure weighs responses to each question differently depending on how well they help discriminate between individuals with different levels of latent self-esteem and produces an approximately Normal score distribution.

The correlation between the AFQT and the Rosenberg test scores is low (0.21) for the full sample, suggesting that ability assessment is imperfect. Our model assumes that labour market experience provides workers with a better self-assessment of ability. Since the age of NLSY79 respondents ranged between 15 and 23 when tested in 1980, a way to see if self-assessment improves over time with job experience is to analyse whether self-confidence and ability are more correlated for older respondents at the time of the tests.[5]

Table 1 shows the correlation between the AFQT and Rosenberg percentile scores broken down by four test-age groups and two educational categories. As expected, for respondents who complete at most a high-school education, this correlation is higher the older they were at the time of taking the tests. Individuals who go on to post-secondary education are less likely to have gathered labour market experience between ages 15 and 23, so it is reassuring that self-confidence and ability are less correlated for this group. Further, this correlation changes much less from age 15 to 23 for those with post-secondary education.

To relate empirical results more closely to our model, we define a junior and a senior period for each individual and classify metropolitan areas into two groups that we can directly relate to big and small cities in the model.

Regarding timing, we set the junior period for all respondents at the year after their highest level of education is completed, excluding educational periods that happen after more than two years away from education (median age of 20 for individuals without post-secondary

[5]We are grateful to referee 2 for making this helpful suggestion.

education and 24 for the college-educated). To remain close to our model, we set a senior period for all respondents by adding ten years to their junior period in our initial results.[6] However, other regression models exploit the full-time dimension of the panel by looking at relocations at any point after the junior period.

Regarding locations, for each respondent, we know the location at the county level at birth, at age 14, and at each interview date since 1979. Based on these counties, we determine whether each respondent lives in a Core Based Statistical Areas (CBSA) with a 2010 population above two million. If so, we classify them as living in a big city, otherwise as living in a small city.[7] This population threshold leads to 40% and 39% of individuals living in big cities during their junior and senior periods respectively. To construct a standardised occupation variable with consistent codes during the analysis period, we rely on Autor and Dorn (2013).

The initial sample includes all 6,111 individuals in the cross-sectional sample of the NLSY79. We exclude individuals for whom the AFQT or the Rosenberg self-esteem scores are missing, which reduces the sample to 5,671 individuals. We can determine the junior period location of 5,462 of these individuals and, due to sampling attrition, the senior period locations of 5,180 of them. The availability of the demographic controls that we include further reduces our sample to 5,254 individuals in the junior period analysis and 4,985 individuals in the senior period analysis.

4. Observed location choices by self-confidence and ability

We first examine how the location choices of individuals vary with self-confidence and ability. To relate these choices to the theoretical predictions depicted in figure 1, we divide the self-confidence and the ability measures into terciles. Figure 2 plots each of the nine possible combinations of self-confidence (horizontal axis) and ability (vertical axis) terciles in a grid.

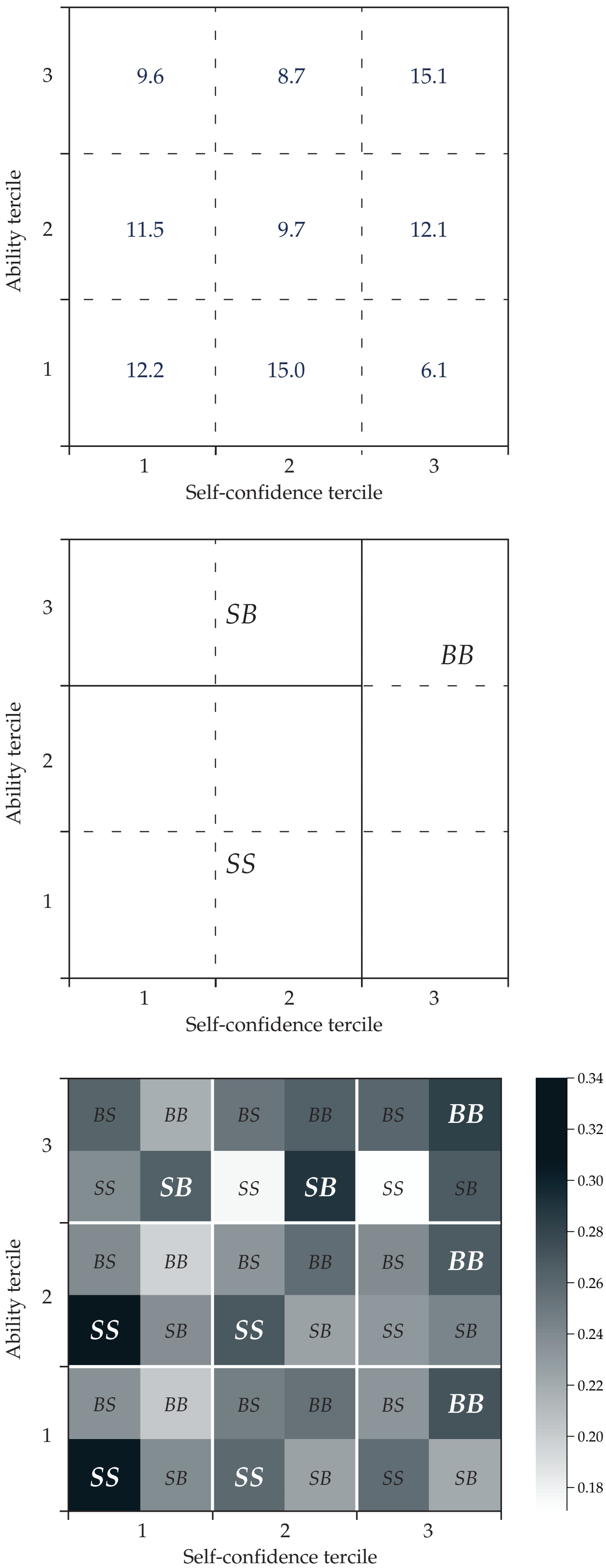
Panel (a) illustrates the bivariate distribution of self-confidence and ability by showing the percentage of NLSY79 respondents in each of the nine cells. We see that individuals are far from being concentrated on the three diagonal cells, and those in the middle tercile of ability are spread almost uniformly across self-confidence terciles.

In panel (b), we define a junior period (the year after completing education) and a senior period (ten years later). Using the same labels as in our theoretical figure 1, we assign each grid cell the most prevalent location trajectory observed in the data for that combination of self-confidence and ability terciles.[8]

[6]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.

[7]Other studies dealing with urban sorting classify cities as big when their population is above a threshold that typically ranges between 1.5 million (Baum-Snow and Pavan, 2012) or 2.5 million (Eeckhout, Pinheiro, and Schmidheiny, 2014). The effects of self-confidence and ability are virtually identical to those we report in the tables below when we define big cities as those that exceed 1.5 and 2.5 million instead of 2 million in 2010.

[8]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). Thus, we measure the prevalence of each location trajectory relative to a random-location benchmark where each individual follows each location trajectory with the same probability as the share of that trajectory in the aggregate population regardless of ability and self-confidence.



Panel (a)

Bivariate distribution of self-confidence and ability

Panel (b)

Prevalent location choice

Panel (c)

Frequency of location choices

Figure 2: Observed location choices by self-confidence and ability terciles

The three cells along the diagonal (representing individuals with well-aligned self-confidence and ability) show the assortative matching between cities and workers predicted by our model. Workers with accurate self-assessment tend to locate in small cities if they have low ability (bottom-left and centre-centre cells) and in big cities, if they have high ability (top-right cell).

Turning to individuals whose self-assessment is less accurate, consider individuals in the top tercile of ability but the bottom or middle tercile of self-confidence (top-left and top-centre cells). Their choices are, again, consistent with our theoretical predictions. Once individuals with low self-confidence find they have high ability, they move away from a small city where their underconfidence led them to locate initially. Had their self-assessment been more accurate, they would have located in a big city from the beginning.

Individuals with intermediate levels of ability and high or low levels of self-confidence also follow the location choices predicted by our model. Those in the top tercile of self-confidence (centre-right cell) start in big cities and remain there. According to our model, they locate in a big city when junior led by their high self-confidence and, hence, acquire valuable experience. They decide to remain in a big city to put that experience to use. Instead, those individuals with lower self-confidence (centre-left cell) but similar intermediate ability tend to locate in a small city and remain there.

Finally, we look at individuals in the bottom tercile of ability who self-assess this inaccurately. Per our theoretical predictions, if their overconfidence is not excessive (bottom-centre cell), they tend to locate in a small city and have no solid reason to move later. The only cell out of nine in figure 2 that seemingly differs from the theoretical prediction of figure 1 is the bottom-right cell. The model can still accommodate this empirical finding—the cell with the least frequent values of ability and self-confidence with only 6.1% of the total—if $\alpha_{BB \succ BS} \equiv \frac{\Delta\gamma}{e_B\, \Delta\Omega\, \pi_2}$ is sufficiently low (requiring large values of e_B and $\Delta\Omega$). Then, workers with low ability who are driven to the big city by their overconfidence when junior acquire valuable experience (large e_B). By remaining there, they take advantage of the much greater opportunities big cities provide (large $\Delta\Omega$).

Panel (b) of figure 2 only shows the most common location choice in each cell. Panel (c) shows the incidence of all choices in each cell. We now split each of the nine cells into four quadrants corresponding to every possible two-period location trajectory, with darker shades representing a higher frequency of that trajectory compared to the overall population. We mark in white the prevalent location choice.[9] Note how strategy *SS* becomes less prevalent and *BB* gradually more prevalent as we move upwards and rightwards.

Overall, the location choices of individuals vary with self-confidence and ability in a way that closely matches our theoretical predictions. Workers with accurate self-assessment tend to locate in small cities if they have low ability and in big cities if they have high ability. Workers with a flawed self-assessment instead make initial location choices that follow their

[9] We are grateful to Jesse Shapiro, our discussant at the NBER Summer Institute, for suggesting this additional panel.

self-confidence rather than their ability. For workers with intermediate ability, any errors in self-assessment are necessarily moderate. Thus, their initial location choices become self-perpetuating even if they do not align with the worker's ability (per our model, because they affect the value of acquired experience).

Workers with high or low ability can make more substantial errors in self-assessment. These are more likely to be corrected, at least for underconfident high-ability workers who, despite lacking the self-confidence to initially locate in a big city, tend to move to one eventually.

All of these conclusions are so far based on raw data, without taking into account other characteristics and experiences of individuals. The main characteristic is education. We next extend our model to incorporate an education choice. This extension highlights why it is important to control for education to accurately characterise how ability and self-confidence determine location decisions over the life cycle. Taking this into consideration, we then present our main empirical results.

5. An extended model with education

We have solved our model by characterising individual location decisions in the two work periods (junior and senior) depending on the values of ability and self-confidence. However, we have so far remained agnostic about how this self-confidence is formed. We now extend the model to include an education period and a decision to attend college or not, which help shape self-confidence.

We think of overall ability as being the combination of scholastic ability and non-scholastic ability. The latter includes attitudes and values, social and emotional skills, and metacognitive skills. Scholastic ability can be assessed with relative ease while going through the education system as a child and adolescent, while non-scholastic ability includes traits that become more evident after gathering some work experience.

Formally, in the education period, each worker becomes informed about her scholastic ability, κ, during free compulsory education. She can opt to also complete college during the education period at a private cost τ and amplify this scholastic ability by a known factor $c > 1$. A worker's non-scholastic ability, $\widetilde{\alpha}$, is only revealed after the junior work period. Until then, she has an imperfect self-assessment of this non-scholastic ability, $\widetilde{\sigma}$. Overall ability is the sum of scholastic ability and non-scholastic ability. Thus, at the beginning of her junior work period, a worker's self-assessment of her overall ability (which, as before, we call self-confidence) is

$$\sigma = \begin{cases} \kappa c + \widetilde{\sigma} & \text{if college-educated ,} \\ \kappa + \widetilde{\sigma} & \text{otherwise .} \end{cases} \tag{11}$$

Then, at the end of her junior work period, after her non-scholastic ability is fully revealed, the worker can perfectly assess her overall ability as

$$\alpha = \begin{cases} \kappa c + \tilde{\alpha} & \text{if college-educated ,} \\ \kappa + \tilde{\alpha} & \text{otherwise .} \end{cases} \tag{12}$$

Each worker's lifetime location trajectory is still fully characterised by proposition 1, based on σ and α. However, it is now also important to characterise the worker's decision to complete college based on her assessment of scholastic ability and evaluation of the impact of college on her working life trajectory. This evaluation is imperfect due to still unascertained non-scholastic ability.

For simplicity, let us focus on parameter values such that $\frac{e_S}{\Omega_B} \leqslant \frac{\Delta e}{\Delta \Omega} \leqslant \frac{e_B}{\Omega_S}$. This is the case represented in figure 1. Following proposition 1, workers expect to locate in the same city in both periods, and relocations are not planned but driven by an inaccurate self-assessment.[10]

In proposition 1, when $\frac{e_S}{\Omega_B} \leqslant \frac{\Delta e}{\Delta \Omega} \leqslant \frac{e_B}{\Omega_S}$, low self-confidence is defined as $\sigma \leqslant \alpha_{BB>SS} \equiv \frac{2\Delta\gamma}{(\Omega_B e_B - \Omega_S e_S)\,\pi_2}$ and high self-confidence as $\sigma > \alpha_{BB>SS}$. Workers with low self-confidence locate in the small city when junior expecting to remain there, while workers with high self-confidence locate in the big city when junior also expecting to remain there.

Each worker chooses whether to attend college anticipating such location strategies. In particular, if the worker attends college, her self-assessed ability when choosing between a small and a big city is $\sigma = \kappa c + \tilde{\sigma}$. Thus, she plans on working in a small city in both periods if $\kappa c + \tilde{\sigma} \leqslant \alpha_{BB>SS}$ and on working in a big city in both periods otherwise. If the worker does not attend college, her self-assessed ability when choosing between a small and a big city is $\sigma = \kappa + \tilde{\sigma}$, so plans on working in a small city in both periods if $\kappa + \tilde{\sigma} \leqslant \alpha_{BB>SS}$ and on working in a big city in both periods otherwise. Since $\kappa c + \tilde{\sigma} > \kappa + \tilde{\sigma}$, this leaves us with three possibilities depending on the worker's scholastic ability and self-assessment of non-scholastic ability.

The first possibility is that $\kappa c + \tilde{\sigma} \leqslant \alpha_{BB>SS}$. This case arises when a worker's combination of scholastic ability and self-assessment of non-scholastic ability is low enough that, even with the scholastic boost of college education, her overall self-confidence remains too low to target a big city. The worker will then opt for college if and only if $U_{SS}(\kappa c + \tilde{\sigma}) - \tau > U_{SS}(\kappa + \tilde{\sigma})$. Using equation (1) to expand the corresponding utilities, the condition for a worker to go to college becomes

$$\kappa(c-1)(\pi_1 + \Omega_S e_S \pi_2) > \tau \ . \tag{13}$$

The left-hand side is the extra return of scholastic ability from attending college if one plans to always work in a small city. The right-hand side is the cost of a college education.

The second possibility is that $\alpha_{BB>SS} < \kappa + \tilde{\sigma}$. This case arises when a worker's combination of scholastic ability and self-assessment of non-scholastic ability is high enough that, even

[10] The other two possible parameter ranges are $\frac{\Delta e}{\Delta \Omega} < \frac{e_S}{\Omega_B}$ and $\frac{e_B}{\Omega_S} < \frac{\Delta e}{\Delta \Omega}$, as we saw in proposition 1. These can be analyzed analogously.

without the scholastic lift of college education, her overall self-confidence is high enough to target a big city. The worker will then opt for college if and only if $U_{BB}(\kappa c + \tilde{\sigma}) - \tau > U_{BB}(\kappa + \tilde{\sigma})$. Again, using equation (1) to expand these utilities, the condition for a worker to go to college becomes

$$\kappa(c-1)(\pi_1 + \Omega_B e_B \pi_2) > \tau \ . \tag{14}$$

The left-hand side is the extra return of scholastic ability from attending college if one plans to always work in a big city, while the right-hand side is the cost of a college education.

The third and final possibility is that $\kappa + \tilde{\sigma} \leqslant \alpha_{BB>SS} < \kappa c + \tilde{\sigma}$. This case arises when the worker's combination of scholastic ability and self-assessment of non-scholastic ability is such that it is worthwhile to target a big city only if she has attended college, i.e., when the scholastic lift of a college education is enough to push her overall self-confidence above $\alpha_{BB>SS}$. The worker will then opt for college if and only if $U_{BB}(\kappa c + \tilde{\sigma}) - \tau > U_{SS}(\kappa + \tilde{\sigma})$. Following equation (1), the condition for a worker to go to college becomes

$$\kappa\left[(c-1)\pi_1 + (c\Omega_B e_B - \Omega_S e_S)\pi_2\right] + \tilde{\sigma}(\Omega_B e_B - \Omega_S e_S)\pi_2 > \tau + 2\Delta\gamma \ . \tag{15}$$

The first term on the left-hand side is the extra return of scholastic ability from attending college and locating in a big city relative to not attending college and locating in a small city. The second term on the left-hand side is the extra return of non-scholastic ability from locating in a big city instead of a small one. The right-hand side is the sum of the cost of college education and the differential urban cost between a big and a small city over the two work periods.

We can draw several conclusions from this extended model. First, although college education tends to provide higher returns in a big city, we expect to see a combination of workers with and without college in both big and small cities. While, as we know from the baseline model, workers with low self-confidence tend to locate in a small city when junior, they may choose to attend college if that low self-confidence arises from a combination of high scholastic ability and a very low self-assessment of non-scholastic ability. Conversely, while workers with high self-confidence tend to locate in a big city when junior, they may choose not to attend college if that high self-confidence results from a low scholastic ability and a high self-assessment of non-scholastic ability.

Second, even some workers with low scholastic ability attend college. They will do so if they are sufficiently self-confident that they expect to succeed in a big city, given that a college education will be particularly beneficial there.

Third, ability and self-confidence matter for location decisions both directly and indirectly through the decision to attend college. For given junior location choice and level of self-confidence, more able individuals are more likely to go to college as they receive a greater expected return from a college education. However, for a given ability level, more self-confident individuals are also more likely to attend college. Indeed, their high self-confidence drives them to a big city when junior, where a college education provides a higher expected benefit.

Moreover, for the same reason, those with a college education are more likely to start working in a big city.

All these matters have implications for our empirical analysis. Ability and self-confidence interact with the decisions to attend college and locate in a big city in complex ways. We expect college education to be correlated with both ability and self-confidence as well as with the choice to locate in a big city. Unless we control for college education in our empirical specifications, we may indirectly capture the effect of personality traits on educational choices rather than the role of self-confidence and ability in determining location choices over the life cycle.

6. Determinants of location in big and small cities

We now test key implications of our model by examining whether self-confidence and ability affect location decisions of individuals across cities of different sizes, while controlling for education and other drivers of location and mobility.

Location trajectories in junior and senior periods

We begin with a specification that remains close to our theoretical framework and its empirical counterpart in figure 2 but accounts for education and other relevant individual characteristics. This estimation involves a multinomial logit where the choices are all four possible combinations of each individual's junior and senior period locations. The dependent variable takes value one if the individual locates in a small city when junior and a big city when senior (*SB*), value two if the individual locates in a big city when junior and senior (*BB*), and value three if the individual locates in a big city when junior and a small city when senior (*BS*). The reference category is individuals who locate in a small city when junior and senior (*SS*). Results are in table 2, where all columns report exponentiated coefficients (odds ratios), so values above (below) one indicate a positive (negative) effect. Standard errors are clustered at the metropolitan area level.

Column (1) examines the trajectory determinants of locating in a small city upon completing education and relocating to a big city (*SB*) ten years later. Results show that, relative to the reference category where individuals locate in a small city in both periods (*SS*), relocating to a big city between the junior and the senior period is more likely if the individual has a higher ability. In particular, an increase of one standard deviation in the ability percentile (28.87 points) raises the probability of a *SB* trajectory by 19%.[11] In contrast, higher self-confidence does not make *SB* significantly more likely than *SS*. This finding matches both our theoretical prediction and our descriptive evidence. In the context of figure 2, it involves moving upwards,

[11]We subtract 1 from the estimated coefficient for the ability percentile and multiply the difference by the variable's standard deviation: $(1.0067 - 1) \times 28.87 = 0.193$.

Table 2: Determinants of individual location trajectories

	Small city when junior, big city when senior (SB)	Big city when junior, big city when senior (BB)	Big city when junior, small city when senior (BS)
	(1)	(2)	(3)
Self-confidence percentile	0.9991	1.0048***	1.0014
	(0.0020)	(0.0017)	(0.0024)
Ability percentile	1.0067***	1.0049*	1.0011
	(0.0024)	(0.0025)	(0.0031)
Male	0.8753	0.9611	0.9399
	(0.0884)	(0.1074)	(0.1293)
Hispanic	1.5200	2.8179***	1.0440
	(0.7319)	(0.8985)	(0.3330)
Black	1.0865	1.5951*	0.9648
	(0.3164)	(0.4179)	(0.2543)
High-school graduate	0.9324	1.0187	0.6696*
	(0.1906)	(0.1545)	(0.1486)
Some college	1.6217**	1.0727	0.7161
	(0.3448)	(0.1801)	(0.1785)
College graduate	2.6919***	2.1652***	1.8016**
	(0.6278)	(0.5281)	(0.5042)
Never married	1.0365	1.3994**	0.8282
	(0.2018)	(0.2138)	(0.1781)
One or more children	0.7230**	0.8097*	0.8609
	(0.1012)	(0.1003)	(0.1331)
Full-time working spouse	1.3755***	0.9335	0.8143
	(0.1507)	(0.1253)	(0.1234)
In a small city at age 14	0.2113***	0.0091***	0.0339***
	(0.0509)	(0.0022)	(0.0053)
Observations		4,985	
Pseudo R^2		0.3317	

Notes: All columns report relative risk ratios (exponentiated coefficients) from a multinomial logit estimation, where coefficients above (below) one indicate a positive (negative) effect. The dependent variable takes value one if the individual locates in a small city when junior and a big city when senior (SB), value two if the individual locates in a big city when junior and senior (BB), and value three if the individual locates in a big city when junior and a small city when senior (BS). The reference category is individuals who locate in a small city when junior and senior (SS). A 'big city' is 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 explanatory categories. All specifications include a constant and birth-year indicators. Standard errors in parentheses are clustered at the metropolitan area level. ***, **, and * indicate significance at the 1, 5, and 10% levels.

starting from the lower-left corner where *SS* is the most prevalent location choice, to the upper-left corner where *SB* becomes the dominant trajectory.

Column (2) analyzes the determinants of locating in a big city in both periods (*BB*). Compared to the reference category (*SS*), individuals are significantly more likely to locate in a big city in both periods when they have higher self-confidence and higher ability. In this case, an increase of one standard deviation in the self-confidence or ability percentiles raises the probability of a *BB* trajectory by 14%.[12] This finding again matches our theoretical prediction and descriptive evidence. In the context of figure 2, it implies an upward-rightward move starting from the lower-left corner where *SS* is the most prevalent choice towards the upper right region, where *BB* becomes the dominant trajectory.

Lastly, column (3) looks at the determinants of locating in a small city upon completing education and relocating to a big city ten years later (*BS*). Here, we do not find a significant effect on either self-confidence or ability. According to the baseline model, we expected *BS* to become the dominant trajectory as we move rightwards from the lower-left corner in figure 2, where *SS* is the most prevalent choice. Nevertheless, this was not the case. The education variables hint at a plausible explanation. The positive and significant coefficient on the college graduate indicator tells us that a central distinguishing feature between those who choose *BS* and *SS* is that the former are more likely to hold a bachelor's degree. Following our extended model with education, attending college can make the difference between locating in a small and a big city in the junior period. Then, having incurred the cost of both attending college and living in a big city early on, individuals may rationally become entrenched in that choice even if they grossly miscalculated their overall ability.

When looking at the education variables across columns, we note that college graduates are much more likely to choose a location trajectory that involves spending some time in a big city rather than remaining in a small city in both periods. Regarding other controls, individuals who never marry tend to locate in a big city in both periods. Those with a full-time working spouse have a higher probability (38%) of transitioning from a small city when junior to a big city when senior (likely seeking the advantages of big cities for dual-career couples documented in Costa and Kahn, 2000). Having children lowers the probability of working in a big city when senior. Hispanics and Blacks are also more prone to always locate in a big city.

Many people are closely attached to the place where they grew up. One year after completing their education, 71% of individuals in our sample are in the same city as at age 14, and 62% remain there by age 40. Thus, we include as a control an indicator variable for living in a small city at age 14.[13] We see that growing up in a small city decreases notably the probability of living in a big city in either the junior or the senior period.

[12]The calculation is $(1.0048 - 1) \times 28.89 = 0.139$ for a one-standard deviation increase in self-confidence and $(1.0049 - 1) \times 28.87 = 0.141$ for a one-standard deviation increase in ability.

[13]Location at age 14 is reasonably exogenous to individuals as it reflects earlier parental location choices. In table 2, 33.6% of individuals move between both periods while only 13.4% change city-size class (i.e, *SB* or *BS*).

The specification of table 2 remains close to our theoretical framework by studying location choices in terms of junior and senior trajectories across two city sizes. However, we must rely on a limited number of observations per trajectory, which constrains our capacity to split the sample further. Moreover, we do not entirely exploit the advantages of our rich panel by focusing on only two periods (junior/senior). For these reasons, we now turn to study location choices upon entering the job market, splitting our sample more finely depending on where people grew up and restricting the analysis to movers. We then study subsequent location choices conditional on that initial location.

Junior period location

A central implication of our model is that junior workers sort on self-confidence rather than ability, with more confident workers more likely to locate in big cities upon entry into the labor market. In column (1) of table 3, we estimate a logit model where the dependent variable takes value one if the individual lives in a big city the year after completing education. As before, all columns report exponentiated coefficients (odds ratios) and standard errors are clustered at the metropolitan area level. Results show that individuals with higher levels of self-confidence are more likely to locate in a big city when junior: an increase of one standard deviation in the self-confidence percentile (28.9 points) raises the probability of locating in a big city by 11%. In contrast, conditioning on self-confidence, individuals with higher ability are not more likely to initially locate in a big city.

Consistent with the extended version of the model, ability positively correlates with higher education, and college-educated workers are more likely to locate in a big city. This outcome is partly due to individuals who grow up in a big city having higher college graduation rates and most people starting to work in the same place they grew up (Bosquet and Overman, 2019). An individual with a bachelor's degree has a 124% higher probability of locating in a big city when junior than someone with primary education, other characteristics being equal. However, as outlined in the extended model, there is substantial heterogeneity in ability among workers with the same level of education. Importantly, self-assessment of ability relative to people with the same education is so imperfect that there is virtually no correlation (0.02) between self-confidence and ability among college-educated workers. As a result, controlling for education, a higher ability does not make the initial location in a big city any more likely.

The estimation also includes a set of standard demographic controls. Having children is associated with a drop in the probability of locating in a big city of 40%. Meanwhile, single individuals and Hispanics are 31% and 114% more likely to live in a big city at that point, respectively.

While growing up in a small city notably decreases the probability of entering the job market in a big city, our results regarding the role of ability and self-confidence are similar whether we control for location at age 14 or not. As an alternative to controlling for living in a

Table 3: Determinants of location in big and small cities in junior period

		Living in a small city at age 14,		Living in a big city at age 14,	
	in a big city when junior (all)	in a big city when junior (all)	in a bigger city when junior (movers)	in a small city when junior (all)	in a smaller city when junior (movers)
	(1)	(2)	(3)	(4)	(5)
Self-confidence percentile	1.0037**	1.0049**	1.0043**	0.9974	0.9920**
	(0.0016)	(0.0020)	(0.0022)	(0.0025)	(0.0036)
Ability percentile	1.0011	1.0023	1.0018	1.0013	0.9981
	(0.0024)	(0.0033)	(0.0037)	(0.0039)	(0.0060)
Male	0.9003	0.9721	1.0135	1.2107	0.8044
	(0.0824)	(0.1277)	(0.1427)	(0.1544)	(0.2348)
Hispanic	2.1355**	1.8488	1.7293	0.2583***	0.2622**
	(0.6827)	(0.7655)	(0.6655)	(0.1167)	(0.1419)
Black	1.4228	1.3422	2.4972***	0.6091*	1.9965
	(0.3480)	(0.4745)	(0.7748)	(0.1783)	(1.0082)
High-school graduate	0.9819	0.7778	0.7027	0.6996	1.3362
	(0.1295)	(0.1564)	(0.1695)	(0.1787)	(0.5600)
Some college	1.0351	1.2983	0.9444	1.2576	0.8573
	(0.1738)	(0.3056)	(0.2693)	(0.3194)	(0.3961)
College graduate	2.2374***	3.8153***	1.2911	1.4754	1.0275
	(0.5908)	(1.0282)	(0.4044)	(0.5071)	(0.4788)
Never married	1.3137*	1.1942	1.6201**	0.5945*	0.4775*
	(0.2151)	(0.2354)	(0.3081)	(0.1652)	(0.1946)
One or more children	0.6030***	0.6057***	0.7086*	1.6894**	1.3947
	(0.0793)	(0.1008)	(0.1454)	(0.3790)	(0.7342)
Full-time working spouse	0.9918	0.8281	0.8128	0.8025	2.3426
	(0.1673)	(0.1746)	(0.1663)	(0.2240)	(1.2715)
In a small city at age 14	0.0167***				
	(0.0040)				
Observations	5,254	3,324	1,129	1,930	406
Pseudo R^2	0.4814	0.0937	0.0596	0.0556	0.0758

Notes: All columns report odds ratios (exponentiated coefficients) from logit estimations, where coefficients above (below) one indicate a positive (negative) effect. The junior period is the year after an individual completes her highest level of continuous education. A 'big city' is a Core Based Statistical Area (CBSA) with a population greater than 2,000,000 in 2010. A 'bigger city' entails an increase in city size and the city of destination exceeds 1,000,000 in 2010. A 'smaller city' entails a drop in city size and the city of destination is below 5,000,000 in 2010. White, female, and ever married are the omitted explanatory categories. All specifications include a constant and birth-year indicators. Standard errors in parentheses are clustered at the metropolitan area level. ***, **, and * indicate significance at the 1, 5, and 10% levels.

small city at age 14, we can split the sample between those who lived in a small or big city at age 14 and re-estimate the specification of column (1) separately for each group. Further, since junior period locations may reflect high moving costs rather than a conscious choice for people who began working in the same city where they grew up, we also focus on the subset of individuals who moved between age 14 and when entering the labour market. We present these alternative specifications in columns (2)-(5) of table 3.

In column (2), we consider all individuals who grew up in a small city, regardless of whether they are still in the same location as at age 14 or not, and examine the determinants of locating in a big city when junior. We find that more self-confident individuals from small cities are more likely to locate in a big city upon entering the labor market. Similarly to column (1), individuals with a bachelor's degree have a much higher probability of living in a big city when junior. Other individual characteristics also continue to matter for the junior location in similar ways.

In column (3), we repeat the estimation of column (2), but now only for individuals who moved between age 14 and when entering the labour market. Since focusing on movers reduces our sample size substantially, we no longer define the dependent variable based on whether the move between age 14 and the junior period involves moving to a big city but instead to a bigger city more broadly.[14] Results show that conditional on no longer living in the same location as at age 14, more self-confident individuals who grew up in a small city are more likely to have moved to a bigger city by the time they enter the labour market. The estimated effect on the self-confidence percentile resembles those of columns (1) and (2). Instead, individuals with higher ability levels are not more likely to follow this path.

In column (4), we consider all individuals who grew up in a big city, regardless of whether they are still in the same location as at age 14 or not, and examine the determinants of locating in a small city when junior. Here, we do not find evidence that less self-confident individuals from big cities locate in small cities in their junior period. This outcome may occur because many people do not move. Indeed, when we restrict the estimation to movers between age 14 and the junior period in column (5), moving to a smaller city is significantly associated with lower self-confidence levels for those who grew up in a big city[15] An increase of one standard deviation in the self-confidence percentile decreases the probability of moving to a smaller city by 23%. It is worth noting that a relatively small share of individuals moves out of big cities early in their lives—only 406 out of 1,930 individuals (21%) move from a big city in column (5), whereas 1,129 of 3,324 individuals (34%) move from a small city in column (3).

[14]In particular, we let the dependent variable take value one if the individual who grew up in a small city resides in a different city in the junior period, provided this new city has a larger population than where the individual grew up and is of at least one million people. It takes value zero when the individual who grew up in a small city resides in an even smaller city or a bigger city with less than one million people.

[15]Our dependent variable takes value one if the individual who grew up in a big city resides in a different city in the junior period, as long as this new city has a smaller population than where the individual grew up and has at most five million people. It takes value zero when the individual who grew up in a big city resides in an even bigger city or a smaller city that exceeds 5 million people. Nine metropolitan areas exceeded five million people in 2010: New York, Los Angeles, Chicago, Dallas, Philadelphia, Houston, Washington DC, Miami, and Atlanta.

Relocations over lifetime careers

We next study location choices later in life. Our model predicts that ability matters for the location of senior workers but that junior location choices have long-term consequences. In particular, conditional on location upon entering the labour market, higher-ability workers should be more likely to locate in big cities later in their careers. Further, self-confidence should no longer drive location decisions directly in the senior period, mattering only indirectly through early location choices.

To test these implications, we exploit the lifetime careers of workers in the NLSY79 to estimate a competing risks discrete duration model using a multinomial logit. Each period, individuals choose whether to stay in their city, move to a small city, or move to a big city.[16]

We show the results regarding relocations after the junior period in table 4. In columns (1a) and (1b), we focus on individuals living in a small city upon completing education. The dependent variable takes value one in the last period prior to migration if the individual relocated to another small city, value two if the individual relocated to a big city, and value zero for all periods an individual remained in the same city. We report exponentiated coefficients (relative risk ratios), where coefficients above (below) one indicate a positive (negative) effect. Results show that self-confidence no longer influences the decision to relocate in any direction. In contrast, the individual's ability is a crucial relocation driver from small to big cities, but not to other small cities. The estimated coefficient on ability in column (1b) implies that a one standard deviation increase in the ability percentile raises the probability of moving from a small to a big city by 22%. Thus, among the set of residents in small cities, the most able move to bigger cities over time.

Analogously, in columns (2a) and (2b), we focus on individuals living in a big city upon completing education. The dependent variable takes value one in the last period before migration if the individual relocated to a small city, value two in the last period before migration if the individual relocated to another big city, and value zero for all periods an individual remained in the same city. Results reveal that neither self-confidence nor ability is a key determinant of senior workers' relocation decisions from big cities in any direction.[17]

[16] The term competing risks derives from the fact that the individual can exit the current location through several alternatives, each involving a move to a different city-size class. See van den Berg (2001) and Bover and Gómez (2004). We focus only on first-time moves, and thus, an individual can move at most once and then drops from the population at risk of migrating for the first time. We can estimate our competing risks (or multiple-exit) discrete duration model using conditional hazard rates or a multinomial logit. In the former, for an individual living in a small city, we would model the probability of moving to a big city at time t conditional on not having done so before and on not having moved to another small city either. In the latter, we would model the probability of either moving to a small city or moving to a big city at time t conditional on not having done either before. Bover and Gómez (2004) show that if the transition intensities are multinomial logit, the conditional exit rates are binary logit with the same parameters. We estimate a multinomial logit by joint maximum likelihood as it is asymptotically more efficient.

[17] The effect of self-confidence is marginally significant for relocations to other big cities. However, in robustness estimations described below, we show the weak effect disappears when controlling for other mobility drivers such as risk aversion, while the effect of ability in column (1b) remains large and highly significant. Moreover, the effect of self-confidence is not robust to alternative thresholds for defining big cities (e.g., 1.5 million or 2.5 million).

Table 4: Determinants of location in big and small cities after junior period

	In a small city upon completing education,		In a big city upon completing education,	
	moved to another small city	moved to a big city	moved to a small city	moved to another big city
	(1a)	(1b)	(2a)	(2b)
Self-confidence percentile	1.0001	1.0004	0.9996	1.0031*
	(0.0009)	(0.0017)	(0.0011)	(0.0018)
Ability percentile	1.0013	1.0075***	0.9963	1.0019
	(0.0013)	(0.0022)	(0.0026)	(0.0033)
Experience	0.9876	0.9996	0.9694*	0.9894
	(0.0123)	(0.0252)	(0.0158)	(0.0247)
Tenure	0.9186***	0.8888***	0.9518***	0.8957***
	(0.0136)	(0.0268)	(0.0173)	(0.0303)
Unemployed	1.1776**	1.3826***	1.4011***	1.2412*
	(0.0866)	(0.1441)	(0.1818)	(0.1592)
Male	1.1036	0.9650	1.1013	0.9304
	(0.0765)	(0.0955)	(0.0961)	(0.1046)
Hispanic	0.9639	1.5538**	0.4905***	1.0836
	(0.2135)	(0.2900)	(0.1036)	(0.2098)
Black	0.6014***	1.1964	0.5491***	0.8610
	(0.0759)	(0.2088)	(0.0905)	(0.1931)
High-school graduate	0.8695	0.8340	0.9135	1.5520
	(0.0780)	(0.1514)	(0.1301)	(0.4549)
Some college	0.9475	1.4271*	0.9776	2.3240**
	(0.0998)	(0.2614)	(0.1850)	(0.8100)
College graduate	0.9230	1.3632	0.9670	2.7661***
	(0.1166)	(0.3225)	(0.1380)	(0.8174)
Never married	0.8857	0.9020	0.7828**	0.9921
	(0.0839)	(0.1090)	(0.0847)	(0.1841)
One or more children	0.7631***	0.6724***	0.9028	0.8580
	(0.0594)	(0.0937)	(0.0964)	(0.1273)
Full-time working spouse	1.0587	1.3484**	1.1250	1.5968***
	(0.0912)	(0.2034)	(0.1426)	(0.2787)
Same city when junior and age 14	0.3512***	0.4140***	0.4142***	0.3918***
	(0.0243)	(0.0482)	(0.0339)	(0.0560)
Years since junior period indicators	Yes	Yes	Yes	Yes
Observations	34,354		24,926	
Pseudo R^2	0.0944		0.0648	

Notes: Columns report odds ratios (exponentiated coefficients) from multinomial logit estimations, where coefficients above (below) one indicate a positive (negative) effect. In columns (1a) and (1b), the sample includes individuals who lived in a small city one year after completing education and the dependent variable takes value one if the individual moves to another small city and value two if she moves to a big city. In columns (2a) and (2b), the sample includes individuals who lived in a big city one year after completing education and the dependent variable takes value one if the individual moves to a small city and value two if she moves to another big city. A 'big city' is 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. All specifications include a constant and birth-year indicators. Standard errors in parentheses are clustered at the metropolitan area level. ***, **, and * indicate significance at the 1, 5, and 10% levels.

This finding is consistent with one of our conclusions from figure 1 when e_B and $\Delta\Omega$ are large: if big-city experience is highly valuable and differences in opportunities between small and big cities are large, then workers who located in a big city upon completing education tend to stay even if their ability is low.

Other findings show that, even conditional on junior period location, having attended college makes locating in a big city later in life more likely. Being partnered with a full-time working spouse increases the odds of moving to a big city, regardless of the worker's initial location (Costa and Kahn, 2000). Having children discourages individuals from leaving small cities. In turn, minorities are less likely to leave a big city. When looking at time-varying labour market variables, a longer job tenure reduces the odds of migrating in any direction. Unemployment is often a major factor that affects the mobility decisions of individuals (Greenwood, 1997). We noted above that workers who initially locate in big cities and found good local opportunities to use their previously acquired experience tend to stay put, even if they turn out to have low ability. On the other hand, individuals who find themselves out of work for an extended period in a big city are more likely to move away. Finally, individuals living in the same city upon completing education and at age 14 are much less likely to move anywhere later in life.

Robustness and alternative explanations

One source of concern is that the sorting by self-confidence that we observe during the junior period is unrelated to an inaccurate assessment of ability. Instead, it may reflect an additional intrinsic value of self-confidence in big cities. To address this concern, we follow De la Roca and Puga (2017). In column (1) of table 5, we replicate their results using our US NLSY79 data (their study uses Spanish Social Security data). We regress log earnings on worker fixed-effects, job characteristics, measures of overall work experience and work experience acquired in big cities, interactions between these measures of experience and worker fixed-effects, and indicator variables for all individual big cities and groups of similarly-sized small cities.[18] The positive and significant coefficient on big-city experience shows that experience acquired in big cities is significantly more valuable than the experience acquired elsewhere, consistent with what we assume in our model.

Furthermore, the significant interaction between big-city experience and worker fixed-effects is evidence of a positive complementarity between ability and the long-term benefits of acquiring work experience in a big city. In column (1), we use worker fixed effects to proxy ability, directly following De la Roca and Puga (2017). Since the NLSY79 includes the AFQT percentile score as a measure of general ability, which we have been using so far, column (2)

[18]We include a separate indicator for every Core Based Statistical Area (CBSA) with a population greater than 2,000,000 in 2010. For CBSAs with smaller populations, we group them in intervals of 100,000 people for population sizes between 1,000,000 and 2,000,000, in intervals of 50,000 people for population sizes between 500,000 and 1,000,000, in intervals of 25,000 people for population sizes between 100,000 and 5,000, and finally group all with population below 100,000, and include an indicator for each group.

Table 5: Relationship between earnings, ability, and self-confidence

	Log earnings			
	(1)	(2)	(3)	(4)
Big-city experience	0.0153*** (0.0025)	0.0152*** (0.0025)	0.0154*** (0.0025)	0.0151*** (0.0025)
Big-city exp. × experience	-0.0004*** (0.0001)	-0.0004*** (0.0001)	-0.0004*** (0.0001)	-0.0004*** (0.0001)
Big-city exp. × worker fixed-effect	0.0118** (0.0052)		0.0128** (0.0053)	
Big-city exp. × ability		0.0068* (0.0036)		0.0078** (0.0036)
Big-city exp. × self-confidence			-0.0041 (0.0034)	-0.0051 (0.0034)
Big city × ability				
Big city × self-confidence				
Experience	0.0289*** (0.0018)	0.0271*** (0.0018)	0.0290*** (0.0018)	0.0273*** (0.0018)
Experience^2	-0.0004*** (0.0001)	-0.0003*** (0.0001)	-0.0004*** (0.0001)	-0.0003*** (0.0001)
Experience × worker fixed-effect	0.0633*** (0.0079)		0.0640*** (0.0081)	
Experience^2 × worker fixed-effect	-0.0011*** (0.0003)		-0.0012*** (0.0003)	
Experience × ability		0.0314*** (0.0050)		0.0309*** (0.0050)
Experience^2 × ability		-0.0005*** (0.0002)		-0.0005*** (0.0002)
Experience × self-confidence			-0.0026 (0.0048)	0.0025 (0.0047)
Experience^2 × self-confidence			0.0001 (0.0002)	0.0000 (0.0002)
Tenure	0.0287*** (0.0014)	0.0289*** (0.0014)	0.0287*** (0.0014)	0.0288*** (0.0014)
Tenure^2	-0.0010*** (0.0001)	-0.0010*** (0.0001)	-0.0010*** (0.0001)	-0.0010*** (0.0001)
City/city group indicators	Yes	Yes	Yes	Yes
2-digit occupation & sector indicators	Yes	Yes	Yes	Yes
Worker fixed effects	Yes	Yes	Yes	Yes
Observations	46,833	46,833	46,833	46,833
R^2	0.2671	0.2583	0.2672	0.2584

Notes: A 'big city' is a Core Based Statistical Area (CBSA) with a population greater than 2,000,000 in 2010. City/city group indicators includes indicator variables for all individual big cities and for groups of similarly-sized small cities. Worker fixed-effect computation follows De la Roca and Puga (2017). All specifications include a constant. Coefficients reported with robust standard errors in parenthesis, which are clustered by worker. ***, **, and * indicate significance at the 1, 5, and 10% levels.

provides an alternative version of column (1) measuring ability with the AFQT score instead. The same results remain, although they are less salient than when using worker fixed effects.

The critical question is whether self-confidence, like ability, has a higher return in big cities. To answer this, in columns (3) and (4), we add to the specifications of columns (1) and (2), respectively, interactions between both experience types and the self-confidence measure. If anything, the small negative point estimate for the interaction between big-city experience and self-confidence suggests more overconfident workers (higher self-confidence for given ability) may benefit less from big cities, but the coefficient is not statistically significant.

It is worth noting that these results do not imply that high self-confidence is not an attribute rewarded in the job market. If we re-estimate the specification in column (1) of table 5 dropping worker fixed effects (and interactions with these) and adding the worker's self-confidence and ability percentiles, the estimated coefficients of both attributes are positive and significant. The coefficient on the ability percentile is four times larger than the coefficient on the self-confidence percentile (the corresponding table is available in the online appendix). What our results indicate is that self-confidence, unlike ability, is not more rewarded in big than in small cities. To allow for immediate, and not just gradual, additional returns to these traits in bigger cities, we have re-estimated column (4) of table 5 including interactions between self-confidence and a big-city indicator and between ability and a big-city indicator. Neither coefficient is statistically significant.

One may also worry that the empirical relationship between self-confidence and living in a big city upon completing education could be driven by other personality traits correlated with self-confidence.[19] Since NLSY79 respondents were not administered a personality test, we turn to a related data set, the NLSY79 Children and Young Adults, which surveys all offspring of NLSY79 female respondents. As part of this survey, young adults were administered the Ten Item Personality Inventory test, measuring the big-five personality traits: extraversion, agreeableness, conscientiousness, neuroticism, and openness to experience. In addition, they were also subjected to the same Rosenberg test measuring self-confidence in our main sample and various ability tests, specifically the Peabody International Achievement Test for math, reading recognition, and reading comprehension. Since this data set follows the offspring of women in our primary sample, respondents are much younger, so we can only examine location determinants upon completing education. When we replicate column (1) of table 3, with and without the big-five personality traits as controls, we find that the coefficient on the self-confidence percentile remains significant and unchanged after controlling for the big-five personality traits (the corresponding table is available in the online appendix). The magnitude of this coefficient is similar to the one in table 3. The effects of the ability percentile in terms of math and reading comprehension is not significant whether or not we control for the big-five personality traits.

[19]For example, high self-confidence tends to be positively related to extraversion (Robins, Tracy, Trzesniewski, Potter, and Gosling, 2001) and extravert individuals may be more likely to choose dense locations (Francis and Rutledge, 2004; Jones *et al.*, 2013, suggest this pattern based on data for doctors and clergy).

A final related concern is that self-confidence may be capturing attitude towards risk, with more self-confident individuals perhaps more willing to take risks. To the extent that locating in a big city may be seen as a risky investment, that association could be driving in part the relationship between self-confidence and junior location in a big city. The NLSY79 includes a measure of attitude towards risk.[20] Respondents grade their willingness to take risks on a scale from 0 to 10. We use the individual's percentile in this scale (with a higher percentile associated with a lower willingness to take risks) as a measure of risk aversion. We re-estimate table 4 controlling for risk aversion (the corresponding table is available in the online appendix). Results show that more risk-averse individuals are less prone to migrate across the board. This finding is consistent with earlier research examining the positive association between willingness to take risks and migration (Jaeger, Dohmen, Falk, Huffman, Sunde, and Bonin, 2010; Bauernschuster, Falck, Heblich, Suedekum, and Lameli, 2014). Importantly, the effect of ability on the probability of moving from small to big cities rises. Further, self-confidence and ability do not affect the probability of moving from a big city in any direction.

7. Conclusions

Bigger cities offer more valuable experience and opportunities in exchange for higher housing costs. While higher-ability workers benefit more from bigger cities, they are not more likely to move to one. Our model of urban sorting by workers with heterogenous self-confidence and ability suggests flawed self-assessment is partly to blame. Workers who misjudge their ability at an early career stage make location decisions they would not have made had they known their actual ability. 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.

Analysis of NLSY79 data shows that, in line with our model predictions, the location choices of young workers are guided by self-confidence rather than ability. Thus, some overconfident young workers start their career in a big city, while they would have chosen a small city with better self-assessment. That initial misjudged decision then becomes self-validating: having incurred an excessive cost to gain more valuable experience, they find they might at least take advantage of this by remaining in the big city. Analogously, some underconfident young workers spend their whole lives in a small city, even though a correct initial ability assessment would have made them self-select into a big city instead. Workers who severely underestimate their ability may nevertheless relocate from a small to a big city, once labour market experience provides them better information about their true capabilities. Young

[20] Unfortunately, this risk measure was collected recently in 2010, whereas our measures of ability and self-confidence were collected at the beginning of the survey, when most respondents were teenagers. This is not ideal, since the measure may be affected by the consequences of earlier location choices, and also leads to a large drop in the number of observations. For these reasons we do not use this as our baseline specification.

workers who are confident enough of their abilities locate in bigger cities to pursue their dreams, but those dreams do not come true for everyone.

Appendix A. Endogenizing urban structure

In the main text, we have determined individual location choices taking as given the existence of big and small cities. However, city sizes result from the combination of multiple location choices of individuals, and we must make sure there is consistency between individual choices and city sizes. In other words, we must make sure that the equilibrium we have characterized exists. For this reason, we now endogenize the urban structure and solve for the general equilibrium of the model presented in section 2. We also show that this equilibrium is unique.

Suppose there are two cities, and each is linear and monocentric.[21] 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).

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.[22] 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 τx. 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 τx and her housing costs $P_i(x)$:

$$\gamma_i(x) = \tau x + P_i(x) \ , \quad i, j \in \{B, S\} \ . \tag{A.1}$$

As a result, any resident in a city is willing to bid τx more for a house that is x closer to the CBD. Equilibrium house prices are then such that the decrease 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

$$P_i(x) = \tau(N_i - x) + \bar{r} \ , \quad i, j \in \{B, S\} \ , \tag{A.2}$$

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 τN_i, but only pays $\bar{r}$ for housing. A worker living at the CBD has no cost of commuting but pays an additional τN_i for her house. Substituting equation (A.2) into (A.1) yields urban cost in city i:

[21] We develop a highly simplified version of the monocentric city model (Alonso, 1964; Mills, 1967; Muth, 1969). For more general versions of the monocentric city model, see Brueckner (1987) and Duranton and Puga (2015).

[22] 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 (A.3) below.

$$\gamma_i = \tau N_i + \bar{r} \ . \tag{A.3}$$

To allow for the coexistence of junior and senior workers in a city, consider 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:

$$n \equiv N_B - N_S \ . \tag{A.4}$$

Note that $0 \leqslant n \leqslant 2$ holds 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 (A.3) and (A.4), we can then express the difference in urban costs between B and S, $\Delta\gamma \equiv \gamma_B - \gamma_S$, as

$$\Delta\gamma = \tau n \ . \tag{A.5}$$

Taking n as given, each worker can calculate $\Delta\gamma$ as per equation (A.5). She can then substitute this into equations (2), (3), (7), (8) and (9) to calculate, respectively, $\alpha_{BS>SS}$, $\alpha_{BB>BS}$, $\alpha_{SB>SS}$, $\alpha_{BB>SB}$ and $\alpha_{BB>SS}$. Given these thresholds, each worker chooses her optimal location as per proposition 1. An equilibrium arises when adding up how many workers choose to locate in each city yields a difference in population between the two cities equal to n.

Adding $N_B + N_S = 2$ to equation (A.4) and solving for N_B, we can express population in B in terms of n:

$$N_B = 1 + \frac{n}{2} \ . \tag{A.6}$$

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 1. Let us denote by $f(\sigma, \alpha)$ the probability density function for the bivariate distribution of ability and self-confidence for workers in the population. Hence, we can write:

$$b(n) = \begin{cases} \displaystyle\int_{\alpha_{BB>SB}(n)}^{1}\int_{0}^{1} f(\sigma,\alpha)\mathrm{d}\alpha\mathrm{d}\sigma + \int_{\alpha_{BB>SB}(n)}^{1}\int_{\alpha_{BB>BS}(n)}^{\alpha_{SB>SS}(n)} f(\sigma,\alpha)\mathrm{d}\alpha\mathrm{d}\sigma + \int_{0}^{1}\int_{\alpha_{SB>SS}(n)}^{1} f(\sigma,\alpha)\mathrm{d}\alpha\mathrm{d}\sigma & \text{if } \frac{\Delta e}{\Delta\Omega} < \frac{e_S}{\Omega_B} \\[2ex] \displaystyle\int_{\alpha_{BB>SS}(n)}^{1}\int_{0}^{1} f(\sigma,\alpha)\mathrm{d}\alpha\mathrm{d}\sigma + \int_{\alpha_{BB>SS}(n)}^{1}\int_{\alpha_{BB>BS}(n)}^{\alpha_{SB>SS}(n)} f(\sigma,\alpha)\mathrm{d}\alpha\mathrm{d}\sigma + \int_{0}^{1}\int_{\alpha_{SB>SS}(n)}^{1} f(\sigma,\alpha)\mathrm{d}\alpha\mathrm{d}\sigma & \text{if } \frac{e_S}{\Omega_B} \leqslant \frac{\Delta e}{\Delta\Omega} \leqslant \frac{e_B}{\Omega_S} \\[2ex] \displaystyle\int_{\alpha_{BS>SS}(n)}^{1}\int_{0}^{1} f(\sigma,\alpha)\mathrm{d}\alpha\mathrm{d}\sigma + \int_{\alpha_{BS>SS}(n)}^{1}\int_{\alpha_{BB>BS}(n)}^{\alpha_{SB>SS}(n)} f(\sigma,\alpha)\mathrm{d}\alpha\mathrm{d}\sigma + \int_{0}^{1}\int_{\alpha_{SB>SS}(n)}^{1} f(\sigma,\alpha)\mathrm{d}\alpha\mathrm{d}\sigma & \text{if } \frac{e_B}{\Omega_S} < \frac{\Delta e}{\Delta\Omega} \ . \end{cases} \tag{A.7}$$

Equation (A.7) can be readily understood by referring back to proposition 1. For example, the first case (for $\frac{\Delta e}{\Delta\Omega} < \frac{e_S}{\Omega_B}$) has three types of workers choosing lo 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 $\alpha_{BB>BS} < \alpha \leqslant \alpha_{SB>SS}$ who in their junior period located in B due to high self-confidence $\alpha_{BB>SB} < \sigma$; and senior workers with high ability $\alpha_{SB>SS} < \alpha$, regardless of their self-confidence.

We can also interpret equation (A.7) 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.

Any equilibrium value of n has to satisfy $b(n) = 1 + \frac{n}{2}$ for $0 \leqslant n \leqslant 2$. 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 2. 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 τ, and increases with the additional opportunities $\Delta\Omega$ and the additional experience Δe provided by the bigger city.

Proof Define the auxiliary function

$$\tilde{b}(n) = 1 + \frac{n}{2} - b(n) \; . \tag{A.8}$$

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 $0 \leqslant n \leqslant 2$.

We begin by showing that $b(n)$ is a continuous decreasing function of n over the interval $[0, 2]$. Consider the case where $\frac{\Delta e}{\Delta\Omega} < \frac{e_S}{\Omega_B}$. By the fundamental theorem of calculus, $b(n)$ is a continuous function of $\alpha_{BB>SB}(n)$, $\alpha_{BB>BS}(n)$, and $\alpha_{SB>SS}(n)$, which are in turn continuous functions of n. From equation (A.7), by the fundamental theorem of calculus and the chain rule of derivation, its derivative with respect to n can be written

$$\begin{aligned} b'(n)\Big|_{\frac{\Delta e}{\Delta\Omega} < \frac{e_S}{\Omega_B}} = & -\alpha'_{BB>SB}(n) \int_0^1 f(\alpha_{BB>SB}(n), \alpha) \mathrm{d}\alpha - \alpha'_{BB>SB}(n) \int_{\alpha_{BB>BS}(n)}^{\alpha_{SB>SS}(n)} f(\alpha_{BB>SB}(n), \alpha) \mathrm{d}\alpha \\ & -\alpha'_{BB>BS}(n) \int_{\alpha_{BB>SB}(n)}^{1} f(\sigma, \alpha_{BB>BS}(n)) \mathrm{d}\sigma - \alpha'_{SB>SS}(n) \int_0^{\alpha_{BB>SB}(n)} f(\sigma, \alpha_{SB>SS}(n)) \mathrm{d}\sigma \; , \end{aligned} \tag{A.9}$$

which is negative given that $\alpha'_{BB>SB}(n) > 0$, $\alpha'_{BB>BS}(n) > 0$ and $\alpha'_{SB>SS}(n) > 0$. It can be shown analogously that $b(n)$ is a continuous decreasing function of n over the interval $[0, 2]$ when

$\frac{e_S}{\Omega_B} \leqslant \frac{\Delta e}{\Delta \Omega} \leqslant \frac{e_B}{\Omega_S}$ and when $\frac{e_B}{\Omega_S} < \frac{\Delta e}{\Delta \Omega}$.

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 (A.5), $n = 0$ implies $\Delta\gamma = 0$; which in turn, by equations (2), (3), (7), (8), and (9), implies $\alpha_{BS>SS} = \alpha_{BB>BS} = \alpha_{SB>SS} = \alpha_{BB>SB} = \alpha_{BB>SS} = 0$; and substituting these into equation (A.7) yields $b(0) = 2$; which, by equation (A.8), 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 proofs 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 $\frac{\mathrm{d}n}{\mathrm{d}\tau}$ yields

$$\frac{\mathrm{d}n}{\mathrm{d}\tau} = \frac{\frac{\mathrm{d}b(n)}{\mathrm{d}\tau}}{\tilde{b}'(n)} . \tag{A.10}$$

Since τ and n always enter $b(n)$ together as a product (because $\Delta\gamma$ enters every threshold level of α and, by equation A.5, $\Delta\gamma = \tau n$), it follows that $\frac{\mathrm{d}b(n)}{\mathrm{d}\tau} = b'(n)$, and we have already shown that $b'(n) < 0$. We have also shown that $\tilde{b}'(n) > 0$. Hence, we can sign equation (A.10): $\frac{\mathrm{d}n}{\mathrm{d}\tau} < 0$. The comparative statics $\frac{\mathrm{d}n}{\mathrm{d}\Delta\Omega} > 0$ and $\frac{\mathrm{d}n}{\mathrm{d}\Delta e} > 0$ can be proven analogously. $\square$

When deciding whether to locate in B, junior workers trade off the greater experience they will 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 and ability, on common parameters capturing the magnitude of the advantages and disadvantages of locating in the big city, and on the choices of all 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 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 then 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, the reverse adjustment occurs if the mass of workers who given n prefer B to S aggregates up to less than n.

The comparative statics for equilibrium differences in city sizes are fairly intuitive. A higher cost of commuting per unit of distance (τ) implies a larger gap in urban costs for any given difference in population between B and S, and so results in a smaller equilibrium difference in population sizes (n). The greater the additional opportunities ($\Delta\Omega$) and the additional experience (Δe) provided by B, the more attractive is B relative to S, so a higher difference in population (n) is needed to balance things out in equilibrium.

Appendix B. Alternative equilibrium location choices by self-confidence and ability

Figure 1 in the main text describes location choices under parameter values such that $\frac{e_S}{\Omega_B} \leqslant \frac{\Delta e}{\Delta\Omega} \leqslant \frac{e_B}{\Omega_S}$ so that, according to proposition 1, low self-confidence is defined as $\sigma \leqslant \alpha_{BB \succ SS}$ and a worker never selects trajectories (B, S) and (S, B) *ex ante* based on her self-assessed ability, but she might still end up following them *ex post* if her initial self-assessment turned out to be wrong. Panels (a) and (b) of figure B.1 describe the only two alternative possibilities.[23]

Panel (a) of figure B.1 describes location choices under parameter values such that $\frac{\Delta e}{\Delta\Omega} < \frac{e_S}{\Omega_B}$. As before, junior workers locate in S if they have low self-confidence and locate in B if they have high self-confidence, although low self-confidence is now defined by proposition 1 as $\sigma \leqslant \alpha_{BB \succ SB}$. When senior, workers locate in S if either they have low ability or they have intermediate ability and did not locate in the big city during their junior period; they locate in B if either they have high ability or they have intermediate ability and located in the big city during their junior period. The main difference is that some junior workers now choose trajectory (S, B) *ex ante*. We can see this from the fact that the diagonal (corresponding to perfectly accurate self-assessment $\sigma = \alpha$) crosses through the area marked SB.

Analogously, panel (b) of figure B.1 depicts the case arising for parameter values $\frac{e_B}{\Omega_S} < \frac{\Delta e}{\Delta\Omega}$. The same general results of proposition 1 hold, although low self-confidence is now defined as $\sigma \leqslant \alpha_{BS \succ SS}$. The main difference is that some junior workers now choose trajectory (B, S) *ex ante*. We can see this from the fact that the diagonal crosses through the area marked BS.

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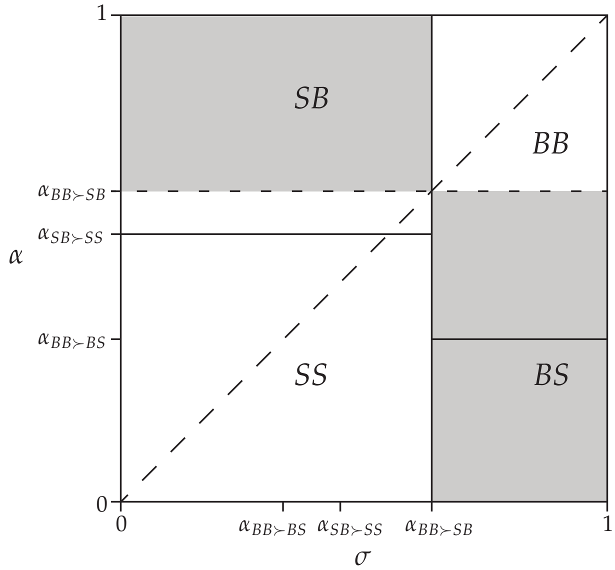
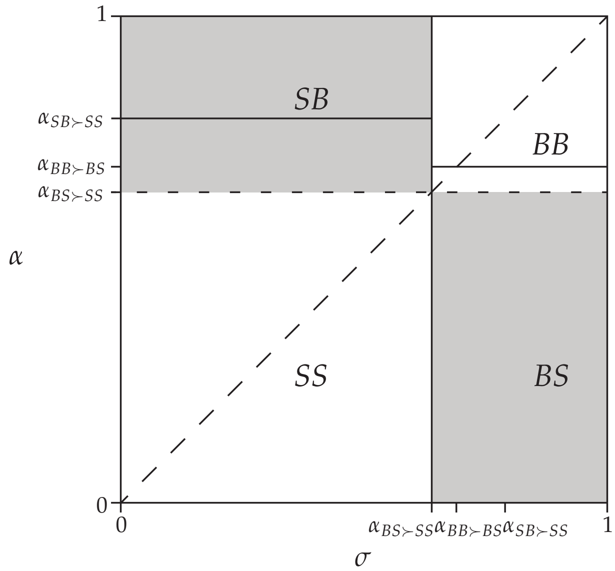
[23]Panel (a) is plotted for $e_B = 0.40$, $e_S = 0.24$, $\Omega_B = 0.95$, $\Omega_S = 0.21$, $\pi_2 = 3.08$, and $\Delta\gamma = 0.30$. Panel (b) is plotted for $e_B = 0.80$, $e_S = 0.70$, $\Omega_B = 0.50$, $\Omega_S = 0.45$, $\pi_2 = 10.80$, and $\Delta\gamma = 0.30$.



Panel (a) $\frac{\Delta e}{\Delta \Omega} < \frac{e_S}{\Omega_B}$



Panel (b) $\frac{e_B}{\Omega_S} < \frac{\Delta e}{\Delta \Omega}$

($\frac{e_S}{\Omega_B} \leqslant \frac{\Delta e}{\Delta \Omega} \leqslant \frac{e_B}{\Omega_S}$ represented in figure 1)

Figure B.1: Alternative equilibrium location choices by self-confidence and ability

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