Bankruptcy, Team-specific Human Capital, and Innovation:

Evidence from U.S. Inventors

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ABSTRACT

We study the impact of corporate bankruptcies on the career and productivity of inventors in the United States. We find that the quality of patents produced by inventors decreases post-bankruptcy; this effect is exacerbated when inventor teams are dissolved during bankruptcy. Furthermore, workers affected by team dissolution are less likely to remain active as inventors. When, instead, inventor teams remain intact and jointly move to a new firm, their post-bankruptcy productivity increases. Consistent with the labor market recognizing the value of team stability, the probability of joint inventor relocation after bankruptcy is positively associated with past collaboration. Our findings highlight the important role of team-specific human capital and team stability for the production of knowledge in the economy, and shed light on the microeconomic channels through which the process of "creative destruction" operates.

1. Introduction

Innovation is vital to economic growth (e.g., Grossman and Helpman 1993). It occurs not only through gradual improvements but also—and perhaps particularly so—through more radical mechanisms, including creative destruction. This process of replacing inefficient firms, firms with obsolete technologies, and firms producing over-abundant and otherwise unmarketable output, is an "essential fact about capitalism" (Schumpeter 1942). Bankruptcies may be important for the process of creative destruction by providing a structured mechanism through which the economy purges itself of obsolete firms and allocates their constituent parts to more productive uses.[1] In this paper, we investigate the microeconomic foundation of this mechanism by studying the impact of Chapter 11 bankruptcies on the career and productivity of inventors in the United States and, in turn, on the economy-wide creation of knowledge.

Whether the process of creative destruction that is catalyzed by bankruptcies leads to a net increase or decrease in inventor productivity depends on whether the losses in productivity incurred due to the bankruptcy are small relative to the gains from allocating the production inputs to their new uses. While resources may on average be used more productively following a bankruptcy, this process is not deterministic and likely involves various imperfections. In particular, in addition to the potential loss in value to the firm's redeployable capital stock (e.g., due to asset fire sales), bankruptcy may involve some deterioration of organizational and human capital (e.g., Graham, Kim, Li, and Qiu 2016). For example, the failure of a firm may result in ongoing R&D projects to be halted and the knowledge accumulated thus far to be lost. Moreover, workers that invested in organizational or other firm-specific human capital will see the value of those skills disappear. Further, frictions in the post-bankruptcy re-allocation of resources across firms may lead capital and labor to be idle for some time or even result in protracted sub-optimal uses. In the case of workers, unemployment spells could also accelerate the depreciation of skills (e.g., Ljungqvist and Sargent 1998).

An important dimension of human capital that may be affected by bankruptcy is team-specific human capital.[2] This is pertinent, because teamwork has become a common way of

[1] In reality, this process is imperfect: firms that enter bankruptcy may not always be inefficient, and inefficient firms may not always enter bankruptcy (e.g., White 1989). Furthermore, bankrupt firms may impose negative externalities on non-bankrupt peers (e.g., Benmelech, Bergman, Milanez, and Mukharlyamov 2014; Benmelech and Bergman 2011; Birge, Parker, and Yang 2015). Bankruptcy also imposes significant direct and indirect costs on creditors, shareholders, and other stakeholders (e.g., Hortaçsu, Matvos, Syverson, and Venkataraman 2013).

[2] We define team-specific human capital as an intangible asset consisting of common knowledge related to communication, coordination, and problem-solving which is not easily codified or transferable across different groups of workers (see, e.g., Bartel, Beaulieu, Phibbs, and Stone 2014).

organizing work in modern firms, in particular when complex tasks are involved.[3] The production of new knowledge is a good example of such tasks. In our sample of patents filed with the United States Patent Office (USPTO), we observe a clear trend towards more teamwork in patent production over time. Figure 1 depicts the evolution of the average number of co-authors per patent over the period 1975 to 2005. While this number was 1.4 in 1975, it rose monotonically to 2.4 in 2005, suggesting an increase over time in the importance of team-specific human capital for generating innovation.[4]

Team-specific human capital is likely to be adversely affected by bankruptcy when well-established inventor teams are broken up. It may be difficult for inventors that are used to collaborating in teams to move jointly to a new firm after bankruptcy, because few firms may have the financial slack to hire whole groups of employees of the distressed firm. This problem could be further aggravated due to common industry shocks. Furthermore, the joint relocation of former team-members to new firms may be rendered onerous by transaction and coordination costs.[5] The resulting shock to the structure of teams, or, at the extreme, their outright dissolution, may have negative consequences for the productivity of inventors. This would be especially relevant for inventors that have built up significant team-specific human capital in the past.

To shed light on the impact of bankruptcies on the career and productivity of inventors, as well as on the role that team-specific human capital plays in this context, we employ micro-level data on corporate innovation in the U.S. Our setting permits us to follow individual inventors across firms and over time (our sample spans the years 1980 to 2004). We measure inventors' individual productivity, both in terms of quantity (patent counts) and quality (citation-based innovation measures and estimates of the monetary value of patents). Because we can trace the composition of teams within and across firms, we can distinguish the role of team-specific human capital from that of firm-specific human capital.[6]

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[3] Lazear and Shaw (2007) report that from 1987 to 1996, the share of large firms that employ more than 20 percent of their workers in problem-solving teams rose from 37 percent to 66 percent. There is evidence that teamwork can be considerably more productive than work in more hierarchical environments (e.g., Hamilton, Nickerson, and Owan 2003; Boning, Ichniowski, and Shaw 2007). Jaravel, Petkova, and Bell (2015) report that team-specific human capital accumulation is associated with higher earnings and productivity of inventors.

[4] A similar pattern can be observed in academia. Card and Delavigna (2013) document that the number of co-authors per paper published in the top 5 academic journals in Economics has increased steadily over the past four decades.

[5] For example, individuals could have different geographic preferences, or family circumstances may make it difficult to coordinate a joint relocation.

[6] In a recent working paper, Liu, Mao, and Tian (2016) quantify the contribution of individuals versus that of firms as determinants of innovation.

We have four main findings. First, on average, corporate bankruptcies have a negative impact on the quality of innovation subsequently produced by affected inventors; this appears contrary to the view that bankruptcies release resources to more productive uses (e.g., Hotchkiss and Mooradian 1998). Interestingly, we find no persistent effects (positive or negative) on the *quantity* of innovation, that is, the number of patents filed.

Second, inventors that tend to work more in teams—those that have a higher share of patents together with other inventors in the financially distressed firm—experience more negative effects on their productivity post-bankruptcy than inventors that rely less on team production. This suggests that team dissolution may be an important, yet (to our knowledge) previously undocumented, cost associated with the process of resource reallocation through bankruptcies. Furthermore, this finding implies that the negative effects on inventor productivity are not (solely) driven by disruptions to R&D and other firm processes during bankruptcy—otherwise all workers' productivity should be similarly affected by bankruptcy, irrespective of the extent to which they work in teams. We also document that team-dependent inventors are less likely to remain active as inventors (by filing patents) after bankruptcy than those that rely less on teamwork.

Third, we find that inventors that co-locate with their team members after the bankruptcy innovate more, both compared to before the bankruptcy and relative to inventors that do not end up working at the same firm. This increase in productivity may arise because the new employer is likely to be less financially constrained and is able to direct more resources to the team than the previous employer.

Fourth, inventors are more likely to co-locate with their co-inventors the higher the fraction of patents that were jointly produced in the respective team before bankruptcy. This suggests that the labor market values team-specific human capital and encourages its preservation after the bankruptcy, perhaps because such capital is hard to codify and time-consuming to acquire (e.g., Berman, Down, and Hill 2002; Bartel, Beaulieu, Phibbs, and Stone 2014).

We perform ancillary tests to establish the robustness of our results in different sub-samples. First, we restrict the sample to include only "star" inventors (defined as the top decile of inventors by number of patents filed). This test alleviates the concern that our findings are driven by unproductive inventors being adversely affected by the bankruptcy-induced separation from a highly productive team member. Second, we consider a sub-sample that focusses only on inventors that at some point during our sample period are affected by the bankruptcy of their employer. This allows us to use the output of inventors whose firms have not *yet* gone bankrupt as a counterfactual for the productivity of inventors whose firms are currently filing for bankruptcy. This test addresses the concern that firms that file for bankruptcy may be inherently low quality firms relative to those that do not experience financial distress (which we use as a benchmark in our main set of tests). Overall, these robustness tests alleviate the concern that our findings are driven by unobservable differences in the quality of inventors between bankrupt and non-bankrupt firms.

Our study contributes to two strands of the literature. First, we add to the body of research on innovation and its causes. Previous literature has identified several important macroeconomic determinants of innovation, such as patent law (Moser 2005), labor laws (Acharya, Baghai, and Subramanian 2013), bankruptcy codes (Acharya and Subramanian 2009), and quality of institutions (Donges, Meier, and Silva 2016). At a micro-level, access to finance (e.g., Kortum and Lerner 2000; Gompers and Lerner 2001; Kerr, Lerner and Schoar 2014; Bernstein 2015; Hombert and Matray 2016), investors' tolerance for failure (Tian and Wang 2014), and the organizational structure of firms (Seru 2014) have also been shown to affect innovation. We contribute to this literature by providing micro-level evidence of a specific channel—bankruptcy and the subsequent redeployment of (team-specific) human capital—through which the process of creative destruction takes place.

Our paper is also related to the work on innovation by Azoulay, Zivin, and Wang (2010), Azoulay, Fons-Rosen, and Zivin (2015), and Jaravel, Petkova, and Bell (2015). These studies report a significant negative effect of co-author deaths on the productivity of academics and inventors. We contribute to this literature by documenting changes in the productivity of inventors whose employers experience bankruptcies. Contrary to the case of deaths, bankruptcies need not lead to a dismantlement of teams. Our work is thus primarily an investigation into the role of bankruptcies and labor market frictions in the process of creative destruction. We also provide evidence that teams are important economic units in the knowledge production industry that surpass firm boundaries: successful inventor teams survive the disintegration of their "host firms" caused by bankruptcies, and may in fact thrive within the successor firms. Our findings are relevant for assessing the relative importance of individual human capital, firm-specific human capital, and team-specific human capital as determinants of innovation.

Second, our study adds to the growing literature that studies the interactions between finance and labor. More specifically, it contributes to the body of research that investigates the labor costs of financial distress (e.g., Brown and Matsa 2016; Baghai, Silva, Thell, and Vig 2016). Our research relates to recent work by Graham, Kim, Li, and Qiu (2016) who, in a sample of manufacturing firms, find that workers' earnings fall when a firm files for bankruptcy and that affected employees are likely to subsequently work fewer hours and leave the firm, industry, and local labor market. Eckbo, Thorburn, and Wang (2016) analyze the careers of CEOs of firms that file for bankruptcy; they find that a large fraction of such CEOs leave the executive labor market and suffer a large drop in the present value of future compensation. Babina (2015) and Hacamo and Kleiner (2016) document the role of bankruptcy in spurring entrepreneurship.

The remainder of the paper is organized as follows: in Section 2 we describe the data and main variables, Section 3 presents the main results on the impact of bankruptcies on the productivity of inventors, Section 4 analyses labor mobility and inventor careers after a bankruptcy, and Section 5 concludes.

2. Data and variables

2.1 Main data sources

We combine three main data sources: patent data, information on individual inventors' careers, and data on firms' financials (including bankruptcy filings). The NBER patent database contains the application dates of granted patents, the number of citations received by these patents, as well as information on the technology classes of patents. It also includes information on the *assignee* of the patent, which is typically the firm or subsidiary at which the research is conducted; the identifier corresponding to an assignee is unique and time-invariant. The NBER patent dataset also includes a link to Compustat for patents applied for between 1975 and 2006; we use this information to link patent assignees to their corporate parents. In addition to citations-based measures of patent quality, we employ a measure of the economic value of patents derived from the stock price reaction to the announcement of new patent grants; we obtain these data from Kogan, Papanikolaou, Seru, and Stoffman (2017).

The data on individual inventors is from Lai, D'Amour, Yu, Sun, and Fleming (2011). These data are based on information from the USPTO and encompass around 4.2 million patent records and 3.1 million inventors for the period 1975 to 2010. The dataset contains disambiguated inventor names and permits us to track the careers of inventors across firms. In our analysis, the place of employment of the inventor is defined as the firm (Compustat's *gvkey*) that a patent assignee belongs to. For example, an inventor that files a patent with firm A in 1999 and one with firm B in 2000 is designated as an employee of firm A in 1999 and as an employee of firm B in 2000. If more than one year passes between two patent filings, we assume that the employment transition between the two firms occurs at the midpoint between the patent application years.[7] Inventors are included in the sample for their entire active career, defined as the years between their first and last patent filings.

Information on bankruptcy filings is from the UCLA-LoPucki Bankruptcy Research Database. Among other information, this dataset contains all Chapter 11 bankruptcy filings of

[7] For example, if an inventor has a patent with firm A in 1995 and one with firm B in 2000 and no patents in between, we assume that the inventor is with firm A until 1997 and is employed by firm B from 1998 onwards.

public U.S. firms between 1980 and 2015, the filing date, and the Compustat firm identifier (*gvkey*). Finally, our source of corporate financial data is Compustat. We collect data on R&D spending, total assets, cash holdings, earnings, and leverage at the firm level for the period 1975 to 2004. Because the UCLA-LoPucki Bankruptcy Research Database only reports information on bankruptcies of firms with $100 million (in 1980 dollars) or more in assets, we restrict the sample of non-bankrupt firms to those whose time-series average and/or median asset values during our sample period also lie above this threshold.

The final sample covers the period 1980 to 2004 and contains 2,244 public firms and 355,441 inventors. 156 of these public firms file for Chapter 11 bankruptcy during our sample period; such firms employ 3,639 inventors one year prior to the bankruptcy. Figure 2 depicts the frequency of bankruptcy filings by year. We observe that the early 1990s and early 2000s are the periods with the largest number of bankruptcy filings. In Figure 3, we tabulate the bankruptcies by industry. Manufacturing is the industry with largest number of bankruptcies, followed by transportation, communications, electricity and gas, and by the services industries. Within manufacturing, the top five sectors with the largest number of bankruptcies are (in descending order): industrial and commercial machinery, electronic and other electrical equipment, transportation equipment, primary metal industries, and chemicals and allied products. Overall, our sample does not seem to be dominated by any one year or any one industry.

2.2 Variables

To conduct our analysis, we first identify the set of inventors that are directly affected by corporate bankruptcies. With a slight abuse of terminology (given the non-random nature of bankruptcies), we refer to such inventors as "treated". To be specific, *Treated* is a time-invariant indicator variable that takes the value of one for inventors that are employed by a firm in the year prior to its bankruptcy filing. That is, if an inventor is present in at least one bankrupt firm in the year that precedes bankruptcy, the inventor is permanently categorized as being in the treatment group. The variable *Post* is a dummy variable that takes the value of one in the years after the bankruptcy filing for inventors in the treatment group; it takes the value of zero for years prior to bankruptcy and for inventors that were never employed by a bankrupt firm in the year prior to bankruptcy.

We employ several patent-based proxies for innovation in our analysis.[8] For a given inventor in a given year, the variable *Ln(Citations)* is defined as the natural logarithm of one plus the total number of citations (until 2006) obtained on all patents that the inventor files in that year. In addition, we also employ the variable *Ln(Patents)*, the natural logarithm of one plus the

[8] There is a long tradition of using patents as proxies for innovative activity (e.g., Griliches 1981, Pakes and Griliches 1980, and Griliches 1990). Measures using information on citations are particularly well suited to capture the economic importance of an invention (e.g., Hall, Jaffe, and Trajtenberg 2005).

number of patents applied for by a given inventor in a given year. Citations, our main measure of innovation, reflect the importance of an invention, while the simple count of patents does not distinguish between important and less significant technological discoveries. Our final patent-based measure of innovation is *Ln(Citations per patent)*, the natural logarithm of one plus the average number of citations per patent for all patents that a given inventor applies for in a given year. Finally, as an additional way to measure the economic value of innovation, we employ the variable *Ln(Dollar value of patents)*, defined as the natural logarithm of one plus the cumulative dollar value of patents (in millions of nominal U.S. dollars) that an inventor applies for in a given year; the dollar value of each patent is obtained from Kogan, Papanikolaou, Seru, and Stoffman (2017). Following the literature, the year refers to the patent application year, and we only consider patents that are eventually granted (e.g., Hall, Jaffe, and Trajtenberg 2001). Citations are naturally censored because patents applied for in later sample years receive on average fewer citations than patents applied for in earlier years. This concern is addressed in two ways. First, we employ year-by-industry fixed effects in our tests (industry is defined at the two digit SIC level). Second, the variable *Ln(Dollar value of patents)* does not suffer from the truncation problem.

Corporate bankruptcies may affect not only the quantity of inventor output (as measured by the number of patents) and the importance and economic value of an innovation (captured by the number of citations and the dollar value of patents). Bankruptcies may also affect the type of innovation produced, specifically, the extent to which an invention is original or general. We follow Hall, Jaffe, and Trajtenberg (2001) and define the originality of an invention as the breadth of patent classes that the patent cites (a patent that cites many classes is deemed to be original). Generality is defined in a similar manner: a patent is considered to be general in nature if the citations it receives are dispersed across patents from many different classes. Following this logic, Hall, Jaffe, and Trajtenberg (2001) construct an "originality index" and a "generality index" for each patent. Using these indices (which are obtained from the NBER Patent Database), we generate the variables *Patent originality* and *Patent generality*. *Patent originality* is the average originality index of patents filed by an inventor in a given year, while *Patent generality* is the average generality index of these patents.

In this study, we are interested not only in the evolution of the productivity of inventors following a bankruptcy, but, more generally, also in the impact of bankruptcies on the careers of affected inventors. For this purpose, we construct the variable *Career end*, an indicator that takes the value of one in the year of the last patent application filed by a given inventor. For each pair of treated inventors that are employed at the same firm in the year prior to bankruptcy, we also create the variable *Move together*, an indicator that takes the value of one if both inventors in the pair jointly move to the same new firm following the bankruptcy.

In terms of explanatory variables, an important focus of our analysis is the role of team-specific human capital as a potential determinant of innovation. In particular, we investigate how the loss of this type of human capital during bankruptcy subsequently affects the productivity of inventors. We construct two measures which capture different aspects of team-specific human capital. First, *Bankruptcy Co-authorships* measures the extent to which an inventor collaborates with others at the firm before its bankruptcy. To be specific, for an inventor that works at a financially distressed firm one year prior to its bankruptcy filing, this variable measures the total share of that inventor's patents that are co-authored with other inventors that are also employed at that firm in the year before bankruptcy; all co-authorships up to the year before the bankruptcy filing are considered in this calculation. For inventors that are not employed at a financially distressed firm in the year prior to bankruptcy, this variable takes the value of zero. *Bankruptcy Co-authorships* is constant within an inventor across time and ranges from zero to one. A value of zero indicates that none of the patents of an inventor are co-authored with other inventors from the bankrupt firm. At the other extreme, a value of one denotes that all patents of the inventor are produced with other inventors that are also present at the bankrupt firm in the year prior to the bankruptcy filing. Therefore, a value of one (zero) indicates a high (low) level of team-specific human capital in that inventor's innovation production function.

Our second measure of the importance of team production is *Stable Team Share*; this variable captures the stability of inventor teams that are affected by bankruptcy. For each inventor that works at the bankrupt firm in the year prior to bankruptcy, this variable measures the fraction of other inventors employed by the same firm in the year prior to bankruptcy that move jointly with that inventor to the same firm post-bankruptcy. Because simply working at the same firm is unlikely to be informative about the intensity of collaboration by itself, we assign more weight to inventors that tend to patent together. For inventors that are not employed by a bankrupt firm in the year prior to its bankruptcy, this variable takes the value of zero. *Stable Team Share* thus captures both an intensive and an extensive margin of team stability and team-specific human capital. Formally, this variable is constructed as follows:

$$Stable\ Team\ Share_i = \frac{\sum_{i=1, i\neq j}^{N_f} \Vert_{ij}\ \ Pair\ Co-dependence_{ij}}{\sum_{i=1, i\neq j}^{N_f} Pair\ Co-dependence_{ij}}$$

where N_f is the set of inventors that were at the financially distressed firm *f* in the year prior to bankruptcy. For two inventors *i* and *j* who were at a bankrupt firm one year prior to the bankruptcy, *Pair Co-dependence*$_{ij}$ is defined as the share of patents of inventors *i* and *j* that are co-authored by both inventors *i* and *j*; it includes all patents of both inventors up to the year before bankruptcy filing. $\Vert_{ij}$ is an indicator variable that takes the value of one if after the bankruptcy, inventors *i* and *j* are employed by the same new firm.

To measure work experience generally and an inventor's experience with patenting more specifically, we calculate the number of years between the current year and the year of the first patent filed by a given inventor. In our regressions, we include a set of fixed effects for years of experience as a way to capture possible non-linearities in the relationship between inventor productivity and experience (e.g., Bell, Chetty, Jaravel, Petkova, and Van Reenen 2016).

Finally, to control for time-varying factors at the firm level that affect innovation, we include the following control variables in the regressions. *Firm Size* is defined as the natural logarithm of total assets; *ROA*, the return on assets, is defined as net income divided by total assets; *R&D Intensity* is expenditures on research and development divided by total assets; *Cash Ratio* is defined as cash and short term marketable securities divided by total assets; and, finally, *Leverage* is the sum of long term debt and debt in current liabilities divided by total assets. We report summary statistics of these variables, separately for inventors in our "treatment" and "control" groups, in Table 1.

3. Main results

3.1 The impact of bankruptcies on inventor productivity

In this section, we examine how bankruptcies affect the post-bankruptcy productivity of inventors. Corporate bankruptcies may be an important stimulant of creative destruction in the economy, as new ideas and ventures displace obsolete firms. Whether this process leads to an increase or a decrease in the productivity of *individual inventors* depends on whether the negative effects due to the bankruptcy (such as work disruption and loss of firm-specific and team-specific human capital) are outweighed by the gains from allocating the production inputs (labor and capital) to their new uses.

We compare the productivity of inventors that are directly impacted by a bankruptcy to that of all other inventors in our sample. The presence of a control group in our analysis allows us to account for industry-level and macroeconomic dynamics in the evolution of innovation that occur in the absence of bankruptcy. We first examine whether corporate bankruptcies affect the productivity of inventors on average. Formally, we use the following regression specification:

$$Ln(Citations)_{ift} = \alpha + \beta_1 \cdot Treated_i + \beta_2 \cdot Treated_i \cdot Post_{ift} + X_{ift}^{\prime}\gamma + \Psi_f + \mu_i + \varepsilon_{ift} \qquad (1)$$

where $Ln(Citations)_{ift}$ is the natural logarithm of one plus the number of forward citations of all new patents filed in year *t* by inventor *i* in firm *f*. $Treated_i$ is a dummy variable that is set to one if inventor *i* is part of the treatment group (inventors that are associated with a bankrupt firm at *t-1* relative to the year of bankruptcy filing), and zero otherwise. $Post_{ift}$ is an indicator variable that takes the value of one in the years following bankruptcy, and zero in the years prior to bankruptcy; for inventors that are not part of the treatment group, this variable takes the value of zero throughout. Thus, the interaction *Treated* × *Post* takes the value of one in the years after the bankruptcy filing for workers in the treatment group; for workers in the control group the interaction takes the value of zero for all years in the sample.

The regression described by equation (1) further includes the following control variables: Ψ is a vector of firm fixed effects, which account for any time-invariant unobservable firm characteristics that may affect innovation. μ are inventor fixed effects, which we include as a way to control for (time-invariant) differences in inventor characteristics that are unobservable to us. Finally, the matrix X contains the following time-varying control variables: dummies for the number of active years of an inventor, to account for any life-cycle related changes in inventor productivity; *Firm Size*; *ROA*; *R&D Intensity*; *Cash Ratio;* and *Leverage*. The matrix X also includes industry–year fixed effects, which permit us to account for a variety of other potential confounding factors, such as the possibility that the incidence of bankruptcies may be higher in industries that are in decline, that the redeployability of human capital post-bankruptcy may vary across industries and time, or that the value of inventor skills is affected by industry dynamics. Standard errors are clustered at the firm level to account for any correlation in error terms within firms.[9]

We present results of these tests in Table 2. The specification reported in column 1 shows that, on average, bankruptcy has a negative effect on innovation productivity. Inventors that experience a bankruptcy event are subject to a drop in citations of roughly 5% relative to what would be expected based on industry trends, inventor experience and other inventor- and firm-level determinants of innovation. Although negative, the coefficient estimate corresponding to the term *Treated* × *Post* is not statistically significant at conventional levels (the t-statistic is 1.6). This suggests that on average, the transaction costs associated with bankruptcies do not lead to a large drop in the productivity of inventors employed by bankrupt firms. This finding complements prior evidence on the effect of bankruptcies on worker human capital. Graham, Kim, Li, and Qiu (2016) report that after bankruptcy, workers experience a large decline in wages. While we do not study compensation, our results are indicative of more modest losses to human capital in the setting we consider. In particular, while we focus on highly skilled, highly mobile workers, Graham et al. focus on blue collar workers for whom job loss may have more severe consequences.

Despite the fact that the average effect of bankruptcies on inventor productivity is small and statistically insignificant, there may be important heterogeneity: some inventors' productivity may be severely negatively affected, while others may even benefit, perhaps because the new employer is less financially constrained. One dimension that is likely to be

[9] All results are also robust to clustering standard errors at the inventor level. We do not report these alternative standard errors for the sake of brevity. They are available upon request.

important relates to teams. Innovation does not happen in isolation: team production is an important aspect of innovation (see Figure 1). A bankruptcy is an event that is likely to impact the stability of teams: it may be difficult to retain the composition of a team and transfer all its members to a new firm post-bankruptcy. Instead, some teams may be dissolved in the event of bankruptcy. Although team dissolution could be an optimal outcome in cases where teams are not productive (e.g., Cornelli, Simintzi, and Vig 2016), frictions in the labor market and inefficiencies in the bankruptcy process could result in significant reductions in team-specific human capital. For example, the new employer of some of the team members may be financially constrained and may not have the necessary resources to hire the entire team. Furthermore, a joint relocation of several inventors to a new firm requires considerable coordination, which may not be feasible due to individual inventors' idiosyncratic constraints. In that case, a bankruptcy event could lead to the loss of team-specific human capital and, consequently, to a decline in innovation output of the affected inventors.

To assess the role that team-specific human capital plays in explaining post-bankruptcy inventor productivity, we employ the variable *Bankruptcy Co-authorships*, which measures the degree to which an inventor's innovation output depends on colleagues in the bankrupt firm (see Section 2 for details). A low value of *Bankruptcy Co-authorships* indicates that only a small amount of team-specific human capital is likely to be lost in the event of bankruptcy. In contrast, a high value of *Bankruptcy Co-authorships* implies high interdependence between the inventors of the bankrupt firm, suggesting that team complementarities may be an important element of inventor productivity.

We first examine this issue graphically in Figure 4. This graph shows the role of team-specific human capital in explaining innovation around the time of bankruptcy. On the y-axis, the figure measures innovation per inventor, while on the x-axis, it plots the time relative to the bankruptcy filing year. From year five before, up to the year of the bankruptcy, inventors with many co-authors in the bankrupt firm are just as productive as they were six years prior to bankruptcy. However, the post-bankruptcy productivity of inventors with many co-authors at the financially distressed firm diminishes significantly relative to the benchmark.

To investigate the role of team-specific human capital for post-bankruptcy inventor productivity in a regression framework, we expand equation (1) by including the variable *Bankruptcy Co-authorships*. The coefficient of interest is associated with the interaction between *Bankruptcy Co-authorships* and *Post × Treated*; it measures whether the change in inventor productivity associated with bankruptcy depends on the implied loss of team-specific capital. If team-specific human capital is irrelevant, we would expect to find a coefficient of zero associated with this interaction term. On the other hand, if team-specific human capital is important, then inventors whose work relies more on co-authorships within the financially distressed firm will be more negatively affected by the collapse of the firm.

We report results from this analysis in column 2 of Table 2. Consistent with the view that team-specific human capital is a key determinant of post-bankruptcy inventor productivity, we find a significant negative coefficient associated with the interaction term *Bankruptcy Co-authorships* × *Post* × *Treated*. In terms of economic magnitude, an inventor that used to co-author all patents with colleagues at the firm filing for bankruptcy experiences a 20% reduction in innovation productivity post-bankruptcy. Interestingly, when we include the interaction *Post* × *Treated* × *Bankruptcy Co-authorships* in the regression, the interaction *Post* × *Treated* becomes positive, albeit statistically insignificant. This confirms the presence of heterogeneous effects of bankruptcy on inventor productivity. For inventors with few (or no) co-authorships within the bankrupt firm, bankruptcy may be an opportunity to move on to a new firm with potentially more resources devoted to innovation, hence resulting in a positive change in inventor productivity.

The reduction in innovation resulting from the dissolution of teams due to bankruptcy may be limited if inventors move jointly to a new firm. In that case, any team-specific human capital accumulated at the bankrupt firm will continue to be valuable in the new firm. Moreover, because the new employer may direct inventors' efforts to more promising technologies or alleviate financial constraints that may have limited R&D activity at the bankrupt firm, the reallocation of teams may in fact lead to an overall increase in efficiency and in innovation productivity.

To assess how team stability affects inventors' productivity after the bankruptcy of the employer, we test whether the productivity loss suffered by inventors that relied more on team production in the bankrupt firm is mitigated in cases where inventors from the bankrupt firm move together to a new employer. To this end, we employ the variable *Stable Team Share*, which measures the share of inventors of the bankrupt firm that move jointly to a new firm, weighed by their co-authorships. We first examine this question graphically. Figure 5 plots annual inventor productivity (as measured by citations per inventor) relative to the bankruptcy year. The figure shows that inventors whose team-members co-locate after the bankruptcy experience an increase in innovation (compared to their output six years prior to the bankruptcy filing), relative to inventors whose team is dissolved.

Next, we examine this question in a regression setting. To do this, we additionally interact the term *Post* × *Treated* in equation (1) with the variable *Stable Team Share*. Column 3 of Table 2 reports the results. Consistent with Figure 5, we find that when team-specific human capital is preserved because inventors move jointly to new firms post-bankruptcy, innovation productivity subsequently increases (relative to "treated" inventors whose co-authors do not co-locate with them). Finally, in column 4, we include both the interactions of *Post* × *Treated* with *Bankruptcy Co-authorships* and with *Stable Team Share*, respectively. As before, the interaction of *Post* × *Treated* with *Bankruptcy Co-authorships* is negative, and the interaction of *Post* × *Treated* with *Stable Team Share* is positive; both coefficients are statistically significant at the 5% level or higher. The coefficient estimates (taking into account both interaction terms) suggest that the net effect on innovation for inventors of bankrupt firms is positive when a large share of team members co-locates after the bankruptcy.

The empirical strategy that we employ in the tests reported in Table 2 permits us to rule out a number of alternative explanations for our findings. First, our results suggest that when a bankruptcy leads to the destruction of team-specific human capital, innovation persistently suffers. This effect is not explained by the possibility that the skills of inventors in firms that go bankrupt are becoming obsolete due to industry-wide changes in the allocation of human capital; the industry-year fixed effects included in our tests would capture this effect. Another concern centers on the selection of workers that work at bankrupt firms, or those that co-locate after the firm experiences bankruptcy. If only successful teams consisting of prolific inventors remain together after a bankruptcy, then the concern may arise that what we are capturing is a comparison of the productivity of good inventors (after the bankruptcy) to the productivity of average inventors in the pre-bankruptcy firm. A related concern is the possibility that firms that become bankrupt employ worse inventors to begin with—which may be the reason why these firms become financially distressed in the first place. These alternative explanations cannot account for our findings due to the inclusion of inventor fixed effects in our regressions, which ensure that selection on time-invariant ability of inventors in bankrupt and non-bankrupt firms does not drive our results. Furthermore, in Section 3.5.1, we present robustness tests in which we consider a sub-sample of high-productivity inventors. In those tests, which are not subject to the two criticisms mentioned above, we find similar results to those reported in Table 2. Finally, our findings are also unlikely to be driven by a shock to firm-specific human capital experienced by employees of the bankrupt firm: the loss of such capital is likely to affect all inventors of the firm, regardless of whether they were part of an R&D team or innovated on their own, and regardless of whether they moved together to a new firm or not. Instead, the most plausible interpretation of our findings is that we are capturing the effect of team-specific human capital on innovation.[10]

In sum, our findings suggest that corporate bankruptcies play an important role in the process of creative destruction and the creation of knowledge in the economy, and that teamwork is an important determinant of successful innovation. In particular, we document cross-sectional heterogeneity in the impact of bankruptcies on the productivity of inventors: when well-attuned innovation teams are dissolved because of the bankruptcy process, inventors become less productive post-bankruptcy. On the other hand, when the composition of innovation teams is preserved, the creative component of bankruptcy attenuates the possible

[10] Nevertheless, in Section 3.5 we present a series of ancillary tests that confirm the robustness of our main findings.

destruction—of firm-specific skills, for example—that may take place. Our estimates also suggest that if entire teams move together, bankruptcies may lead to an overall increase in innovation. Many economists highlight the role of general and firm-specific human capital as determinants of productivity (e.g., Becker 1975; Topel 1991). Our results provide evidence that another important aspect to consider in the context of innovation is the existence of complementarities that do not span the entire firm, but that occur at the team level, giving rise to team-specific human capital. A question that arises from our analysis so far is whether the labor market recognizes the value of team-specific human capital, which would be the case if well-established teams tended to co-locate after a bankruptcy event. We investigate this interesting question in Section 4 below.

3.2 Dissecting innovation: quantity versus quality of innovation following a bankruptcy

The results discussed in the previous section show how team-specific human capital and, in particular, the stability of teams during a corporate bankruptcy, affects the productivity of inventors. We have so far focused on the number of citations received by patents filed in a given year as the main outcome variable. We believe that this variable is an informative proxy for the innovation output generated by an inventor. However, this measure captures both aspects related to the importance and quality of innovation, as well as the quantity of patents produced.[11] It is possible, however, that a bankruptcy event affects the quality and quantity of subsequent innovation activity in different ways. For example, inventors may continue to produce patents (perhaps even at a higher rate than before the bankruptcy), but these patents may turn out to be less cited, that is, economically less valuable, when team-specific human capital is lost due to the bankruptcy.

In this section, we examine whether bankruptcy affects the quantity and quality of innovation produced by inventors in different ways. That is, after the bankruptcy, do inventors produce fewer patents, less influential patents, or a mixture of both? To answer this question, we employ the same regression specifications as in the previous section (corresponding to equation (1) above), but we consider a different set of dependent variables: *Ln(Patents)*, as a measure of the quantity of innovation output, and *Ln(Citations per patent)*, which measures the quality of patents produced.

In the tests reported in Table 3, we employ *Ln(Patents)* as the dependent variable. First, in column 1, we find that, on average, inventors do not experience any substantial change in their

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[11] For example, suppose that an inventor's output changes from one patent per year that receives two citations, to either three patents per year that each receive one citation, or, alternatively, one patent per year that receives three citations. Based on the measure *Ln(Citations)* employed in the regressions reported in Table 2, both of these cases would suggest an equivalent increase in innovation output.

ability to obtain patents in the years after bankruptcy relative to the years prior to bankruptcy: the coefficient associated with the variable *Treated* × *Post* is negative but statistically insignificant. In column 2, consistent with our results from Table 2, we find that the quantity of patents declines post-bankruptcy for those inventors that were part of an active innovation team at the bankrupt firm in the year leading up to bankruptcy. The regression reported in column 3 suggests that when teams of inventors move as a group to a new firm, the number of patents granted significantly increases. Finally, in column 4, we report coefficients from a specification that includes both our measure of team-specific human capital (*Bankruptcy Co-authorships*) and the proxy for team stability (*Stable Team Share*). In this specification, first, we find that an inventor that is employed at the bankrupt firm one year prior to bankruptcy and who co-authors all of her patents with other inventors in the bankrupt firm, produces fewer patents after the bankruptcy than an inventor that does not co-author patents with her colleagues at the bankrupt firm. The coefficient associated with this effect is, however, not statistically significant at conventional levels. Second, we find that—holding everything else constant—if all members of an inventor team jointly move to a new firm, the number of patents filed per year increase by about 30%.

In Table 4, we test whether team-specific human capital also impacts the quality of the patent output post-bankruptcy in addition to affecting the number of patents filed. To measure the quality of innovation, we employ the variable *Ln(Citations per patent)*. We find that the quality of patents produced by "treated" inventors deteriorates by about 4%, on average, following a bankruptcy event. The results reported in column 2 of Table 4 show that inventors that were more dependent on team production prior to the bankruptcy filing suffer the most, as they see the quality of their innovation deteriorate post-bankruptcy (relative to inventors that did not rely on co-authorships). In columns 3 and 4 of Table 4, we find that moving together has a positive effect on patent quality.

In sum, we find that inventors that rely to a larger extent on team production experience declines in both the quantity and the quality of innovation output after the bankruptcy. However, when team-specific human capital is preserved post-bankruptcy, inventor productivity increases, both with regard to number of patents as well as the number of citations per patent. Finally, we note that while the effects we document are directionally similar in Tables 3 and 4, the magnitudes of the relevant coefficients are larger in Table 4. This suggests that the effects on the quality of innovation output may be stronger than those observed on the quantity of the patents filed.

3.3 The impact of bankruptcies on the dollar value of patents

In the previous sections we focused on the number of patents and citations as measures of innovation productivity. While these are informative, they are imperfect proxies for the economic value of innovation. To better capture the impact of bankruptcies on the economic value of patents, we employ the variable *Ln(Dollar value of patents)* in the following tests. This measure is based on the stock market reaction to the announcement of new patent grants (see Section 2 for details).

First, in column 1 of Table 5, we document that inventors that were employed at the bankrupt firm in the year prior to the bankruptcy filing experience a 10% reduction in the value of their innovation output in their post-bankruptcy career. In column 2, we verify that this decline in productivity is attributable to team-dependence: the coefficient associated with the interaction *Post* × *Treated* becomes positive (but insignificant) when we include the interaction of *Post* × *Treated* with *Bankruptcy Co-authorships*. This implies that inventors that do not depend on team-production within the bankrupt firm do not experience a reduction in the value of their patents post-bankruptcy. On the other hand, the value of patents of team-dependent inventors declines significantly. In column 3, we test whether joint mobility of teams and the associated team-stability alleviate the negative effect on innovation that team-dependent inventors experience after the bankruptcy. Indeed, we observe that when the original team structure is maintained post-bankruptcy, the value of patents filed by affected inventors increases. Finally, in column 4, we include all previously discussed interactions in the regression specification. We find that inventors that exclusively patented with their peers at the bankrupt firm experience a 17% decline in the dollar value of innovation post bankruptcy. However, retaining team stability achieved by joint mobility increases the monetary value of innovation after the bankruptcy. In terms of magnitude, inventors that used to exclusively work with other inventors at the bankrupt firm and then co-locate with those team members after the bankruptcy experience a 14% net increase in the value of innovation (14% = - 4% - 17% + 35%).

3.4 Characteristics of patents following bankruptcy: original and general innovation

Corporate bankruptcies and the subsequent changes in the composition of inventor teams may affect not only the productivity of inventors (as measured by the number of patents) and the economic value of the innovation output (number of citations and dollar value of patents). These events may also affect the *type* of the innovation produced. Two measurable dimensions of innovation that may be affected by bankruptcies are the original and / or general nature of the innovation. Teamwork is also likely to matter for these dimensions of innovation: different team members may contribute a range of experiences and diverse knowledge—such as familiarity with different research fields—to the production of innovation, which, in turn, may affect the generality and originality of the patents produced. Therefore, bankruptcy and the associated shock to team composition may be a determining factor of the ability to create original and / or general patents.

In the regression specifications reported in Panel A of Table 6, we employ *Patent originality* as the dependent variable. While bankruptcy does not, on average, significantly affect the originality of patents subsequently filed by affected inventors (column 1), we find that inventors that depend more on teams subsequently produce innovation that is less original (column 2). The statistical and economic significance of the effects documented in column 2 are modest, however. Interestingly, we find that inventors whose team stays together post-bankruptcy experience a relative increase in the originality of their patents (columns 3 and 4). Our results are similar when we focus on patent generality. We report those tests in Panel B of Table 6. Although on average there is no significant decrease in patent generality post-bankruptcy, when teams that collaborated at the bankrupt firm move together to a new firm, there is an increase in the generality of innovation. In brief, the evidence in Table 6 suggests that when well-practiced teams move together to a new firm after the bankruptcy, the nature of innovation changes—the originality and generality of the patents produced increases.

3.5 Discussion and robustness

3.5.1 Star inventors

Firms that go bankrupt may employ inventors that are in many ways different from inventors in firms that do not experience a bankruptcy. In fact, it could be that the main reason why firms in our sample file for bankruptcy is the low quality and quantity of innovation produced by their employees. If, for example, inventors in firms that become bankrupt are of worse quality than inventors in firms that are not financially distressed, then what we are interpreting as a "bankruptcy effect" should instead be attributed to selection. There are several reasons why this is unlikely to be driving our results. First, our regressions reported in Tables 2—6 include inventor fixed effects, which control for any time-invariant unobservable characteristics of inventors, including differences in ability of inventors employed by different firms. Second, we also include industry-year fixed effects to account for the possibility that the value of inventor skills varies across industries and time. This implies that we are not simply capturing the effect of an industry in decline, which may be associated with a reduction in innovation productivity that would occur independently of bankruptcy events. Finally, firm fixed effects in our regressions alleviate concerns that firms that go bankrupt and those that do not are fundamentally different from each other, and that these differences are driving our results.

To further address the concern related to the non-random assignment of different types of inventors to firms that become bankrupt and firms that do not, in Table 7, we repeat the analysis from Table 2, but we focus exclusively on what we call "star inventors." We define such inventors as those that belong to the top decile of inventors in terms of number of granted patents in our sample.[12] If bankrupt firms employing low quality inventors drove some of the previously discussed effects, we would not expect our results to hold when we restrict the sample to the set of the most productive inventors in the U.S. economy. On the other hand, if our results apply equally to all inventors (including star inventors), then we are more likely capturing a general "bankruptcy effect" rather than an effect attributable to heterogeneity in inventor quality.

The results in Table 7, focusing on the sub-sample of star inventors, confirm our findings from earlier tests: star inventors that have co-authored a large share of their patent portfolio with other inventors from the bankrupt firm experience a significant decrease in their innovation productivity post-bankruptcy. On the other hand, when the entire team moves jointly to a new firm, the post-bankruptcy innovation output increases relative to the years prior to the bankruptcy.

3.5.2 Sample focusing exclusively on inventors experiencing a bankruptcy event

To further alleviate concerns that firms that go bankrupt and the inventors that work at these firms are fundamentally different from the set of "control" firms that we compare them to, we perform an additional variation on our empirical analysis: we create a sample that only consists of "treated" inventors. Because bankruptcies occur in most of the sample years, we can use inventors of firms that have not gone bankrupt *yet* as a control group for firms that are currently filing for bankruptcy (e.g., Bertrand and Mullainathan 2003). In the sense that all inventors in this sample will at some point experience a bankruptcy event, we are comparing similar firms and inventors to each other. We report results based on this alternative sample in Table 8. We find effects that are similar to our main results reported in Table 2, both in terms of statistical and economic significance. The regressions reported in Table 8 also render it less likely that our findings are driven by unobserved differences in the characteristics of inventors between treatment and control firms. Instead, the bulk of our evidence suggests that team-specific human capital plays a crucial role for understanding the evolution of the productivity of inventors after bankruptcies.

3.5.3 Team-specific human capital versus firm-specific human capital

In the results discussed so far, we document the importance of team-specific human capital for the production of knowledge. We use corporate bankruptcies as a laboratory for our study for two reasons: first, bankruptcies are significant corporate events that have the potential to be important catalysts of the process of creative destruction in the economy; second, bankruptcies act as a shock to the structure of research and development teams. Because this shock affects not only team stability but also other aspects of the firm, one worry that arises is

[12] We note that "star inventors" are over-represented in the sample as they tend to have long careers.

that what we attribute to team-specific human capital may instead be driven by firm-specific human capital. That is, while a bankruptcy may indeed result in the breaking up of successful innovator teams, the reduction in inventor productivity post-bankruptcy may primarily stem from a loss of firm-specific human capital experienced by such inventors (such as the familiarity with firm-specific software or other complementarities between the inventor and the organization's assets). Moreover, because bankruptcies may lead to the dissolution of the firm, any organizational capital may also be lost around the time of the bankruptcy filing (e.g., Eisfeldt and Papanikolau 2013).

We believe that our tests effectively separate the impact of the bankruptcy-induced disruption to firm-specific human capital from the role played by team-specific human capital. The average effect on innovation attributable to firm-specific human capital and organizational capital is captured by the interaction term *Post × Treated* in our regressions. Furthermore, we note that firm-specific human capital or organizational capital that is shared by all inventors within the firm should not affect our team variables, *Bankruptcy Co-authorships* and *Stable Team Share*. With these team variables, we are measuring the differential effect of team dissolution on innovation that is incremental to the average effect of the bankruptcy-induced separation, which is captured by the interaction *Post × Treated*.

4. Labor mobility and inventor careers after a bankruptcy

4.1 Inventor career terminations in the shadow of bankruptcy

The results in the previous section conditioned on inventors continuing to innovate post-bankruptcy: an inventor is included in the sample only from the year of the first patent filing to the year of the last patent filed. Of course, after a bankruptcy, some inventors may cease patenting altogether, which our previous tests are unable to take into account. For example, if innovation productivity relies heavily on firm-specific human capital, a corporate bankruptcy may, in the extreme, lead inventors to terminate their innovation career. In addition, if valuable team-specific human capital is destroyed due to the bankruptcy, inventors that are more dependent on teams may be especially prone to leave the profession. We study these questions in this section.

We analyze whether inventors that were employed at a bankrupt firm in the year prior to its bankruptcy filing experience a reduction in the length of their careers as inventors. Our outcome variable is *Career end*, a dummy variable which takes the value of one in a given year if an inventor ceases to invent (i.e., stops filing patents) after that year. As before, we control for a host of firm characteristics, as well as industry-year fixed effects in our regressions.[13] Further, we include fixed effects for the number of years that an inventor has been active to account for the fact that older inventors may be more likely to stop inventing than young inventors. In these regressions, in the case of inventors in the "treatment" group, we consider only observations for the bankruptcy filing year and thereafter: by construction, inventors that worked at a bankrupt firm in the year prior to its bankruptcy filing could not have ended their career before that.

Figures 6 and 7 depict the evolution of the likelihood that an inventor career ends after bankruptcy. First, Figure 6 shows that, on average, treated inventors do not experience a statistically significant change in the probability of ending their careers in the years that follow the bankruptcy filing. In Figure 7, we present the differential effect of bankruptcies on the likelihood of inventor careers ending depending on the inventors' reliance on teamwork in the firms experiencing bankruptcy. We find that in the years after the bankruptcy filing, team-dependent inventors are more likely to stop patenting compared to inventors that rely less on team production. This effect tapers off three years following the bankruptcy event.

In Table 9, we study the likelihood of inventors ceasing to innovate in a regression setting.[14] In column 1, we find that on average, inventors exposed to bankruptcy are about 1.3% more likely to end their career after the bankruptcy filing than the average inventor with similar characteristics working at similar firms (this effect is statistically significant at the 10% level). In column 2, we test whether inventors that are more dependent on team production are more likely to experience a career end. Indeed, our estimates suggest that inventors who produced most of their patents with other inventors at the bankrupt firm are more likely to exit the profession, following the bankruptcy. In terms of magnitude, going from zero to 100 percent co-authorships within the financially distressed firm is associated with a 2.3 percent increase in the probability of an inventor's career end post-bankruptcy. Consistent with the pattern observed in Figure 7, the impact of team-specific human capital on the post-bankruptcy exit probability becomes slightly stronger when we focus on the years immediately following the bankruptcy event (see column 3 of Table 9). Specifically, excluding observations from treated inventors more than six years after the bankruptcy filing, we find a 3% increase in the probability that team-

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[13] In these specifications, we do not control for inventor fixed effects because such variables would absorb the cross-sectional variation we are interested in, and we would instead capture a within-inventor *time-series* effect. In addition, we do not include firm fixed effects in these specifications, because we want to capture whether being at a bankrupt firm increases the probability of a career end; firm fixed effects would absorb this type of variation of interest.

[14] We implement these tests using linear regressions. An alternative would be to employ probit or logit models. While our results are robust to using these non-linear models, we do not report those specifications for the sake of brevity.

dependent "treated" inventors stop innovating, relative to "treated" inventors that are used to innovating independently.[15]

Overall, the findings in this section confirm the importance of team-specific human capital for the post-bankruptcy careers of inventors: the share of patents co-authored with other inventors at the bankrupt firm positively affects the probability that the inventor career ends post-bankruptcy.

4.2 Are well-established inventor teams more likely to co-locate post bankruptcy?

One question that arises in light of the role played by team-specific human capital for the post-bankruptcy productivity of inventors is whether the labor market recognizes the value of this type of human capital in the sense that, on average, productive team configurations are retained post-bankruptcy. Because inventor productivity is enhanced in the cases of joint mobility (see column 4 in Tables 2—6), one may expect the labor market to attempt to preserve the valuable team-specific human capital and hire inventors as groups, instead of individually.

To shed light on this question, we proceed as follows. First, for each bankruptcy event, we create all possible pairs of inventors that are employed by the firm one year prior to bankruptcy, and that remain active post-bankruptcy. For example, a firm with four inventors has six possible inventor pairs. We then construct the variable *Pair Co-dependence*, a pairwise measure of the team-specific human capital, by calculating the share of patents of the pair that is co-authored by its constituent members up to the year prior to the bankruptcy. We use this measure to test whether inventors that work closely together in the firm pre-bankruptcy are more likely to move together to a new employer post-bankruptcy. In this test, each inventor pair enters the sample once and the dependent variable of interest, *Move Together*, is an indicator that takes the value of one if the firm to which the two inventors move after the bankruptcy is the same for both inventors in the pair.

Results are presented in Table 10.[16] Column 1 reports the coefficients from a regression specification without any controls, while the specification reproduced in column 2 includes fixed effects for each bankrupt firm. Consistent with the conjecture that the labor market recognizes the importance of team-specific human capital, we find that in cases where co-authorships are important, inventors are indeed more likely to move together to the same firm after the bankruptcy. In terms of magnitude, the coefficient reported in column 2 implies that an inventor pair that has produced all patents together pre-bankruptcy is almost 25% more likely to co-locate than a pair that has no co-authored patents, and for whom separation is likely to have

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[15] In this part of the analysis we do not perform tests with the variable *Stable Team Share*, as by construction, an inventor's movement to a new firm can only be observed if the inventor remains active.

[16] As in Table 9, the reported results reflect estimates from linear regressions. We obtain similar results using non-linear models (such as logit).

a small or inexistent impact on productivity (according to our previous analysis reported in Tables 2—9).

5. Conclusion

Innovation is a crucial engine for economic growth and prosperity. Creative destruction is commonly perceived as a key mechanism through which innovation occurs. This makes corporate bankruptcies and the associated flow of resources from failing businesses to growing firms an important area of inquiry.

In this paper, we analyze the impact of corporate bankruptcies on innovation by tracking the careers and productivity of inventors employed by firms that file for bankruptcy. Innovation is typically a collaborative effort; we therefore take into consideration the role of team-specific human capital when assessing changes in inventor productivity post-bankruptcy. We find that team stability (or lack thereof) is a crucial factor in determining whether there is more knowledge creation than destruction when human capital is reallocated post-bankruptcy. When teams are dissolved and inventors that had previously worked together go their separate ways, innovation decreases. This effect is partly mitigated when inventors that have active working relations move together to a new firm post bankruptcy. In fact, we provide evidence that full preservation of team-specific human capital through joint mobility of the whole inventor team leads to a subsequent increase in inventor productivity. The labor market for inventors takes the importance of teams into account: inventors with strong complementarities (as measured by their past joint output) are more likely to be hired together.

Our findings provide micro-level evidence of the process of creative destruction in a setting that focusses on the productivity and careers of individual inventors. Our results also highlight the importance of team-specific human capital for the production of knowledge in the economy and suggest that an efficient bankruptcy procedure that aims to maintain an environment that is conducive to innovation should consider the impact that bankruptcies have on team stability.

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Table 1: Summary Statistics

This table presents summary statistics, separately for treatment group (inventors that experience a corporate bankruptcy) and control group (inventors that are not associated with a corporate bankruptcy during the sample period). Panel A reports summary statistics for the sample of individual inventors, while Panel B presents summary statistics for the time-invariant team-specific human capital variables of inventors that belong to the treatment group. In Panel A, *Ln(Citations)* is defined as the natural logarithm of one plus the total number of citations (until 2006) obtained on all patents that the inventor files in a given year; *Ln(Patents)* is the natural logarithm of one plus the sum of patents applied for (and ultimately granted) by a given inventor in a given year; *Ln(Citations per patent)* is the natural logarithm of one plus the average number of citations per patent for all patents that a given inventor applies for in a given year; *Ln(Dollar value of patents)* is the natural logarithm of one plus the cumulative dollar value of patents (in millions of nominal U.S. dollars) that an inventor applies for in a given year (Kogan, Papanikolaou, Seru, and Stoffman, 2017); *Patent originality* is the average originality index of patents filed by an inventor in a given year, while *Patent generality* is the average generality index of these patents (see Hall, Jaffe, and Trajtenberg 2001 for the construction of these indices). *Experience* is the number of years between the current year and the year of the first patent filing by a given inventor. *Firm Size* is the natural logarithm of total assets; *ROA* is net income divided by total assets; *R&D Intensity* is expenditures on research and development divided by total assets; *Cash Ratio* is cash and short term investments divided by total assets; *Leverage* is the sum of short and long term debt divided by total assets. In Panel B, *Bankruptcy Co-authorships* measures the total share of an inventor's patents that are co-authored with other inventors that were also at the bankrupt firm in the year before bankruptcy; *Stable Team Share* measures the stability of innovation teams post-bankruptcy; *Pair Co-dependence* is the share of patents that each possible pair of "treated" inventors has co-authored until bankruptcy; finally, *Move Together* is a dummy variable that takes the value of one if the two inventors in the pair move to the same new firm after bankruptcy. The sample spans the period 1980 to 2004. The sample construction and variables are described in detail in Section 2 of the paper.

Panel A: Full inventor-level sample

	Control			Treatment		
Variable	Obs.	Mean	SD	Obs.	Mean	SD
Ln(Citations)	2,421,657	0.79	1.341	36,438	0.761	1.283
Ln(Patents)	2,421,657	0.32	0.49	36,438	0.339	0.506
Ln(Citations per patent)	2,421,657	0.691	1.176	36,438	0.647	1.092
Ln(Dollar value of patents)	2,421,657	0.786	1.366	36,438	0.519	1.062
Patent originality	2,421,657	0.172	0.307	36,438	0.188	0.32
Patent generality	2,421,657	0.143	0.29	36,438	0.156	0.306
Experience	2,421,657	6.818	5.675	36,438	8.776	6.437
Firm Size	2,421,657	9.093	1.809	36,438	8.509	1.801
ROA	2,421,657	0.046	0.087	36,438	-0.011	0.128
R&D Intensity	2,421,657	0.059	0.049	36,438	0.044	0.040
Cash Ratio	2,421,657	0.101	0.116	36,438	0.067	0.075
Leverage	2,421,657	0.231	0.140	36,438	0.264	0.167

Panel B: Team-specific human capital of treated inventors post bankruptcy

Variable	Obs.	Mean	SD
Bankruptcy Co-authorships	3,639	0.678	0.382
Stable Team Share	3,639	0.104	0.195
Pair Co-dependence	2,155	0.138	0.109
Move together	2,155	0.172	0.378

Table 2: The impact of corporate bankruptcies on the productivity of inventors

This table examines the impact of corporate bankruptcies on inventor-level innovation output. We report coefficients from estimating the following OLS regression:

$$Ln(Citations)_{it} = \alpha + \beta_1 \cdot Treated_i \times Post_{it} + \beta_2 \cdot Treated_i + X'_{it}\gamma + \epsilon_{it}$$

where *Ln(Citations)* is the natural logarithm of one plus the number of forward citations of all patents filed in year t by inventor i; *Treated* is a dummy variable that takes the value of one if inventor i is part of the treatment group, and zero otherwise. *Post* is an indicator variable that takes the value of one in the years after bankruptcy, and zero in the years prior to bankruptcy; it always takes the value of zero for inventors that are part of the control group. In columns 2 and 4 we add to the specification the interaction *Post* × *Treated* × *Bankruptcy Co-authorships*, and in columns 3 and 4 we include the interaction *Post* × *Treated* × *Stable Team Share*. The matrix of controls X includes inventor fixed effects, firm fixed effects, industry × year fixed effects, fixed effects for years of inventor experience, *Firm Size*, *ROA*, *R&D Intensity*, *Cash Ratio* and *Leverage*. All variables and the sample construction are detailed in Section 2 of the paper. The t-statistics in parentheses are calculated based on standard errors clustered at the firm level. Statistical significance at 1%, 5% and 10% is market with ***, ** and * respectively.

	Ln(Citations)			
	(1)	(2)	(3)	(4)
Post × Treated	-0.047	0.071	-0.128***	-0.028
	(-1.6)	(1.5)	(-4.5)	(-0.4)
Post × Treated × Bankruptcy Co-authorships		-0.200***		-0.160**
		(-2.9)		(-2.0)
Post × Treated × Stable Team Share			0.666***	0.619***
			(5.4)	(4.7)
Firm Size	0.115***	0.115***	0.115***	0.115***
	(7.4)	(7.4)	(7.4)	(7.4)
ROA	0.058	0.058	0.058	0.058
	(1.2)	(1.2)	(1.2)	(1.2)
R&D Intensity	0.536***	0.536***	0.535***	0.535***
	(3.4)	(3.4)	(3.4)	(3.4)
Cash Ratio	-0.016	-0.016	-0.016	-0.016
	(-0.3)	(-0.3)	(-0.3)	(-0.3)
Leverage	-0.083*	-0.084*	-0.084*	-0.084*
	(-1.8)	(-1.8)	(-1.8)	(-1.8)
Inventor F.E.	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y
Industry × Year F.E.	Y	Y	Y	Y
Years of experience F.E.	Y	Y	Y	Y
Adjusted R^2	0.341	0.341	0.341	0.341
Observations	2,458,095	2,458,095	2,458,095	2,458,095

Table 3: The impact of corporate bankruptcies on the number of patents filed

This table examines the impact of corporate bankruptcies on the quantity of innovation produced by individual inventors. We report coefficients from estimating the following OLS regression model:

$$Ln(Patents)_{it} = \alpha + \beta_1 \cdot Treated_i \times Post_{it} + \beta_2 \cdot Treated_i + X'_{it}\gamma + \epsilon_{it}$$

where *Ln(Patents)* is the natural logarithm of one plus the number of new patents filed in year t by inventor i. *Treated* is a dummy variable that takes the value of one if inventor i is part of the treatment group, and zero otherwise; *Post* is an indicator variable that takes the value of one in the years after bankruptcy, and zero in the years prior to bankruptcy; it always takes the value of zero for inventors that are part of the control group. In columns 2 and 4 we add to the specification the interaction *Post × Treated × Bankruptcy Co-authorships*, and in columns 3 and 4 we also include the interaction *Post × Treated × Stable Team Share*. The matrix of controls X includes inventor fixed effects, firm fixed effects, industry × year fixed effects, fixed effects for years of inventor experience, *Firm Size*, *ROA*, *R&D Intensity*, *Cash Ratio* and *Leverage*. All variables and the sample construction are detailed in Section 2 of the paper. The t-statistics in parentheses are calculated based on standard errors clustered at the firm level. Statistical significance at 1%, 5% and 10% is market with ***, ** and * respectively.

	Ln(Patents)			
	(1)	(2)	(3)	(4)
Post × Treated	-0.006	0.031	-0.047***	-0.021
	(-0.6)	(1.6)	(-2.8)	(-0.7)
Post × Treated × Bankruptcy Co-authorships		-0.063***		-0.042
		(-2.6)		(-1.5)
Post × Treated × Stable Team Share			0.336***	0.324***
			(4.8)	(4.5)
Firm Size	0.046***	0.046***	0.046***	0.046***
	(5.5)	(5.5)	(5.5)	(5.5)
ROA	0.017	0.017	0.017	0.017
	(0.6)	(0.6)	(0.6)	(0.6)
R&D Intensity	0.208**	0.208**	0.207**	0.207**
	(2.5)	(2.5)	(2.5)	(2.5)
Cash Ratio	-0.038	-0.038	-0.038	-0.038
	(-1.4)	(-1.4)	(-1.4)	(-1.4)
Leverage	-0.058**	-0.058**	-0.058**	-0.058**
	(-2.4)	(-2.4)	(-2.4)	(-2.4)
Inventor F.E.	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y
Industry × Year F.E.	Y	Y	Y	Y
Years of experience F.E.	Y	Y	Y	Y
Adjusted R^2	0.373	0.373	0.373	0.374
Observations	2,458,095	2,458,095	2,458,095	2,458,095

Table 4: The impact of corporate bankruptcies on the number of citations per patent

This table examines the impact of corporate bankruptcies on the inventor-level quality of innovation. We report coefficients from estimating the following OLS regression:

$$\textit{Ln(Citations per patent)}_{it} = \alpha + \beta_1 \cdot \textit{Treated}_i \times \textit{Post}_{it} + \beta_2 \cdot \textit{Treated}_i + X_{it}'\gamma + \epsilon_{it}$$

where *Ln(Citations per Patent)* is the natural logarithm of one plus the average number of citations per new patent filed in year t by inventor i. *Treated* is a dummy variable that takes the value of one if inventor i is part of the treatment group, and zero otherwise; *Post* is an indicator variable that takes the value of one in the years post bankruptcy, and zero in the years prior to bankruptcy; it always takes the value of zero for inventors that are part of the control group. In columns 2 and 4 we add to the specification the interaction *Post* × *Treated* × *Bankruptcy Co-authorships*, and in columns 3 and 4 we also include the interaction *Post* × *Treated* × *Stable Team Share*. The matrix of controls X includes inventor fixed effects, firm fixed effects, industry × year fixed effects, fixed effects for years of inventor experience, *Firm Size*, *ROA*, *R&D Intensity*, *Cash Ratio* and *Leverage*. All variables and sample construction are detailed in Section 2 of the paper. The t-statistics in parentheses are calculated based on standard errors clustered at the firm level. Statistical significance at 1%, 5% and 10% is market with ***, ** and * respectively.

	Ln(Citations per patent)			
	(1)	(2)	(3)	(4)
Post × Treated	-0.039*	0.054	-0.100***	-0.020
	(-1.8)	(1.3)	(-4.5)	(-0.4)
Post × Treated × Bankruptcy Co-authorships		-0.158***		-0.128*
		(-2.6)		(-1.9)
Post × Treated × Stable Team Share			0.499***	0.462***
			(5.1)	(4.4)
Firm Size	0.085***	0.085***	0.085***	0.085***
	(7.9)	(7.9)	(7.9)	(7.9)
ROA	0.043	0.043	0.042	0.042
	(1.3)	(1.3)	(1.3)	(1.3)
R&D Intensity	0.385***	0.385***	0.384***	0.384***
	(3.2)	(3.2)	(3.2)	(3.2)
Cash Ratio	0.006	0.005	0.005	0.005
	(0.2)	(0.2)	(0.1)	(0.1)
Leverage	-0.047	-0.047	-0.048	-0.048
	(-1.4)	(-1.4)	(-1.4)	(-1.4)
Inventor F.E.	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y
Industry × Year F.E.	Y	Y	Y	Y
Years of experience F.E.	Y	Y	Y	Y
Adjusted R^2	0.341	0.341	0.341	0.341
Observations	2,458,095	2,458,095	2,458,095	2,458,095

Table 5: The impact of corporate bankruptcies on the dollar value of patents

This table examines the impact of corporate bankruptcies on the dollar value of patents produced by inventors. We report coefficients from estimating the following OLS regression:

$$\textit{Ln(Dollar value of patents)}_{it} = \alpha + \beta_1 \cdot \textit{Treated}_i \times \textit{Post}_{it} + \beta_2 \cdot \textit{Treated}_i + X'_{it}\gamma + \epsilon_{it}$$

where *Ln(Dollar value of patents)* is the natural logarithm of one plus the cumulative dollar value of patents (in millions of nominal U.S. dollars) that an inventor applies for in a given year (Kogan, Papanikolaou, Seru, and Stoffman, 2017). *Treated* is a dummy variable that takes the value of one if inventor i is part of the treatment group, and zero otherwise; *Post* is an indicator variable that takes the value of one in the years post bankruptcy, and zero in the years prior to bankruptcy; it always takes the value of zero for inventors that are part of the control group. In columns 2 and 4 we add to the specification the interaction *Post* × *Treated* × *Bankruptcy Co-authorships*, and in columns 3 and 4 we also include the interaction *Post* × *Treated* × *Stable Team Share*. The matrix of controls X includes inventor fixed effects, firm fixed effects, industry × year fixed effects, fixed effects for years of inventor experience, *Firm Size*, *ROA*, *R&D Intensity*, *Cash Ratio* and *Leverage*. All variables and sample construction are detailed in Section 2 of the paper. The t-statistics in parentheses are calculated based on standard errors clustered at the firm level. Statistical significance at 1%, 5% and 10% is market with ***, ** and * respectively.

	Ln(Dollar value of patents)			
	(1)	(2)	(3)	(4)
Post × Treated	-0.100**	0.016	-0.149***	-0.040
	(-2.2)	(0.3)	(-3.3)	(-0.6)
Post × Treated × Bankruptcy Co-authorships		-0.197***		-0.174**
		(-2.9)		(-2.3)
Post × Treated × Stable Team Share			0.401***	0.350***
			(3.6)	(3.0)
Firm Size	0.214***	0.215***	0.215***	0.215***
	(9.3)	(9.3)	(9.3)	(9.3)
ROA	0.307***	0.307***	0.307***	0.307***
	(4.3)	(4.3)	(4.3)	(4.3)
R&D Intensity	1.255***	1.255***	1.254***	1.254***
	(4.3)	(4.3)	(4.3)	(4.3)
Cash Ratio	0.174**	0.174**	0.174**	0.174**
	(2.0)	(2.0)	(2.0)	(2.0)
Leverage	-0.161**	-0.161**	-0.161**	-0.161**
	(-2.5)	(-2.5)	(-2.5)	(-2.5)
Inventor F.E.	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y
Industry × Year F.E.	Y	Y	Y	Y
Years of experience F.E.	Y	Y	Y	Y
Adjusted R^2	0.344	0.344	0.344	0.344
Observations	2,458,095	2,458,095	2,458,095	2,458,095

Table 6: The impact of corporate bankruptcies on the originality and generality of patents

This table examines the impact of corporate bankruptcies on the originality (Panel A) and generality (Panel B) of inventor-level innovation output. We report coefficients from estimating the following OLS regression:

$$Y_{it} = \alpha + \beta_1 \cdot \mathit{Treated}_i \times \mathit{Post}_{it} + \beta_2 \cdot \mathit{Treated}_i + X'_{it}\gamma + \epsilon_{it}$$

where Y is *Patent originality* in Panel A and *Patent generality* in Panel B. *Patent originality* is the average originality index of the new patents filed in year t by inventor i; *Patent generality* is the average generality index of those patents (see Hall, Jaffe, and Trajtenberg 2001 for the construction of the originality and generality indices). *Treated* is a dummy variable that takes the value of one if inventor i is part of the treatment group, and zero otherwise; *Post* is an indicator variable that takes the value of one in the years post bankruptcy, and zero in the years prior to bankruptcy; it always takes the value of zero for inventors that are part of the control group. In columns 2 and 4 we add to the specification the interaction *Post* × *Treated* × *Bankruptcy Co-authorships*, and in columns 3 and 4 we also include the interaction *Post* × *Treated* × *Stable Team Share*. The matrix of controls X includes inventor fixed effects, firm fixed effects, industry × year fixed effects, fixed effects for years of inventor experience, *Firm Size*, *ROA*, *R&D Intensity*, *Cash Ratio* and *Leverage*. All variables and sample construction are detailed in Section 2 of the paper. The t-statistics in parentheses are calculated based on standard errors clustered at the firm level. Statistical significance at 1%, 5% and 10% is market with ***, ** and * respectively.

Panel A: The impact of bankruptcies on the originality of innovation

	Patent originality			
	(1)	(2)	(3)	(4)
Post × Treated	0.003	0.020	-0.016	-0.005
	(0.3)	(1.4)	(-1.4)	(-0.3)
Post × Treated × Bankruptcy Co-authorships		-0.029*		-0.019
		(-1.7)		(-1.2)
Post × Treated × Stable Team Share			0.156***	0.151***
			(3.3)	(3.3)
Inventor F.E. and Years of experience F.E.	Y	Y	Y	Y
Firm F.E. and Industry × Year F.E.	Y	Y	Y	Y
Controls	Y	Y	Y	Y
Adjusted R^2	0.275	0.275	0.275	0.275
Observations	2,458,095	2,458,095	2,458,095	2,458,095

Panel B: The impact of bankruptcies on the generality of innovation

	Patent generality			
	(1)	(2)	(3)	(4)
Post × Treated	-0.010	0.006	-0.023***	-0.010
	(-1.3)	(0.6)	(-2.8)	(-1.0)
Post × Treated × Bankruptcy Co-authorships		-0.026		-0.020
		(-1.6)		(-1.1)
Post × Treated × Stable Team Share			0.105***	0.099***
			(3.9)	(3.6)
Inventor F.E. and Years of experience F.E.	Y	Y	Y	Y
Firm F.E. and Industry × Year F.E.	Y	Y	Y	Y
Controls	Y	Y	Y	Y
Adjusted R^2	0.251	0.251	0.251	0.251
Observations	2,458,095	2,458,095	2,458,095	2,458,095

Table 7: The impact of corporate bankruptcies on the productivity of 'star' inventors

This table examines the impact of corporate bankruptcies on inventor-level innovation output. We restrict the sample to "star inventors," which we define as those that are in the top 10% of inventors in terms of number of filed patents in our sample. We report coefficients from estimating the following OLS regression:

$$Ln(Citations)_{it} = \alpha + \beta_1 \cdot Treated_i \times Post_{it} + \beta_2 \cdot Treated_i + X'_{it}\gamma + \epsilon_{it}$$

where *Ln(Citations)* is the natural logarithm of one plus the number of forward citations of all new patents filed in year t by inventor i. *Treated* is a dummy variable that takes the value of one if inventor i is part of the treatment group, and zero otherwise; *Post* is an indicator variable that takes the value of one in the years post bankruptcy, and zero in the years prior to bankruptcy; it always takes the value of zero for inventors that are part of the control group. In columns 2 and 4 we add to the specification the interaction *Post* × *Treated* × *Bankruptcy Co-authorships*, and in columns 3 and 4 we include the interaction *Post* × *Treated* × *Stable Team Share*. The matrix of controls X includes inventor fixed effects, firm fixed effects, industry × year fixed effects, fixed effects for years of inventor experience, *Firm Size*, *ROA*, *R&D Intensity*, *Cash Ratio* and *Leverage*. All variables and sample construction are detailed in Section 2 of the paper. The t-statistics in parentheses are calculated based on standard errors clustered at the firm level. Statistical significance at 1%, 5% and 10% is market with ***, ** and * respectively.

	Ln(Citations)			
	(1)	(2)	(3)	(4)
Post × Treated	-0.071	0.117*	-0.196***	-0.036
	(-1.4)	(1.8)	(-4.4)	(-0.4)
Post × Treated × Bankruptcy Co-authorships		-0.329***		-0.257**
		(-3.1)		(-2.0)
Post × Treated × Stable Team Share			0.707***	0.632***
			(4.9)	(3.9)
Firm Size	0.153***	0.153***	0.153***	0.153***
	(6.7)	(6.7)	(6.7)	(6.7)
ROA	0.110	0.110	0.109	0.109
	(1.2)	(1.2)	(1.2)	(1.2)
R&D Intensity	0.664**	0.662**	0.661**	0.660**
	(2.5)	(2.5)	(2.5)	(2.5)
Cash Ratio	-0.058	-0.059	-0.059	-0.059
	(-0.7)	(-0.7)	(-0.7)	(-0.7)
Leverage	-0.164*	-0.164*	-0.164*	-0.164*
	(-1.9)	(-1.9)	(-1.9)	(-1.9)
Inventor F.E.	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y
Industry × Year F.E.	Y	Y	Y	Y
Years of experience F.E.	Y	Y	Y	Y
Adjusted R^2	0.287	0.287	0.287	0.287
Observations	813,484	813,484	813,484	813,484

Table 8: The impact of corporate bankruptcies on the productivity of inventors: sub-sample of "eventually treated" inventors

This table examines the impact of corporate bankruptcies on inventor-level innovation output. The sample includes only inventors that are eventually treated, that is, only inventors that are associated with a bankrupt firm in the year prior to a bankruptcy. We report coefficients from estimating the following OLS regression:

$$Ln(Citations)_{it} = \alpha + \beta_1 \cdot Treated_i \times Post_{it} + \beta_2 \cdot Treated_i + X_{it}'\gamma + \epsilon_{it}$$

where *Ln(Citations)* is the number of forward citations of all new patents filed in year t by inventor i, and *Treated* is a dummy variable that takes the value of one if inventor i is part of the treatment group (inventors that were associated with a bankrupt firm at t-1 relative to the bankruptcy filing date), and zero otherwise. *Post* is an indicator variable that takes the value of one in the years post bankruptcy, and zero in the years prior to bankruptcy. In columns 2 and 4 we add to the specification the interaction *Post* × *Treated* × *Bankruptcy Co-authorships*, and in columns 3 and 4 we also include the interaction *Post* × *Treated* × *Stable Team Share*. The matrix of controls X includes inventor fixed effects, firm fixed effects, industry × year fixed effects, fixed effects for years of inventor experience, *Firm Size*, *ROA*, *R&D Intensity*, *Cash Ratio* and *Leverage*. All variables and sample construction are detailed in Section 2 of the paper. The t-statistics in parentheses are calculated based on standard errors clustered at the firm level. Statistical significance at 1%, 5% and 10% is market with ***, ** and * respectively.

	Ln(Citations)			
	(1)	(2)	(3)	(4)
Post × Treated	-0.019	0.120*	-0.118**	0.009
	(-0.4)	(1.7)	(-2.5)	(0.1)
Post × Treated × Bankruptcy Co-authorships		-0.253***		-0.219**
		(-3.0)		(-2.4)
Post × Treated × Stable Team Share			0.757***	0.704***
			(5.8)	(4.9)
Firm Size	0.178***	0.183***	0.181***	0.184***
	(4.3)	(4.3)	(4.3)	(4.3)
ROA	0.282***	0.278***	0.273***	0.270***
	(3.0)	(3.0)	(3.0)	(2.9)
R&D Intensity	0.983	0.958	0.961	0.941
	(1.4)	(1.4)	(1.4)	(1.4)
Cash Ratio	-0.395	-0.403	-0.390	-0.398
	(-1.5)	(-1.5)	(-1.5)	(-1.5)
Leverage	-0.148	-0.159	-0.165	-0.173
	(-1.0)	(-1.1)	(-1.1)	(-1.1)
Inventor F.E.	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y
Industry × Year F.E.	Y	Y	Y	Y
Years of experience F.E.	Y	Y	Y	Y
Adjusted R^2	0.305	0.306	0.307	0.307
Observations	36,317	36,317	36,317	36,317

Table 9: The impact of corporate bankruptcies on the likelihood of an inventor's career ending

The regressions reported in this table examine how bankruptcy and team-specific human capital affect the likelihood that an inventor ceases to patent. We report coefficients from estimating the following OLS regression:

$$\textit{Career end}_{it} = \alpha + \beta_1 \cdot \textit{Treated}_i \times \textit{Post}_{it} + \beta_2 \cdot \textit{Treated}_i + X'_{it}\gamma + \epsilon_{it}$$

where *Career end* is a dummy variable that takes the value of one if year t is the last active year of inventor i, and zero otherwise. *Treated* is a dummy variable that takes the value of one if inventor i is part of the treatment group, and zero otherwise; *Post* is an indicator variable that takes the value of one in the years post bankruptcy, and zero in the years prior to bankruptcy; it always takes the value of zero for inventors that are part of the control group. In columns 2 and 3, we add to the specification the interaction *Post* × *Treated* × *Bankruptcy Co-authorships*. In column 3, we restrict the sample to only include the post periods up to 6 years after bankruptcy for treated inventors. The matrix of controls X includes industry × year fixed effects, fixed effects for years of inventor experience, *Firm Size*, *ROA*, *R&D Intensity*, *Cash Ratio* and *Leverage*. All variables and sample construction are detailed in Section 2 of the paper. In these regressions, in the case of inventors in the "treatment" group, we consider only observations for the bankruptcy filing year and thereafter: by construction, inventors that worked at a bankrupt firm in the year prior to its bankruptcy filing could not have ended their career before that. The t-statistics in parentheses are calculated based on standard errors clustered at the firm level. Statistical significance at 1%, 5% and 10% is market with ***, ** and * respectively.

	Career end		
	(1)	(2)	(3)
Post × Treated	0.013*	-0.001	-0.009
	(1.7)	(-0.2)	(-1.0)
Post × Treated × Bankruptcy Co-authorships		0.023**	0.030**
		(2.2)	(2.3)
Firm Size	0.001*	0.001*	0.001*
	(1.9)	(1.9)	(1.9)
ROA	-0.076***	-0.076***	-0.076***
	(-5.3)	(-5.3)	(-5.3)
R&D Intensity	-0.105***	-0.105***	-0.105***
	(-4.4)	(-4.4)	(-4.4)
Cash Ratio	-0.044***	-0.044***	-0.044***
	(-5.0)	(-5.0)	(-5.0)
Leverage	-0.012	-0.012	-0.012
	(-1.4)	(-1.4)	(-1.4)
Industry × Year F.E.	Y	Y	Y
Years of experience F.E.	Y	Y	Y
Adjusted R^2	0.207	0.207	0.207
Observations	2,431,047	2,431,047	2,429,242

Table 10: Team-specific human capital and joint mobility of inventors post bankruptcy

This table examines the impact of team-specific human capital on the probability of joint mobility of inventors after bankruptcy. For each bankruptcy event, we first create all possible pairs of inventors that were employed by the firm one year prior to bankruptcy. For example, a firm with four inventors has six possible inventor pairs. Each inventor pair enters the sample only once. We then estimate the following OLS regression model:

$$\textit{Move Together}_{ijf} = \alpha + \beta \cdot \textit{Pair Co-dependence}_{ijf} + B_f + \epsilon_{ij}$$

where *Move Together* is a dummy variable that takes the value of one if the two inventors in the pair move to the same new firm after bankruptcy. *Pair Co-dependence* is the share of patents of the inventors in the pair that is co-authored by its constituent members until bankruptcy. B_f denotes bankruptcy firm fixed effects, which we include in the specification corresponding to column 2. The t-statistics in parentheses are calculated based on heteroskedasticity-robust standard errors. Statistical significance at 1%, 5% and 10% is market with ***, ** and * respectively.

	Move Together	
	(1)	(2)
Pair Co-dependence	0.167**	0.245***
	(2.3)	(3.4)
Firm F.E.	N	Y
Adjusted R^2	0.00	0.31
Observations	2,155	2,155

Figure 1: Team production in corporate innovation over time

This figure shows the evolution of the average number of co-authors per patent between 1975 and 2005. The data are from the NBER Patent Dataset.

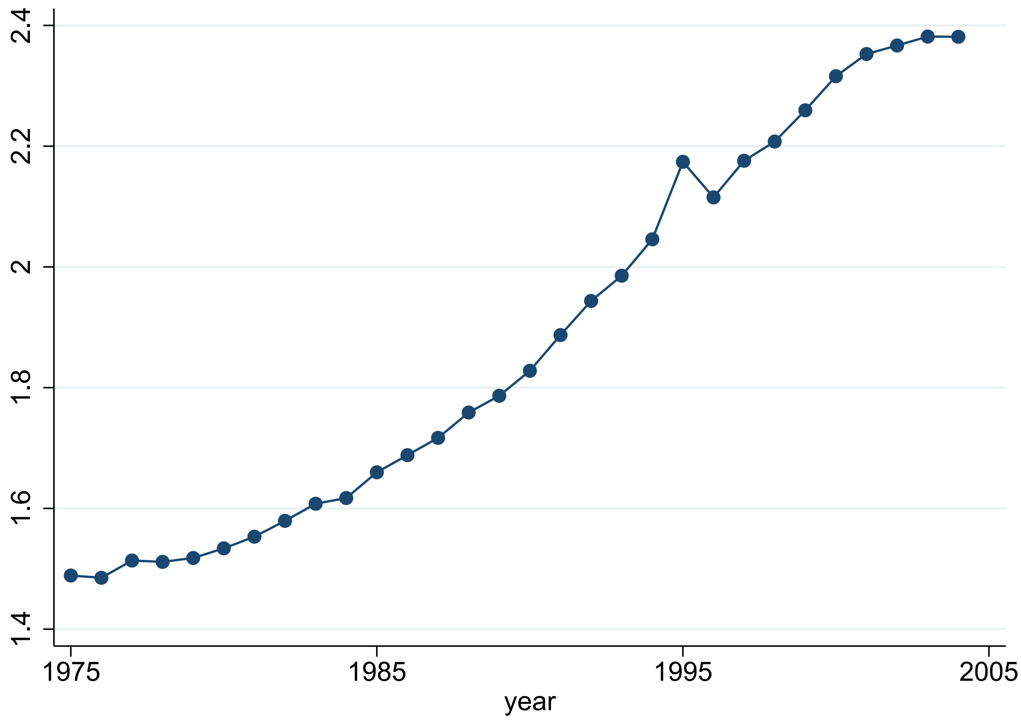

Figure 2: Corporate bankruptcies over time

This figure shows the distribution of corporate bankruptcies by year during the period of our sample (1980 to 2004). Information on bankruptcy filings is from the UCLA-LoPucki Bankruptcy Research Database.

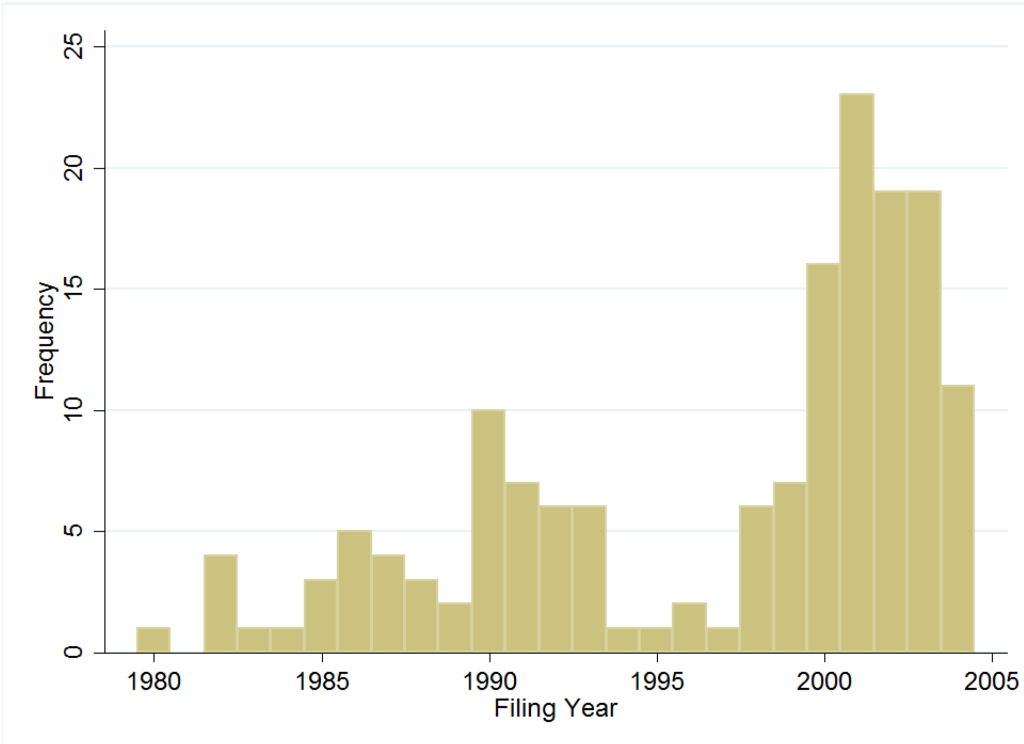

Figure 3: Corporate bankruptcies across industries

This figure shows the distribution of corporate bankruptcies by industry during the period of our sample (1980 to 2004). Information on bankruptcy filings is from the UCLA-LoPucki Bankruptcy Research Database.

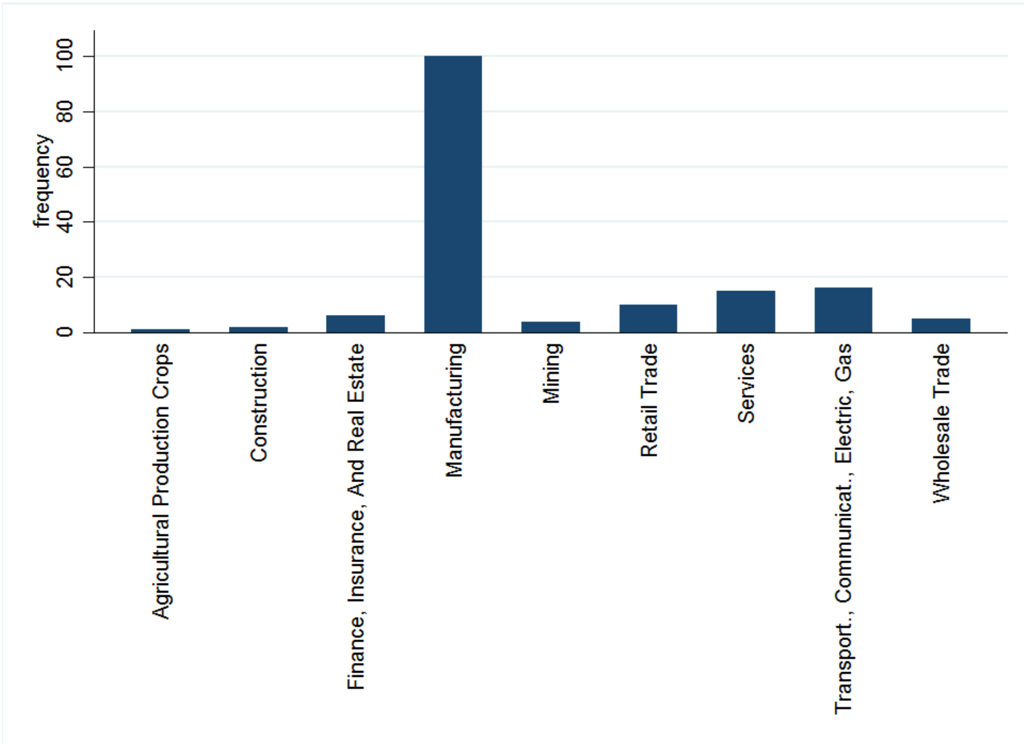

Figure 4: Team dissolution and innovation around corporate bankruptcies

This figure presents the impact of disruptions to team-specific human capital on the evolution of inventors' productivity around bankruptcy events. It shows the differential evolution of innovation (as measured by citations) for inventors with varying *Bankruptcy Co-authorships*. We first estimate the following OLS regression model:

$$Ln(Citations)_{it} = \alpha + \beta \cdot Treated_i \times T_{it} + \theta \cdot Treated_i \times Bankruptcy\ Co\text{-}authorships_i \times T_{it} + \delta \cdot Treated_i + X'_{it}\gamma + \epsilon_{it}$$

We then plot the coefficients θ associated with the interaction between *Treated* $\times$ *Bankruptcy Co-authorships* and the event-time dummies included in matrix T: we include dummies for the years t-5, t-4, t-3, t-2, t-1, 0 (bankruptcy year), t+1, t+2, t+3, t+4, and t+5 relative to the bankruptcy event. These event-time dummies always take the value of zero for firms that are part of the control group. We require firms to be present in the sample at time t-6 and exclude any observations after year t+5. The matrix of controls X includes inventor fixed effects, firm fixed effects, industry $\times$ year fixed effects, fixed effects for the number of active years of an inventor, *Firm Size*, *ROA*, *R&D Intensity*, *Cash Ratio* and *Leverage*. The 95% confidence bounds are calculated based on standard errors clustered at the firm level.

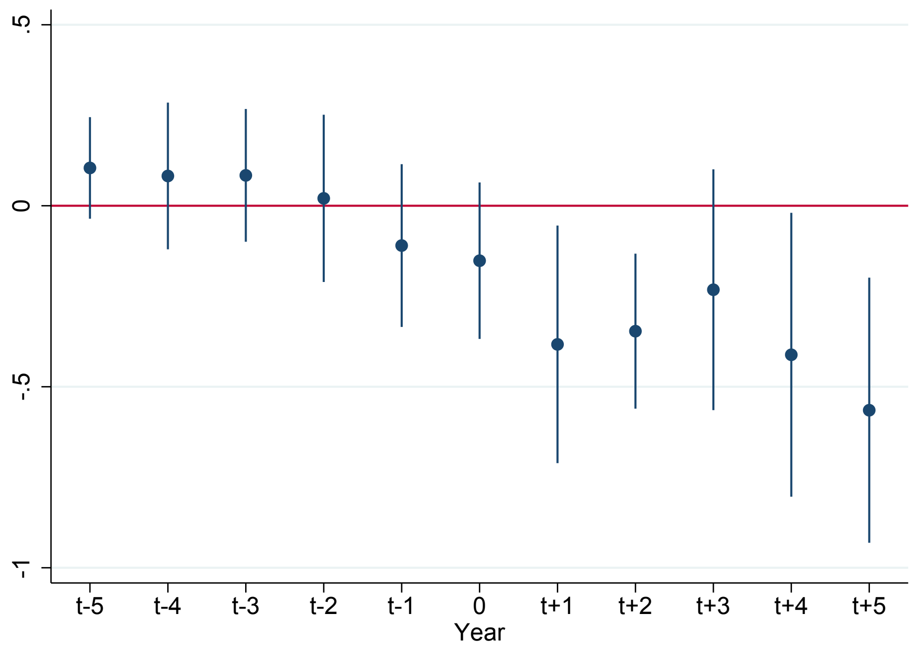

Figure 5: Team stability and innovation output around corporate bankruptcies

This figure presents the impact of disruptions to team-specific human capital on the evolution of inventors' productivity around bankruptcy events. It shows the differential evolution of innovation (as measured by citations) for inventors with varying *Stable Team Share*. We first estimate the following OLS regression model:

$$Ln(Citations)_{it} = \alpha + \beta \cdot Treated_i \times T_{it} + \theta \cdot Treated_i \times Stable\ Team\ Share_i \times T_{it} + \delta \cdot Treated_i + X'_{it}\gamma + \epsilon_{it}$$

We then plot the coefficients θ associated with the interaction between *Treated* $\times$ *Stable Team Share* and the event-time dummies included in matrix T: we include dummies for the years t-5, t-4, t-3, t-2, t-1, 0 (bankruptcy year), t+1, t+2, t+3, t+4, and t+5 relative to the bankruptcy event. These event-time dummies always take the value of zero for firms that are part of the control group. We require firms to be present in the sample at time t-6 and exclude any observations after year t+5. The matrix of controls X includes inventor fixed effects, firm fixed effects, industry $\times$ year fixed effects, fixed effects for the number of active years of an inventor, *Firm Size*, *ROA*, *R&D Intensity*, *Cash Ratio* and *Leverage*. The 95% confidence bounds are calculated based on standard errors clustered at the firm level.

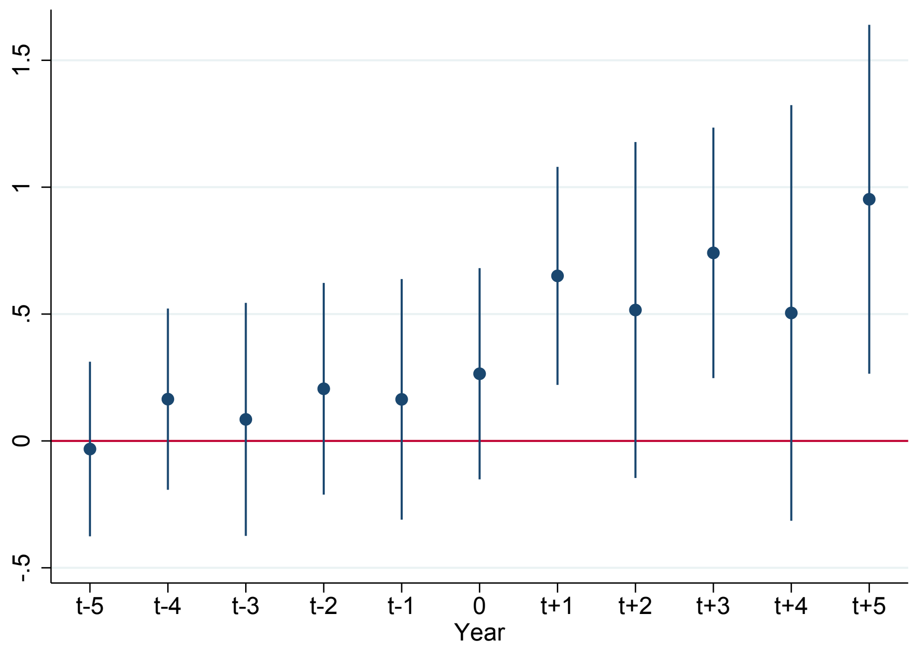

Figure 6: The impact of corporate bankruptcies on the likelihood of an inventor's career ending

This figure examines how bankruptcy affects the likelihood of an inventor ceasing to patent. We report coefficients from estimating the following OLS regression:

$$Career\ end_{it} = \alpha + \beta \cdot Treated_i \times T_{it} + X'_{it}\gamma + \epsilon_{it}$$

We plot the coefficients β associated with the interaction between *Treated* and the event-time dummies included in matrix T: we include dummies for the years 0 (bankruptcy year), t+1, t+2, t+3, t+4, t+5, and t+6 relative to the bankruptcy event. These event-time dummies always take the value of zero for firms that are part of the control group. The matrix of controls X includes industry $\times$ year fixed effects, fixed effects for the number of active years of an inventor, *Firm Size*, *ROA*, *R&D Intensity*, *Cash Ratio* and *Leverage*. For treated inventors, we exclude any observations prior to the bankruptcy filing year and after year t+6. The 95% confidence bounds are calculated based on standard errors clustered at the firm level.

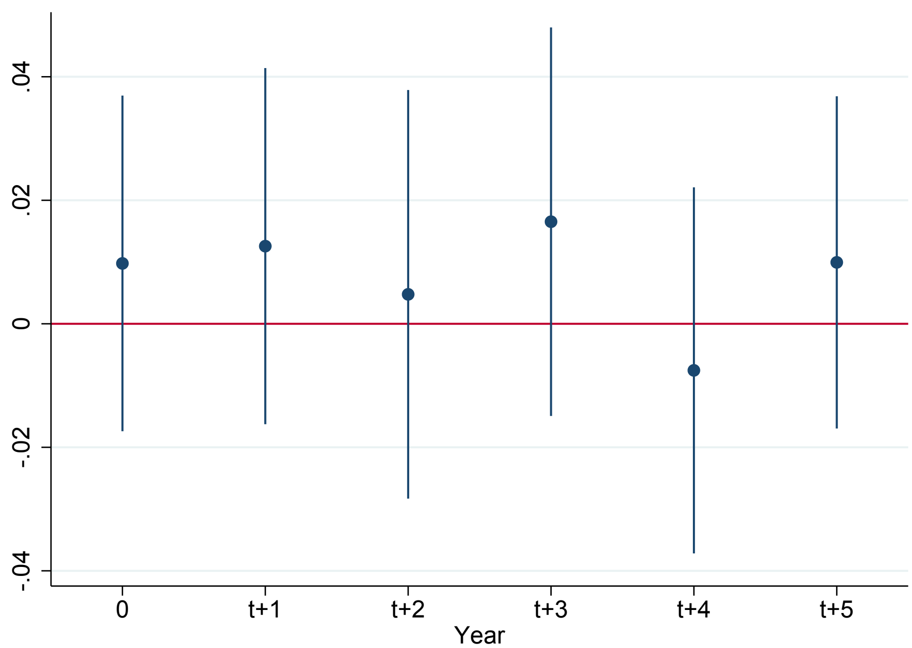

Figure 7: The impact of team dependence on the likelihood of an inventor's career ending post-bankruptcy

This figure examines how co-authorships impact inventors' choice to end their inventor careers post bankruptcy. We report coefficients from estimating the following OLS regression:

$$\textit{Career end}_{it} = \alpha + \beta \cdot \textit{Treated}_i \times T_{it} + \theta \cdot \textit{Treated}_i \times \textit{Bankruptcy Co-authorships}_i \times T_{it} + \delta \cdot \textit{Treated}_i + X'_{it}\gamma + \epsilon_{it}$$

We plot the coefficients θ associated with the interaction between *Treated* $\times$ *Bankruptcy Co-authorships* and the event-time dummies included in matrix T: we include dummies for the years 0 (bankruptcy year), t+1, t+2, t+3, t+4, t+5, and t+6 relative to the bankruptcy event. These event-time dummies always take the value of zero for firms that are part of the control group. The matrix of controls X includes industry $\times$ year fixed effects, fixed effects for the number of active years of an inventor, *Firm Size*, *ROA*, *R&D Intensity*, *Cash Ratio* and *Leverage*. For treated inventors, we exclude any observations prior to the bankruptcy filing year and after year t+6. The 95% confidence bounds are calculated based on standard errors clustered at the firm level.