# Interpreting The "Fair and Equitable" Standard In Labor Force Seniority Integration*

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**Abstract**

This paper develops an analytical framework for assessing the effects of workforce seniority integration resulting from a merger or consolidation of two firms. In addition to developing a formal model that can be used to analyze the relative equity effects of integrating two workforces, we demonstrate why the interpretation of the "fair and equitable" standard embedded in the two most commonly proposed methods of seniority integration (the so called "date-of-hire" and "ratio" methods) are in conflict, thereby necessitating binding third party arbitration. We also demonstrate that measures of aggregate equity distortion can often be reduced using a hybrid method that combines elements of both the date-of-hire and ratio methods.

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*"There are four basic lessons to be learned from those submissions... that each case turns on its own facts; that the objective is to make the integration fair and equitable; that the proposals advanced by those in contest rarely meet that standard; and that the end result, no matter how crafted, never commands universal acceptance." (Federal Express and Flying Tiger Pilots Seniority Integration Decision of Arbitrator Nicolau, (1990) at pp. 27-28.)*

# 1 Introduction

Among the many challenges facing two firms attempting to merge is the issue of labor force integration. Potential problems related to workforce integration can become especially acute when some or all employees at one or both of the merging firms are ranked according to seniority. Because an employee's relative position on his or her seniority list can dramatically impact that employee's current and future compensation, job security and other benefits, the method by which two seniority lists are integrated and the resulting ranking of employees is of paramount interest to the employees of merging firms.[1] Indeed, over the past decade, there have been a number of high-profile mergers requiring seniority integration that have required binding, independent arbitration—some of which have even resulted in post-arbitration litigation or new Federal legislation.[2] The recently enacted McCaskill-Bond Amendment which explicitly requires U.S. airline mergers to provide for the integration of seniority lists in a "fair and equitable" manner, for example, was a direct result of dissatisfaction by the two U.S. senators from Missouri (the former headquarters of TWA) over the "stapling" of TWA's flight attendants to the bottom of American's seniority list following the TWA-American merger in 2001.[3] In other instances, failure to successfully negotiate a method of seniority integration pre-merger has prevented one firm from acquiring another. For example, in

[1] Although the details of how two seniority lists are integrated is typically left in the hands of the respective workgroups, the merging firms nonetheless have a direct interest in the process, as labor disruptions can significantly impact a firm's operational and financial performance.

[2] For example, pilots from US Airways' "East" and "West" groups are still embroiled in a seniority integration dispute resulting from the 2005 merger of US Airways and America West. *See* Don Addington et al., Plaintiffs, vs. US Airline Pilots Association and US Airways, Defendants. *In the United States District Court for the District of Arizona, No. CV-08-1633-PHX-NVW.* Likewise, litigation between the pilots of Air Canada and Canadian Airlines continued for nearly a decade following the merger of the two companies in 2000. *See* Air Canada Pilots Association vs. Air Line Pilots Association, Rob McInnis and Air Canada, *Canadian Federal Court of Appeal, Docket A-144-06, Citation 2007 FCA 241.*

[3] See "McCaskill and Bond Work to Protect Airline Workers In Mergers", December 17, 2007, `http://mccaskill.senate.gov/?p=press_release&id=226`.

2009, the inability of the pilots from Southwest Airlines' and Frontier Airlines' to agree upon a method of seniority integration was the primary reason why Southwest's attempted bid for Frontier failed.

Although the effects of the seniority system on wages, earnings and employment has been well-studied by economists (Grossman 1983, Lang 1984, Drazen and Gottfries 1994, Booth and Frank 1996), there has been surprisingly little attention paid to the economics of seniority *integration* since the early work of Kahn (1955), Kennedy (1963) and Mater and Mangum (1963), which examined the broad principles surrounding several seniority integration arbitration decisions from the first half of the 20th century in the railroad (and other) industries.[4] This is somewhat surprising in light of the significant implications on both workers and firms that mergers and a resulting seniority integration can have. For example, when economic conditions dictate that a firm must reduce the size of its workforce, furloughs are virtually always taken off the bottom of a seniority list when one exists.[5]

This paper attempts to fill this void in the literature in several ways. We start by developing a simple model of seniority integration. We note at the outset that the focus of our model is on what we believe to be the most critical aspect of the seniority integration problem: the relative position of employees on the integrated seniority list. In doing so, however, our model abstracts from certain details that may be at issue in a particular integration of workforces, such as differences in wages or rates of attrition across the two pre-merger firms. Nevertheless, we believe that our model enables one to systematically analyze important questions regarding equity and fairness, which is the cornerstone of the seniority integration problem.

With our basic framework in hand, we then turn to analyzing several pertinent (and heretofore unaddressed) questions regarding seniority integration. The first question we attempt to shed light on is why seniority integration is typically such a contentious issue? To answer this question, we turn to the airline industry, where a history of consolidation both in the U.S. and abroad combined with unionized workforces has resulted in frequent, well-documented seniority disputes, particularly amongst pilots of merging carriers. An examination of several seniority integration disputes reveals a repeated pattern whereby one of the merging workgroups advocates for what is known as "date-of-

[4]Kahn (1990) studied occupational safety provided by firms in unionized industries and found that firm-supplied safety reflects the preferences of the most senior and most junior workers in terms of seniority. Hodge (2008) provides a legal perspective overview of many seniority arbitration decisions from the airline industry.

[5]Likewise, the seniority integration dispute between US Airways "East" and "West" pilots was identified as one of the factors leading up to an illegal work slowdown by its East pilots in the summer of 2011. *See* Memorandum Opinion and Order, US Airways, Inc., Plaintiff, v. US Airline Pilots Association and Michael J. Cleary, Defendants. *United States District Court Western District of North Carolina Charlotte Division 3:11-cv-371–RJC–DCK*, September 29, 2011.

hire" integration while the other advocates for what is known as the "ratio" method. These methods will be discussed in detail in Section 2; however, "date-of-hire" integration consists of constructing the post-merger seniority list by ranking employees solely based on their longevity at their respective *pre-merger* firm, while the "ratio" method constructs the new seniority list with the characteristic that each employee's pre- and post-merger percentile ranking on his or her seniority list remains constant.

When examined closely, however, we demonstrate that these two methods reflect differing views of how one should interpret the "fair and equitable" benchmark that governed past seniority integrations in the U.S. airline industry for nearly four decades under the Allegheny-Mohawk Labor Protective Provisions ("LPPs"), and likewise applies to today's mergers under the more recent McCaskill-Bond Amendment. At the core of the "fair and equitable" standard in the date-of-hire method is the notion that the only determinant of an employee's competitive rank within a firm should be his or her experience at that firm. Put differently, any worker senior to another on the merged seniority list should be from a cohort with equivalent or greater length of service with the pre-merger firm, a property we refer to as the ability to *retain cohort stability*. In contrast, the interpretation of the "fair and equitable" standard embedded in the ratio method is one based on the premise that if a member is above (below) a relevant threshold pre-merger (i.e., is unlikely to be furloughed or qualifies for premium pay assignments), he should remain above (below) the same threshold post-merger, a property we refer to as the ability to *preserve initial status*. We demonstrate that the conditions under which the two methods are equivalent (thereby satisfying both concepts of what is fair and equitable) rarely hold. Consequently, a main proposition of our analysis formalizes why the two interpretations of what is fair and equitable are in direct conflict, thus explaining why seniority integration is frequently the subject of binding arbitration.

We then turn our attention to an analysis of the equity distortions resulting from different methods of seniority integration. After defining measures of equity distortion that can be used to compare and evaluate competing methods of integration, we characterize the conditions under which a "hybrid" method that combines elements of the "date-of-hire" and "ratio" methods can reduce aggregate equity distortion. We believe that our findings can serve as a useful tool for arbitrators that are frequently confronted with choosing between conflicting proposals.[6]

[6]For example, arbitrators in the recent Delta-Northwest pilot seniority integration noted that "Notwithstanding months of vigorous negotiations and subsequent good faith participation in mediation efforts, the parties to this dispute are deeply divided, as is apparent from their respective proposals: Each does little more than stack the deck for their own constituencies in ways that are neither fair nor equitable." *See* Integrated Seniority List and Award, *In the Matter of the Seniority Integration Between the Pilots of Northwest Airlines and the Pilots of Delta Air Lines, Before the Seniority Integration Arbitration Board Richard I. Bloch, Dana E. Eischen and Fredric R. Horowitz,*

It is important to emphasize that while the most direct application of our analysis is in the context of a merger involving two (typically unionized) labor forces, there are a host of other real-world contexts in which seniority integration can and does occur. Indeed, seniority integration issues can even arise without the triggering event of a merger. For example, if a firm downsizes and is forced to consolidate its operations and close certain facilities, employment contracts may dictate that employees from the shuttered facilities are "merged" with employees from the remaining facilities. Likewise, a municipality that is forced to consolidate schools or fire stations because of budget cuts may likewise need to merge seniority lists prior to furloughing teachers, school administrators and fire-fighters.

Finally, while it has been well-documented (Hirsch 2008, Hirsch and Mcpherson 2003) that the percentage of the overall U.S. labor force that is unionized has declined from nearly 25% in the 1970's to approximately 12% in 2008, there are still numerous sectors of the economy where union membership (and thus the potential for seniority integration issues) is quite high.[7] For example, the proportion of workers in the utilities, transportation & warehousing and education services sectors in 2008 stood at 30.2%, 31.1% and 38.4% respectively. Moreover, specific subsets of these sectors have particularly high levels of union membership. For example, the percentage of rail and air transportation workers that were unionized in 2008 stood at 64.8% and 45.1% respectively. Finally, while the percentage of U.S. workers that are unionized has become relatively low, rates of union membership in other countries remains very high. For example, in 2009, union density rates in Denmark, Sweden, Norway and Belgium were 69%, 68%, 54% and 52% respectively, while the union density rates in the UK, Ireland, Canada and Italy stood at approximately 30%.[8]

The remainder of this paper is organized as follows. Section 2 presents a basic two-firm model of seniority integration. Section 3 addresses the question of why seniority integration is typically a contentious issue by demonstrating that the concepts of "fair and equitable" that are embedded in the two most commonly advocated methods of seniority integration (date-of-hire and ratio) are in conflict. Section 4 offers a number of ways to quantity the different types of equity distortions that result from seniority integration. Section 5 demonstrates that combining elements of the date-of-hire and ratio methods can reduce the amount of aggregate equity distortion. Section 6 provides brief

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[7] Data on aggregate and sector specific union membership levels courtesy of the database maintained by Barry Hirsch and David Macpherson, `http://www.unionstats.com`.

[8] *See* `http://stats.oecd.org/Index.aspx?DataSetCode=UN_DEN`. It is important to emphasize that unionization of workforces is *not* a necessary condition for seniority integration. For example, the merger between Delta Air Lines and Northwest Airlines required seniority integration of virtually all workgroups despite the fact that most non-pilot work groups at Delta were (and remain) non-unionized.

concluding remarks.

# 2 A Model of Seniority Integration

We start by developing a simple analytical framework that can be used to define and compare various methods of seniority integration. We begin by defining the elements of a pre-merger firm that are relevant to our model.

## 2.1 Firm Basics

A firm $A$ is described by three characteristics:

1. A set of $N$ employees or *workgroup*, denoted $U^A = \{u_1, u_2, \ldots, u_N\}$. $u_i$ can be thought of employee $i$'s name.
2. For each employee, $u_i$, his or her *longevity* (i.e., years of service) with the firm, denoted $y_i$.
3. An ordering, or *seniority ranking* of the employees names, denoted as a set of integer-name pairs of length $N$, $S^A = \{(1, u_i), \ldots, (N, u_j)\}$. Denote $s_i^A$ as the seniority rank of worker $u_i$, with $s_i^A = 1$ representing the most senior worker and $s_i^A = N$ representing the most junior member.

Across industries and throughout the world, many employee groups rely on a seniority systems to competitively determine certain types of job characteristics that can impact an employee's level of compensation and/or job security. For example, workers' relative positions on a seniority list are often used to competitively determine which employees receive assignments at higher pay-grades, which employees might become furloughed in the event the firm is forced to downsize, or for the purposes of bidding for the most desirable work assignments and/or vacation periods.

Although there are several conceivable ways of ordering a seniority list, the most common methods (among firms that have not experienced a merger) tend to be a function of employees' longevity, either with the firm as whole or at a particular division or geographic location within the firm. One of the simplest and most widespread ways of determining seniority relies upon an employee's "date-of-hire". For any set of real numbers $X = \{x_1, \ldots, x_N\}$, we define $\Gamma(x_i|X)$ to be $x_i$'s rank among the elements of $X$ in *descending* order (i.e., $\Gamma(x_i|X) = 1$ for $\max\{x_1, \ldots, x_N\}$ and $\Gamma(x_i) = N$ for $\min\{x_1, \ldots, x_N\}$). Likewise, we define $\psi(x_i|X)$ to be $x_i$'s rank among the elements of $X$ in *ascending* order (i.e., $\psi(x_i|X) = 1$ for $\min\{x_1, \ldots, x_N\}$ and $\psi(x_i|X) = N$ for $\max\{x_1, \ldots, x_N\}$).

**Definition 1** *Consider firm $A$ with a workgroup of $N$ employees. A seniority list $S^A$ is said to be* **date-of-hire** *if $s_i^A = \Gamma(y_i), \forall i = 1, 2, \ldots, N$.*

Thus, a "date-of-hire" seniority list simply ranks a members of a workgroup by their longevity, the most senior employee (i.e., seniority rank #1) being the one with the longest service to the firm.[9] By construction, a resulting property of a date-of-hire seniority list is that $s_i^A < s_j^A \iff y_i \geq y_j, \forall i, j$.

As an example, consider an employee group $U^A$ consisting of five workers, $U^A = \{u_1, u_2, u_3, u_4, u_5\}$ with 8, 12, 15, 10 and 7 years of longevity respectively. Table 1 summarizes the seniority list that would result if $S^A$ were organized by *date-of-hire*.

Table 1: Example of a Date-of-Hire Seniority List

| Seniority Rank | Name | Longevity (years) |
|---|---|---|
| $s_i^A$ | $u_i$ | $y_i$ |
| 1 | $u_3$ | 15 |
| 2 | $u_2$ | 12 |
| 3 | $u_4$ | 10 |
| 4 | $u_1$ | 8 |
| 5 | $u_5$ | 7 |

For the remainder of this paper, we make the simplifying assumption that all *pre-merger* seniority lists have been organized by "date-of-hire".

## 2.2 The Seniority Integration Problem

When two firms merge, the issue of how to combine seniority lists can become highly contentious. This is because most real world mergers involve somewhat different workforces in terms of size and longevity profile. Thus, regardless of the method, integrating seniority lists tend to benefit certain employees at the expense of others.

The *seniority integration problem* that we are interested in exploring can be summarized as follows:

1. There are two firms, $A$ and $B$, that want to merge. $A$'s workgroup has $N$ members, denoted $U^A = \{u_1, u_2, \ldots, u_N\}$ and $B$'s workgroup has $M$ members, denoted $U^B = \{u_{N+1}, u_{N+2}, \ldots, u_{N+M}\}$.

2. Firms $A$ and $B$ have pre-existing seniority lists denoted $S^A$ and $S^B$.

[9] When multiple employees were hired on the same day, various tie-breaking formula can (and have) been used, such as date of birth, randomization, or alphabetical ranking of last name. For the purposes of our analysis and without loss of generality, we assume that every employee has a unique date-of-hire.

A solution to the seniority integration problem is a merged firm $C$ with a combined workgroup $U^C = U^A \cup U^B$ and a unified seniority list $S^C$ that ranks each of the $N + M$ workers. The means by which $S^C$ is determined is via a seniority integration method. Denote $I$ as the set of integers.

**Definition 2** *A* **seniority integration method** *is a function* $g : U^A \bigcup U^B \rightarrow I$ *that assigns a unique rank* $s_i^C$ *to each member of* $U^C = U^A \bigcup U^B$.

Put simply, a seniority integration method $g$ solves the seniority integration problem by ranking the members of the combined workforce $U^C$ according to some method.

## 2.3 Methods of Seniority Integration

There are several different methods of seniority integration that have been used. The two most common, however, are the so called "date-of-hire" and "ratio" methods.

### 2.3.1 The Date-of-Hire Method

**Definition 3** *Consider merging firms A and B that integrate seniority lists* $S^A$ *and* $S^B$ *with* $N$ *and* $M$ *employees respectively into a single seniority list* $S^C$. *Under a* **date-of-hire** *seniority integration,* $s_i^C = \Gamma(y_i),\ \forall i = 1, 2, \ldots, N + M$.

Thus, as the name implies, under *date-of-hire* seniority integration, employees from merging firms retain their accrued longevity from their pre-merger firm, are pooled together, and are re-ranked according to their original date-of-hire. The *date-of-hire* seniority integration method has been frequently relied upon because of its inherent simplicity and because it retains the property that for any particular member of $S^C$, every member senior to him on the list has greater length of service, i.e., $s_i^C < s_j^C \iff y_i \geq y_j, \forall i, j$.[10] Likewise, at least some unions have formally adopted date-of-hire as the method of seniority integration that governs their association, should two firms it represents merge.[11]

[10] Arbitration decisions adopting date-of-hire (or a slight variation of it) include: Airwest (Gill 1968), North Central-Southern (Vass 1980), Republic-Hughes Airwest (Bloch 1981), Northwest-Republic (Roberts 1989), US Air-Piedmont (Kagel, 2000), Air New Zealand-National Airways (Feller, 1980), Canadian-Wardair (Munroe 1990) and Queen Charlotte Airlines-Pacific Western (Becker, 2000). The variants of date-of-hire often include adjusting date-of-hire to reflect the time an employee is on leave from the firm (i.e., length of service).

[11] For example, date-of-hire is the defined merger policies of both the Association of Flight Attendants-CWA, which represents over 55,000 flight attendants at 21 airlines as well as the International Association of Machinists and Aerospace Workers. *See* `https://www.unitedafa.org/news/merger/policy/protection.aspx` and `http://www.iamnow.org/category/seniority`.

Consider the following example of firms $A$ and $B$ with employee groups $U^A$ (with 5 workers) and $U^B$ (with 4 workers) respectively. $S^A$ and $S^B$ are both organized by date-of-hire, as summarized by Table 2.

Table 2: Pre-Merger Seniority Lists for Firms $A$ and $B$

| $S^A$ | | | $S^B$ | | |
|---|---|---|---|---|---|
| Seniority Rank | Name | Longevity | Seniority Rank | Name | Longevity |
| $s_i^A$ | $u_i$ | $y_i$ | $s_i^B$ | $u_i$ | $y_i$ |
| 1 | $u_3$ | 15 | 1 | $u_6$ | 16 |
| 2 | $u_2$ | 12 | 2 | $u_7$ | 13 |
| 3 | $u_4$ | 10 | 3 | $u_8$ | 6 |
| 4 | $u_1$ | 8 | 4 | $u_9$ | 5 |
| 5 | $u_5$ | 7 | | | |

Table 3 summarizes the result of firms $A$ and $B$ merging and integrating $S^A$ and $S^B$ by *date-of-hire*. As demonstrated by Table 3, members of $S^A$ and $S^B$ are pooled together and re-ranked in order of longevity, without consideration given to either the relative size or financial condition of their pre-merger firms.

Table 3: Example of Seniority Integration of $S^A$ and $S^B$ By Date-of-Hire

| Post-Merger Seniority Rank | Name | | Longevity |
|---|---|---|---|
| $s_i^C = \Gamma(y_i)$ | $U^A$ | $U^B$ | $y_i$ |
| 1 | | $u_6$ | 16 |
| 2 | $u_3$ | | 15 |
| 3 | | $u_7$ | 13 |
| 4 | $u_2$ | | 12 |
| 5 | $u_4$ | | 10 |
| 6 | $u_1$ | | 8 |
| 7 | $u_5$ | | 7 |
| 8 | | $u_8$ | 6 |
| 9 | | $u_9$ | 5 |

### 2.3.2 The Ratio Method

A second common method of integrating two workforces is known as the *ratio* method. Recalling that $\psi(x_i)$ is the inverse rank function for any set of real numbers, the ratio seniority integration method can be defined as follows:

**Definition 4** *Consider merging firms A and B that integrate seniority lists $S^A$ and $S^B$ with N and M employees respectively into a single list $S^C$. Under the* **ratio** *seniority integration method, $s_i^C = \psi(r_i)$, where:*

$$r_i = \begin{cases} \frac{s_i^A(N+M)}{N} & i = 1, 2, \ldots, N \\ \frac{s_i^B(N+M)}{M} & i = N+1, \ldots, N+M \end{cases} \tag{1}$$

In effect, the ratio method constructs an integrated seniority list by alternating back and forth between members of the two pre-merger seniority lists in their original order, based on the *ratio* of the sizes of the pre-merger lists.[12] Thus, when the two pre-merger lists are of equal length, $S^C$ is formed by alternating members from $S^A$ and $S^B$ one-for-one. Alternatively, if $S^A$ had twice as many members as $S^B$, $S^C$ would be formed by selecting two members from $S^A$, followed by one member of $S^B$, followed by two members from $S^A$ and so forth. Although the ratio method formally specifies that the first pick comes from larger of the two seniority lists, as a practical matter, this is determined on a case-by-case basis (e.g., it may be decided that members should be chosen off the acquiring firm's list first). Table 4 summarizes the results of integrating $S^A$ and $S^B$ from Table 2 by ratio.

The *ratio* method of seniority integration has been frequently used in practice because it is also easy to implement and has the property of maintaining the *relative* position of members on their pre- and post-merger seniority lists.[13] That is, under the ratio method, if a member is at the 90th percentile on her pre-merger seniority list, she will also be at approximately the 90th percentile of the post-merger seniority list.[14]

[12] A variation of the ratio method known as the rank-ratio method first sub-divides both pre-merger lists into common categories and then applies the ratio method separately to members within each category. For purposes of simplification and without loss of generality, our analysis focuses on the basic ratio method.

[13] For example, the ratio method (or variation thereof) has been used in Flying Tiger-Slick Airways (Aaron 1954), Continental-People Express (Ross 1991), Transair-Pacific Western (Gallagher 1977), Air Canada/Canadian Airlines (Mitchnick 2001), US Airways-America West (Nicolau 2008) and Delta-Northwest (Bloch, Eischen and Horowtiz 2008).

[14] Formally, if $S^C$ is organized using ratio:

$$\frac{s_i^A}{N} - \frac{s_i^C}{N+M} \leq \varepsilon, \quad i = 1, 2, \ldots, N \quad \text{and} \quad \frac{s_j^B}{M} - \frac{s_j^C}{N+M} \leq \varepsilon, \quad j = N+1, \ldots, N+M \quad \text{where} \quad \varepsilon = \frac{1}{N+M}.$$

TABLE 4: EXAMPLE OF SENIORITY INTEGRATION OF $S^A$ AND $S^B$ BY RATIO

| Post-Merger Seniority Rank | Name | | Longevity |
|---|---|---|---|
| $s_i^C = \psi(r_i)$ | $U^A$ | $U^B$ | $y_i$ |
| 1 | $u_3$ | | 15 |
| 2 | | $u_6$ | 16 |
| 3 | $u_2$ | | 12 |
| 4 | | $u_7$ | 13 |
| 5 | $u_4$ | | 10 |
| 6 | | $u_8$ | 6 |
| 7 | $u_1$ | | 8 |
| 8 | | $u_9$ | 5 |
| 9 | $u_5$ | | 7 |

### 2.3.3 The Appending (or "Stapling") Method

Finally, we briefly consider a third method of seniority integration that has been applied in practice, which is simply to append or "staple" one seniority list to the bottom of another.

**Definition 5** *Consider merging firms A and B that integrate seniority lists $S^A$ and $S^B$ with $N$ and $M$ employees respectively into a single list $S^C$. If $S^B$ is* **appended (a.k.a. "stapled")** *to $S^A$, then $s_i^C = s_i^A, i = 1, 2, \ldots N$ and $s_i^C = s_i^B + N, i = N+1, \ldots, N+M$.*

Thus, when $S^B$ is appended to the bottom of $S^A$, even the most senior member of $S^B$ becomes junior to the least senior member of $S^A$, regardless of their longevity with their original firms. Notwithstanding the apparent inequity of integrating seniority lists by appending one to another, it has been applied in a number of well-known mergers and is typically justified on the basis that the acquired firm was financially insolvent and would have been forced to liquidate had it not been acquired.

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Because rounding to the nearest integer can result in an employee's relative position changing slightly, $\varepsilon \geq 0$. For example, referring to Table 4, for $u_8$, $\frac{s_8^B}{M} = 0.75$ and $\frac{s_8^C}{N+M} = 0.66$. Given that this error term is due to rounding to the nearest integer, the upper bound of the difference between the two ratios is $\varepsilon = \frac{1}{N+M}$, or $\frac{1}{9}$ in the example from Table 4. For large workgroups, therefore, the error term is typically inconsequential.

# 3 Why Is Seniority Integration So Contentious?

The primary goal of seniority integration is to produce an outcome that is "fair and equitable". The concept of "fair and equitable" in the context of seniority integration was first made explicit in the Allegheny-Mohawk LPPs outlined by the U.S. Civil Aeronautics Board in the 1970s following several airline mergers:

> ... insofar as the merger affects the seniority rights of the carriers employees, provisions shall be made for the integration of seniority lists in a *fair and equitable* manner, including, where applicable, agreement through collective bargaining between the carriers and representatives of the employees affected. (59 C.A.B 45, Section 3)

The "fair and equitable" standard contained in the Allengheny-Mohawk LLPs was adopted nearly forty years later as part of the McCaskill-Bond Amendment in the wake of what many believed to be the unfair or inequitable treatment of many former TWA employees after its merger with American.

However, what is "fair and equitable" in the eyes of one group of employees party to a merger may not be considered "fair and equitable" to the other group and is likely to be colored by the specifics of each workforce and the economic circumstances of their respective pre-merger firms.[15] This is especially true when two pre-merger firms have diverging economic prospects and/or different histories.

As discussed below, most major seniority integration disputes have arisen because one party advocates some variation of the date-of-hire method while the other party advocates some variation of the ratio method. Since the original Allengheny Mohawk LPPs and more recent McCaskill-Bond Amendment explicitly require that seniority integration be conducted in a "fair and equitable" manner, it is incumbent upon parties advocating for a particular integration method to justify to an arbitrator that their proposed method is rooted in some notion of equity and thus meets the "fair and equitable" standard. In order to gain a better understanding of why seniority integration is so contentious, we now distill the date-of-hire and ratio methods to their interpretation of the "fair and equitable" standard.

[15] For example, the Preamble to Section 45 of the Air Line Pilots Association's *Administrative Manual* (Merger and Fragmentation Policy) states "It must be understood that what appears to be truly 'fair and equitable' often differs depending upon the eyes of the beholder and that there may be no consensus of what is "fair and equitable." *See* `https://crewroom.alpa.org/ual/DesktopModules/ViewDocument.aspx?DocumentID=40794.`

### 3.1 Fair and Equitable Interpretation of The Date-of-Hire Method

Date-of-hire has been justified by parties advocating its use based on a variety of reasons. Many of the common justifications, however, are not related to a notion of equity or fairness. Historical precedence, for example, has been frequently used as a justification for date-of-hire. For example, in Delta-Northwest, pilots for Northwest argued that "...prior mergers at Northwest have led ALPA arbitration boards to merge seniority lists through date-weighted methods..." and that "[T]hese mergers worked well for the carriers and their pilots."[16]

Similarly, proponents of date-of-hire have also argued that it should be the default method in any seniority integration dispute because of its inherent simplicity. For example, numerous Canadian arbitrators have chosen to use date-of-hire based largely on its ease of use.[17] More recently, lawyers for US Airways pilots argued that "... but we feel that whatever the merger policy has said over the years, the pilots and arbitrators have been drawn to *first examine* whether the integration of lists can be accomplished in a fair and equitable manner using a date based methodology. Here we feel that can be done, and that is what we propose the arbitration panel should do is to integrate the two seniority lists on the basis of date-of-hire."[18] Likewise, in Delta-Northwest, Northwest pilots argued that "...prior NWA date-weighted arbitration determinations have accepted the results because they understand them and recognize the immutability of their dates of hire."[19]

The equity-based justification for date-of-hire, however, is rooted in the notion that employee's competitive rank within a firm should be a function solely of his or her experience at that firm.

[16] *See* Arbitration Post-Hearing Brief of the Northwest Merger Representatives, *In the Matter of the Seniority Integration Between the Pilots of Northwest Airlines and the Pilots of Delta Air Lines, Before the Seniority Integration Arbitration Board Richard I. Bloch, Dana E. Eischen and Fredric R. Horowitz*, November 1, 2008, page 3. Likewise, at the arbitration, lawyers for Northwest pilots argued "If you're going to have to restrict (sp) a list, it seems the bias should be towards date-of-hire. That's what our career is based on. It's the long history of ALPA. Seniority is the bedrock of our profession, and that's, I think, a very strong and powerful reason why the date-of-hire approach should be considered. And that's why we have proposed it." Transcript at 2,047.

[17] *See*, for example, Queen Charlotte Airlines/Pacific Western (1960): "the only simple method was to make seniority depend upon length of service [at either carrier]" and Canadian/Wardair (1990): "I do not say that some other approach will never be appropriate. But as a complementary point of principle, a party who proposes that an integrated seniority list be constructed on some basis other than date-of-hire must bear the onus of showing that the situation demands it." *See* Award, *In The Matter Of An Arbitration Under Section 18.1 Of The Canada Labour Code Between: Air Canada Pilots Association (ACPA) And Air Line Pilots Association (ALPA) Re: Seniority Integration At Air Canada, Before: M.G. Mitchnick - Sole Arbitrator*, pages 15 and 23.

[18] *See* hearing transcript from December 4, 2006 page 14. *Before The ALPA Arbitration Board, The Crew Members Of US Airways, Plaintiff vs. The Crew Members Of America West Airlines, Defendant.*

[19] *See* Arbitration Post-Hearing Brief of the Northwest Merger Representatives, *In the Matter of the Seniority Integration Between the Pilots of Northwest Airlines and the Pilots of Delta Air Lines, Before the Seniority Integration Arbitration Board Richard I. Bloch, Dana E. Eischen and Fredric R. Horowitz*, November 1, 2008, page 4.

For example, in advocating date-of-hire following the Delta/Northwest merger, pilots of Northwest argued that "[W]e further submit that everyone who has "paid his dues" at a job for years appreciates that it is fair for a coworker to bid ahead of him when that person has greater length of service on the job."[20] Similarly, in US Airways-America West, pilots for US Airways argued that: "we also believe that the list, by sorting people for length of service, gives credit for the sweat equity that each pilot group has brought into this agreement. We have people that have contributed significant amount to the US Airways name, the company, and the revenue that we have."[21] This equity concept embedded in date-of-hire can thus be generalized as follows: members of the same cohort (i.e., workers with approximately equivalent experience or longevity from their pre-merger firm) should be treated similarly when two seniority lists are integrated.[22] Put differently, while some small longevity distortions may be unavoidable when integrating two large workforces, it is natural to think that a "fair and equitable" seniority integration method should order members in such a way that an employee from firm $A$ with only a few years of service doesn't become more senior to an employee from firm $B$ with significantly more years of service, and vice-versa. We formalize this concept as follows.

**Definition 6** *Suppose $S^A$ and $S^B$ are integrated using seniority integration method $g$ to form $S^C$ and let $k \geq 0$ denote the relevant cohort size. $S^C$* ***retains cohort stability*** *if $\nexists\, u_i, u_j \in U^C$ such that $y_i - y_j > k$ and $s_i^C > s_j^C$.*

Simply put, a seniority integration method retains cohort stability if and only if there exists no worker $u_i$ that is left junior to a co-worker $u_j$ with $k$ fewer years of longevity than $u_i$ ($k$ need not be an integer). For example, if one-year cohorts are deemed to be the relevant cohort size (i.e., $k = 1$), cohort stability requires that no worker with 5 years of longevity be left junior to any worker with fewer than 4 years longevity, no worker 4 years of longevity be left junior to any worker with 3 or few years longevity, and so forth.

**Example 1** Consider firms $A$ and $B$ with seniority lists $S^A$ and $S^B$ as presented in Table 2 above. If firms $A$ and $B$ merge and integrate $S^A$ and $S^B$ using date-of-hire, (see Table 3), it is easy to see that cohort stability is retained for any $k$. In contrast, if $S^A$ and $S^B$ are integrated by the ratio

[20] *Ibid.*

[21] *See* hearing transcript of December 14, 2006, page 1,353. *Before The ALPA Arbitration Board, The Crew Members Of US Airways, Plaintiff vs. The Crew Members Of America West Airlines, Defendant.*

[22] For example, for any given aircraft type and seat (captain or first officer), hourly pay rates for pilots worldwide are based on their "years of service" at the airline. Thus, if a seniority list were integrated using a method other than date-of-hire, it is likely that there will be instances where one pilot receives a higher hourly rate than other pilots higher than him on the seniority list. Under date-of-hire, such anomalies would not occur.

method (see Table 4), it is easy to see that cohort stability is not retained when $k$ is small, i.e., 1 year. For example, Table 4 shows that ratio integration results in $u_8$ (with 6 years of service) becoming more senior than $u_1$ who has 8 years of service. Likewise, Table 4 also demonstrates that $u_9$ (with five years of service) becomes more senior than $u_5$ with 7 years of service. However, if an arbitrator deemed that the relevant cohort size was three years, cohort stability would still be retained using the ratio method, since the largest longevity gap between any two workers out of longevity sequence is two years (i.e., $u_8$ vs. $u_1$ and $u_9$ vs. $u_5$).

In sum, by constructing an integrated seniority list based strictly on the length of service from each employee's pre-merger firm, date-of-hire prevents those with less experience from become senior to more experienced employees, and based on this notion of equity, produces a "fair and equitable" outcome.

## 3.2 Fair and Equitable Interpretation of The Ratio Method

In contrast to date-of-hire, the ratio method is not premised on the notion that longevity should be the defining feature of an employee's relative position on a merged seniority list. Rather, it seeks to ensure that employees face approximately the same economic prospects (both opportunities and risks) on the merged list as they did on their original, pre-merger seniority list. For example, in his decision to adopt the ratio over date-of-hire method in the 1981 merger of Flying Tigers and Seaboard World Airlines, the arbitrator noted that:

> Seniority is a coin of exchange as among pilots; it has value only on a basis relative to the seniority possessed by other fellow pilots. Consequently, the placement of an overly large number of SWA pilots near the top of a merged seniority list necessarily has the effect of disadvantaging the FTL pilots who are forced in disproportionately large numbers to the bottom of the seniority list. Such adverse placement will damage FTL pilots with respect to their ability to hold their present status, their rights to fly preferred lines of flying, their rights to hold domicile and to bid vacation preference, their rights to present and future earnings opportunities, and their right to upgrade. I conclude, therefore, that use of a date-of-hire or adjusted service method of integration will not produce an acceptable accommodation throughout the list and is neither fair nor equitable in light of the surrounding circumstances of this case.[23]

[23] Pages 243-4, as quoted in *Award, In The Matter Of An Arbitration Under Section 18.1 Of The Canada Labour Code Between: Air Canada Pilots Association (ACPA) And Air Line Pilots Association (ALPA) Re: Seniority Integration At Air Canada, Before: M.G. Mitchnick - Sole Arbitrator*, page 27.

Similarly, in Delta-Northwest, Delta's pilots advocated a ratio method, to prevent Delta pilots—who it was argued faced no risk of furlough pre-merger—from being furloughed post-merger:

> If the merger was not taking place and NWA was continuing on a stand alone basis, these pilots - most of whom are currently DC-9 FOs - would now be on furlough. And more furloughs would be on the immediate horizon, because of continuing DC-9 and B-747-200 freighter dispositions.... In contrast, the record demonstrates that the Delta pilots come to the merger with no immediate risk to the bottom of their list. Put simply, in stark contrast to the NWA pilot group's plight, the Delta pilot group faces no known furlough risk.[24]

In order to formalize the equity concept described in these (and other) cases, we begin by defining the concept of a *status granting threshold*, $t^A$ which is a point on firm $A$'s seniority list (expressed as a percentage) above which employees are granted—or have the reasonable expectation of being granted—a desired status. For example, a status granting threshold could be the position on the seniority list above which employees are unlikely to be furloughed or above which they can choose among shifts that are eligible for pay premiums. Next, denote $P^A(t^A)$ as the subset of $U^A$ above the status granting threshold $t^A$, i.e., $P^A(t^A) = \{u_i \in U^A | s_i^A \leq t^A N\}$. Likewise, denote $Q^A(t^A)$ as the subset of $U^A$ below the status granting threshold $t^A$, i.e., $Q^A(t^A) = U^A \setminus P^A(t^A)$. Denote $T$ as the set of "relevant" status granting thresholds for a merger ($T$ will vary from merger to merger, both in terms of the number of elements and their value(s)).[25] Proponents of ratio method advocate that a fair and equitable method should *preserve initial status*, which means that there are no employees on either pre-merger seniority list that were above (below) a relevant status granting threshold prior to a merger that fall below (above) the same status granting threshold as a result of the merger and ensuing seniority integration. For example, if a worker from firm $A$ was unlikely to be furloughed based on his pre-merger seniority rank on $S^A$, he should also be unlikely to be furloughed (all other things equal) based on his seniority rank on the merged list $S^C$. Formally:

**Definition 7** *Suppose $S^A$ and $S^B$ are integrated using seniority integration method $g$ to form $S^C$. $S^C$* ***preserves initial status*** *if, for any $t \in T$:*

[24] *See* Post-Hearing Statement on Behalf of the Delta Air Lines Merger Committee, *In the Matter of the Seniority Integration Between the Pilots of Northwest Airlines and the Pilots of Delta Air Lines, Before the Seniority Integration Arbitration Board Richard I. Bloch, Dana E. Eischen and Fredric R. Horowitz*, November 1, 2008, page 13.

[25] We assume that the relevant thresholds are at the same percentile for each of the pre-merger firms and the merged firm. When this is not the case, variations of the ratio method, like those discussed in footnote 12 may be more appropriate.

1. $\nexists\ u_i \in P^k(t)$ *such that* $u_i \in Q^C(t), \quad k = A, B,$ *and*

2. $\nexists\ u_i \in Q^k(t)$ *such that* $u_i \in P^C(t), \quad k = A, B$

In sum, by ranking employees strictly based on their percentile rank, the ratio method by construction prevents any employee from falling crossing (above or below) a status granting threshold as a result of the merger, and based on this notion of equity, achieves a "fair and equitable" outcome.

**Example 2** Consider firms $A$ and $B$ with seniority lists $S^A$ and $S^B$ as presented in Table 2 above. Suppose $T = \{80\%\}$ (e.g., suppose that economic conditions are such that each firm will likely retain 80% of its workforce but will need to furlough the remaining 20% — rounded to the nearest employee — or one employee). Absent a merger, each firm would therefore furlough its most junior employee, i.e., $u_5$ for firm $A$ and $u_9$ for firm $B$. Now suppose that firms $A$ and $B$ merge, and integrate $S^A$ and $S^B$ into seniority list $S^C$ *prior to* any furloughs taking place. Facing the same economic conditions that existed pre-merger, firm $C$ decides that it must furlough the same percentage of its workforce (i.e., 20% or two employees) from the bottom of $S^C$. If $S^C$ is constructed using the "ratio" method, Table 4 above demonstrates that the two most junior employees (i.e., $u_5$ and $u_9$) are the same two employees that would have been furloughed had the merger not taken place. Thus, in this example, the ratio method *preserves initial status*. However, if $S^C$ is constructed using the "date-of-hire" integration method, Table 3 above demonstrates that the two most junior employees come from firm $B$ (i.e., $u_8$ and $u_9$) and that $u_8$—who would not have been furloughed without a merger—finds himself furloughed *as a result of the merger*. Similarly, $u_5$, who was to be furloughed absent a merger would no longer be furloughed post-merger. Thus, the date-of-hire integration method *fails to preserve initial status* in this example because there exist employees (in this case $u_8$ and $u_5$) that were above (below) a status granting threshold (i.e., the 20% furlough line) prior to the merger that are now placed below (above) the furlough threshold post-merger.[26]

## 3.3 Conflicting Interpretations of "Fair and Equitable"

Having examined the foundations of "fair and equitable" underlying the date-of-hire and ratio methods, we now turn our attention to understanding the nature of the conflict in seniority integration

[26]It is important to emphasize, however, that the date-of-hire method can preserve initial status, depending on what the relevant thresholds are. For example, suppose furloughs are not a concern for workers in this merger but that the top 25% of employees are eligible for premium pay positions, i.e., $T = \{25\%\}$. Then, it is easy to see from Table 2 that date-of-hire preserves initial status since the same two workers ($u_3$ and $u_6$ with 15 and 16 years of longevity respectively) are above the relevant threshold pre- and post-merger while all other workers remain below the threshold irrespective of the merger.

disputes. Although the very fact that most seniority integrations are decided by an independent arbitrator underscores that a conflict exists, Proposition 1 below formally establishes why this is typically the case. We begin by establishing the conditions under which the date-of-hire and ratios method are *not* in conflict. Consider the following definition:

**Definition 8** *$U^A$ and $U^B$ are said to have* **identical longevity profiles** *if and only if when $g$ is date-of hire, for each $u_i \in U^A \bigcup U^B$:*

$$\frac{s_i^A}{N} - \frac{s_i^C}{N+M} \leq \varepsilon \quad i = 1, 2, \ldots, N \quad \textit{and} \quad \frac{s_j^B}{M} - \frac{s_j^C}{N+M} \leq \varepsilon, \quad j = N+1, \ldots, N+M. \tag{2}$$

*Where $\varepsilon = \frac{1}{N+M}$.*

In essence, two workgroups are said to have identical profiles when their patterns of growth and hiring have effectively been the same.[27] Table 5 below provides an example of two workgroups with identical longevity profiles.

Table 5: Example of Workgroups with Identical Longevity Profiles

| $U^A$ | | | $U^B$ | | |
|---|---|---|---|---|---|
| Seniority Rank | Name | Longevity | Seniority Rank | Name | Longevity |
| $s_i^A$ | $u_i$ | $y_i$ | $s_i^B$ | $u_i$ | $y_i$ |
| 1 | $u_3$ | 10 | 1 | $u_6$ | 9 |
| 2 | $u_2$ | 8 | 2 | $u_7$ | 7 |
| 3 | $u_4$ | 6 | 3 | $u_8$ | 5 |
| 4 | $u_1$ | 4 | 4 | $u_9$ | 3 |
| 5 | $u_5$ | 2 | | | |

It is straightforward to show that if $U^A$ and $U^B$ are characterized by identical longevity profiles, the date-of-hire and ratio methods yield equivalent integrated seniority lists, and thus, preserves both initial status and cohort stability. For example, Table 6 demonstrates that integrating the seniority lists in Table 5 by date-of-hire or ratio is equivalent.

Thus, while it is possible to construct examples in which the date-of-hire and ratio methods are equivalent (thus satisfying cohort stability and preserving initial status), Proposition 1 establishes

[27]Note that because rounding to the nearest integer can result in a person's relative position changing slightly, equation (2) does not require $\varepsilon$=0. Moreover, note that the workgroups need not have identical longevities or even be of the same size.

TABLE 6: EXAMPLE OF SENIORITY INTEGRATION OF $S^A$ AND $S^B$ BY DATE-OF-HIRE AND RATIO

| Post-Merger Seniority Rank | Name | | Longevity |
|---|---|---|---|
| $s_i^C$ | $U^A$ | $U^B$ | $y_i$ |
| 1 | $u_3$ | | 10 |
| 2 | | $u_6$ | 9 |
| 3 | $u_2$ | | 8 |
| 4 | | $u_7$ | 7 |
| 5 | $u_4$ | | 6 |
| 6 | | $u_8$ | 5 |
| 7 | $u_1$ | | 4 |
| 8 | | $u_9$ | 3 |
| 9 | $u_5$ | | 2 |

that for most real-world applications, there exists no seniority integration method that both preserves initial status and retains cohort stability for sufficiently small cohorts. Indeed, as demonstrated in our earlier examples above, these two properties are typically orthogonal in the sense that when one holds the other does not. This dichotomy between the underpinnings of what is viewed as "fair and equitable" under the date-of-hire and ratio methods is the fundamental reason why many seniority integrations cannot be resolved consensually and require the intervention of a neutral, third-party arbitrator.

**Proposition 1** *If $U^A$ and $U^B$ are not characterized by identical longevity profiles, there exists no seniority integration method that results in an integrated seniority list $S^C$ that retains cohort stability as $k \to 0$ and preserves initial status for all $t \in [0, 1]$.*

To prove Proposition 1, we rely on two Lemmas, the proofs of which are also contained in the Appendix.

**Lemma 1** *As $k \to 0$, an integrated seniority list $S^C$ retains cohort stability if and only if $g$ is date-of-hire.*

**Lemma 2** *If $U^A$ and $U^B$ do not have identical longevity profiles and $g$ is date-of-hire, $S^C$ does not preserve initial status for some $t \in [0, 1]$.*

**Proof of Proposition 1:** By Lemma 1, the only seniority integration method that retains cohort stability as $k \to 0$ is date-of-hire. But by Lemma 2, if $g$ is date-of-hire, $S^C$ does not preserve initial

status for some $t \in [0,1]$ when $U^A$ and $U^B$ do not have identical longevity profiles.

Although there may be instances in which ratio also retains cohort stability when $k$ is sufficiently large, some workers could rightfully argue that a merger should not permit any worker from another firm with even one day less of longevity to leapfrog over them on the post-merger seniority list (i.e., that the only relevant cohort size is $k = 0$). Under this assumption, Lemma 1 establishes that the only seniority method that retains cohort stability as cohorts becomes very small is date-of-hire.

Similarly while there may be instances in which date-of-hire also preserves initial status for given relevant thresholds, this is not a general property. Indeed, in most real-world applications, it is likely to be the case that the thresholds are not known *a priori*. For example, different industries or sectors of the economy can be subject a variety of external shocks that may result in an unexpected and large proportion of employees being furloughed. Examples of such shocks (and the resulting furloughs) include the impact of the September 11th terrorist attacks on the airline industry, the bursting of the "dot-com" bubble on the telecommunications industry and the effect of the 2008 global financial crisis on many Federal, State, local government departments. Moreover, it is also likely to be the case that there are numerous relevant thresholds. For example airline pilots tend to be paid higher hourly rates based on the type of the aircraft they fly and their so-called "seat" (Captain or First-Officer), which in turn is determined by seniority rank. Because a given airline may operate several different aircraft types, there can therefore be a very large number of relevant thresholds for this reason alone. In light of these factors, for many real-world applications, it may be reasonable to consider whether or not a seniority integration method preserves initial status for all $t \in [0,1]$.

# 4 Comparing Equity Distortions From Seniority Integration

In light of the fact that there exists no seniority integration method that retains cohort stability *and* preserves initial status in general, we now turn our attention to measuring the two main types of distortion that result from seniority integration. Quantifying the distortions that result from applying different methods of seniority integration serves two purposes. First, it allows us to compare the relative inequities that result from the application of commonly applied methods of seniority integration (i.e., date-of-hire and ratio) to a particular integration scenario. Second, it provides a basis for developing and evaluating alternative methods of seniority integration that might mitigate undesirable equity effects. Our focus is on what we believe are two important types of distortion resulting from seniority integration: threshold distortion and cohort distortion.

## 4.1 Threshold Distortion

We say that *threshold distortion* occurs when an employee who would have been above (below) a status granting threshold absent integration falls below (above) the equivalent threshold as a result of integration. Put differently, threshold distortion occurs when an employee has the potential to be treated differently than he or she would otherwise have been treated but for the integration. For example, having noted that Air Canada was in "an unprecedented growth mode" while Canadian Airlines had ceased hiring for several years, Arbitrator Mitchnick's Award in the integration of the two carriers' pilots found that "Preexisting Air Canada employees should not be laid off as a result of this CAIL-rescuing merger, and it is necessary for me to build into this award a protection against that for some time into the future."[28]

To formalize this concept, denote $|D^A(t)|$ and $|D^B(t)|$ as the number of members of $U^A$ and $U^B$ that either fall above or below status granting threshold $t$ as a result of integration.[29] Then, $TD(t)$ measures the proportion of employees from the combined workforce that are "distorted" at a given threshold level $t$.

**Definition 9** *Suppose $S^A$ and $S^B$ are integrated using seniority integration method $g$ to form $S^C$. The* **threshold distortion** *for a given status granting threshold $t \in [0,1]$ is defined as:*

$$TD(t) = \frac{|D^A(t)| + |D^B(t)|}{N+M}\%, \tag{3}$$

Although a particular integration scenario is likely to have specific levels of $t$ that are relevant (i.e., a potential furlough threshold or the threshold for premium pay positions), there is no way of knowing *a priori* what the most relevant values of $t$ are in general. Therefore, we also consider the *maximum potential threshold distortion*, defined as $MPTD = \max_t TD(t)$, which as its name implies, is a measure of the highest proportion of workers from the joint workforce that *could* become distorted. One property of $MPTD$ is that its lower bound is $\frac{1}{N+M}$, and the lower bound is achieved under the ratio method.[30]

[28] *See* Award, *In The Matter of an Arbitration Under Section 18.1 of the Canada Labour Code Between: Air Canada Pilots Association (ACPA) and Air Line Pilots Association (ALPA) Re: Seniority Integration at Air Canada, Before: M.G. Mitchnick - Sole Arbitrator*, page 39.

[29] Recalling the definition of $P(t)$ and $Q(t)$ from Section 3.2 above, $D^A(t) = \left\{u_i \in \{P^A(t) \bigcap Q^C(t)\} \bigcup \{Q^A(t) \bigcap P^C(t)\}\right\}$ and $D^B(t)$ is defined analogously.

[30] To see this, let $t = 1-\epsilon$, such that for any workforce there is exactly one employee below the threshold, pre- and post-merger, or $|Q^k(1-\epsilon)| = 1, k = A, B, C$. Since only one of the two pre-merger employees can be at the bottom of the merged seniority list and $|Q^k(1-\epsilon)| = 1, k = A, B$ there exists an employee that was below the threshold $t = 1-\epsilon$ that is above it post-merger. Therefore for any seniority method $g$, there exists a threshold $t$ such that at least one

**Example 3** Suppose firms $A$ and $B$ with seniority lists $S^A$ and $S^B$ as presented in Table 2 merge and integrate workforces. As described above, the ratio method has the property of maintaining the relative position of the members on the pre- and post-merger seniority list, and therefore, aside from some minor distortions caused by rounding, $TD(t)$ will be small. For example, referring to Table 2, suppose a relevant threshold is $t = .80$, which could represent the threshold below which employees would be furloughed (i.e., the bottom 20% of employees). $u_5^A$ is the only member of $S^A$ below the status granting threshold, thus, $Q^A(.80) = \{u_5\}$ and $P^A(.80) = \{u_1, u_2, u_3, u_4\}$. Similarly, $Q^B(.80) = \{u_9\}$ and $P^B(.80) = \{u_6, u_7, u_8\}$. Likewise, Table 4 demonstrates that for $t = .80$, $Q^C(.80)$ is comprised of the last two members of $S^C$, thus $Q^C(.80) = \{u_5, u_9\}$ and $P^C(.80) = \{u_1, u_2, u_3, u_4, u_6, u_7, u_8\}$. Thus, $D^A(.80) = D^B(.80) = \emptyset$ and $TD(.80) = 0\%$ (that is, there is no threshold distortion for $t = .80$). Moreover, it can be demonstrated that in this example $MPTD = 11.1\%$ indicating that at most one member of the combined workgroup experiences threshold distortion. Thus, by construction, threshold distortion is minimized when ratio integration is applied.

Now consider the threshold distortion in the same example (i.e., $t = .80$) when the $S^A$ and $S^B$ are integrated using date-of-hire. $P^A(.80), Q^A(.80), P^B(.80)$ and $Q^B(.80)$ are unchanged from when the ratio method was used. However, as shown in Table 3, date-of-hire integration results in $Q^C(.80) = \{u_8, u_9\}$ and $P^C(.80) = \{u_1, u_2, u_3, u_4, u_5, u_6, u_7\}$. Now, $u_8$ has been displaced below the 80 percent threshold level (i.e., would not have been furloughed absent the merger, but would be as a result of the merger), thus $D^B(.80) = \{u_8\}$. Likewise, $u_5$ jumps above the 80 percent threshold because of the merger, and therefore, $D^A(.80) = \{u_5\}$. Consequently, $TD(.80) = 2/9 = 22.2\%$. Moreover, it can be demonstrated in this example that $MPTD = 33.3\%$. Thus, unlike the ratio method, date-of-hire integration typically results in non-trivial amounts of threshold distortion.

## 4.2 Cohort Distortion

While threshold distortion measures the proportion of workers that have the potential to be treated differently as a result of a merger based on their relative positions on the pre- and post-merger seniority lists, cohort distortion attempts to measure distortion in terms of potential inequity that results from workers from one seniority list "leapfrogging" over members of the other. Stated differently, cohort distortion (for an employee of firm B) occurs when an employee with fewer years of

employee experiences threshold distortion. As a result, $MPTD$ can never be less than $\frac{1}{N+M}$. As demonstrated in footnote 14, the ratio method achieves this lower bound.

service from firm $A$ is placed higher than an employee from firm $B$ on a merged seniority list.[31] As described by one neutral board members' post-award opinion to the Nicolau award in the contested US Airways-America West integration:

> As a consequence of the Boards decision, America West pilot Odell, who was hired less than 2 months before merger was announced, has been placed immediately senior to US Airways pilot Colello who was hired more than 16 years earlier and who had over 16 years of credited length of service. I disagree with this placement, which disregards Colello's substantial service time.[32]

Before formally defining a measure of cohort distortion, we observe that cohort distortion is maximized (with respect to firm $B$) when its seniority list is appended to firm $A$'s. Thus, for any $u_i \in U^B$, we denote $AD^{\max}(u_i)$ as the average years of "displacement" $u_i$ would experience if $S^B$ were appended to $S^A$.[33]

$$AD^{\max}(u_i) = \frac{\sum_{u_j \in U^A} \max\{0, y_i - y_j\}}{|U^A|}, \quad u_i \in U^B \tag{4}$$

Now consider seniority integration method $g$. Our measure of cohort distortion measures the amount distortion relative to the worst case scenario as captured by $AD^{\max}$ above. That is, for any $u_j \in U^A$ and $u_i \in U^B$, denote $\tilde{U}^A(u_i)$ as the members of $U^A$ that $S^C$ places higher than $u_i$, i.e., $\tilde{U}^A(u_i) = \{u_j \in U^A : s_j^C < s_i^C\}$. Then, $AD(u_i)$ denotes the average number of years that $u_i$ is displaced by members of $U^A$ *that are more senior to him* as a result of seniority integration method $g$.

$$AD(u_i) = \frac{\sum_{u_j \in \tilde{U}^A(u_i)} \max\{0, y_i - y_j\}}{|\tilde{U}^A(u_i)|}, \quad u_i \in U^B \tag{5}$$

Our cohort displacement measure is then expressed as the ratio of of the aggregate (i.e., across all members of $U^B$) distortion under $g$ relative to worst case scenario (i.e., where $S^B$ is appended to $S^A$), i.e.:

**Definition 10** *The cohort displacement for Firm B resulting from seniority integration method g*

[31] Recall that an underlying assumption is that all pre-merger seniority lists are arranged by date-of-hire. In the discussion of cohort distortion we assume the parameter $k = 0$.

[32] *See* Concurring and Dissenting Opinion of James P. Brucia, *In the Matter of the Seniority Integration of The Pilots of US Airways, Inc. and The Pilots of America West Airlines, Inc.*, May 1, 2007.

[33] Note that $u_i \in U^B$ can only be "displaced" by someone with fewer years of service, but that because $S^B$ is appended to $S^A$, all members of $U^A$ are higher than $u_i$ on the merged list and therefore counted in the denominator.

*is defined as:*

$$CD^B = \frac{\sum_{u_i \in U^B} AD(u_i)}{\sum_{u_i \in U^B} AD^{max}(u_i)}\%$$

Firm $A$'s cohort displacement is defined analogously.[34]

**Example 4** Suppose firms $A$ and $B$ with seniority lists $S^A$ and $S^B$ as presented in Table 2 above merge and integrate workforces. By Lemma 1 above, $CD^A = CD^B = 0$ when $g$ is date–of-hire. Likewise, it is straightforward to compute that $CD^B$=17.4% and $CD^A$=11.1% when $g$ is ratio.

# 5 The Arbitrator's Optimization Problem: Reducing Equity Distortions

As demonstrated above, the two most commonly advocated methods of seniority integration (date-of-hire and ratio) are premised on opposing views of equity and fairness, and consequently, lead to different types of equity distortion. Given the goal of implementing seniority integration in a "fair and equitable" manner, it would be useful to have a single measure of aggregate distortion that an arbitrator could seek to minimize, subject to having the flexibility to tailor the measure to the specifics of the merger and integration at issue. In this section, we begin by proposing a measure of aggregate distortion and defining the arbitrator's optimization problem. We then define a class of integration methods that combines elements of both the date-of-hire and straight-ratio methods and show that using this "hybrid" integration method can reduce aggregate distortion relative to the date-of-hire and ratio methods. Finally, using simulations, we characterize the solution to the optimization problem and identify conditions under which an arbitrator can lower aggregate distortion by using a hybrid method.

Suppose $S^A$ and $S^B$ are integrated using seniority integration method $g$ to form $S^C$. Our definition of aggregate distortion is as follows:

**Definition 11** *The* **aggregate distortion**, $\Delta(g;\theta)$, *resulting from integration method $g$ is equal to:*

$$\Delta(g;\theta) = \theta(CD^A + CD^B) + (1-\theta)MPTD \tag{6}$$

[34] A variation of cohort displacement measure would be to square the $\max\{0, y_i - y_j\}$ term in the numerator of equations (4) and (5) above. Under this formulation, cohort distortion between any two workers would increase at an increasing rate based magnitude of the difference, rather than being measured linearly. For simplicity, we have adopted the linear measure.

In the definition above, $0 \leq \theta \leq 1$ is a conversion parameter that can be chosen by an arbitrator based on the circumstances involved with the particular integration.[35] This conversion parameter allows for the comparison of two distortion measures that have different units of measurement. The arbitrator must choose a value for $\theta$ that reflects the trade-offs between cohort and threshold distortion. Suppose an arbitrator decided that the circumstances of a particular merger dictate that preserving initial status is of paramount importance, while retaining cohort stability is not important. In this case, the arbitrator can set $\theta = 0$, and thus, $\Delta(g;\theta) = MPTD$. As discussed above, using the ratio method would achieve the arbitrator's goal of minimizing aggregate distortion under these circumstances. Alternatively, if an arbitrator wishes to retain cohort stability at the expense of preserving initial status, the relative weight parameter can be chosen such that $\theta = 1$, which would imply that $g$ should be date-of-hire in order to minimize aggregate distortion. While we make no attempt to identify a desirable range of values for $\theta$, in most real world applications, an arbitrator seeking a "fair and equitable" integration will want to give at least some weight to each of the distortion measures, and thus, he would assign $0 < \theta < 1$.[36] After choosing $\theta$, the arbitrator's optimization problem becomes:

**Definition 12** *The* **arbitrator's optimization problem** *is:*

$$\min_{g \in G} \Delta(g;\theta) \tag{7}$$

*where $G$ is defined as the set of all seniority integration functions that the arbitrator considers and $\theta$ is the conversion parameter.*

It is easy to see that this quickly becomes an intractable problem for integrations of large workgroups. If no restrictions are imposed on the set of integrated seniority lists considered there are $(N+M)!$ possible seniority integrations. One reasonable restriction would be to require that the integrated seniority list *preserves initial rank*.[37] Restricting $G$ to those methods that preserve initial rank reduces the number of possible integrations to $(N+M)!/N!M!$. Although this is a considerable

[35] While alternate measures of aggregate distortion (such as squaring each term) could be used, we believe that this sufficiently captures the tradeoffs between cohort and threshold distortion.

[36] It is also possible that an arbitrator would want to weight $CD^A$ and $CD^B$ differently, in which case an additional weighting parameter could be introduced. In some cases (for example when one workgroup is much larger than the other) it may be desirable to give more weight to the cohort distortion of one group over the other. For our purposes, we assume that the cohort distortion of each group is treated the same.

[37] We say that a seniority integration method $g$ that integrates seniority lists $S^A$ and $S^B$ into a single list $S^C$ *preserves initial rank* if $s_i^k < s_j^k \Rightarrow s_i^C < s_j^C, k = A, B \quad \forall i, j$. That is, if Mary Smith was above John Davis on firm $A$'s pre-merger seniority list, she should remain above John Davis on the merged seniority list.

improvement, there are still over 126 billion possible integrations that preserve initial rank when both workgroups have only 25 employees.

## 5.1 Hybrid Seniority Integration Methods

Looking at every possible integration method that preserves initial rank may not be feasible in most situations, especially as workgroup size increases. We propose further limiting the set of considered integration methods to a class of methods that can be easily implemented and compared.

Consider merging firms $A$ and $B$ that integrate seniority lists $S^A$ and $S^B$ with $N$ and $M$ employees respectively into a single list $S^C$. Denote $s^C_{i,doh}$ as the resulting seniority rank for employee $i$ if the date-of-hire method is used, and denote $s^C_{i,r}$ as the resulting seniority rank if the ratio method is used.

**Definition 13** *A seniority integration method $h(\omega) \in G$ is said to be a* **hybrid method** *if $s^C_i = \psi(\omega s^C_{i,doh} + (1-\omega)s^C_{i,r}), \forall i = 1, 2 \dots M+N$.*

$0 \leq \omega \leq 1$ is a parameter that determines the relative weights given to the ratio and date-of-hire methods. The arbitrator can then approximate the original minimization problem by solving:

$$\min_{\omega \in [0,1]} \Delta(h(\omega); \theta) \tag{8}$$

We can then denote the values of $\omega$ that solve the above problem for a given value of $\theta$ as $\omega^*(\theta)$. In some rare instances, $\omega^*(\theta)$ may contain zero or one, indicating that the hybrid method cannot improve upon the date-of-hire or ratio methods. Under certain conditions (and ranges of $\theta$), $\omega^*(\theta)$ does not contain zero or one, indicating that an arbitrator could produce a more "fair and equitable" result using the hybrid method over either the date-of-hire or ratio method. It is worth noting that because date-of-hire and ratio are special cases of the hybrid method, minimizing aggregate distortion over all possible values of $\omega \in [0,1]$ cannot result in more distortion than date-of-hire or ratio integration.

Hybrid methods have two additional properties worth mentioning. First, every employee's seniority in a hybrid integration will be between the employee's date-of-hire and ratio seniorities:

$$s^C_{i,h(\omega)} \in [\min\{s^C_{i,r}, s^C_{i,doh}\}, \max\{s^C_{i,r}, s^C_{i,doh}\}] \quad \forall i = 1, 2, ..., N+M, \forall \omega \in [0,1]$$

Another property of the hybrid methods is that unlike other possible seniority integrations that preserve initial rank, the hybrid method treats all employees of a given workgroup symmetrically.[38]

[38]For example, an integration method that included the most senior members of group $A$ (or those in leadership

Although asymmetric treatment for different members of a given group could be desirable in circumstances where there are asymmetric thresholds at each workgroup (i.e. if one workgroup had furloughed members before the merger but the other group had not), we ignore that possibility here.

Given these two properties of the hybrid class of seniority integrations and the fact that date-of-hire and the ratio method are special cases of the hybrid method, we believe that it is reasonable to restrict the set of considered integrations in this way to make the arbitrator's problem significantly simpler.

## 5.2 When Is the Hybrid Method Likely To Reduce Equity Distortion?

We now demonstrate that an arbitrator can typically reduce the aggregate level of equity distortion relative to what could be achieved by simply applying either the date-of-hire or ratio methods.

Due to the way that $\Delta(h(\omega);\theta)$ is constructed, for a given merger, $\omega^*(\theta)$ will be monotone nondecreasing in $\theta$. When $\theta = 0$ the optimal value of $\omega$ is 0 since the ratio method minimizes threshold distortion. Similarly, when $\theta = 1$ the optimal value of $\omega$ is 1 since date-of-hire minimizes cohort distortion. Since larger values of $\theta$ reflect a preference for lower cohort distortion, increases in $\theta$ therefore result in larger (or equal) values of $\omega^*$ because larger values of $\omega$ place more weight on date-of-hire which minimizes cohort distortion. This means that for workgroups that do not have identical longevity profiles (i.e., where date-of-hire and ratio integration produce identical lists) there will be values of $\theta$ where the hybrid method outperforms both of the original methods.

In order to characterize the conditions where the hybrid method offers meaningful improvements over the date-of-hire and ratio methods, it is first necessary to define a measure of workforce compatibility. The distortions that result from merging two similar workgroups might have different properties than the distortions resulting from the integration of two firms with very different hiring histories. We define a measure of workforce compatibility as follows:

**Definition 14** *The* **longevity profile compatibility**, $\lambda$, *of two workgroups is:*

$$1 - \left[ \frac{1}{(N+1)(M-1)} \sum_{i=1}^{M+N} \left| s^C_{i,doh} - s^C_{i,r} \right| \right], N \leq M$$

Note that for workgroups with identical longevity profiles $\lambda = 1$. At the other end of the spectrum where the most recent hire from one workgroup has more longevity than the most senior employee in the other $\lambda$ approaches 0. Although longevity profile compatibilities of zero or one are unlikely to

positions) with group $B$ by date-of-hire, but appended the remaining members of group $A$ to group $B$ preserves initial rank even though some members of group $A$ receive preferential treatment.

occur in the real world, actual mergers often span a wide range of longevity profiles. A large value of $\lambda$ can be thought of as a "merger of equals", while a smaller value of $\lambda$ would represent a merger between more differentiated firms in terms of workforce size and demographics.

### 5.3 Simulations

Our simulations aim to capture mergers from across the spectrum of longevity profile compatibility. For 5,000 hypothetical mergers, we randomly generate two seniority lists $S^A$ and $S^B$ with $N$ and $M$ members, respectively, and the following set of properties:

1. $S^A$ and $S^B$ are organized by date-of-hire.
2. $N$ is drawn from the uniform distribution, $U[400, 500]$, and $M$ is drawn from the uniform distribution, $U[50, 200]$.
3. $y_i$ is drawn from the uniform distribution $U[15, 30]$ for $i = 1, 2, \ldots, N$ (i.e., workers from firm $A$).
4. $y_i$ is drawn from a uniform distribution $U[15-\nu, 30-\nu]$ for $i = N+1, N+2, \ldots, N+M$ (i.e., workers from firm $B$), and $\nu$ ranges from 0 to 15 in increments of 0.15.[39]

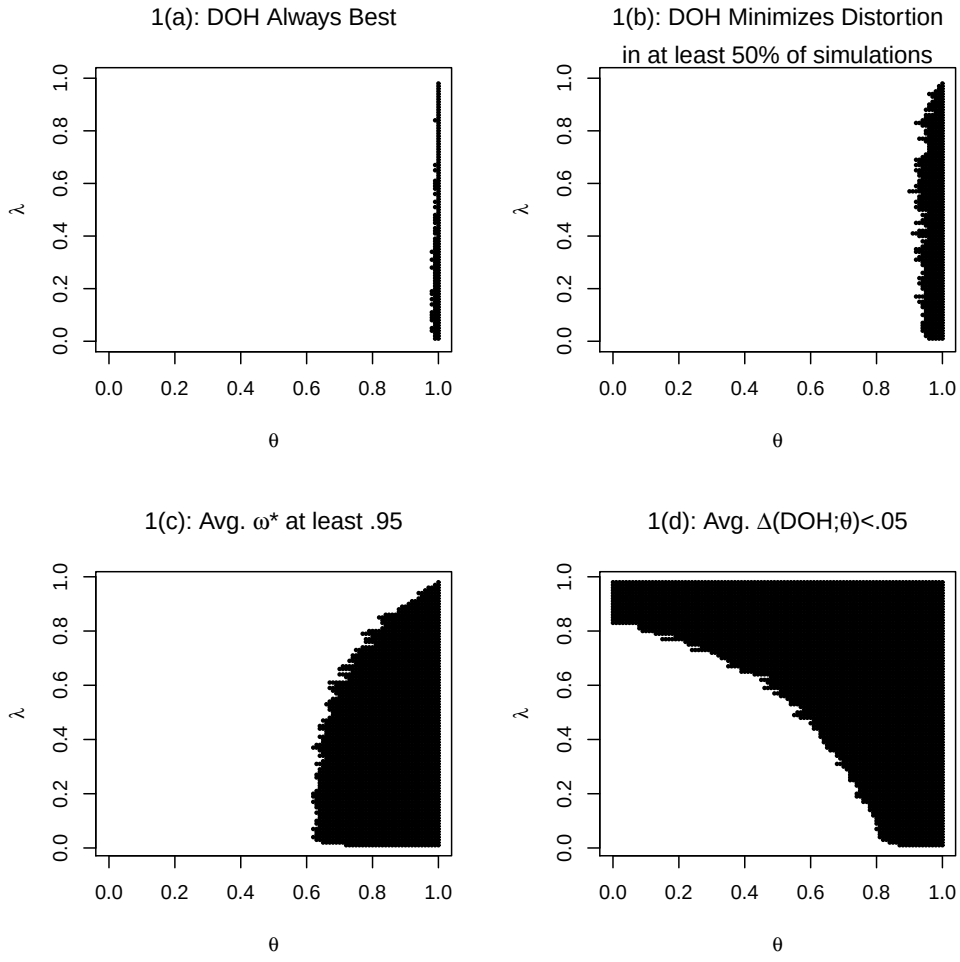
Next, we compute $\Delta(h(\omega); \theta)$ for all values of $\theta \in [0, 1]$ at increments of 1/100 and find the value(s) of $\omega$ that minimize aggregate distortion. Finally we round the value of $\lambda$ for each simulated merger to two decimals and average across all simulations with the same rounded values of $\lambda$. For each rounded value of $\lambda$, the number of simulations ranges from 1 to 265 with the median number of simulations equal to 38.

Figure 1(a) shows points on the parameter space $(\theta, \lambda)$ where date-of-hire minimized distortion for every simulation with those parameter values. From here we can see that for any value of $\lambda$ (the measure of workforce compatibility), date-of-hire minimizes distortion only for values of $\theta$ (the conversion parameter chosen by the arbitrator) close to 1.[40] Figure 1(b) shows parameter values where in at least half of the simulations date-of-hire minimized distortion and demonstrates that date-of-hire generally does well for only relatively large values of $\theta$. Figure 1(c) shows points where the *average* value of $\omega^* \geq 0.95$. From this we can see the parameter values for which the lowest

[39] A single value of $\nu$ is used for all employees on a given seniority list. Each value of $\nu$ is used an equal number of times (i.e. if 100 simulations are run each value of $\nu$ is used once and if 1,000 simulations are performed each value of $\nu$ is used 10 times).

[40] Recall that as $\theta$ approaches 1, an arbitrator has deemed that circumstances of a particular merger favor minimizing cohort distortion.

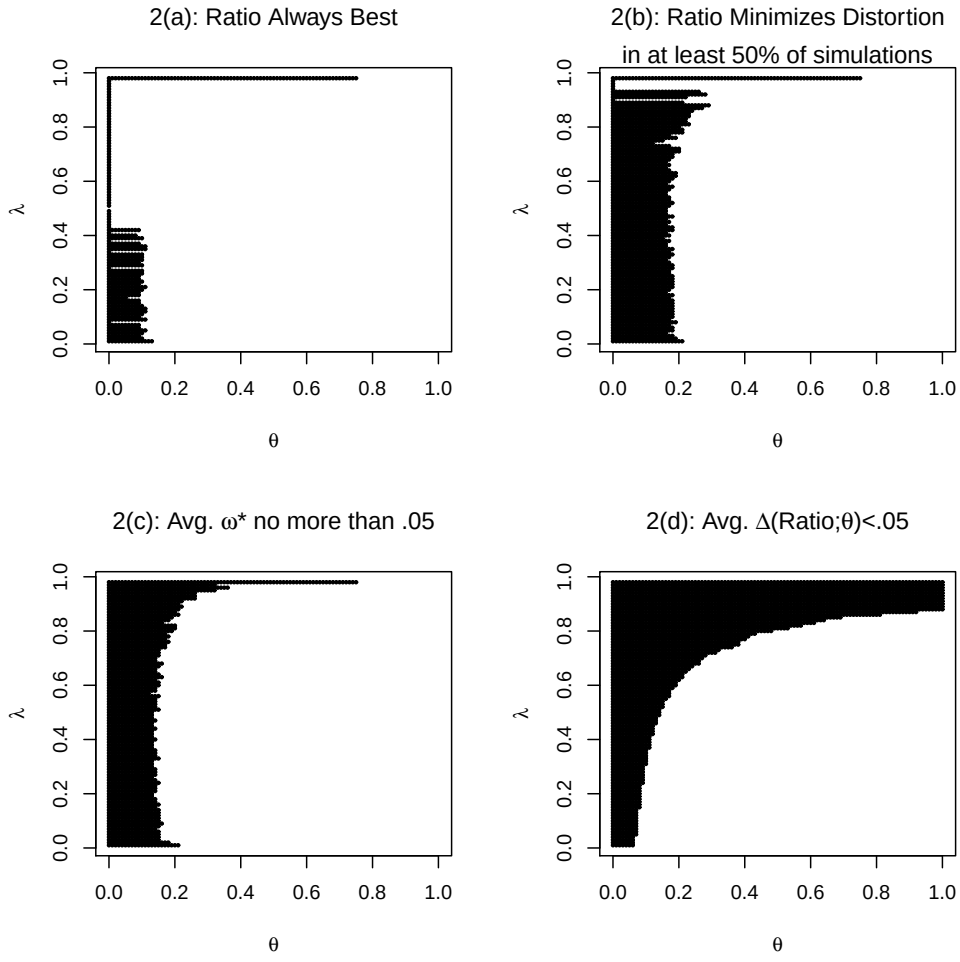
FIGURE 1: DATE OF HIRE INTEGRATION




values of distortion are obtained by a method that on average is very close to date-of-hire. Finally, Figure 1(d) shows points where the average value of the aggregate distortion was less than 0.05 under date-of-hire, demonstrating that date-of-hire results in low levels of distortion when either $\lambda$ or $\theta$ are large.

Figure 2 repeats the exercise using the ratio method. As expected, the ratio method always minimizes distortion for values of $\theta$ close to 0 (Figure 2(a)), but for most values of $\lambda$ minimizes distortion at least half of the time when $\theta$ is less then 0.2 (Figure 2(b)). Figure 2(c) shows parameter values where the average value of $\omega^* \leq 0.05$ and implies that the ratio method usually comes close to minimizing distortion when $\theta$ is less than approximately 0.2. Figure 2(d) shows points where the value of the aggregate distortion was less than 0.05 when ratio is used. Similar to figure 1(d),

FIGURE 2: RATIO INTEGRATION




this shows that the ratio method produces low levels of aggregate distortion when $\lambda$ is larger than approximately 0.8, or when $\theta$ is small.

The parameter values that are neither in figures 1(c) nor 2(c) are places where $\omega^*$ is typically between 0.05 and 0.95. In these cases the hybrid method takes elements of both date-of-hire and ratio and generally $\omega^*$ has more variation for simulations with common parameter values. Values of $\theta$ in this range can be thought of as placing more of an equal balance on the different distortion measures. For example in each one of the simulated mergers, if one were to choose a value of $\theta$ so that the aggregate distortion was equal when using either the date-of-hire or ratio methods, the optimal value of $\omega$ is between 0.31 and 0.84.

Parameter values that are included in both figures 1(d) and 2(d) are points where either date-of-hire or ratio produce values of distortion less than 0.05. From this we can conclude that for larger values of $\lambda$, seniority integration may not be as contentious since both date-of-hire and ratio produce relatively "low" levels of distortion. Parameter values that are in neither figures 1(d) nor 2(d) have distortion greater than 0.05 in both methods and are therefore likely to be the most contentious. It is for these mergers that we expect the greatest reduction in aggregate distortion to come from the application of the hybrid method.

FIGURE 3: PARAMETER VALUES WHERE THE HYBRID METHOD OFFERS IMPROVEMENT

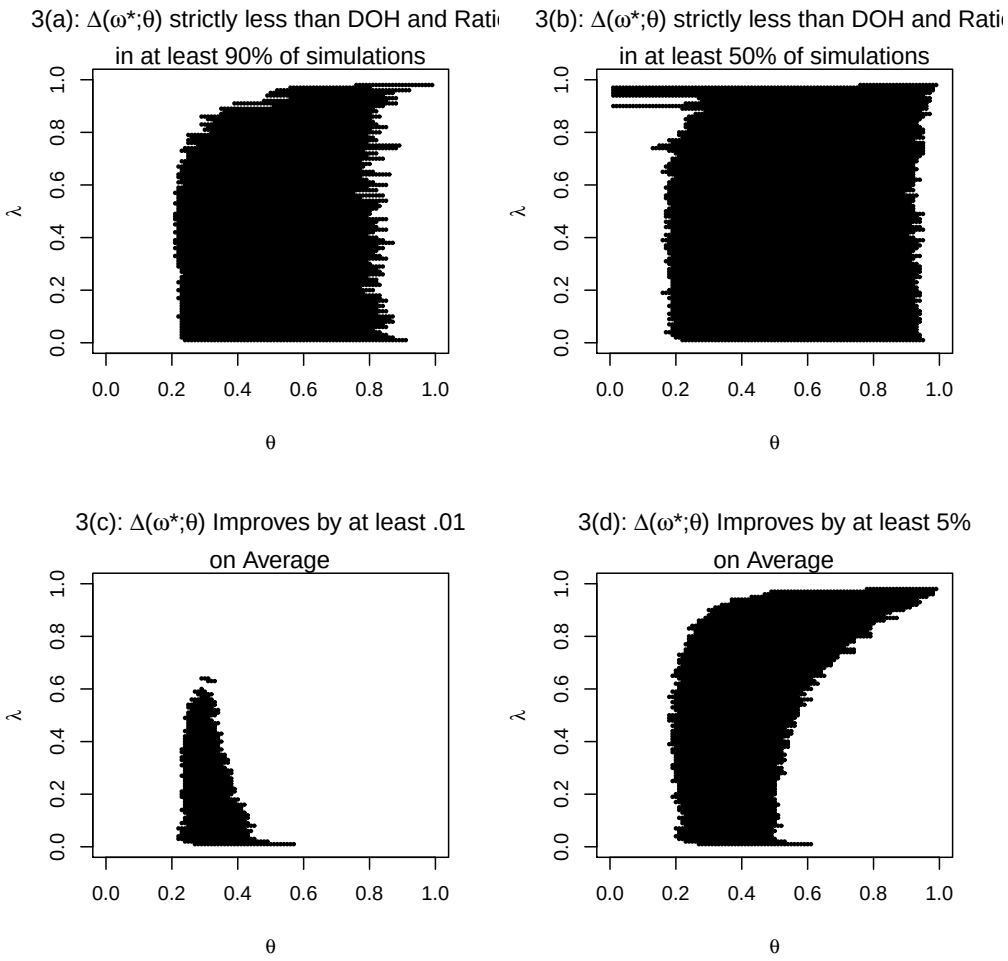



Figure 3(a) shows parameter values where the hybrid method strictly improves upon both the date-of-hire and ratio methods in at least 90 percent of the simulations. This demonstrates that when the chosen values of $\theta$ are between approximately 0.25 and 0.9, an arbitrator can generally

obtain a lower level of aggregate distortion by using a hybrid method. Figure 3(b) shows parameter values where the hybrid method is strictly improving in at least 50 percent of the simulations. This further emphasizes that for the majority of the parameter space the hybrid method tends to be strictly less distortive than both of the other integration methods.[41]

Figure 3(c) plots $(\theta, \lambda)$ pairs where the average absolute improvement is at least 0.01. It is for this more limited range of parameter values that the hybrid method can produce the largest absolute gains. The largest absolute improvement obtained in our simulations was 0.064 and the largest average improvement for a $(\theta, \lambda)$ pair was 0.045. Although these improvements may appear modest, in percentage terms the improvement can be substantial. Figure 3(d) shows points where the average percentage reduction in $\Delta(g;\theta)$ of the hybrid method versus the lower (i.e., less distortive) of the date-of-hire and straight-ratio methods for each simulation is at least 5 percent. For these values of $\theta$, the hybrid method offers the largest improvement. Large percentage improvements can occur for values of $\lambda$ close to 1 since aggregate distortion will already be very small for firms with similar longevity profiles. In the simulations the largest percent improvement from using the hybrid method was 50% (the largest average percent improvement for a $(\theta, \omega)$ pair was 26%).

Although the magnitude of the improvement may appear small, figures 3(c) and 3(d) taken together demonstrate that the hybrid method can produce meaningful reductions in aggregate distortion. However, the full benefit of using the hybrid method for a particular merger is not apparent until all of its components are examined individually for each integration method. Table 7 shows the individual components of the aggregate distortion and $\Delta(g;\theta)$ for one simulated merger when $\theta = 0.25$. In this example the firms do not have similar longevity profiles and $\lambda = 0.0611$. The first column shows that date-of-hire is slightly less distorting than the ratio method at the chosen value of $\theta$ and the hybrid method (at $\omega^*$) reduces aggregate distortion by 0.0228 or 17.1%. The next two columns show that the date-of-hire method does not cause cohort displacement for either workgroup, but the ratio method produces a value for firm $A$'s cohort displacement of 0.6744, meaning that 67% of the displacement occurs relative to the cohort displacement that would occur if employees from firm $A$ were appended to employees from firm $B$. Using the hybrid method reduces firm $A$'s cohort displacement by approximately two thirds relative to the ratio method. Since firm $B$ has a considerably younger workforce than firm $A$, neither the ratio method nor the hybrid method result in

[41] It is also worth noting that for all simulated mergers, there was at least one value of $\theta \neq \{0, 1\}$ that resulted in the hybrid method strictly improving upon both the date-of-hire and ratio methods. The contrast between figures 3(a) and 3(b) serves to demonstrate that $\lambda$ does not completely characterize the variation across types of mergers and that for a given value of $\lambda$ there can be a considerable amount of variation in the optimal value of $\omega$ and the resulting aggregate distortion. Despite that variability, mergers with similar values of $\lambda$ tend to have similar properties on average.

cohort displacement for firm $B$'s employees.

Table 7: Example of Reduction in Distortion Measures Using the Hybrid Method

| | $\Delta(g;\theta)$ | $CD^A$ | $CD^B$ | $MPTD$ |
|---|---|---|---|---|
| DOH | 0.1682 | 0.0000 | 0.0000 | 0.2243 |
| Ratio | 0.1699 | 0.6744 | 0.0000 | 0.0017 |
| Hybrid; $h(\omega^*)$ | 0.1394 | 0.2237 | 0.0000 | 0.1113 |

Notes: Simulated merger where $N = 487$, $M = 97$, $y_i$ is drawn from the uniform distribution $U[15, 30]$ for $i = 1, 2, \ldots, N$ (i.e., workers from firm $A$), $y_i$ is drawn from a uniform distribution $U[3, 18]$ for $i = N + 1, N + 2, \ldots, N + M$ (i.e., workers from firm $B$). $\lambda = 0.0611$, $\omega^* = 0.525$, and distortion calculated for $\theta = .25$.

The last column of table 7 shows that while the ratio method results in essentially no threshold distortion, the date-of-hire method has a $MPTD = 0.224$. This means that there is a threshold where 22.4% of the combined workgroup is displaced above or below the threshold because of the merger (half of these employees will be below the threshold and will therefore be negatively effected). The hybrid method reduces $MPTD$ by approximately half compared to date-of-hire. From this example we can see that the hybrid method balances cohort and threshold distortion and finds a middle ground between the two methods.

Finally, we are able to conclude from the simulations that in general, a true "merger of equals" will tend to have less distortion than a merger of two more diverse workforces, and on average aggregate distortion increases as $\lambda$ decreases. For values of $\lambda$ close to 1, integration may not be as contentious since both the date-of-hire or ratio methods produce only limited amounts of distortion. For smaller values of $\lambda$, large values of $\theta$ allow for date-of-hire to be used without substantial distortion and low values of $\theta$ indicate that the ratio method may be more appropriate. Where $\theta$ gives more equal balance to cohort and threshold distortion, the hybrid method is able to offer the largest improvements. In sum, the results from the simulations demonstrate that independent arbitrators could lower aggregate distortion relative to the ratio or date-of-hire methods in many cases by applying a fairly straightforward combination of the two methods. Moreover, this finding is robust to mergers of firms with a wide range of longevity profiles.

# 6 Conclusions

In industries or sectors of the economy where an employee's compensation, benefits and job security are linked to their seniority rank and where mergers or consolidation can occur, seniority integration plays an important role in shaping employee job satisfaction, labor relations, and even market structure. Despite the important role that seniority integration plays in many labor markets and the fact that it is frequently the subject of lengthly and contentious disputes, there has been surprising little attention paid to better understanding the economics of seniority integration in the literature.

This paper attempts to partially fill that void by providing a framework to analyze the effects of seniority integration. We demonstrate why the interpretation of the "fair and equitable" standard embedded in the two most commonly proposed methods of seniority integration (date-of-hire and ratio) are in conflict, thereby necessitating binding third party arbitration. Although we show that there typically exists no method of seniority integration satisfying the equity and fairness concepts underlying both methods, we demonstrate that measures of aggregate equity distortion can be reduced using a class of hybrid methods that combine elements of both the date-of-hire and ratio methods. Although we defer the determination of optimal, unrestricted seniority integration methods for future research, we believe that this finding can serve as a useful tool for arbitrators that are frequently confronted with conflicting proposals.

# A Proofs:

**Proof of Lemma 1:** We prove Lemma 1 in two parts.

1. *$g$ is date-of-hire implies cohort stability for $k = 0$.* If $g$ is date-of-hire, then by Definition 3, $s_i^C = \Gamma(y_i),\ i = 1, 2, \ldots, N + M$. Since $\Gamma$ is the function that organizes any random variable in descending order, $s_i^C < s_j^C \Longrightarrow y_i \leq y_j, \forall i = 1, 2, \ldots, N + M$.

2. *Cohort stability for $k = 0$ implies $g$ is date-of-hire.* Suppose $k = 0$, $S^C$ retains cohort stability but $g$ is not date-of-hire. Then there exists some $u_k \in S^C$ such that $s_k^C \neq \Gamma(y_k)$. This implies that for some other $u_i \in S^C, s_k^C < s_i^C$ and $y_k < y_i$, or $s_k^C > s_i^C$ and $y_k > y_i$. But this contradicts the assumption that $S^C$ retains cohort stability.

**Proof of Lemma 2:** If $g$ is date-of-hire and $U^A$ and $U^B$ *do not* have identical longevity profiles, then there exists $u_i \in U^A \bigcup U^B$ such that:

$$\frac{s_i^A}{N} - \frac{s_i^C}{N+M} > \varepsilon, \quad i = 1, 2, \ldots, N \quad \text{or} \quad \frac{s_i^B}{M} - \frac{s_i^C}{N+M} > \varepsilon \quad i = N+1, \ldots, N+M. \tag{9}$$

Where $\varepsilon = \frac{1}{N+M}$. Suppose $\frac{s_i^A}{N} - \frac{s_i^C}{N+M} > \varepsilon$ (the proof is equivalent for the case with $s_i^B$). Then $\frac{s_i^A}{N} > \frac{s_i^C}{N+M} + \varepsilon$. Define:

$$t^{A*} = \frac{1}{2}\left[\frac{s_i^A}{N} + \frac{s_i^C}{N+M} + \varepsilon\right] \tag{10}$$

Then, if $\frac{s_i^A}{N} > \frac{s_i^C}{N+M} + \varepsilon$, it must be that $u_i \in Q^A(t^{A*})$ but $u_i \notin Q^C(t^{A*})$. Therefore, $\exists t \in [0, 1]$ such that $S^C$ does not preserve initial status.

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