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I Z A
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Evidence-based policy making

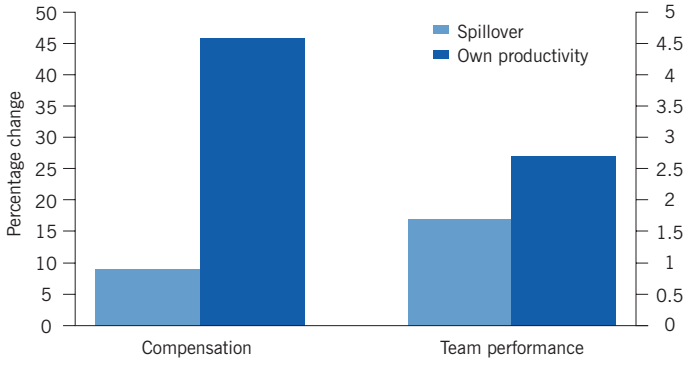
Production spillovers: Are they valued?

Spillovers can contribute to team success, although workers are not compensated for them

Keywords: production spillovers, marginal revenue product, team performance

ELEVATOR PITCH

Workers can contribute to total firm production directly through their own output or indirectly through their influence on the output of co-workers. Workers with positive productivity spillover effects cause individuals around them to perform better and increase overall team production. In contrast to the "peer effects" literature, workers with positive productivity spillovers may not be the workers with the highest levels of personal output. Such productivity spillovers are important for team success even though they play only a minor role in determining worker pay.



KEY FINDINGS

Pros

- Workers influence team performance through their own output and their influence on the output of co-workers.
- Workers are generally not appropriately compensated for their influence on their co-workers.
- Positive productivity spillovers are not limited to high-productivity workers.

Cons

- Productivity spillovers can be very difficult to measure and require high-frequency data on performance.
- Traditional peer effects estimates may not identify productivity spillovers since high-performing workers can create negative productivity spillovers.
- Determining the precise nature of a team's production function—the physical output of their production process—has proven to be difficult.

AUTHOR'S MAIN MESSAGE

Workers who bring out the best in others do not necessarily have the highest levels of productivity themselves—for example, workers who take time away from their assignment to help a struggling new hire, or academics who provide comments that benefit the work of other researchers, even when their own research productivity is lagging. Firms often undercompensate workers for their indirect impact on team outputs. However, positive production spillovers should be considered when assigning compensation, and firms should look for ways to assign workers into team settings that balance an optimal mix of workers with high productivity and those with positive productivity spillovers.

MOTIVATION

Traditional labor theory suggests that workers will be paid according to their marginal revenue product—i.e. the individual contribution they make to the revenue of the firm. However, while measuring a worker's individual productivity is relatively straightforward in many settings (such as piece-rate settings), calculating the total marginal product of a worker can be complicated when that worker may also be indirectly affecting total output through his or her influence on the output of other workers (i.e. productivity spillover effects). Workers with large positive productivity spillovers might also be highly productive themselves, but this may not necessarily always be the case. High-productivity workers can face incentives to be more self-focused and ignore the collective good of the team, while other workers may bring out the best in others but not be particularly productive themselves. Examples include the academic whose comments improve the scholarship of colleagues, and basketball players whose selfless passing and picks—where a player blocks a defender, allowing his teammate to get away from a defender—raise the performance of teammates.

Firms that are able to measure productivity spillovers and to identify the optimal way in which high spillover workers can complement the contribution of other workers will be able to reallocate workers across teams in a way that maximizes team output, by having workers with high positive spillovers paired up with workers with high productivity. In addition, it is likely that many firms undervalue the role of productivity spillovers (since they are computationally challenging to estimate). This provides an opportunity for firms that are able to measure and take into account productivity spillovers to adjust their compensation approach in order to retain and attract high-spillover workers who are likely to be undervalued by other firms.

While many of the insights in this article are drawn from research using data from professional basketball [1], the main findings regarding productivity spillovers are also relevant for other labor markets and firms. The increasing complexity of most production processes requires that even more workers engage in team production. In the medical field, for example, many procedures require the efforts of multiple workers, and the ability to influence the performance of other team members can be the key to successful outcomes [2]. In education, teachers not only have responsibility for their own students but can also play a crucial role in mentoring and assisting other teachers [3]. In fact, in almost every workplace, each worker has the ability through their attitude and assistance to influence the productivity of their co-workers.

DISCUSSION OF PROS AND CONS

Spillovers in team production

One US study provides an excellent example of spillovers in team production by looking at the placement of cashiers in a supermarket [4]. The study finds that placing the most productive cashiers in full view of the other cashiers results in the other cashiers working faster, although the increase in performance is small. In this setting, the assumption is that the workers with the highest productivity will have the greatest productivity spillovers. This, in all likelihood, stems from the fact that the type of work that cashiers do involves much less interaction between team members than other team settings (since each cashier is largely engaged in an individual task). Another study looks at spillovers in academia, which is a setting that involves interaction between workers who operate

through co-author networks [5]. The authors of the study constructed a sample of eminent life scientists who experienced an untimely or unexpected death and find that the co-authors of these scientists experienced a 5–8% drop in their own publications. Supporting evidence is also found in a study that uses data on baseball players to analyze how batting performance is related to the performance of other batters on the team. This study finds that batting before a high-performing player results in receiving better pitches, because the pitcher will not want to risk a walk—a situation in which the batter receives four poor pitches and is allowed to "walk" to first base—prior to facing the high-performing player [6].

Other studies have documented other important aspects of team production and ways in which teams can bring out the best in individual workers. One study examines data on steel mills to show that the use of group incentive pay increases productivity, and that using problem solving teams increases productivity for complex production processes [7]. Another study demonstrates that working with others has been shown to increase productivity relative to working in isolation, providing further evidence that team production increases productivity [8]. Finally, the introduction of "high-performance" work practices is correlated with increased productivity [9].

One of the assumptions often made in studies of productivity spillovers is that the individuals who are most productive themselves are also the ones who will make others most productive. In fact, this assumption is common in almost all of the peer effects literature. However, it may not be true in many contexts. For example, there are professors who choose to focus exclusively on their own research, providing little in terms of public good, while other professors are adept at helping their colleagues and may do so at the expense of their own research. Similarly, a brilliant but introverted student may not be as helpful to the learning of the other students as the less able student who asks good questions in class.

One study provides an example where production spillovers need not operate solely based on the average ability of the other workers in one's team [10]. The authors study a garment factory that shifted from paying workers a piece-rate for individual tasks to a group piece-rate for completing the entire product (with teams consisting of six or seven workers). They found that shifting to team production increased overall productivity and reduced turnover. In addition, controlling for average ability, the teams with the most variation in ability were the most productive, suggesting that an important part of the increase in production operated through mutual team learning.

Despite this encouraging evidence, team production can complicate the way in which firms measure the contribution of individual workers and decide how to compensate their employees.

Evidence from the National Basketball Association

Worker skills are multidimensional. One of the skills that may be important to a variety of production processes is the ability to bring out the best in others. In a recent study, data from the National Basketball Association (NBA) were used to identify three measures for each player: (i) their ability to score; (ii) their ability to defend; and (iii) their ability to help others score [1]. All three factors are important components of overall team productivity and probability of success.

The effect of each parameter on team success is quantified in terms of the "per-possession" point differential (which includes the change in your own team's scoring plus the degree to which they stop the other team from scoring on the next possession). The standard deviation for this measure is 0.087. Adding a player with a standard deviation higher than his or her own productivity measure will increase the team's output by 0.027 (or 31% of a standard deviation). By comparison, adding a player with a standard deviation higher spillover parameter will improve team output by 0.017 (or 20% of a standard deviation). Thus, while having players with higher productivity adds more to team output, the ratio of the contribution of the two factors is only about 1.6.

By using estimates of this model, the authors were able to form player rankings based on the overall contribution to team production. These rankings were then compared with estimates of team production when spillovers are ignored. Ignoring spillovers has a substantial effect on assessing the overall contribution of specific players, causing previous approaches to underestimate the contribution of "team" players. For example, Carmelo Anthony, a high-volume shooter, has an output measure that is 1.31 standard deviations higher when the loss in team output that operates through his negative spillover on his teammates is not accounted for. In contrast, Steve Nash, a player widely believed to be one of the best offensive facilitators in the NBA, has a performance measure that is 1.30 standard deviations higher in an estimation model that allows for spillovers, compared with a model where spillovers are not accounted for.

Optimal assignments

The estimates used for the NBA also suggest that teams will have higher outputs when they have the optimal mix of high-productivity players combined with spillover players. As such, some teams will value particular players more than others, based on the current composition of their team. Similarly, most firms have various teams within their organization and have the ability to reassign workers across them.

Since individual productivity and productivity spillovers play a complementary role, the overall contribution of a player/worker will depend on the characteristics of the other players/workers already on the team. It transpires in the study that assignments that produce the greatest increases in team productivity are often those that do not maximize the direct productivity of individual players. This suggests a tension that firms need to balance between team and player/worker productivity, especially in firms where individual productivity has a large effect on compensation.

One high-profile trade in 2010 illustrates this potential trade-off. Lebron James was a free agent who was deciding between playing for Cleveland (his current employer) and Miami. Based on the other starters present on the two teams, the research model made it possible to predict the impact of this decision on Lebron James's individual performance, as well as his impact on the performance of the team he chose to play for. Cleveland provided the greatest opportunity for individual output, while Miami offered the greatest chance for team success. The estimated parameters indicated that, by switching to Miami, Lebron James would experience a drop in his own productivity of 11.8%, but he would dramatically increase the points produced per possession of Miami. Lebron James ended up signing with Miami and in his first year his personal points score dropped by 8.5%, but he led his team to the NBA finals for the next four years.

Compensation

The NBA setting provides a useful way to examine whether productivity spillovers are properly accounted for in providing compensation. The data and estimation approach that was used in this study made it possible to estimate the productivity and spillover parameters for each player and to combine this with data on their salary. The degree to which productivity spillovers are undervalued in the NBA was measured by estimating the relationship between the different productivity parameters and team success and then comparing this with the relationship between these same parameters and compensation. The conclusion was that a standard deviation increase in own productivity results in 1.6 times as much team success as a standard deviation increase in the spillover parameter, but results in 8.7 times as much income for the player. Thus, productivity spillovers are undervalued by more than a factor of five relative to own productivity.

The study also examined what would happen if a team were to trade away a player who was one standard deviation above the mean in terms of his ability to score and used the money to purchase a player with a more positive spillover effect on his teammates' performance. The results suggest that obtaining an extra standard deviation of offensive ability costs about five times as much as obtaining an extra standard deviation of productivity spillover. It was found that an average team that gives up a standard deviation better offensive ability player experiences a 0.027 drop in the per-possession point differential. However, with the money saved, the average team is able to purchase players who together have an additional five standard deviations of positive productivity spillovers. This increase in spillover productivity would raise the per-possession point differential for the average team by 0.084. Thus, the net benefit of making this trade would be an increase in the per-possession point differential of the average team by 0.057. In the sample from 2007–2010, the average team had 92.9 possessions per game. This would give a net increase of about 5.3 points per game relative to the team's opponent. Between 2007 and 2010, about 3.9% of NBA games fell within one point, 14.7% fell within three points, and 26.8% fell within five points. Thus, the proposed trade for skills would have a significant impact on expected total wins, with no associated increase in salary costs. Similarly, firms that can identify workers with high spillovers will likely be able to increase overall productivity without spending more on salaries.

Finally, the NBA study also found that players are primarily compensated based on their direct contributions to team production, with little weight given to their ability to increase the productivity of their teammates. This misalignment of incentives might reduce the incentive for players to invest or engage in actions that increase their positive effects on the productivity of their teammates, especially in cases where compensation is based on relative performance. This problem is likely to be even worse in many "real" work/life settings, where productivity spillovers may be observable within a firm but not to outside firms. Spillovers could include traits such as whether the worker is a good team player, has a positive attitude, or has a strong work ethic. However, if other firms cannot observe the productivity spillovers of a worker, then that worker is likely to get paid less at his or her current job since any outside offers would not take this information into account.

LIMITATIONS AND GAPS

The main challenges in estimating productivity spillovers are: (i) having a measurable output; (ii) having teams that change often enough to observe workers across multiple

teams; (iii) determining the nature of the team production function; and (iv) having the computational resources to estimate the model. While this will be a limitation for many firms, there are a number of industries for which the approach described in this article could be employed. For example, sports data provide an excellent opportunity to study team production, because the members of a team can be clearly identified, there are frequent changes in the players who make up a particular team, and compensation data are available. There are also likely to be many additional settings that fit these requirements. Some examples include spillovers in education (test scores are available each year), health (doctors and nurses treat patients each period), or entertainment (actors perform in many movies). The scope of firms that meet these requirements is likely to continue to expand as more firms become part of the "big data" revolution. In addition, particular econometric contributions will continue to make the computational side of the challenge less onerous [11].

One limitation of the specific illustrative example that was used in this article is that the data provide information only on wins and not on profits. There are several reasons to believe that an increase in wins will directly contribute to the profits of the team. However, it is certainly possible that there are a number of selfish players who may lower the chances of a team winning but actually increase revenues by catering to the preferences of the supporters. As such, part of the mismatch between compensation and a player's contribution to team productivity may stem from a demand from fans for the output of selfish players.

SUMMARY AND POLICY ADVICE

Workers' skills are multidimensional, and one of the skills that may contribute to team production is the ability to bring out the best in others. Most of the peer effects literature assumes that workers with the highest own productivity are the ones who bring out the best in others. The research used in this article, however, suggests that this need not be the case and, in fact, in the study of NBA players, a slight negative correlation was found between own productivity and the ability to increase the productivity of others. In addition, it is apparent that players who have a selfish style of play boost their own performance measures at the expense of their team's success.

The ability to identify the spillover parameter of individual workers has a unique set of data requirements, but more and more firms are employing the types of data systems that make this sort of estimation possible. Currently, many firms are using employee engagement software to assess team and individual performance. However, this software typically relies on surveys to assess individual performance. As mentioned earlier, previous literature on productivity spillovers has assumed that the most productive workers have the highest spillovers. It also seems likely that employees would assume that those with the highest individual productivity have the highest spillovers, and thus would not accurately report the effects of spillovers within the team. Therefore, the firms that find ways to accurately identify the productivity and spillover parameter of each worker will be able to optimally assign groups within the firm that maximize team output.

NBA teams tend to compensate players based on their direct contribution to team production, with little weight given to their ability to increase the productivity of their teammates. This is even more likely to occur in other firms, since the NBA tends to be on

the high end of firms that use data analytics to make compensation decisions. Such a misalignment of incentives could result in a reduction in the number of players who are willing to play in ways that would increase the positive productivity of their teammates. This would particularly be the case when compensation is based on the relative performance of players. Those firms that can better identify high spillover workers will be able to adjust their compensation in ways that encourage positive spillovers and retain high-spillover workers who may be overlooked when using traditional performance measures.

Finally, there are likely to be settings in which spillovers are incredibly important, but very difficult to measure. These might include settings where it is difficult to measure the output of individual workers within a team, or where the composition of teams rarely changes. In these settings, another option would be to base more of an individual's compensation on team production, such as in the form of profit sharing or stock options. This recommendation comes with the natural caveat that team-based forms of compensation need to be structured in a way that reduces free riding. The results described in this article, however, highlight that the benefits of properly tapping into positive productivity spillovers can contribute greatly to team and hence firm output.

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Competing interests

The IZA World of Labor project is committed to the *IZA Guiding Principles of Research Integrity*. The author declares to have observed these principles.

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