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Lockouts and Player Productivity: Evidence From the National Hockey League

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Abstract

We implement a propensity score matching technique to present the first evidence on the impact of professional sports lockouts on player productivity. In particular, we utilize a unique natural experiment from the 2012-2013 National Hockey League lockout, during which approximately 200 players decided to play overseas, while the rest stayed in North America. We separate players based on their nationality and investigate the effect of playing abroad on postlockout player performance. We find limited evidence of enhanced productivity among European players and no evidence of a benefit or drawback for North American players. Our study contributes to the understanding of lockouts in professional sports and the general discussion of labor disputes and worker productivity.

Keywords

lockout, professional sports league, player performance, matching, propensity scores

Introduction

Professional sports is a highly publicized field that has witnessed over a dozen incidents of lengthy or failed collective bargaining in the past three decades. Almost all of these labor negotiations resulted in player-organized strikes or owner-initiated

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lockouts that led to the loss of part of or the entire professional sports seasons. Since the Major League Baseball (MLB) strike in 1994, lockouts have become the dominant form of work stoppage in professional sports leagues in the event of unsuccessful collective bargaining. Understandably, there is extensive scholarly interest in and media coverage on these lockouts.[1]

Economists have studied the impact of lockouts in professional sports on local economy and employment (e.g., Coates & Humphreys, 2001), consumer demand (e.g., Schmidt & Berri, 2004), fan substitution (e.g., Winfree & Fort, 2008), on-ice infractions (e.g., Kahane, Longley, & Simmons, 2013), and competitive balance (e.g., Zimbalist, 2000). Intriguingly, there have not been studies that directly explore the impact of lockouts on professional sports player performance despite the abundant amount of player productivity data. Outside the field of sports economics, however, there are numerous studies in industrial relations on the overall topic of labor strife and its impact on productivity and product quality. Researchers have studied various industries and examined the impact of labor unrest on firm-level productivity (e.g., Katz, Kochan, & Gobeille, 1983; Kleiner, Leonard, & Pilarski, 2002), worker productivity (e.g., Chandrasekher, 2013; Mas, 2006), and product quality (e.g., Krueger & Mas, 2004; Mas, 2008). The impact of absenteeism has also been investigated (e.g., Herrmann & Rockoff, 2012). While much of the literature confirms a negative relationship between labor unrest and the economic performance of the employees and firms, there is also mixed empirical evidence, suggesting that labor disputes may not lead to lower effort or poor product quality (e.g., Lee & Rupp, 2007).

While lockouts have grown to represent a record percentage of work stoppages in the United States, lockouts received considerably less overall scholarly attention outside the field of professional sports, compared to strikes or other forms of work stoppage on the subject.[2] With the decline of union representation and increasing empowerment to employers in many industries, it is important to understand the impact of lockouts as an alternative form of work stoppage during labor disputes. Professional sport provides an excellent testing ground for studying the productivity impact of lockouts due to its numerous recent incidents and readily available sources of performance data. In addition, professional athletes have a variety of options to practice their production skills during the lockout. This unique feature allows us to explore how player behaviors during the lockout affect postlockout performance. Our article thus seeks not only to bridge a gap in the sports economics literature but also to provide additional evidence toward the general discussion about labor disputes and productivity.

This article examines the effect of playing abroad during the 2012-2013 National Hockey League (NHL) lockout on postlockout player productivity. Studying the overall causal impact of a lockout on player performance is inherently difficult, if not impossible, because all players are affected by the lockout. Instead, we decide to focus on the differences of productivity outcomes within the group by utilizing different training and conditioning choices players make during a lockout. The 2012-2013 NHL

lockout provides a unique natural experiment because approximately 200 NHL players chose to play in highly competitive professional hockey leagues in Europe to keep up with their athletic conditioning and receive additional compensation, while others decided to stay in North America and either trained on their own or played in less competitive domestic games with nominal compensation.[3] Because the competitive nature of professional hockey games calls for more effort on and off the ice and European hockey leagues are the most competitive alternative outside the NHL, those players who chose to play in Europe during the lockout were presumably less affected by the stoppage of games and thus more likely to keep their athletic conditioning than their peers who chose to stay in North America. Separating players based on their nationality, we implement a propensity score matching technique to explore the implications of such a natural experiment on player performance once the season resumed. We then derive the average treatment effect (ATT) of playing abroad among those who chose to play overseas on five hockey productivity measures. We find limited evidence of enhanced productivity, as measured only by a significantly higher goal-scoring rate, among European players who chose to play abroad, relative to those who did not. Additionally, we find no evidence of a benefit or drawback for North American players.

The findings in this article suggest that playing overseas during the lockout did not systematically improve postlockout player performance. Possible explanations for a lack of improved performance from playing abroad include (1) the lockout may actually motivate *all* players to exert effort to prepare for the new season, regardless of the location and format of preparation; (2) the relatively short duration of the lockout may not allow any significant performance gap to form, especially since a timely resolution was already expected based on past lockout experience in the NHL; (3) European hockey leagues are different from the NHL in terms of intensity, rink sizes, and rules, which may require significant adjustment from players, especially North American ones; (4) players may not exert full effort while playing in Europe due to weak financial incentives and concerns about potential injuries, and they may also have chosen to play in Europe for noncompetitive and nonmonetary reasons. Our data, however, do not allow us to cleanly parse the four proposed explanations.

Our article fits within the overall discussion of work stoppage and worker productivity and contributes to the existing literature in the following ways. Firstly, by identifying the effect of player choices of playing abroad on postlockout productivity, our study is the first article that provides evidence toward the overall discussion of the impact of work stoppage on employee performance in the field of professional sports. A unique feature of our article is that players were able to make choices about whether and how to practice their "production skills" during the work stoppage. While such opportunities for retaining and replacing skills during work stoppages may be limited to certain specialized industries,[4] our results suggest that the choice of training had minimal impact on postlockout productivity. Secondly, economists and statisticians have recently started to utilize matching techniques in the field of sports economics (e.g., De Paola & Scoppa, 2012; Krumer, Rosenboim, & Shapir,

2014), and our article is among the first to employ propensity score matching to study causal inferences in sports industrial relations. Our study is also among the few to use propensity score matching in the overall literature on work stoppage since most of the previous studies utilize event study approaches. Lastly, this article also contributes to the general understanding of the effect of employer-initiated lockouts, an increasingly popular phenomenon across industries, on labor productivity.

The article is organized as follows: Second section provides background information on the 2012-2013 NHL lockout. Third section introduces a simple conceptual framework for our study. Forth section outlines the propensity matching technique employed in the study. Fifth section describes the data used in the study and present results from the design and analysis phases. We then discuss the empirical results in the sixth section followed by concluding remarks in the seventh section.

Background on the 2012-2013 NHL Lockout

Due to disagreements between owners and players on revenue sharing schemes and contract structures, the four professional leagues of major sports in the United States have witnessed more than a dozen strikes and lockouts in the past four decades. A strike happens in a labor dispute when players collectively refuse to play for a number of games, while a lockout is the cancelation of part or all of the professional season initiated by team owners. Since the 1994-1995 MLB strike that resulted in the cancelation of the remainder of the season, work stoppage in professional sports has been predominantly in the form of lockouts because lockouts offer a clear bargaining advantage for the owners by transferring most of the financial burden to the players (Staudohar, 2013).[5] Among the the recent lockouts in North American professional sports leagues, the 2004-2005 NHL lockout was the first to result a cancelled season.

Following the season-ending lockout in 2005, the NHL and its players reached a 7-year agreement, due to expire by the beginning of 2012-2013 season. Despite a strong growth of over 50% in league's revenue and additional TV broadcast deals during the seven seasons following the lockout, the revenue was generated and kept by a few large city teams and almost half of the teams claimed to have incurred a financial loss in the 2011-2012 season. On the other hand, players were not as affected by their teams' worsening financial conditions, thanks to the 57:43 split on the hockey-related revenue between players and owners. Such disparity in economic well-being between players and owners naturally led to strife when the renewal time came for a new collective bargaining agreement. Specifically, owners intended to drastically reduce players' share of the hockey-related revenue, while players were reluctant to budge and instead demanded profit sharing among teams.[6] Owners also hoped to increase the free-agency threshold to age 30 as well as 10 full years of NHL experience.[7] The negotiation started near the end of the 2011-2012 season, but no agreement was made before the old collective bargaining agreement expired on September 15, 2012. The NHL called a lockout for all preseason games

on September 19 and progressively canceled all regular-season games up to January 14, 2013, as the two parties continued to disagree on the make-whole issue (i.e., whether to honor contracts from previous agreement) and the length of contracts. Just as the hope for a new season started to dim, the two parties resumed the negotiations with mediation from the Federal Mediation and Conciliation Service and miraculously narrowed their disagreement within days. On January 6, the two parties reached a tentative new collective bargaining agreement to end the lockout, and a 48-game new season started on January 19, following a rushed week of training camp.

Since the 2012-2013 NHL lockout canceled only part of the season, it provides a unique natural experiment to study the impact of labor strife and work stoppage on player productivity.[8] While waiting for the settlement, approximately 200 players began signing contracts with teams in European leagues. Most players joined the top-tier hockey leagues in Russia (38 players, Kontinental Hockey League), the Czech Republic (28, Czech Extraliga), Switzerland (27, National League A), Finland (27, SM Liiga), Sweden (17, Hockeyallsvenskan), and Slovakia (3, Slovak Extraliga), each of which were ranked by Metter (2012) as among the world's Top 10 professional leagues, second only to the NHL. Additional large subsets of players joined the top league's in Germany (13, Deutsche Eishockey Liga) and Austria (11, Erste Bank Hockey League). Finally, a total of roughly two dozen players found themselves on rosters in either Great Britain, Denmark, Italy, Norway, Poland, or in the lower tier leagues in Germany or Sweden. Among those who did not play in Europe, any player with eligibility for the American Hockey League (AHL) was allowed to train with their NHL team's affiliate. However, detailed information about which players made the choice to play in the AHL was not kept at the time, apart from those players appearing in the AHL's box scores.

The 2012-2013 NHL lockout thus offers a further identification advantage in studying the impact of the lockout on player productivity because there are players who could not only receive compensation but also stay in competitive conditioning by playing in European leagues, while the rest of the players decided to practice on their own or play in less competitive games, earning (virtually) no compensation until NHL play resumed. Such features of the NHL lockout allow us to formulate a simple conceptual framework and test whether playing overseas effects future performance. We would not be able to explore such identification strategy for the National Basketball Association or National Football League lockouts because those lockouts did not cause large outflows of players to temporarily play in other comparable professional leagues.

Conceptual Framework

We present a simple conceptual framework and provide testable hypotheses in this section. Much of the literature on production functions in professional sports focuses on team performance, and researchers have adopted linear specification

(Scully, 1974), log-linear functional form (Gustafson, Hadley, & Ruggiero, 1999), constant elasticity of substitution function (Bairam, Howells, & Turner, 1990), and stochastic production frontier model (Kahane, 2005). Our study focuses on the performance outcomes of individual players rather than teams. We argue that a player's morale and effort are likely to be affected during a lockout because of the financial loss as well as the uncertainty about the future. Thus, we incorporate effort as a key input in the player's production function and explore its role in a player's preparedness when the season resumed. Since players were, in principle, not paid by the NHL or their respective teams during the lockout,[9] a player's effort may be driven by additional financial compensation that he found elsewhere as well as his expectation about the length of the lockout. Similar to Lee and Rupp (2007), we then model a player's effort following the partial gift model by Akerlof (1982). We treat the effort level E as a function of the wage offer (during the lockout) w and the player's view about the survival probability of the lockout h, which further depends on how long the lockout has lasted τ:[10]

$$E = E\Big(w, h(\tau)\Big), \tag{1}$$

where

$$\frac{\partial E}{\partial w} > 0, \quad \frac{\partial E}{\partial h} < 0, \quad h'(\tau) > 0.$$

This setup implies that effort is increasing in wage and decreasing in the player's perception of the survival probability of the lockout. We hypothesize that if the European clubs can offer significant compensations, players who played overseas would exert more effort during the lockout than those who trained domestically.[11] As the lockout progressed, our model also suggests that players who were practicing on their own or playing for limited compensation during the lockout would perceive the end of lockout to be less likely. The erosion of trust, uncertainty about professional development and financial stress, may depress these players and cause them to exert less effort over time, which also implies the costly nature of effort in our setting.

It is worth noting that while our simple theoretical framework suggests that effort fades away as the lockout continues, the general prediction on how the lockout duration affects a player's effort may be ambiguous. Besides the possibility outlined in our model, there can exist a hunger effect as the lockout progressed, that is, as players started to worry about their career or even making a living, they would actually be motivated to put in more effort. Moreover, the ambiguous relationship between lockout duration and its survival probability can also affect the prediction on effort. For instance, it is possible that if the players can learn from past lockout incidents, then they would expect the end of lockout to be likely as the lockout progressed, that is, $h'(\tau) < 0$, although there can exist a tipping point, after which a resumed season would not be practical. Alternatively, one may simply assume that,

as in a typical hazard model, the lockout would eventually fade away. However, given the precedent of the 2004-2005 NHL lockout which cost the entire season and the high financial stake involved, we believe that it is still reasonable to posit a positive relationship between the lockout duration and its survival probability as suggested in our model. Admittedly, such an assumption may need to be revised if the work stoppage was initiated by the players such as in the case of a strike.

Since the employer monopsony power in sports has exhibited similar effect as found in other occupations such as public school teachers (Kahn, 2000), we adopt an individual player production function following the literature on labor strife and the performance of public school teachers (e.g., Todd & Wolpin, 2007 and Turner, 2013):

$$Y_i = Y(E_i, \xi_i, \boldsymbol{X}_i), \tag{2}$$

where, at any given time, Y_i is a performance measure for player i, E_i is the effort level as defined in Equation 1, ξ_i is a player's endowed talent, and $\boldsymbol{X}_i$ is a set of individual inputs that contributes to productivity, including age, position, number of competitive games played, and so on. Detailed descriptions of Y_i and $\boldsymbol{X}_i$ in the context of our data are provided in the fifth section. Because we posit that effort, morale, and experience (number of competitive games played) are positively linked to player performance in our model, we hypothesize a productivity gap between players who played overseas and players who stayed in North America during the lockout due to the financial incentives from playing in European leagues as well as additional number of competitive games played.[12] Our framework also implies that such productivity gap may widen as lockout progressed due to diverging effort levels.

Since both E_i and ξ_i in our conceptual framework are unobservable to researchers and they may correlate with $\boldsymbol{X}_i$, estimating the model using regression-based empirical strategies can lead to biased results. In the next section, we outline a matching strategy that will overcome such an identification issue.

Matching Technique

A simple comparison of players who chose to play overseas versus those who did not is problematic because those who played abroad were, by and large, more talented. One option to account for differences in player talent and other prelockout characteristics is regression adjustment or some modification thereof (i.e., a difference-in-differences design). However, these methods can be problematic when the distributions of covariates used in the regression model—say, a player's goals or assist totals in the 2011-2012 season—are not equal between each of the treatment cohorts (Cochran & Rubin, 1973; Rubin, 2001). Additional weaknesses of multivariate regression adjustment include a sensitivity to covariate choice and model specification, which, relative to matched designs, can often perform poorly (Dehejia & Wahba, 1998; Stuart, 2010).

In place of standard regression adjustment, we present a matched method using propensity scores. We adopt the notation of the Rubin Causal Model (RCM), initially described by Splawa-Neyman, Dabrowska, and Speed (1923/1990) for randomized experiments and adopted for observational data by Holland (1986). Let Y_i be a player-specific performance measure for player i, $i = 1, ..., n$, where n is the total number of players and Y_i is measured after the lockout. Let T_i be our treatment variable, $T_i = \{0, 1\}$, indicating whether or not player i played overseas during the latter months of 2012, and let $\boldsymbol{X}_i$ be a set of covariates that are associated with Y_i and T_i. The variables in $\boldsymbol{X}_i$ are "pretreatment" variables; that is, they are measured before a player made the choice to play overseas.

It is a common practice within the RCM to make the stable unit treatment value assumption (SUTVA). SUTVA states that both the treatment assignment of one subject does not impact the set of potential outcomes for other subjects and also that there are not multiple versions of each treatment. Under SUTVA, the potential outcome for i can be written as $Y_i(T_i = t) = Y_i(t)$, which is the outcome we would have observed had i received treatment t.

Our estimand of interest is the effect of playing overseas among the players who chose to play overseas, referred to the ATT on the treated, where

$$\text{ATT} = E[Y(T = 1) - Y(T = 0)|T = 1]. \tag{3}$$

The ATT is commonly estimated by averaging the difference in potential outcomes among the population who chose to play abroad, $\frac{1}{n_t}\sum_{i=1}^{n}((Y_i(1) - Y_i(0)) \times I(T_i = 1))$, where $I(T_i = 1)$ is an indicator variable for whether or not player i played overseas and n_t is the number of players who chose to play overseas. Because only $Y_i(0)$ or $Y_i(1)$ is observed for each player, ATT must be estimated from the data by imputing the missing potential outcomes. This issue is referred to as the fundamental problem of causal inference (Holland, 1986).

To approximate the unobservable potential outcome, the RCM requires the assumption of strong unconfoundedness, which states that (i) $Pr(\{Y(0), Y(1)\}|T, \boldsymbol{X}) = Pr(\{Y(0), Y(1)\}|\boldsymbol{X})$ and (ii) $0 < Pr(T = t|\boldsymbol{X})$for $t \in \{0, 1\}$ (Rosenbaum & Rubin, 1983). Under strong unconfoundedness, treatment assignment and the set of potential outcomes are independent given $\boldsymbol{X}$, and as a result, the contrast of outcomes with the same $\boldsymbol{X}$ provides an unbiased estimate of the treatment's causal effect to units with that $\boldsymbol{X}$.

For a multidimensional $\boldsymbol{X}$, individual matching is difficult and often infeasible. Instead, matched methods using propensity scores are popular for estimating the ATT and related treatment effects (Rosenbaum & Rubin, 1983). The propensity score is defined as $r(t, \boldsymbol{X}) = Pr(T = 1|\boldsymbol{X})$. Under strong unconfoundedness, if two individuals have the same $r(t, \boldsymbol{X})$ but different treatment assignments, the difference in their outcomes provides an unbiased unit-level estimate of the treatment's causal

effect. For a further description of propensity scores with a dichotomous treatment assignment, see Stuart (2010).

Before we look at the data, it is important to point out the unclear validity of SUTVA in our example. For North American players, the possibility of language barriers, difficulty of identifying living arrangements, and a less traditional style of play are all the factors of playing overseas that, in all likelihood, made playing abroad easier for European players. It is perhaps too strong of an assumption to believe that North American players and European players received the same experience when overseas. Moreover, empirical evidence has shown that European players earn relatively favorable wages in the NHL, and that they were more likely to have played abroad during the lockout, implying that there are additional distinctions between the two cohorts (von Allmen, Leeds, & Malakorn, 2015). In light of the difficulty in making the constant treatment assumption, we make the a priori decision to estimate causal effects separately for each subgroup: one treatment effect for North American players (ATT_{NA}) and another for European players (ATT_{E}).

Data and Empirical Results

To ensure a large enough sample of games in each season on which to compare players, we only considered the players who participated in at least half of the season's games in each of the 2011-2012 and the shortened 2012-2013 seasons. Such restriction also helps minimize the potential impact of injuries on players' behaviors during the lockout. We eliminated the 16 goalies from the NHL who played abroad; goalie performance has been shown to be inconsistent over time (Berri & Brook, 2010), and so we focus on skaters for whom there is a larger sample size. This yielded a sample size of 529 NHL forwards and defensemen, 404 of which were from either the United States or Canada (72%). The remaining group of 125 skaters, for simplicity, will be referred to as the Europeans; these players are primarily from Sweden (36 players, 7%) and the Czech Republic (31, 6%), with others also from Austria, Belarus, Finland, France, Germany, Kazakhstan, Latvia, Lithuania, Norway, Russia, Switzerland, Slovakia, Slovenia, and the Ukriane. Player nationalities were extracted from QuantHockey.com (http://www.quanthockey.com).

A player's participation in overseas competition was cross checked using a list published on The Sports Network's website (http://www.tsn.ca). A much larger percentage of European players (63%) chose to play overseas, relative to North American ones (17%), perhaps speaking to the perceived advantages that players from Europe would have upon returning to play near their hometowns.

Design Phase

A matched analysis should be separated into two phases: the design phase, which is done without the outcome in sight, and the analysis phase (Rubin, 2001). The goal of

Table 1. Covariates.

Variable	Description
Shot%	Shot percentage, 2011-2012 season
Defense	{1 for defensemen, 0 for forwards}
Goals/60	Goals per 60 min, 2011-2012 season
Assists/60	Assists per 60 min, 2011-2012 season
Games	Games played, 2011-2012 season
Hits	Hits, 2011-2012 season
Hits taken	Hits taken, 2011-2012 season
Penalties	Penalties, 2011-2012 season
Penalties taken	Hits taken, 2011-2012 season
Time on ice	Time on ice per game, 2011-2012 season
Salary	Salary, 2011-2012 season
Age	Age, in years
Age squared	Age^2

the design phase is to reduce the bias in the covariates' distributions between those who received the treatment and those who did not. In essence, we attempt to replicate the balance from a completely randomized design, under which those treated and untreated are similar in expectation with respect to observed covariates. While a randomized design also provides the benefit that unobserved covariates are similar in expectation, like with many other examples, the randomization of players to participate in overseas competition during the lockout would have been infeasible and unethical.

Choice of $\boldsymbol{X}$ should be driven to satisfy the assumption of strong unconfoundedness, and Stuart (2010) recommends including any pretreatment variable known to be associated with both treatment assignment and the outcome. Factors that may influence a player's choice to play abroad and his subsequent performance include his overall performance level prior to the lockout, salary, age, and position. Given our desire to estimate treatment effects separately for North American and European players, covariate matrices are distinct for each cohort.

We identified 13 variables for our propensity score model, drawn from familiarity with the sport of hockey and literature written around the time of the lockout.[13] These variables are listed in Table 1, along with a brief description. The first 10 variables (*Shot%*, ..., *Time on ice*) represent player statistics from the 2011-2012 season and were each extracted from war-on-ice.com (http://www.war-on-ice.com), a professional hockey analytics source. *Shot%* is defined as the percentage of on-ice shot attempts (on goal or missed) taken by a players team when that player was on the ice. Among hockey analytics followers, this variable is known as a player's Corsi percentage. Empirical evidence has found that *Shot%* is preferred for predicting a players' future success over statistics such as goals, assists, and plus/minus rating because the latter metrics are more variable (Macdonald, 2012; Schuckers, Lock, Wells, Knickerbocker, & Lock, 2011). Moreover, possession measures such as

relative *Shot* % are more informative for evaluating the performance of defensive players, whose primary roles on the ice may not come on offense. Remaining variables drawn from war-on-ice.com help account for a players position (defense or forward), offensive production, and proxies for aggressiveness, such as hits and penalties.

The 11th variable in Table 1, *Salary*, represents the player's yearly salary for the 2011-2012 season and was extracted using data from CapGeek.com (http://www.capgeek.com). To address the concern that a player's contract status at the time of the lockout may affect his behaviors and incentives during the lockout, we cross checked each player's contract information and free agent signing history during the 2012 offseason using data from war-on-ice.com. All but one player in our matched sample had a contract for the 2012-2013 season in place before the lockout started, which implies that contract status may not play a role in players' decisions during the lockout.[14] Finally, we include each player's age as of February 1 of the 2011-2012 season, *Age*, taken from Hockey-Reference.com (http://www.hockey-reference.com), and we add a squared term for age to account for a possible quadratic trend between *Age* and the probability of playing overseas.

After estimating propensity scores using separate multivariate logistic regression models for each of the the North American and European players, we match subjects based on their estimated propensity score, $\hat{r}(t, \boldsymbol{X})$, by using the Matching package in *R* statistical software (Version 3.2.3) (Sekhon, 2011). Matching with propensity scores can be done with or without replacement. The latter strategy, which is generally recommended for creating more similar groups of subjects (Abadie & Imbens, 2006), allows for players who played abroad to be matched to the same player who did not play abroad. We match with replacement using a caliper of $\epsilon = 0.10$, which ensures that the propensity scores of each subject in a matched pair are within $\pm\epsilon$ of one another. Relatedly, players with relatively distinct propensity scores cannot be matched to one another when matching with a caliper. Finally, because our outcome variables include offensive output measured after the lockout, we use exact matching by position, which ensures that defensemen are only matched to defensemen and forwards are only matched to forwards.

The success of a propensity score model is judged not by the significance or insignificance of each covariate, but rather in the similarity, with respect to their pretreatment characteristics, of the subjects who are matched to one another. In our example, we look for the similarity of players with respect to their characteristics in the season before the lockout. If covariate imbalances remain after matching, one solution is to refit the propensity score model with inclusion of additional covariates, including interaction or quadratic terms.

The matching procedure yielded 65 pairs of North American and 55 pairs of European players. Table 2 shows four examples of matched pairs, along with a subset of variables from Table 1 and their estimated propensity scores. Within each pair of players shown, the $\hat{r}(t, \boldsymbol{X})$'s are within 0.04 of one another, and the players are relatively similar on most of the variables shown. As one example, European forwards Henrik Zetterberg and Daniel Sedin are matched to one another. The two

Table 2. Example of Players Matched and Selected Covariates.

Ethnicity	Position	Player	Abroad?	$\hat{r}(t, X)$	Goals/ 60[a]	Assists/ 60[a]	Shot%[a]	Salary[a]	Age
European	Forward	H. Zetterberg	Yes	.70	1.32	1.63	66.9	6.1	31
		D. Sedin	No	.70	0.81	1.74	60.0	6.1	31
European	Forward	M. Kruger	Yes	.60	0.04	0.60	44.7	3.5	24
		N. Hjalmarsson	No	.56	0.06	0.49	41.3	4.0	29
NA	Forward	M. Duchene	Yes	.33	0.90	0.90	54.6	3.2	21
		N. Gerbe	No	.32	0.41	1.29	49.9	1.5	24
NA	Forward	M. Pacioretty	Yes	.40	1.35	1.01	59.2	1.6	23
		C. Wilson	No	.40	0.82	1.10	59.7	1.7	22

Note. Salary taken in millions of dollars.
[a]For the 2011-2012 season.

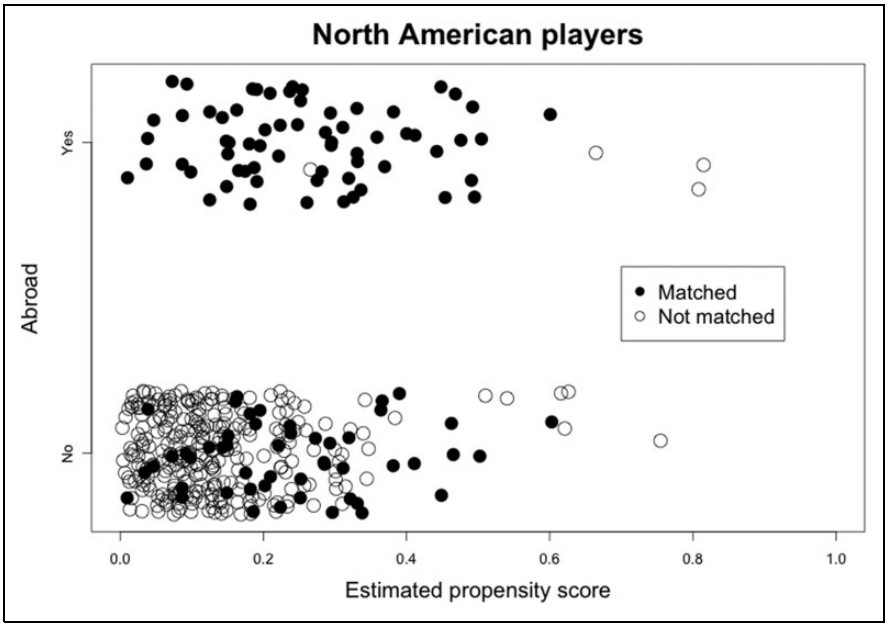

Figure 1. Distribution of estimated propensity scores, North American players.

players show similar *Age* and *Salary* variables, with Zetterberg posting a higher goal total, lower assist total, and a better *Shot%*. Similar conclusions can be made within the other sets.

Figures 1 and 2 depict the distributions of $\hat{r}(t, \boldsymbol{X})$ for the North American and European players, respectively. Each of the darkened circles in Figures 1 and 2 refer to a player that was matched to someone with the other treatment and represent the

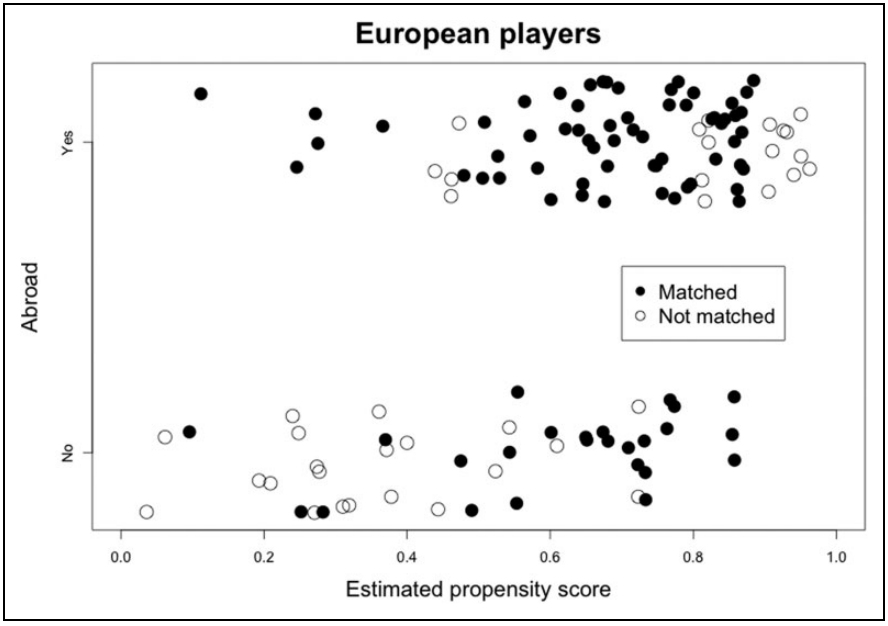

Figure 2. Distribution of estimated propensity scores, European players.

cohort of players that we can generalize to. Subjects not matched are depicted by open circles.

In general, within each of the North American (Figure 1) and European (Figure 2) player cohorts, the distributions of propensity scores among those matched appears roughly similar, as judged by the shape, center, and spread of the darkened circles in Figures 1 and 2. The $\hat{r}(t, \boldsymbol{X})$'s for North American players, on average, are much lower than European players, and there is a large group of North American players with a very low estimated probability (<15%) of playing overseas. All but four players in the North American cohort that went overseas were matched to a player who did not play overseas; the four subjects not matched did not have a corresponding player at the same position with a similar $\hat{r}(t, \boldsymbol{X})$.

For European players, most $\hat{r}(t, \boldsymbol{X})$'s were between 0.40 and 0.95. There were a handful of players who played overseas with too large of an estimated probability of playing abroad, such that there was no corresponding player to be matched to among the Europeans who chose not play overseas. Including subjects with extreme propensity scores requires extrapolation, and it is often recommended that subjects in this group be discarded (Dehejia & Wahba, 1998). As a result, these players were not included in our analysis phase.

Table 3 provides descriptive statistics of the covariates in our study. Overall, for both the European and North American cohorts, players matched showed better performance metrics during the 2011-2012 season than unmatched players. In

Table 3. Means (Standard Deviations) of Players Matched and Not Matched.

	North American		European	
Variable	Not Matched	Matched	Not Matched	Matched
Age	27.5 (4.1)	25.2 (3.5)	27.7 (5.9)	27.3 (4.7)
Shot%	49.3 (6.5)	50.9 (5.6)	52.4 (5.3)	52.0 (6.1)
Salary[a]	2.4 (1.8)	2.2 (1.8)	2.7 (1.7)	3.3 (2.1)
Goals/60	0.49 (0.39)	0.64 (0.38)	0.45 (0.35)	0.63 (0.42)
Assists/60	0.82 (0.46)	0.94 (0.43)	0.94 (0.43)	1.09 (0.48)
Games	64.1 (18.1)	69.4 (14.7)	65.0 (15.3)	70.8 (13.5)
Hits	91.5 (60.9)	84.3 (54.5)	78.4 (55.1)	68.4 (48.0)
Hits taken	83.2 (39.3)	88.5 (34.6)	84.0 (33.0)	93.2 (42.8)
Penalties	16.2 (10.0)	14.2 (7.4)	13.8 (7.1)	13.9 (7.2)
Penalties taken	13.7 (9.3)	16.4 (9.4)	11.4 (6.7)	13.0 (7.2)
Time on ice[b]	1,094 (494)	1,158 (408)	1,172 (380)	1,313 (362)
Defense (%)	37.5	24.1	48.0	34.2
n	288	116	45	80

[a]In millions of U.S. dollars. [b]Total minutes.

addition, the summary statistics point out a potential selection issue—European players who play in the NHL have different performance profiles compared to North American ones, including higher salaries and *Shot%*.

The magnitudes of differences in the covariates' distributions between treatment groups are commonly assessed using standardized bias (Austin, 2009). Let $\bar{x}_{p1}$ and $\bar{x}_{p2}$ be the sample means of covariate p among subjects receiving the treatment and control, respectively, and let σ_{p1} be the standard deviation of covariate p in the treatment group. The standardized bias of covariate p, SB_p, is calculated as

$$\mathrm{SB}_p = \frac{\bar{x}_{p1} - \bar{x}_{p2}}{\sigma_{p1}}. \quad (4)$$

Rubin (2001) recommends that defensible causal statements can be made only if the standardized bias between the treatment and control groups are less than 0.25 for each covariate.

We calculated the standardized bias between players who played overseas and those who did not both before and after the matching. Figures 3 and 4 show "Love" plots of the pre- and postmatched absolute standardized biases for both the North American and European cohorts, respectively (Ahmed et al., 2006).

Of the 13 standardized biases in each of the unmatched groups of players, 8 are greater than 0.25 for each of the North American (in descending order, *Age*^{2}, *Age*, *Goals/60*, *Assists/60*, *Shot%*, *Penalties*, *Defense*, and *Games*) and European (*Games*, *Hits*, *Age*^{2}, *Penalties*, *Hits taken*, *Time on ice*, *Age*, and *Penalties taken*) cohorts. After matching, the standardized bias for each variable is less than 0.25 in both groups; and for most variables, the standardized bias is less than 0.10 among

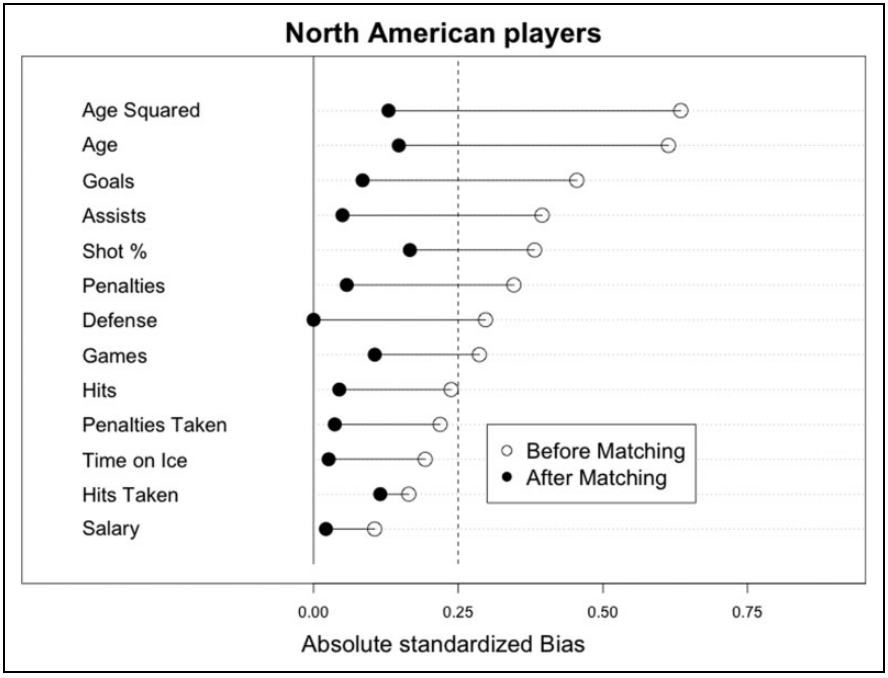

Figure 3. Absolute standardized biases, North American players.

matched subjects. Given the reductions in bias after matching, it appears reasonable to consider the covariates' distributions balanced between the different treatment groups within the matched cohort.

Figures 1–4 also highlight the potential weaknesses of relying on regression-based strategies, such as multiple linear regression or a difference-in-differences design. More than half of the covariates' bias in the full sets of each of the North American and European players are greater than 0.25, which is problematic because differences in the distributions of $\boldsymbol{X}$ between treatment groups can lead to biased regression-based estimates when the regression model is misspecified (Cochran & Rubin, 1973; Rubin, 2001). Further, there is a large subset of North American players with near-zero probabilities of playing abroad; attempting to identify the effect of playing abroad on players who may not have actually been able to play abroad, as would be done using a regression approach, requires extrapolation and making unjustifiable assumptions.

Analysis Phase

We chose five measures to judge a player's performance and conditioning after the lockout; his goals per 60 min, assists per 60 min, *Shot*% (Corsi percentage), time on

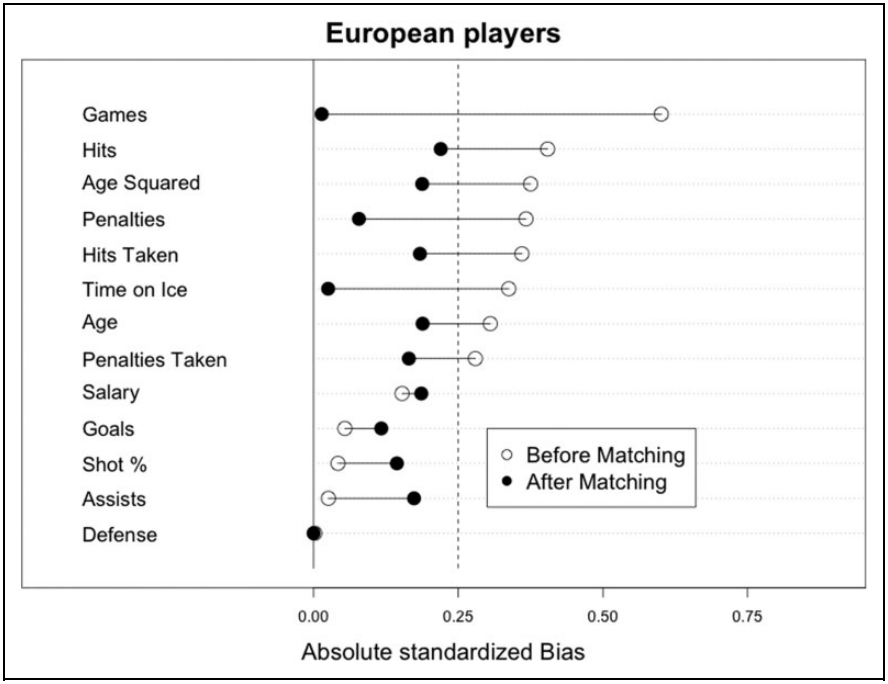

Figure 4. Absolute standardized biases, European players.

ice, and hits. These outcomes were contrasted in both the short run (1 month since the season resumed) and the long run (the entire resumed season), as one may expect a performance gap to be short lived.

Under unconfoundedness, differences in outcomes within the matched cohort provide unbiased estimates of the effect of playing overseas. We used Abadie–Imbens standard errors for each treatment effect, which helps account for the uncertainty in the matching procedure (Abadie & Imbens, 2006).[15] Table 4 shows the estimated treatment effects (and standard errors) for our five outcome variables.

Our results indicate no more than a limited support for enhanced productivity as a result of playing overseas during the lockout. The only statistically significant finding is that for European players, those who chose to play overseas during the lockout had significantly more goals per 60 min (p value < .01) during the shortened 2012-2013 season than those who did not.

We do not observe a similar significant productivity gain (in terms of goals per 60 min) among European players in the short run. For all the other outcome variables, there is no evidence of a significant positive or negative treatment effect of playing overseas on player outcomes regardless of the time frame or ethnicity. Among North American players, 9 of the 10 estimated ATT_{NA}'s were negative. In the next section,

Table 4. Estimated ATT of Playing Abroad.

	North Americans (ATT_{NA})		Europeans ATT_E	
Variable	1 Month	Full Season	1 Month	Full Season
Goals/60	−0.02 (0.07)	−0.03 (0.06)	0.08 (0.07)	0.16 (0.06)***
Assists/60	−0.03 (0.12)	0.02 (0.09)	−0.15 (0.12)	0.01 (0.94)
Shot%	−0.05 (1.39)	−0.45 (1.12)	−1.62 (1.79)	−1.79 (1.60)
Time on ice	−13.48 (12.31)	−6.14 (36.1)	−2.74 (17.21)	−14.05 (45.02)
Hits	−0.05 (0.95)	−2.66 (6.11)	−2.23 (2.17)	1.65 (6.32)

Note. Standard errors are in parentheses. ATT = average treatment effect.
*$p < .10$. **$p < .05$. ***$p < .01$.

we will offer several possible explanations for our findings and discuss their implications.

Discussion

Our results offer little evidence that playing overseas during the 2012-13 NHL lockout offered a competitive advantage, suggesting that it is unlikely that player choices during the work stoppage systematically affected their on-ice performance.[16] We take into account the unique aspects of the 2012-13 NHL lockout and propose the following four possible explanations that are in line with our conceptual framework which focuses on the impact of effort and experience on player productivity, though our data do not allow us to cleanly parse these four proposed explanations.

First, much of the previous literature on labor strife and productivity considers strikes instead of lockouts. Because strikes are initiated by workers while lockouts are imposed by employers, workers are more unprepared and have less control over the situation under lockouts, whereas if the workers are able to strike, then they may also intentionally shirk to exert more pressure toward the employers. And in the case of NHL, since the lockout was imposed before the season started, players also carried more of the financial burden—the lockout resulted in a significant financial loss to the players since an NHL player's annual salary is often on a million-dollar scale. The temporary but hefty financial loss together with the feeling of lack of control over the negotiation may actually motivate *all* players to exert more effort into their extended off-season, regardless of whether they chose to engage in training domestically or playing competitively overseas, though effort may be more costly for those who stayed in North America.[17] Our results also echo recent labor conflict studies on industries where employees collect large labor market rents. For example, Lee and Rupp (2007) find limited support for reduced effort and productivity among commercial airline pilots following pay cuts.[18]

Secondly, the lockout lasted only 3 months, which may not be enough time for sizable productivity differences to form.[19] Moreover, given the financial loss of the cancelled 2004-2005 season, there was also a wide expectation that the 2012-2013 lockout would resolve in a timely manner (Staudohar, 2013). Such expectation and hope could alleviate some of the players' uncertainty, allowing them to focus on improving their competitive strength. Because players expected that the season could resume at any given moment, those who chose not to play overseas could exert as much effort in their training as those who played overseas to be ready for in-game competition.

Furthermore, the advantage of playing more competitive games in European leagues may be offset by the high transaction costs and heterogeneity in competitiveness. Besides new teammates, coaches and fans, there are other nontrivial differences between European games and NHL games that require significant and costly adjustments from the players. For instance, European games follow a different rink size,[20] rules (Olympic hockey rules), and playing styles. The fact that we find limited productivity gains for European players but no impact for North American provides further evidence to this argument since it is presumably easier for European players to adjust to European leagues due to their background and experience. Long-distance travel between North America and Europe can also negatively affect athletic conditions, especially when the new season resumed on short notice. Despite being the most competitive option outside the NHL, few European leagues can match the NHL in terms of competitiveness and talents, and there is strong heterogeneity in competitiveness among the European leagues.

Lastly, those who played overseas may not perceive European leagues as their long-term destinations and thus may not exert full effort during their stay in Europe. Such hesitation could be due to the relatively weak financial offers from European clubs[21] and a fear of injuries that may affect their NHL career.[22] Because most of the players who played overseas during the lockouts are European players, it is possible that some of them may also have chosen to play in Europe for noncompetitive reasons, just as most American and Canadian players chose to remain near home.

Our one significant finding is that of a scoring benefit among European players who played abroad (estimated $ATT_E = 0.16$). In our cohort, this difference represents between two and three more goals per season among the Europeans that chose to play abroad. This effect does not appear to be driven by outliers; within the matched cohort of European players, 62% of those who played abroad yielded higher *Goals/60* than the player that they were matched too, and the median difference in *Goals/60* was 0.14.

As for the practical significance of our *Goals/60* result for European players, we also looked for an association between the number of Europeans who played abroad and team scoring during the postlockout season. The Chicago Blackhawks, Detroit Red Wings, and Arizona Coyotes ranked highest with seven European players abroad, among our subset of players who were matched. While Chicago finished

second in the league in scoring (of 30 teams), Detroit and Phoenix finished 21st and 19th, respectively. Meanwhile, Pittsburgh led the league in scoring while playing only a single European who played abroad. All together, the link between a team's number of Europeans who played abroad and their performance in the postlockout season appears weak.

A significant result among European players was not identified when looking at only the first month of the season. Such a result may be due to the season resuming on short notice, which could have resulted in a high transition cost for those who played in Europe since they would need to almost immediately report to the team and adjust to the new season in North America.

One final robustness check was made to account for the differences in competitiveness across the European professional leagues. The analysis above treats all players who played abroad equally, which assumes that joining lower tiered leagues, including those in England, Germany, and Italy, would have yielded the same benefits as joining the elite leagues. Such an assumption could make it difficult to discern a positive effect of playing in one of the elite leagues, particularly if playing in a lower tier league was detrimental to one's career.

Among the European players included in our matched analysis who played abroad, all but 3 (of 55) were members of the top leagues in either the Czech Republic, Finland, Russia, Slovakia, Sweden, and Switzerland, generally considered to be the six best ice-hockey leagues, where players participated during the lockout (Metter, 2012). Among the North American players, however, 23 of the 65 (35%) joined a league besides those six. Repeating our analysis within the subset of the 42 players in the top-six leagues, none of our five ATT_{NA} estimates were significant (p value > .05). Further, as in Table 4, estimates of offensive output for goal, assist, and shot rates were negative within this subset of players. Given this and the above aggregated evidence, it is difficult to argue that there was any benefit for North Americans of playing in one of the top leagues.

Conclusion

In this article, we utilize a propensity score matching technique to present the first set of evidence on the impact of player behavior during a lockout on postlockout performance in the context of professional hockey. In particular, we consider a unique natural experiment from the 2012-2013 NHL lockout, during which approximately 200 players decided to play overseas while the rest stayed in North America and practiced on their own. We find limited evidence of enhanced productivity only among European players who chose to play abroad during the lockout and no evidence of a benefit or drawback for North American players. This suggests that playing overseas during the lockout did not systematically improve postlockout player productivity, from which we can infer that player choices during the NHL lockout did not consistently affect performance.

While we made use of the most recent NHL lockout, a related analysis would contrast hockey players before and after the entire 2004-2005 season was lost. However, not only would it be difficult to ascertain information about which players chose to play abroad during this period, such an analysis could be compromised by the myriad changes to league policies made before the start of the 2005-2006 season, including the implementation of the shootout, which were designed to increase game scoring and excitement. Franck and Theiler (2012) and Lopez (2015), for example, identified changes in game outcomes when comparing behavior before and after the 2004 lockout. In this respect, the analysis of the 2012 lockout would be preferred; when NHL play resumed in January 2013, it did so with, by and large, an identical set of rules and incentives to the previous season. A related area could consider the effects of midseason stoppages in play, although, admittedly, these are rare in professional sports.

Within the field of professional sports, our study suggests that playing in alternative leagues in the event of lockouts may not offer a systematic advantage over self-motivated practices, especially if the lockouts are expected to be short-lived. On a broader note, while much of previous literature identifies negative relationships between work stoppage and labor productivity as a result of strike, slowdown or absence (e.g., Herrmann & Rockoff, 2012; Katz et al., 1983; Kleiner et al., 2002; Krueger & Mas, 2004; Mas, 2006, 2008), little has been done to record a similar productivity impact under a lockout. Our results suggest that the (within group) labor outcomes may not be consistently affected under a lockout. Given the growing popularity of lockouts as an alternative form of work stoppage during labor strife and the inherently different incentive schemes behind strikes and lockouts, further research from other industries is warranted for a more complete discussion of labor disputes and worker productivity.

Our findings also provide several additional avenues for future research. As part of the robustness check, we examined the association between the number of European players who played abroad and team scoring capability during the post-lockout season. A further extension is to think about the impact of playing overseas on different team productivity measures, for example, did the teams with more players who played abroad during the lockout perform better once the season resumed? We may observe a more salient aggregate impact of playing overseas compared to the limited individual-level impact found in our study. Another direction is to study the impact of the NHL lockout on the European leagues as a result of the influx and outflow of NHL players. Specifically, one may investigate the impact on player productivity as well as the competitive balance in European leagues. More generally, it is also natural to ask whether the impact of player decisions during a lockout may be generalized to other sectors or other forms of work stoppages, including strikes and work absence. While opportunities for honing production skills during work stoppage incidents may be limited to certain specialized industries, one can relate and extend our study to reconsider a variety of industrial relations topics such as retaining and replacing production skills

during work stoppagesand the overall discussion about discouraged and displaced workers.

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Author's Note

The remaining errors are ours.

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Notes

1. See *The Huffington Post* (http://www.huffingtonpost.com/tag/2012-nhl-lockout/) for a list of news updates on the 2012 National Hockey League (NHL) lockout.
2. The limited coverage could be attributed to the fact that lockouts were once rare in most industries, and employers have historically been favoring letting employees strike instead of initiating a lockout because of its legal and worker replacement implications. For example, employers in the United States may only temporarily hire replacements under lockouts and locked-out workers are eligible for benefits. On the other hand, workers on strike may be replaced permanently and may not qualify for benefits.
3. Out of the approximately 400 players who stayed in North America during the lockout, 169 of them chose to play in the American Hockey League (AHL). The AHL is considered to be less competitive than the NHL and the elite European leagues because it serves as the primary development league for the NHL and caters to primarily inexperienced young players who are just starting a professional career.
4. For instance, during the 2007-2008 Writers Guild of America strike, a number of writers wrote scripts of their own during the work stoppage. See *The Huffington Post* http://www.huffingtonpost.com/news/writers-strike/ for news coverage related to the 2007-2008 WGA strike.
5. A lockout is announced prior to the start of the season, which means players are not being paid for each day they are on the labor dispute with the management and thus shifts much of the economic burden of work stoppage to players.

6. Owners hoped to reverse the split ratio to 57:43 favoring owners, while players were willing to lower their share by only a few percents if there was a new revenue sharing among teams.
7. Under the 2005 agreement, the age and tenure threshold for unrestricted free agent is age 27 and 7 years, respectively.
8. If the entire season were canceled, the new season would resume following the off-season of the canceled season. The impact of the lockout would be blurred by the fact that players could be more prepared when they had an extra off-season to prepare for the new season.
9. The NHL players' association did issue a lockout pay to all players on a monthly basis during the lockout. The pay was between US$5,000 and US$10,000 per player, which was insignificant compared to players' regular salary.
10. Much of the literature on effort focuses on incentivizing effort using specific pay structures. This is not the focus of our study as we intend to use a simple framework to highlight the role of effort and its determinants in a player's relative preparedness for the season.
11. It is worth pointing out that, consistent with our framework, the impact of compensation on effort may be small during the recent NHL lockout since it is reported that many NHL players only received nominal compensation (especially compared to their NHL contracts) for their games in Europe.
12. As mentioned earlier, since Europe affords the most competitive hockey leagues outside the NHL, we assume that games in top European leagues are more competitive than AHL games or individual training on one's own.
13. *The Hockey Writers* (http://thehockeywriters.com/nhl-players-go-overseas/) and *The Wall Street Journal* (http://www.wsj.com/articles/SB110565436846425695), among others, discussed the phenomenon of playing abroad during the NHL lockout.
14. We found that 51.4% of the full sample (and 68.7% in matched sample) had a multi-year contract that carried through 2012-2013 season. For players who became free agents after the 2011-12 season, most were able to secure a contract (1 year or multi-year) during the off-season prior to the lockout. In total, 90.5% of the sample (and 100% in matched sample) had a contract for 2012-2013 season. Regarding the timing of the signing, 19 free agents were signed after the league declared a lockout on September 15, with only one of them (Jochen Hecht) in our matched sample.
15. We opt against using bootstrap resampling to compute standard errors, which can yield biased standard errors when sampling with replacement (Abadie & Imbens, 2008).
16. We assume that there is no systematic selection issue when making the decision to play overseas. Specifically, if players who chose to play abroad were the ones who knew that they needed extra conditioning through competitive games, then finding limited evidence for improved performance might actually suggest that there could still be a positive effect on productivity because those players would have had *more* of a drop in productivity if they had not gone to Europe to play. We believe, however, our matching strategy has addressed much of such selection concern.
17. Besides the differences in compensations, those who played aboard may also find it easier to maintain and improve competitive conditioning due to the competitive nature of European leagues.

18. The scale of labor market rent in occupations such as commercial airline pilots is of course not comparable to professional sports players.
19. It is also possible that the veteran players are used to keeping up their conditions during the annual off-season. A short lockout may be viewed by some as an extended off-season, and it may not influence a player's competitiveness if he follows his routine off-season training schedule.
20. The NHL rink is 200 ft. by 85 ft. with goal lines being 11 ft. from the end boards, while in most European leagues, the ice rink is 210 ft. by 98 ft. with goal lines being 13 ft. from the end boards.
21. For instance, Russia's Kontinental Hockey League, one of the highest paying leagues in Europe, limited the compensation of locked-out NHL player to no more than 65% their NHL salary (pro rata). And there are reports of players who took nominal compensation or were paid on a per-game basis for their games in Europe. On the other hand, the NHL Players' Association offered its members an escrow payment in October that was worth 8% of previous year's salary, which already surpassed many of the short-term or per-game–based contracts offered by European clubs.
22. Adding to these factors is also the fact that player insurance provided by the NHL teams does not cover games played outside the NHL.

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