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Productivity under Large Pay Increases: Evidence from Professional Baseball

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ABSTRACT

Productivity under Large Pay Increases: Evidence from Professional Baseball

The establishment of the free agency system in the 1970s resulted in large salary increases among professional baseball players. Historical data show that players have tended to perform better at early stages of their careers since free agency was introduced. Under the current salary bargaining system, players only become eligible for salary arbitration and free agency at predetermined points in their careers, resulting in sudden changes in salary growth rates at these points. Using data on official days of major league service, it is found that players with high expected salary growth perform better, consistent with efficiency wage theory.

JEL Classification: J24, J31

Keywords: efficiency wages, productivity, baseball

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"The five-dollar day was the greatest cost-cutting move I ever made."
HENRY FORD

1. Introduction

Economists have traditionally believed that in a competitive labor market, workers will receive wage rates equal to their productivity levels and that the latter is determined exogenously by factors such as education and training. In recent decades, however, a number of studies have cast doubt on this assumption and have suggested that, at least to some extent, productivity may *respond* to wages.

U.S. professional baseball provides an ideal setting in which to study whether pay can influence a person's productivity. Not only is accurate and comprehensive productivity data available at the individual level, in the form of performance statistics, but a major change in the salary bargaining system occurred in the 1970s. Prior to this point, players were tied to the same team for their entire career, giving each team monopsonistic powers. However, since 1977 players with at least 3 years of experience may choose to have an independent arbitrator settle salary disputes and players with at least 6 years of experience have the right to become "free agents" once they are out of contract, meaning they can sign for any team they like. The introduction of salary arbitration has resulted in much higher salary growth among those players who are affected, while contract durations have increased among those who are eligible for free agency (Kahn 1993). Since the free agency system induces extremely large and sudden changes in salaries at predetermined points in a player's career, it provides an exogenous source of income growth, unrelated to a player's past performance.

The paper will take two approaches to determining whether the free agency system influences how well a player performs. In the first, performance data from before and after the introduction of free agency will be compared. Other factors have been responsible for aggregate changes in the relative performance of hitters and pitchers over time, however since salary arbitration and free agency only apply to those with more than 3 or 6 years of experience, respectively, the performance of players at different stages of their careers can be compared. The second approach focuses on five recent seasons for which exact information on a player's salary and eligibility for free agency is available.

The rules governing the free agency system allow the separate effects of experience and salary growth on performance to be identified, using both instrumental variables and regression-discontinuity approaches.

This paper makes three main contributions to the literature studying the effects of pay structure on productivity. Firstly, it uses accurate measures of individual productivity for *all* workers within a particular industry, rather than just a single firm as in previous related studies. Secondly, because the pay increases associated with free agency were essentially imposed on team owners and because teams are unlikely to incur any costs of monitoring players' effort levels, there should be no problem of endogenous adoption or adjustment of pay policy by teams. Finally, by introducing exogenous shifts in players' salary growth rates at different points throughout their careers, the free agency system allows a test of whether a given player exhibits a spike in performance at those points, thus controlling for unobserved person-specific differences in productivity.

2. Background

The literature studying the productivity effects of efficiency wages consists of two broad approaches. The first involves analyzing firm-, region- or industry-level data. These papers typically use the average productivity of workers within each firm, sometimes controlling for the average attributes of the firm's workers. Examples include Wadhwani and Wall (1991), Levine (1992), Nickell and Nicolitsas (1997) and Fuess and Millea (2002). The majority of these studies find that average productivity rises when the relative wage at a firm increases.

The second class of papers analyses surveys of individuals within certain sectors of the economy. Although these studies examine the labor market behavior of individual workers, they do not often have good direct measures of productivity, so tend to look for indirect evidence of efficiency wage models. Moretti and Perloff (2002) studied the U.S. agricultural labor market and found that direct-hire growers receive higher wages than farm contractors and that both offer deferred payments to workers, suggesting that the direct-hire growers are paying an efficiency wage. Georgiadis (2008) found that the introduction of a minimum wage in the United Kingdom resulted in a reduction in the fraction of managerial staff employed at residential care homes, consistent with the

notion that higher wages circumvent the need for supervision of employees. Georgiadis's study is closely related to the current paper in that it focuses on the productivity effects of a rise in the minimum wage, which is an enforced pay increase for an entire segment of the workforce rather than a profit-maximizing decision by a firm. In contrast to both Moretti and Perloff and Georgiadis, however, data are available for players on *all* major league baseball teams, akin to having observations for all workers in an industry rather than in just one firm.

A separate but related literature has analyzed the effect performance related pay has on worker productivity.[1] These generally find support for the idea that productivity is higher under piece rates than under fixed wages. Again, this literature includes those papers using firm-level data (*e.g*. Gielen, Kerkhofs, and van Ours 2010) and those using worker-level data (*e.g*. Booth and Frank 1999; Pekkarinen and Riddell 2008), but also a number of studies that look at workers within a single firm (*e.g*. Lazear 2000; Shearer 2004; Bandiera, Barankay, and Rasul 2005). These intra-firm studies collect direct measures of individual productivity and use longitudinal data, allowing them to control for the fact that more able workers are more likely to have performance-related contracts. However, as Pekkarinen and Riddell note, they are still likely to suffer from a selection problem, since compensation policy at the firm level is likely to be endogenous. This analysis in this paper avoids this problem by using longitudinal data for the workers in *all* firms in an industry (or, in this case, for players in all major league teams).

A handful of previous authors have examined what happens to performance among major league baseballers who elect to become free agents and sign contracts with different teams. Grad (1998) and Holden and Sommers (2005) noted that players might be motivated to put in extra effort in the year prior to filing for free agency in order to impress potential bidders. Krautmann (1990) argued instead that there is an incentive for a player to shirk immediately after signing a multiple-year contract. Both hypotheses predict that a player's performance will decline immediately after he signs a free agent contract, however none of the papers find significant evidence of this.

In contrast to the aforementioned studies, this paper examines the effects of eligibility

[1] All major league baseball players receive bonuses if their team reaches the post-season and some contracts also include bonuses for reaching specific performance targets, although they are not piece rates as studied by the authors listed.

for salary arbitration and free agency on the performance of all players, not just those players who sign new free-agent contracts. Average annual salary growth is highest among those players who pass the threshold for eligibility for salary arbitration, before they are even eligible for free agency. Furthermore, focusing on the effects of filing for free agency will induce an endogeneity problem, since the decision of whether and when to file may be affected by a player's past performance.

3. The free agency system

The early days of professional baseball were plagued by players regularly shifting teams during the middle of seasons in search of pay increases. To combat this, team owners made an agreement before the 1879 season not to sign any of five "reserved" players on each others' teams. The number of reserved players rose to include the entire team by 1883 and in 1887 was made a formal contract clause. This so-called reserve clause formed the basis of the baseball labor market for almost a century. Essentially, it meant that teams could make take-it-or-leave-it offers to their players. Players had no means by which to persuade the team to increase their salary offer, except the threat of retirement: if a player refused to accept a contract, he was unable to play anywhere else in the major leagues.

Throughout the 1970s, the reserve clause system was progressively dismantled. Firstly, team owners agreed to a system of salary arbitration in 1973, following a strike by players the previous year. Under this system, if a player and team cannot agree on a contract, either party may file for arbitration. The arbitrator must choose between the final contract offers made by the player and team, based solely on the player's performance, the club's record and attendance and the salaries of players with the same amount of major league experience.[2] Both sides are obligated to accept this contract. In practice, most contracts are settled by players and teams before reaching arbitration. Under current rules, a player is eligible for salary arbitration if he has accrued more than three, but less than six, years of major league service. In addition, among those players with between two and three years of service who have accumulated at least 86 days of

[2] For players with less than 5 years of major league service, arbitrators may also take into account the salaries of players with one extra year of experience.

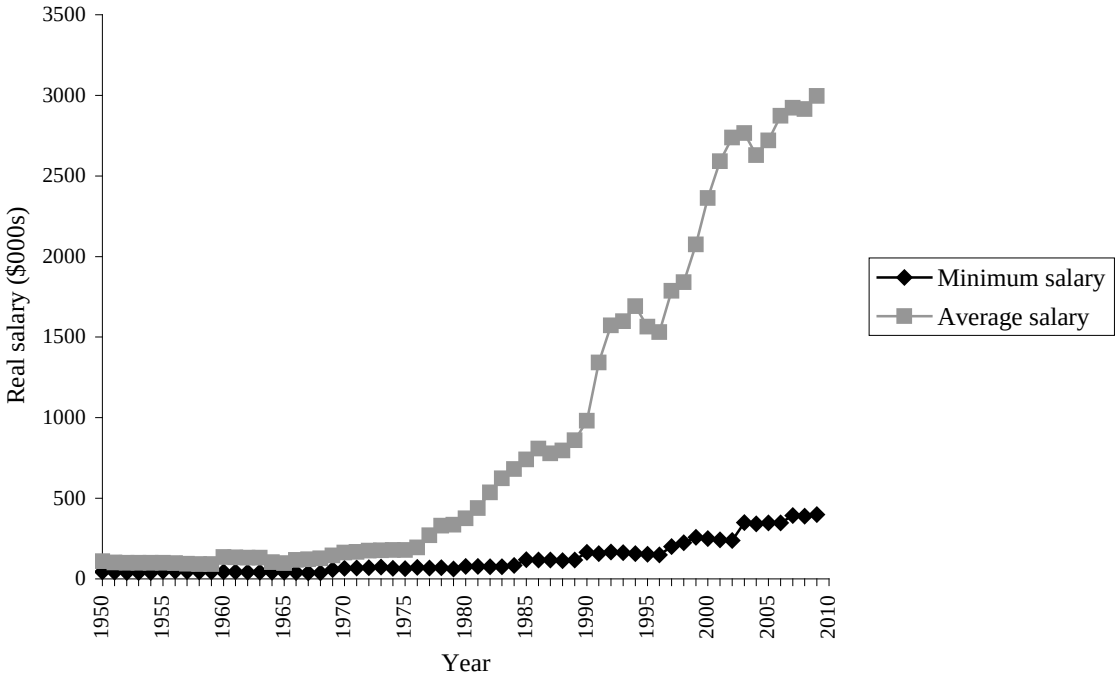
service during the previous season, the top 17% ranked by total service time are eligible for salary arbitration. This is known as the "Super Two" exception.

Meanwhile, beginning in 1970, the legality of the reserve clause was challenged in a series of cases. Although the Supreme Court ruled that the reserve clause was legal in 1972, Catfish Hunter became the first free agent in 1974 after he won a contract dispute in arbitration. The contract he subsequently signed made him the highest paid player in baseball the following season. Finally, in 1975 Andy Messersmith and Dave McNally refused to sign new contracts. Although their teams renewed their contracts from the previous season, the players argued that since no contract had been signed, they would not be bound to the team for the following season and in December 1975 an arbitrator agreed. Although team owners finally conceded that the reserve clause was unenforceable, they argued that the cost of developing young players was so high they needed a guaranteed period of time during which they could recover their investment. Under an agreement reached with the players' union in 1977, a player is bound to his original team for his first six years, as per the reserve clause. However, after they have accumulated six years of major league service, players can now become free agents and sign with whichever team they wish. Of course, if players sign long-term contracts before the end of their sixth season, they relinquish this right.

In the three decades since the introduction of the free agency system, average salaries have risen dramatically in the major leagues. Figure 1 plots the evolution of the average salary across the major leagues between 1950 and 2009, along with the league minimum salary. Average salaries began increasing rapidly after the introduction of free agency and have continued to rise at a reasonably steady rate since. The minimum salary has also been raised regularly since the early 1970s, although it has not kept pace with the average salary. The ratio of the average to minimum salary was around 4 in 1977, rose to a maximum of 11.5 in 2002 before falling back to 7.5 in 2009 as the minimum was doubled.

Players' salaries typically follow three distinct phases over the course of their careers. During their first three complete seasons, they are almost always signed to one-year contracts at the prevailing league minimum. For their next three seasons, during which they are not free agents but are eligible for salary arbitration, they tend to receive rapidly increasing salaries, regardless of whether they actually file for arbitration or not. Finally,

Figure 1
Average and Minimum Salaries, 1950-2009

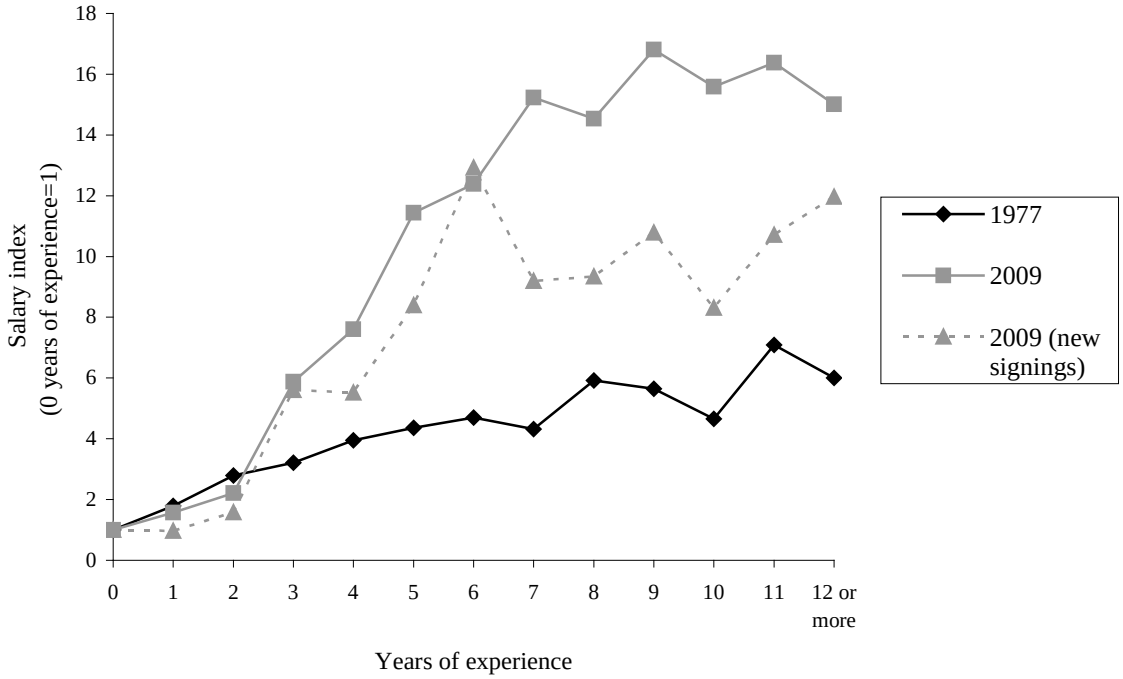


Notes: The average salary data are obtained from the Major League Baseball Players Association for 1964-2009, with decadal averages taken from Haupert (2007) used for earlier years.
Both series are expressed in 2009 dollars, adjusted using the Consumer Price Index deflator.

after six years, players receive relatively stable salaries that are close to (and may even exceed) their marginal revenue product (Sommers and Quinton 1982; Blass 1992). This is seen in Figure 2, which depicts the average salary-experience profile in 1977 and 2009. Salaries typically increased with experience in both years (although initial salaries were about 11 times higher in real terms in 2009).[3] As predicted, earnings grew at a similar rate over a player's early career in both periods, however they grew much faster during the player's salary arbitration eligibility period in 2009. The pattern is exacerbated if only players in the first year of their contracts in 2009 are considered. Among this group, salaries actually fall after the first year of free agency eligibility, because the best players are tied to long-term contracts as soon as they become eligible.

[3] As Blass (1992) speculates, the fact that an upward-sloping career earnings profile already existed in 1977 (before free agency was established) might be the result of a compromise between the desire of teams to ensure performance incentives by paying piece rates and the desire of players to have a smooth source of income.

Figure 2
Salary-Experience Profiles for 1977 and 2009



Notes: 1977 data are from Rodney fort's sports business website (http://www.rodneyfort.com); 2009 data are from the Baseball Archive.
The data points are the coefficients from separate regressions of annual salary on a set of dummies for years of major league experience in 1977 and 2009. All players are used except for the new signings series, where only players in the first year of their contracts are used.
Estimated years of experience are used for the series including all players; actual service time is used for the new signings series.

Major league service time is used to determine whether a player is eligible for salary arbitration or free agency and is measured in years and days. The maximum amount of service time that a player may accumulate each year is 172 days, even though a season typically lasts longer than that. As well as time spent on a team's 25-man active roster, service time includes time spent injured (known as being on a team's disabled list) or on the suspended list. Time spent in the minor leagues does not generally count towards service time, however players who spend no more than 20 days on optional assignment in the minor leagues in a season are credited with service time for the length of their assignments.

4. Data

The primary data for this paper are taken from Sean Lahman's Baseball Archive (available from www.baseball1.com) for the period 1950-2009. This contains annual data on the performance of each player in the major leagues. This study will focus on two measures of performance: on-base plus slugging (OPS) for non-pitchers and earned run average (ERA) for pitchers. A player's OPS is the sum of his on base percentage (defined as times-on-base per plate appearance, excluding sacrifice hits, fielder's obstruction or catcher's interference) and his slugging percentage (defined as total bases scored per at-bat).[4] ERA is defined as earned runs conceded per 9 innings pitched. Hence, a higher OPS but a lower ERA indicates higher productivity. Non-pitchers are excluded from regressions for OPS in seasons where they have fewer than 100 plate appearances and pitchers are excluded from regressions for ERA in seasons when they pitch fewer than 50 innings.

Since the Baseball Archive dataset does not record the time players spend on the disabled list, it is impossible to calculate a player's service time using it. However, data on players' career service time at the beginning of each season from 2005-2009 were obtained from the Cot's Baseball Contracts website (www.mlbcontracts.blogspot.com) and merged with the Baseball Archive data.[5] Information on the start and finish years of every contract signed between 2005 and 2009 was also obtained from the same source, along with whether the contract specified any performance bonuses (such as additional pay for being selected for the annual All-Star Game). Service time data are available for 89% of observations on both pitchers and non-pitchers, however the unmatched observations account for very little game time (they account for only 4% of at-bats among non-pitchers and 5% of innings pitched among pitchers).

The service time data reveal that, on average, non-pitchers who attain a year of service time play at least 110 games (out of 162). Similarly, for pitchers to complete a full year of service requires an average of 60 games for relievers and 30 games for

[4] OPS is preferred to batting average as it takes into account a player's ability to draw walks and score extra-base hits, as well as to hit singles. Nonetheless, the results in the next two sections were very similar when batting average was used to measure non-pitchers' performance.

[5] Cot's Contracts is maintained by Jeff Euston, who updates the service time data each year largely based on information from the Associated Press and local newspapers covering individual clubs. *Sports Illustrated Interactive* described it as "the unofficial clearinghouse for MLB contracts" and "the most reliable public source" on baseball contract data (Donovan 2008).

starters (defined as those who start at least one game during the season). Using this information, a rough estimate of the service time completed by players in the 1950-2009 sample can be constructed. Table A1 presents descriptive statistics for pitchers and non-pitchers, separately for the 1950-1969 and 1981-2009 periods. OPS among non-hitters rose between the two periods, which naturally meant that ERA also rose among pitchers. The average player was slightly more experienced (as measured by estimated service time) in the later period.

Means for the 2005-2009 sample are given in Table A2. Around 40% of non-pitchers and 50% of pitchers are in their first three years in the major leagues and are thus ineligible for salary arbitration. A quarter of both samples are eligible for salary arbitration but not free agents (including those in their last year before free agency), while the remainder are free agents. Table A2 also gives means for the narrower sample of players with 2-4 years of experience that will be used in the next section. This sample is evenly split between those eligible and those ineligible for salary arbitration.

5. Historical approach

To determine whether the advent of salary arbitration and free agency has changed how well players of different experience levels perform, the individual-level data for 1950-2009 are analyzed. As noted in the previous section, multiple changes in baseball labor relations occurred during the 1970s, suggesting that it is not appropriate to analyze the seasons that immediately preceded the change to free agency. As a result, data for the 1970s are excluded and the performance of players between 1950 and 1969 will be compared with players during the 1981-2009 period.

The performance measures are regressed on a set of 15 dummies for major league experience interacted with whether it is before or after the introduction of free agency, along with player dummies and year dummies.[6] Tables 1 and 2 present the estimates on the experience terms, with 0 years of experience being the omitted category. OPS tended to drop off early in a player's career in the 1950s and 1960s, as seen in the first two columns of Table 1. Since 1980, however, it has actually *risen* over a player's first three

[6] The results are almost identical if a set of home ballpark dummies are added to control for the effects of stadia of different dimensions. Gould and Winter (2009) provide evidence that the ability of a player's team-mates may also influence his performance, however that possibility is ignored here.

Table 1

Regressions for On-Base Plus Slugging Before and After the Introduction of Free Agency

Variable	Full sample		Players with at least 10 seasons	
	1950-1969	1981-2009	1950-1969	1981-2009
1 year of experience	-0.000	0.009**	0.035***	0.035***
	(0.005)	(0.003)	(0.010)	(0.007)
2 years of experience	-0.007	0.019***†††	0.042***	0.074***††
	(0.007)	(0.005)	(0.013)	(0.008)
3 years of experience	-0.011	0.013**††	0.058***	0.079***
	(0.009)	(0.006)	(0.016)	(0.010)
4 years of experience	-0.021*	0.010††	0.039**	0.086***††
	(0.011)	(0.007)	(0.019)	(0.011)
5 years of experience	-0.036***	0.003†††	0.036	0.082***†
	(0.013)	(0.008)	(0.023)	(0.013)
6 years of experience	-0.056***	0.000†††	0.027	0.093***††
	(0.015)	(0.009)	(0.027)	(0.015)
7 years of experience	-0.066***	-0.007†††	0.016	0.091***††
	(0.017)	(0.010)	(0.031)	(0.017)
8 years of experience	-0.083***	-0.019†††	0.006	0.085***††
	(0.019)	(0.012)	(0.035)	(0.019)
9 years of experience	-0.096***	-0.032**†††	-0.021	0.076***††
	(0.022)	(0.013)	(0.039)	(0.021)
10 years of experience	-0.126***	-0.034**†††	-0.055	0.073***†††
	(0.024)	(0.014)	(0.043)	(0.023)
11 years of experience	-0.137***	-0.050***†††	-0.063	0.063**††
	(0.027)	(0.016)	(0.048)	(0.025)
12 years of experience	-0.173***	-0.060***†††	-0.098*	0.058**†††
	(0.030)	(0.017)	(0.052)	(0.027)
13 years of experience	-0.143***	-0.074***†	-0.068	0.051*†
	(0.036)	(0.018)	(0.058)	(0.030)
14 or more years of experience	-0.183***	-0.112***†	-0.108*	0.027††
	(0.037)	(0.020)	(0.062)	(0.034)
Adjusted R-squared	0.496		0.548	
Number of observations	16,589		5,664	

Notes: Both regressions also include a full set of year and player dummies.
Standard errors are presented in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. †, †† and ††† denote significance from the pre-1970 coefficient at the 10%, 5% and 1% level, respectively.

years in the major leagues and even then has fallen more slowly than in the earlier period. The difference between the coefficients across the two time periods is significant among players with two or more years of experience. Although not reported, the predicted change in a player's OPS from gaining an additional year of experience was calculated for the pre- and post-free agency periods. Only the change from one to two years of experience was significantly different between the two eras. Figure 3 presents the

Table 2
Regressions for Earned Run Average Before and After the Introduction of Free Agency

Variable	Full sample		Players with at least 10 seasons	
	1950-1969	1981-2009	1950-1969	1981-2009
1 year of experience	0.240***	0.076†	0.145	-0.523***†††
	(0.082)	(0.050)	(0.144)	(0.113)
2 years of experience	0.321***	0.219***	0.037	-0.496***††
	(0.111)	(0.066)	(0.176)	(0.126)
3 years of experience	0.409***	0.300***	0.074	-0.520***††
	(0.139)	(0.081)	(0.211)	(0.143)
4 years of experience	0.502***	0.412***	0.274	-0.606***†††
	(0.168)	(0.097)	(0.251)	(0.162)
5 years of experience	0.528***	0.612***	0.150	-0.617***††
	(0.199)	(0.113)	(0.294)	(0.183)
6 years of experience	0.703***	0.745***	0.462	-0.532***†††
	(0.229)	(0.129)	(0.335)	(0.206)
7 years of experience	0.903***	0.700***	0.668*	-0.597***†††
	(0.262)	(0.146)	(0.381)	(0.232)
8 years of experience	0.879***	0.982***	0.656	-0.460*††
	(0.299)	(0.163)	(0.423)	(0.256)
9 years of experience	0.983***	1.135***	0.830*	-0.322††
	(0.337)	(0.182)	(0.471)	(0.282)
10 years of experience	1.271***	1.307***	1.426***	-0.030††
	(0.375)	(0.200)	(0.517)	(0.310)
11 years of experience	1.048**	1.398***	1.247**	-0.012††
	(0.423)	(0.222)	(0.567)	(0.340)
12 years of experience	1.397***	1.609***	1.668***	0.120††
	(0.459)	(0.244)	(0.619)	(0.369)
13 years of experience	1.243**	1.652***	1.557**	0.112†
	(0.525)	(0.268)	(0.681)	(0.399)
14 or more years of experience	1.997***	2.201***	2.395***	0.531††
	(0.558)	(0.286)	(0.734)	(0.457)
Adjusted R-squared	0.230		0.221	
Number of observations	15,935		3,886	

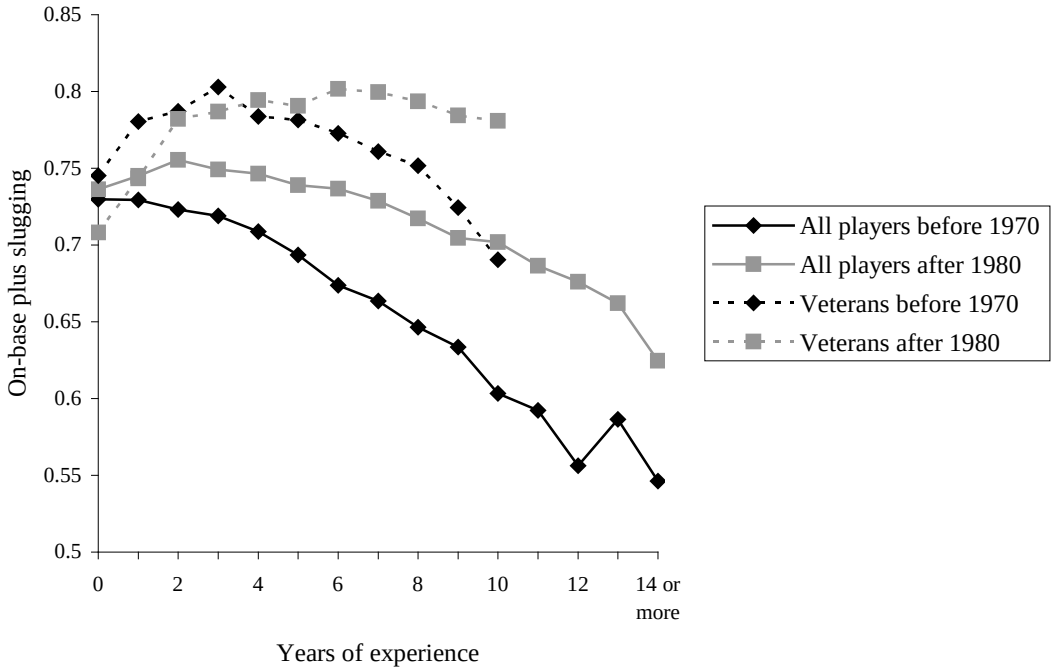
Notes: Both regressions also include a full set of year and player dummies.
Standard errors are presented in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. †, †† and ††† denote significance from the pre-1970 coefficient at the 10%, 5% and 1% level, respectively.

predicted OPS at each experience level for the pre-1970 and post-1980 periods.[7] Although hitters post higher OPS values at every point during their careers in the post-free agency period, the gap widens significantly after two years of experience, as noted above.

Among pitchers, ERA has followed a different pattern. In both the pre- and post-free agency periods, pitchers have tended to decline steadily in performance as they age, as

[7] The predicted OPS is the coefficient on experience plus the average of the year effects for either the pre-1970 or post-1980 period.

Figure 3
Regression-Adjusted Performance Profiles for Non-Pitchers



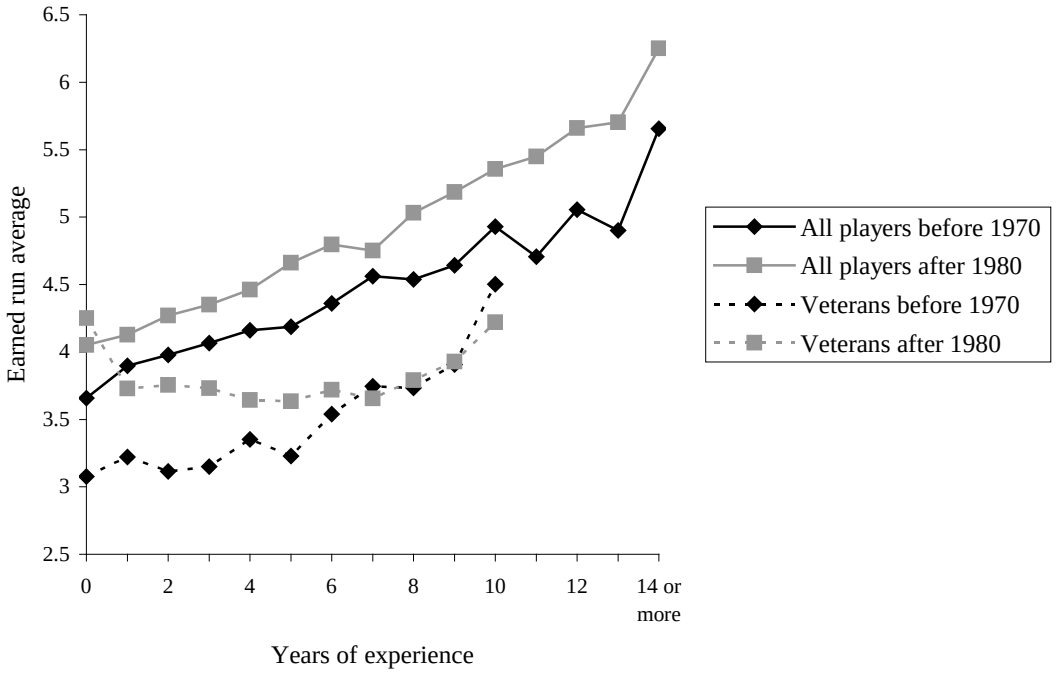
Notes: The data points for "all players" and "veterans" are the predicted performance levels from the regressions in the first two and last two columns of Table 1, respectively.
"Veterans" are players who completed at least 10 seasons during their careers.

seen in the first two columns of Table 2. Furthermore, the gap between the coefficients is significant only for players with one year of experience and Figure 4 shows that although ERAs have been higher for all players since 1980, the rate of increase in ERA over a player's career is very similar in the two periods.

Over time, less successful players are more likely to retire, meaning that the higher experience levels are dominated by more able players. By including player effects, the regressions in the first two columns of Tables 1 and 2 already control for this fact.[8] However, they still force all players to have the same career performance profile, regardless of how long their careers are. The estimated experience coefficients are then interpreted as the change in performance from a player's debut season to a given point in his career, averaged over *all* players who made it to that point. The players who manage

[8] If player effects are excluded, an upward-sloping career performance profile is found for both pitchers and non-pitchers.

Figure 4
Regression-Adjusted Performance Profiles for Pitchers



Notes: The data points for "all players" and "veterans" are the predicted performance levels from the regressions in the first two and last two columns of Table 2, respectively.
"Veterans" are players who completed at least 10 seasons during their careers.

to reach their seventh season and attain free agency eligibility are likely to have performed better over their first six seasons than indicated by Figures 3 and 4, because only the best players survive this long in the major leagues.

To examine the performance profiles of those players, Figures 3 and 4 also plot the predicted performance at each experience level among only players who completed at least 10 seasons in the major leagues. Not surprisingly, these players perform better than their team-mates at most points during their careers. Among veteran non-pitchers, OPS increases sharply during the first four seasons in both time periods, however as with the full sample, it increases much more in the third season in the post-1980 period. On the other hand, while long-serving pitchers experienced steadily declining performances before 1970 (like the full sample of pitchers), since 1980 veteran pitchers have tended to experience falling ERAs in their first two seasons and relatively stable ERAs thereafter.

Taken together, the evidence in this section indicates that in the modern era both

pitchers and non-pitchers enjoy rapid improvements early in their careers followed by a period of remarkably consistent performances. Other than changing career salary profiles generated by the introduction of the free agency system, alternative explanations for why players have aged "more gracefully" in the free agency era exist. Since the 1960s, there has been increased use of relief pitchers, which is likely to benefit older pitchers, by allowing them to pitch fewer innings per game than in the earlier era. Similarly, the introduction of the designated hitter in the American League in 1973 may have aided older non-pitchers. It is possible to control for these factors by introducing controls for the proportion of a pitcher's games in which he started and a dummy for designated hitter. These did not affect the pattern seen in Figures 3 and 4.

Despite these controls, the fact that salary arbitration and free agency were introduced for all players at the same point in time means that the results in this section may be driven by some other (possibly unobservable) factor that altered the performance-experience profile and occurred during the 1970s. For example, advances in medicine or the increased prevalence of steroid use during the 1980s could explain why older players are increasingly able to maintain higher performance levels. Of course, these trends could themselves be driven in part by the higher salaries arising from the introduction of salary arbitration and free agency, however the approach used is unable to determine this. For that reason, the next section will focus on differences in performance over players' careers in the post-free agency period using detailed data on their salaries and contracts.

6. Quasi-experimental approach

As Krautmann (1990) observed, once a player signs a contract, there is no incentive for him to expend extra effort, regardless of his salary, as he is guaranteed an income for the duration of the contract. Unlike the assumptions underlying traditional efficiency wage models, performance in baseball is measurable and publicly observable but teams have no ability to fire players for underperforming after a contract has been signed. However, if a player shirks he reduces his likelihood of signing a lucrative contract in the future. Hence, the *expectation* of future salary increases might spur baseballers to improve their performances.

Of course, future income is likely to be influenced by a player's current performance,

leading to an identification problem. Fortunately, the rules surrounding eligibility for salary arbitration and free agency provide an ideal method of isolating the causal effect of expected salary growth on performance. Since players are only eligible for free agency after they have completed six full years of major league service and since free agency may only be awarded at the end of a season, one player may be a free agent and another not a free agent, even though the former had accrued only one extra day of service time prior to the current season. Similarly, players are eligible for salary arbitration if they have completed more than three but less than six years of service or satisfy the Super Two exception.[9] As seen in Figure 2, these phases of a player's career are associated with vastly different rates of salary growth. However, although a player's performance is likely to be affected by his experience, there is no reason to expect it to jump or fall abruptly as a player becomes eligible for salary arbitration or free agency. Therefore, any sharp change in performance that occurs at the thresholds for salary arbitration or free agency can be attributed to the effects of changes in salary growth.

The approach taken in the previous section used players from the pre-free agency era as a control group for players in the modern era. In contrast, the quasi-experimental approach used below isolates the instantaneous effects that changes in salary growth have on a given player's performance. Although this approach is better placed to isolate the causal influence of the free agency system on players' performances, it is unable to detect any long-run effects that increased salaries may have had on the behavior of players. In other words, while the results reported below may provide evidence that players expend more effort in seasons when they are affected by changing salaries, they do not capture any long-run adjustments that players make to their training regimes or playing styles in anticipation of high future salaries.

Instrumental variables estimation

Tables 3 and 4 present the results of estimating the effects of salary growth on a player's performance, controlling for his experience. The following equation was estimated for player *i* in year *t*:

[9] A difference here is that the existence of the Super Two exception means that teams are effectively prevented from manipulating their players' service times to avoid letting them become eligible for arbitration, as they do not know in advance what the service time threshold will be.

Table 3
Regressions for On-Base Plus Slugging Using Service Time Data

Variable	(1)	(2)	(3)	(4)
Salary growth rate	0.026***	0.011*	0.010*	0.009*
	(0.002)	(0.004)	(0.004)	(0.003)
Career service time	-0.011	-0.015	-0.014	-0.004
	(0.014)	(0.017)	(0.016)	(0.016)
Career service time	-0.061**	-0.079**	-0.089**	-0.120***
squared/100	(0.012)	(0.019)	(0.017)	(0.014)
Last year of contract	–	–	0.012**	0.009*
			(0.003)	(0.003)
Bonuses in contract	–	–	0.010	0.012
			(0.008)	(0.008)
Log salary	–	–	–	-0.012*
				(0.005)
Adjusted R-squared	0.551	0.541	0.542	0.543
Number of observations	1,636	1,636	1,636	1,636

Notes: All regressions include a full set of player and year dummies.
Standard errors are clustered by salary bargaining class and are presented in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.
In columns (2)-(4), the salary growth rate is instrumented for using a set of salary bargaining class dummies and the average salary growth rate of players with an extra year of experience.

$$y_{it} = \alpha_1 \Delta \ln SAL_{i(t+1)} + \alpha_2 SERV_{it} + \alpha_3 SERV_{it}^2 + \mu_i + \gamma_t + \varepsilon_{it}, \quad (1)$$

where y is OPS for non-pitchers and ERA for pitchers, *SERV* is career service time (in years) at the beginning of the season and μ and γ are player and year fixed effects, respectively.[10] $\Delta \ln SAL$ is the change in a player's log real salary (or approximate salary growth rate) from season t to season $t+1$. For players who are not observed in or are missing salary data for $t+1$, $\Delta \ln SAL$ is set equal to zero, equivalent to assuming they would have earned the same salary as in *t*. Players in the middle of multiple-year contracts will know their following year's salary with certainty, however most players will not know this. The full sample of players for whom service time data were available over the 2005-2009 period is used, although the 2009 observations are lost during the construction of the salary growth variable.

Among non-pitchers, the salary growth rate is found to have a positive effect on OPS when Equation (1) is estimated by OLS (as reported in column (1) of Table 3). As noted, however, this specification suffers from an obvious endogeneity problem; to alleviate this problem, an instrumental variables approach is taken. A set of "salary bargaining class"

[10] Again, the results are virtually identical if home ballpark effects are added.

Table 4
Regressions for Earned Run Average Using Service Time Data

Variable	(1)	(2)	(3)	(4)
Salary growth rate	-0.438***	-0.174*	-0.174*	-0.293*
	(0.045)	(0.067)	(0.071)	(0.116)
Career service time	0.496**	0.524**	0.495**	0.529**
	(0.104)	(0.143)	(0.110)	(0.132)
Career service time	0.084	0.364	0.458	0.213
squared/100	(0.486)	(0.302)	(0.343)	(0.647)
Last year of contract	–	–	-0.163**	-0.200**
			(0.033)	(0.043)
Bonuses in contract	–	–	-0.018	-0.018
			(0.193)	(0.187)
Log salary	–	–	–	-0.072
				(0.139)
Adjusted R-squared	0.326	0.315	0.315	0.323
Number of observations	1,769	1,769	1,769	1,769

Notes: All regressions include a full set of player and year dummies.
Standard errors are clustered by salary bargaining class and are presented in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.
In columns (2)-(4), the salary growth rate is instrumented for using a set of salary bargaining class dummies and the average salary growth rate of players with an extra year of experience.

dummies was used as instruments for salary growth, indicating whether a player is eligible for salary arbitration but has less than 5 years of service time, has at least 5 but less than 6 years of service time or has at least 6 years of service time and is therefore eligible for free agency.[11] These are measured at the end of the current season, as new contracts are typically signed after a given season has concluded.[12]

As noted in Section 3, arbitrators take into account the salaries of players with the same amount of experience when settling salary disputes between players and teams, which has the effect of anchoring the salaries of players who are eligible for salary arbitration, even if they do not file for arbitration. Therefore, players may expect to receive salary growth rates that are similar to those recent cohorts of players received at the same stage in their careers. This suggests the construction of an additional instrument: the salary growth rate in the past year among players with one extra year of service time

[11] A separate dummy for being in the last year before free agency is included because salaries of players in their fifth season are close to those of free agents, as seen in Figure 2. Kahn (1993) argues that teams wish to tie such players to long-term contracts at free agency salary levels before they are able to leave the team as free agents.

[12] One concern is that a player does not know for certain what his service time will be at the end of the current season, as injuries or demotions may prevent him from moving up a bargaining class. However, only a tiny number of players fail to move up a class when they require less than a year of service time during a season to do so.

than a given player.

Equation (1) was estimated for non-pitchers using this set of instruments for salary growth. All the instruments are found to have highly significant positive coefficients in the first stage equation, as expected. As reported in column (2) of Table 3, the coefficient on $\Delta \ln SAL$ falls, although it is still significant. Players who become eligible for salary arbitration at the end of a season experience an average salary growth rate of 1.23 compared to just 0.15 for the previous season. The results indicate that these players will experience a 0.012 increase in their OPS as a result of this change. Service time has a negative effect on OPS, which is consistent with the pattern seen in Figure 3.

Holden and Sommers (2005) and Grad (1998) noted that players might increase their effort in the year before filing for free agency in order to sign for another team. Therefore, in column (3) of Table 3, a dummy variable (*LASTYR*) is added for those players who are in the last years of their contracts.[13] A dummy variable (*BONUS*) is also added for those players whose current contracts include any performance bonuses, since such payments might be expected to improve performance. The inclusion of these terms does not affect the coefficient on the salary growth rate. Being in the last year of a contract raises a batter's OPS. This contradicts the findings of Grad and Holden and Sommers, who found no evidence of a "contract year" effect, although those authors looked only at players who actually filed for free agency (meaning that they were both eligible for free agency and did not sign a new contract with their current team). The bonus dummy has a positive coefficient, but it is not significant.

Column (4) of Table 3 adds the player's current log salary as a regressor, to examine whether the relationship between performance and expected pay growth is affected by how much a player is already earning. As mentioned earlier, a player's salary is guaranteed for the duration of his contract, so that salary in a given season can be treated as predetermined from the perspective of a player choosing how much effort to put into his performance. Including log salary as a regressor in Equation (1) reduces the coefficient on salary growth only slightly. Current salary has a negative effect on

[13] Players who are in the last year of their contracts but whose contracts give them the option to unilaterally re-sign for the following season are given zeros for the last year dummy.

performance, suggesting that for a given level of salary growth, those already earning more perform worse.

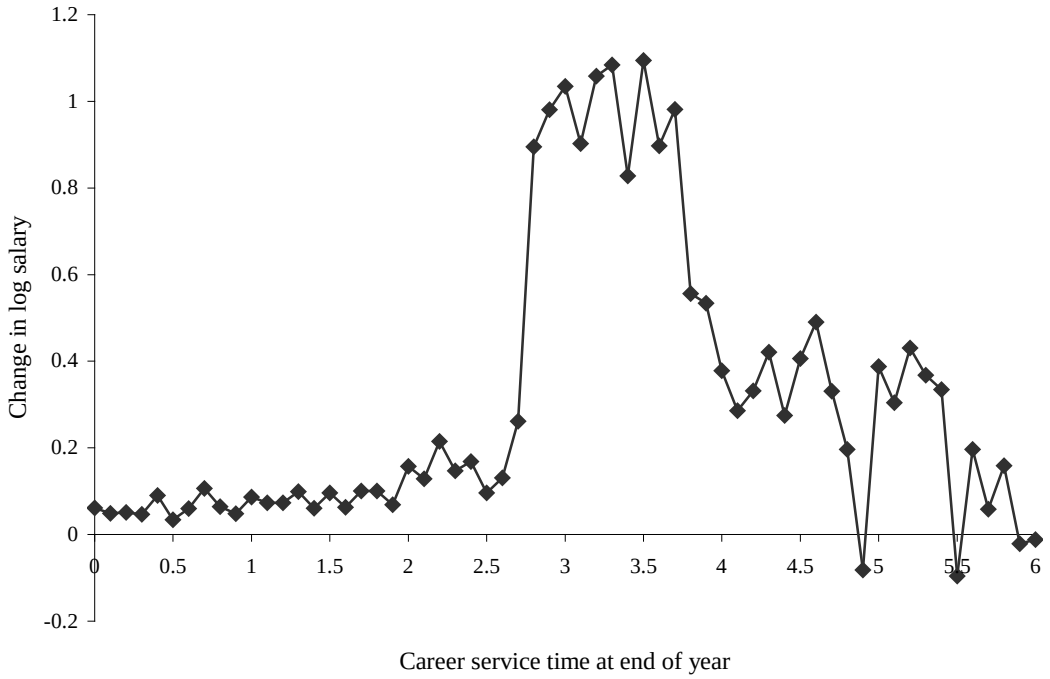
Table 4 reports of the results of estimating Equation (1) for pitchers. Once again, a player's salary growth rate is associated with improved performance – in this case a reduced ERA. The IV results imply that a pitcher who passes the threshold for salary arbitration eligibility at the end of a season will experience a decline in ERA of between 0.147 and 0.275. Being in the last year of a contract also decreases a pitcher's ERA, however bonus payments have no effect on performance.

Regression-discontinuity estimation

The effect of salary growth in the above approach is identified solely by the discontinuities in the relationship between salary growth and experience. Exploiting this fact more explicitly, a tighter test can be obtained by comparing performances between players with experience levels just below and just above the thresholds for eligibility for salary arbitration or free agency. This approach, known as regression-discontinuity analysis, has been taken by other studies that have attempted to identify the causal effect an endogenously-determined variable has on some outcome using discontinuities between the endogenous variable and an "assignment variable" (*e.g*. Angrist and Lavy 1999; Jacob and Lefgren 2004; Hoekstra 2009). Since the largest change in a player's salary occurs at the point he becomes eligible for salary arbitration (and because sample sizes become too small among more experienced players), the sample was restricted to those players with at least 2 but less than 4 years of service time at the end of the season: that is, one year either side of the official salary arbitration threshold. Figure 5 shows the average change in log salary over the next year by a player's years of service time at the end of the season. The dramatic increase in salary growth at 2.8 years of service reflects the fact that most players qualify for the Super Two exception at this point.

Column (1) of Table 5 repeats the specification from column (3) of Table 3 on the restricted sample of non-pitchers, using only the salary arbitration dummy variable to instrument $\Delta \ln SAL$. The salary growth rate is found to have a significant positive effect on OPS, with a coefficient that is almost twice that found in the full sample. The last year and bonus dummies are insignificant, which is not surprising, given that almost all these

Figure 5
Salary Growth by Career Service Time



Notes: Players without salary data for the following season are excluded.

players are signed to one-year contracts with no bonuses. In contrast, no significant effect of salary growth on pitchers' ERA is now found, as seen in column (3) of Table 5.

In the case of a sharp (rather than fuzzy) regression-discontinuity design, everyone with a value above a threshold on some assignment variable receives treatment. This is arguably the case here, since only those who accrue more service time than the Super Two cut-off are eligible for salary arbitration.[14] In this case, it is appropriate to estimate the effect arbitration eligibility has on performance directly. Therefore, the following equation was estimated:

$$y_{it} = \beta_1 SARB_{it} + \beta_2 SERV_{it} + \beta_3 SERV_{it}^2 + \beta_4 LASTYR_{it} + \beta_5 BONUS_{it} + \mu_i + \gamma_t + \varepsilon_{it}, \qquad (2)$$

[14] Furthermore, almost all players receive much larger salaries once they pass the salary arbitration threshold. 77% of non-pitchers and 65% of pitchers at least double their salary the year after they become eligible for salary arbitration, while only 5% of non-pitchers and 8% of pitchers experience falls in salary (and even they may have been anticipating an increase).

Table 5
Regression-Discontinuity Regressions for Players With 2-4 Years of Service time

Variable	OPS among non-pitchers		ERA among pitchers	
	(1)	(2)	(3)	(4)
Salary growth rate	0.022*	–	-0.140	–
	(0.002)		(1.065)	
Salary arbitration eligible	–	0.042**	–	-0.120
		(0.003)		(0.923)
Career service time	-0.226***	-0.231**	0.276	0.355
	(0.001)	(0.012)	(0.559)	(1.212)
Career service time	1.290	0.896**	-6.827	-8.526
squared/100	(0.300)	(0.018)	(41.994)	(55.285)
Last year of contract	0.001	-0.001	-0.638*	-0.667
	(0.002)	(0.001)	(0.075)	(0.313)
Bonuses in contract	-0.005	0.000	0.721	0.668
	(0.025)	(0.020)	(0.568)	(0.965)
Adjusted R-squared	0.609	0.588	0.294	0.305
Number of observations	330	330	362	362

Notes: All regressions include a full set of player and year dummies.
Standard errors are clustered by salary bargaining class and are presented in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.
In columns (1) and (3), the salary growth rate is instrumented for by a dummy for salary arbitration eligibility.

where *SARB* is a dummy indicating whether a player is eligible for salary arbitration at the end of the current season. This specification compares those in their last year before salary arbitration eligibility, who are likely to earn much larger salaries in the following season, with those who still need to play at least one more season before attaining salary arbitration eligibility and consequently expect much lower salary growth in the following year. Hence, *ceteris paribus*, performance is predicted to be higher among the latter group, meaning that $\beta_1 > 0$.

When Equation (2) is estimated on the sample of non-pitchers, a significant positive coefficient on *SARB* is found, as seen in column (2) of Table 5. Those who become eligible for salary arbitration at the end of a season have OPS values that are 0.042 points lower than those in their last year before eligibility. This is around three times larger than the change implied by the IV estimates in Table 3. This approach is crucially dependent on having adequate controls for service time and, although unreported, the coefficients on $\Delta \ln SAL$ or *SARB* are robust to the inclusion of a cubic or quartic in service time (or, conversely, to the exclusion of service time altogether). Column (4) of Table 5 shows that *SARB* has an insignificant effect on ERA among pitchers, reflecting the findings from the

IV approach.

7. Conclusion

This paper examines whether the large pay rises enjoyed by professional baseballers since the introduction of salary arbitration and free agency in the 1970s have resulted in performance improvements. According to certain efficiency wage models, workers who experience pay increases should increase their output to lower the possibility of layoff. Although baseball players are guaranteed employment for a specified number of seasons after they sign a contract, they may not receive another contract (or may receive a less lucrative contract) if they shirk. In this case, the higher a player's expected future salary, the more effort he should expend in the current season. Evidence suggests that since the introduction of free agency both pitchers and non-pitchers have tended to exhibit rapidly improving performances during the early stages of their careers, during which they also typically experience the largest increases in salaries. Data on exact major league service time for players between 2005 and 2009 provide exogenous determinants of players' salary growth rates. Both instrumental variables and regression-discontinuity estimation indicate that, controlling for experience, players perform better when they face rapidly rising salaries. Players also record better performances when they are in the last year of their contracts. The evidence suggests that while the free agency system has increased the costs of signing experienced players, this may have been partly offset by improved performances among younger players and those with expiring contracts.

References

Angrist, Joshua D., and Victor Lavy. 1999. Using Maimonides' Rule to estimate the effect of class size on scholastic achievement. *Quarterly Journal of Economics* 114, no. 2 (1999): 533-575.

Bandiera, Oriana, Iwan Barankay, and Imran Rasul. 2005. Social preferences and the response to incentives: Evidence from personnel data. *Quarterly Journal of Economics* 120, no. 3: 917-962.

Blass, Asher A. 1992. Does the baseball labor market contradict the human capital model of investment? *Review of Economics and Statistics* 74, no. 2: 261-268.

Booth, Alison L., and Jeff Frank. 1999. Earnings productivity and performance-related pay. *Journal of Labor Economics* 17, no. 3: 447-463.

Donovan, John. 2008. Cot's is one-stop shopping for baseball contract info. *SI.Com*, November 28 (http://sportsillustrated.cnn.com/2008/writers/john_donovan/11/25/donovan.cots).

Fuess, Scott M., Jr., and Meghan Millea. 2002. Do employers pay efficiency wages? Evidence from Japan. *Journal of Labor Research* 23, no. 2: 279-292.

Georgiadis, Andreas. 2008. Efficiency wages and the economic effects of the minimum wage: Evidence from a low-wage labor market. CEP Discussion Paper No. 857, Centre for Economic Performance London School of Economics.

Gielen, Anne C., Marcel J.M. Kerkhofs, and Jan C. van Ours. 2010. How performance related pay affects productivity and employment. *Journal of Population Economics* 23, no. 1: 291-301.

Gould, Eric D., and Eyal Winter. 2009. Interactions between workers and the technology of production: Evidence from professional baseball. *Review of Economics and Statistics* 91, no. 1: 188-200.

Grad, Benjamin D. 1998. A test of additional effort expenditure in the "walk year" for major league baseball players. *University Avenue Undergraduate Journal of Economics* 2, no. 1: 1-18.

Haupert, Michael J. 2007. The economic history of major league baseball. In *EH.Net Encyclopedia*, ed. Robert Whaples. (http://eh.net/encyclopedia/article/haupert.mlb).

Hoekstra, Mark. 2009. The effect of attending the flagship state university on earnings: A discontinuity-based approach. *Review of Economics and Statistics* 91, no. 4: 717-724.

Holden, Evan C., and Paul M. Sommers. 2005. The influence of free-agent filing on MLB player performance. *Atlantic Economic Journal* 33: 489-489.

Jacob, Brian A., and Lars Lefgren. 2004. Remedial education and student achievement: A regression-discontinuity analysis. *Review of Economics and Statistics* 86, no. 1: 226-244.

Kahn, Lawrence M. 1993. Free agency long-term contracts and compensation in major league baseball: Estimates from panel data. *Review of Economics and Statistics* 75, no. 1: 157-164.

Krautmann, Anthony C. 1990. Shirking or stochastic productivity in major league baseball? *Southern Economic Journal* 56, no. 4: 961-968.

Lazear, Edward P. 2000. Performance pay and productivity. *American Economic Review* 90, no. 5: 1346-1361.

Levine, David I. 1992. Can wage increases pay for themselves? Tests with a productive function. *Economic Journal* 102, no. 414: 1102-1115.

Moretti, Enrico, and Jeffrey M. Perloff. 2002. Efficiency wages, deferred payments and direct incentives in agriculture. *American Journal of Agricultural Economics* 84, no. 4: 1144-1155.

Nickell, Stephen, and Daphne Nicolitsas. 1997. Wages, restrictive practices and productivity. *Labor Economics* 4, no. 3: 201-221.

Pekkarinen, Tuomas, and Chris Riddell. 2008. Performance pay and earnings: Evidence from personnel records. *Industrial and Labor Relations Review* 61, no. 3: 297-319.

Shearer, Bruce. 2004. Piece rates, fixed wages and incentives: Evidence from a field experiment. *Review of Economic Studies* 71, no. 2: 513-534.

Sommers, Paul M., and Noel Quinton. 1982. Pay and performance in major league baseball: The case of the first family of free agents. *Journal of Human Resources* 17, no. 3: 426-436.

Wadhwani, Sushil B., and Martin Wall. 1991. A direct test of the efficiency wage model using UK micro-data. *Oxford Economic Papers* 43, no. 4: 529-548.

Appendix

Table A1
Descriptive Statistics for the 1950-2009 Sample

Variable	Non-pitchers		Pitchers	
	1950-1969	1981-2009	1950-1969	1981-2009
On base plus slugging	0.709	0.732	–	–
Earned run average	–	–	3.981	4.411
Experience	2.704	3.980	2.461	3.079
0-2 years of experience	0.588	0.462	0.632	0.577
3-5 years of experience	0.242	0.241	0.218	0.210
6 or more years of experience	0.170	0.297	0.151	0.213
Number of observations	4,845	11,744	4,169	11,766

Table A2
Descriptive Statistics for the 2005-2009 Sample

Variable	Non-pitchers		Pitchers	
	Full sample	2-4 year sample	Full sample	2-4 year sample
On base plus slugging	0.753	0.759	–	–
Earned run average	–	–	4.496	4.192
Real salary ($)	3,304,285	725,598	2,265,696	604,099
Salary growth rate	0.169	0.710	0.150	0.528
Not salary arbitration eligible	0.312	0.424	0.444	0.456
Salary arbitration eligible	0.198	0.576	0.190	0.544
Last year before free agency	0.073	0	0.059	0
Free agent	0.417	0	0.307	0
Career service time (in years)	4.827	1.946	3.847	1.657
Last year of contract	0.751	0.882	0.838	0.914
Bonuses in contract	0.226	0.109	0.157	0.099
Number of observations	1,636	330	1,769	362

Note: Salary is in 2009 dollars, adjusted using the Consumer Price Index price deflator.