Diversity and Productivity in Teams

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The popular press often touts workforce demographic (e.g., ethnicity and age) diversity as profit enhancing. For instance, diversity may reduce the firm's communication costs with particular segments of customers and may yield greater team problem solving abilities. On the other hand, diversity also may raise communication costs in teams thereby retarding problem-solving ability and slowing productivity growth. Unfortunately, the effect of team diversity on productivity has not been studied formally and little empirical evidence concerning the impact of team diversity on productivity is found in the literature. This paper formally and empirically explores the impact of diversity in the abilities and demographics of a firm's workforce on the productivity of teams and worker turnover. Our formal model argues that diversity in skill level and ability enhances the team productivity if there is significant mutual learning and collaboration within the team, while demographic diversity is likely to harm productivity by making learning and peer pressure less effective and to increase team-member turnover. To evaluate these propositions we use a novel data from a garment plant that shifted from individual piece rate to group piece rate production over three years. Because we observe individual productivity data, we are able to econometrically distinguish between the impacts of diversity in worker abilities and demographic diversity. Consistent with our formal model, our results indicate that more heterogeneous teams in terms of worker abilities are more productive. Holding the distribution of team ability constant, teams with greater diversity in age are less productive, and those composed only of one ethnicity (Hispanic workers in our case) are more productive, but the findings for team demographics are not robust to alternative specifications of the regression model. Finally, workers on all Hispanic teams are less likely to leave the team, even after accounting for team productivity, indicating some preference for segregation among these workers.

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Workplace diversity is often claimed to be one of the most important challenges facing managers today. Demographic trends, changing labor supply patterns, immigration, and increased globalization imply a much more heterogeneous group of employees for firms to manage. Recently, partially in response to the weakening of affirmative action programs in states like California, a number of firms and business executives have proposed a "business case for diversity," which argues that a more diverse workforce is not necessarily a moral imperative, but is in fact a source of competitive advantage. The "business case for diversity" may be summarized by two major arguments. First, a more diverse customer base may be better served by a more diverse workforce that can effectively communicate with customer subgroups. Second, some assert that "diverse teams produce better results"[1] arguing that heterogeneous teams will provide a broader range of ideas and potential solutions to a given problem. Unfortunately, few formal arguments and empirical research have explored the business case for diversity.

In this paper, we investigate the second claim that "diverse teams produce better results." Lazear (1998a, 1998b) asserts that a diverse team can generate productivity gains if three factors are present. First, team members must have different skills or information. In this way the team may gain from the complementarities among the skills of its members. Second, the different skills of team members must be relevant to one another. Obviously, little complementarity occurs if the skills of one team member are not relevant to the production of a teammate. Third,

[1] Quote from Lew Platt, former CEO of Hewlett-Packard, to the Diversity Research Network, Stanford Business School, March 18, 1998, reported in Kochan et al (2002).

communication is necessary for team members to perform the relevant joint tasks and engage in knowledge transfer to enhance productivity. Increases in communication costs reduce the gains achievable from skill diversity. These factors suggest that at least two aspects of diversity should be considered when analyzing teams: (1) diversity in the skills, ability, and information sets of team members; and (2) diversity in other factors that may enhance or inhibit within-team communication. In fact, Lazear's argument implies that productive teams should be diverse along the skill dimension, but homogeneous in other dimensions, such as demographics, that reduce communication costs or what he calls "costs of cross-cultural dealing."

Lazear's argument concerning within team communication costs resonates with other research in economics and organizational behavior. For instance, Arrow (1974) was one of the first to focus on the effects of within team communication costs on performance. More recent research suggests that demographic differences are likely to increase communication costs. Zenger and Lawrence (1989) find that age differences within teams reduce technical communication. Lang (1986) shows that language differences and racial and gender diversity increase communication costs. Others argue that if workers in the same demographic group are more likely to belong to overlapping social networks, peer pressure may be more effective in mitigating free-riding to achieve a group norm within the team (Kandel and Lazear (1992)). In sum, this research suggests that more demographically diverse teams may be less productive, holding skill diversity constant.

While workers may prefer more demographically homogeneous groups in order to reduce communication costs and increase productivity and pay, Becker's (1957) model of co-worker discrimination suggests that demographically diverse teams also may reduce worker utility. If workers are prejudiced, then they may choose to segregate themselves within the workplace and

form teams with similar individuals, even if these teams generate less pay for their members. Consequently, Becker's model implies that increasing demographic diversity within teams at the firm may increase turnover if employees have preferences for working with similar individuals.

We formally explore the effect of diversity on team productivity and team-member turnover. We provide a theoretical framework that allows us to jointly analyze the impacts of both skill diversity and demographic diversity on productivity. First, we confirm Lazear's argument that output is higher when there are significant skill diversity and benefits of collaboration. Second, we identify three channels through which demographic diversity affects productivity and turnover: (1) diversity could inhibit knowledge transfer among team members; (2) diversity could reduce peer pressure by weakening social ties and trust among team members; and (3) "tastes for discrimination" create non-pecuniary disutility of joining a demographically diverse team. These three channels collectively imply that demographic differences should harm team productivity and raise team-member turnover.

Empirical analysis of the relationship between diversity, productivity, and turnover in teams faces many challenges. Demographic characteristics may be correlated with worker skill. While characteristics such as age and race are typically collected in most data sets, worker ability generally is not. Consequently, it is difficult to empirically separate the role of skill diversity from communication costs induced by demographic diversity in teams. Moreover, team membership is often not available. Researchers then are often forced to examine the role of demographic heterogeneity at the firm or plant level. However, diversity at the plant level may mask substantial segregation among teams within a particular location, which will bias productivity and turnover estimates. In addition, more diverse plants or firms may differ in other

ways not observed by the econometrician, but which also affect productivity and turnover, contaminating estimates of the impact of diversity.

Our approach to the empirical analysis of diversity in teams attempts to address these issues by utilizing the personnel records of workers employed between 1995 and 1997 at a garment factory operated in Napa, California, by the Koret Company, first studied by Hamilton, Nickerson and Owan (2003). The facility initially used progressive bundling system production, in which sewing is divided into independent tasks and seamstresses are paid piece rates. Between 1995 and 1997, the facility changed the organization of its sewing activity to module production, in which autonomous work teams of typically six to seven workers receive a group piece rate and perform all sewing tasks. Because we observe productivity of individual production for almost all workers that eventually join a team, we are able to construct measures of both skill level and skill diversity for each team. We are therefore able to distinguish between the roles of skill and communication costs, as measured by team demographics, on productivity and turnover. Similarly, because we focus on teams operating side-by-side within in the same factory, our results will not be biased by other variations in human resource practices across plants that may bias the results of other studies.

Our findings are largely consistent with our formal model. First, our results indicate that more heterogeneous teams in terms of worker abilities are more productive. Second, holding the distribution of team ability constant, teams with greater diversity in age are less productive, and those composed only of one ethnicity (Hispanic workers in our case) are more productive, but these findings are not robust to alternative specifications of the regression model. Finally, workers on all Hispanic teams are less likely to leave the team, even after accounting for lagged team productivity, indicating some preference for segregation among these workers.

The paper proceeds in six sections. In the first section we introduce our formal analysis of the effects of worker diversity on team productivity and team-member turnover. The next two sections describe production at Koret and our data. Sections IV and V describe our empirical results on the effects of diversity on productivity and turnover, respectively. We discuss our findings and conclude in the final section.

1. Theoretical Background

We develop a model which captures two different consequences of diversity that seem to be relevant to team production in the context of the garment factory we analyze. First, diversity in the skills and ability may enhance the productivity of a team because more skilled workers help and teach less skilled ones. Second, demographic diversity potentially inhibits within-team communication and thus reduces the effectiveness of collaboration and peer pressure, and the non-pecuniary benefit of joining the team. Our model is built on the works of Kandel and Lazear (1992) and Kandori (2003), but also includes the benefit of collaboration between workers with difference skill levels and psychological payoff from team participation.

The Model

Consider a team with N workers where workers are indexed by $i \in \{1, 2\ldots N\}$. Assume that the team operates over an unspecified number of discrete time periods. In each period, each worker makes a decision about how much total effort, e_i, to exert by incurring personal cost of $c_i(e_i)$. e_i is measured in efficiency units and differences in $c_i(e_i)$ equate to skill heterogeneity. Let $\mathbf{e} = \{e_1, e_2, \ldots, e_N\}$. Assume that effort can be allocated to perform assigned tasks, called *individual effort*, and to help the other workers and coordinate team activities, called *collaborative effort*. Hence, the production function is nonseparable in e_i.

Although we can assume that workers allocate their time between individual effort and collaborative effort deliberately, we use the following reduced form production function for simplicity. A worker's collaborative effort becomes more productive than her individual effort only when her total effort exceeds the average effort of the other members. In other words, a worker can teach and help others and coordinate activities well only when her work pace is at least the average of the others'. The total output of worker *i* is given by:

$$q_i = e_i + g[e_i - \frac{\sum_{j \neq i} e_j}{N-1}]_+ + l \qquad (1.1)$$

where *g* and *l,* the factors relating collaborative effort to increased output, are greater than 0 and $[x]_+$ denotes $\max\{x, 0\}$.

For comparison, we assume that the firm can also design the work organization so that the production function is separable in e_i and workers only perform assigned tasks with no possibility of cooperation and coordination. <<We need a comment to explain this assumption in contrast the she statement above in which we assume the production function is non-separable.>> In this work organization, the total output of worker *i* is given by $\underline{q}_i = e_i$.

Consequently, $g[e_i - \frac{\sum_{j \neq i} e_j}{N-1}]_+ + l$ is the additional output created by the worker's collaborative effort. It is collaborative effort that could make team production more productive than individual production. In Hamilton, Nickerson and Owan (2003), we argue that there are two kinds of learning promoted by teams: collective and mutual learning. You can view them as knowledge creation and knowledge transfer activities. Teams facilitate the discovery of new ways to assign, organize, and perhaps alter tasks to produce more efficiently by putting together the teammates' idiosyncratic information. But at the same time, technical abilities often spread

from more skillful workers to the less skillful. Workers learn how to execute tasks better and more quickly from each other. l in (1.1) primarily measures the value of collective learning and g represents the effect of mutual learning.

A worker's utility depends on his wage w_i and the disutility of total effort $c_i(e_i)$. Utility also depends on psychological payoffs such as disutility from peer pressure and utility from socialization. We assume that the mean of **e** in the prior period, m, becomes the standard or *team norm* in the current period and peer pressure arises when the workers performs below the team mean and is proportional to the deviation. Hence, utility from peer pressure takes the form $-k[m - e_i]$ whereas other psychological payoff from joining a team is represented by b. <<Do we need a comment about why we assume peer pressure proportional to the deviation? What would happen if we chose some other specification? Is there any research to suggest this assumption is valid?>> Participation in teams may offer non-pecuniary benefits, such as less repetitive work and more social interaction than in individual production. Thus, we model team-member i's utility as:

$$u_i(w_i, e_i, m) = w_i - c_i(e_i) - k[m - e_i]_+ + b \qquad (1.2)$$

$-k[m - e_i]$ is a psychological disutility and individuals treat k and m as given. Workers are boundedly rational in the sense that they do not choose e_i's strategically taking into account their impact on m in the future periods. A worker's pay is an equal portion of the team pay, which depends on the piece rate, w, and the team output, $Q = \sum_{i=1}^{N} q_i = \sum_{i=1}^{N} (e_i + g[e_i - \frac{\sum_{j \neq i} e_j}{N-1}]_+ + l)$.

Namely, $w_i = \frac{w}{N} \sum_{i=1}^{N} (e_i + g[e_i - \frac{\sum_{j \neq i} e_j}{N-1}]_+ + l)$.

It is natural to assume that *g, k*, and *b* are parameters that depend on team and individual characteristics and are not constant from team to team or even from person to person.[2] In order to keep our analyses as simple as possible, we assume that *g* and *k* do not vary among team members. But *b* may still depend on individual characteristics.

A couple of comments about our specification are in order. First, the value of collaborative effort increases as the skill difference and the resultant difference in effort choices among the workers increases. This relationship implies that know-how shared by a highly skilled worker has more value when there are many workers who possess little skill. Second, skill diversity can be defined as the differences in marginal costs of efforts among teammates. Since $\{c_i(e_i)\}$ is different among the workers, they should choose different levels of outputs when they work individually. Third, a change in non-skill-related heterogeneity is expected to affect the parameters *g* and *k* because differences in personal background or language hinder communication needed to coordinate activities and development of trust among team members which are the backbones of collaboration. If workers have "tastes for discrimination" as Becker (1957) argues, demographic differences in a team could also affect non-monetary payoff from working in team, *b*. Specifically, benefits may be reduced if the worker is not part of the majority group on the team, due to tastes for discrimination or isolation.

In order to simplify the definition and the measurement of skill diversity, we assume the quadratic cost function $c_i(e_i) = \frac{e_i^2}{2c_i}$. The quadratic form has the following advantage. Suppose, when worker *i* can choose to work alone under a piece rate *w*, she can produce $\underline{q}_i = e_i$ and will

[2] We can let *k* depend on *m* as Kandori (2003) does. It implies that greater cooperation in the last period leads to a higher marginal disutility of defecting in the current period. Such specification does not affect our results.

maximize her utility $u_i = we_i - \frac{e_i^2}{2c_i}$. The optimal output is $q_i = e_i = c_i w$. Therefore, differences in individual productivity before joining teams can be used to construct the measure of skill diversity in teams.

Now, worker *i* in a team solves

$$\max_{e_i} u_i = \frac{w}{N}\sum_{i=1}^{N}(e_i + g[e_i - \frac{\sum_{j\neq i} e_j}{N-1}]_+ + l) - \frac{e_i^2}{2c_i} - k[m - e_i]_+ + b \qquad (1.3)$$

Note that key interactions among e_i's take place through *m*. An increase in the worker *j*'s effort e_j should raise *m* and gives an additional incentive to worker *i* who would try to avoid peer pressure. This increase in *m* might further boost the effort of worker *i* when $e_i > m$ if the change makes worker *i*'s skill more valuable by reducing the number of team members for whom $e_{i'} - \frac{\sum_{j\neq i'} e_j}{N-1} > 0$.

Equilibrium

We look for the steady-state level of effort and team norm. We call $\mathbf{e}^* = (e_1^*, ..., e_N^*)$ and m^* the *steady-state equilibrium* when

$$\begin{aligned} u_i(\mathbf{e}^*, m^*, \sigma, \tau) \geq u_i(\mathbf{e}_{-i}^*, e_i, m^*, \sigma, \tau) \text{ for all } i \text{ and } e_i, \\ m^* = mean(\mathbf{e}^*). \end{aligned} \qquad (1.4)$$

This definition is equivalent to the *morale equilibrium* defined in Kandori (2003) except that Kandori uses median to define the norm. First, we identify the Nash equilibrium $\mathbf{e}^*$ given m^* by solving the first-order conditions. In other words, we determine $\mathbf{e}^*$ that satisfy $u_i(\mathbf{e}^*, m^*, \sigma, \tau) \geq u_i(\mathbf{e}_{-i}^*, e_i, m^*, \sigma, \tau)$ for all *i* and e_i given m^*. Assume $c_1 < c_2 < ... < c_N$ without loss of generality.

Lemma 1

If $\frac{c_i w}{N}(1+\frac{i-1}{N-1}g) \le c_i(\frac{w}{N}+k)$,

$e_i^* = c_i(\frac{w}{N}+k)$ when $m^* > c_i(\frac{w}{N}+k)$,

$e_i^* = m^*$ when $\frac{c_i w}{N}\{1+\frac{i-1}{N-1}g\} \le m^* \le c_i(\frac{w}{N}+k)$, and

$e_i^* = \frac{c_i w}{N}\{1+\frac{i^*-1}{N-1}g\}$ when $m^* < \frac{c_i w}{N}\{1+\frac{i-1}{N-1}g\}$

where i^* is the minimum integer I that satisfies $m^* < \frac{c_I w}{N}(1+\frac{I-1}{N-1}g)$

If $c_i(\frac{w}{N}+k) < \frac{c_i w}{N}(1+\frac{i-1}{N-1}g)$,

$e_i^* = \frac{c_i w}{N}\{1+\frac{i^*-1}{N-1}g\}$ when $m^* < c_i(\frac{w}{N}+k)$,

$e_i^* = c_i(\frac{w}{N}+k)$ when $m^* > \frac{c_i w}{N}\{1+\frac{i-1}{N-1}g\}$, and

there are two local optima $e_i^* = c_i(\frac{w}{N}+k)$ and $e_i^* = \frac{c_i w}{N}\{1+\frac{i^*-1}{N-1}g\}$, and worker i chooses whichever gives her the higher utility when

$c_i(\frac{w}{N}+k) \le m^* \le \frac{c_i w}{N}\{1+\frac{i-1}{N-1}g\}$.

Proof: Note that $e_i^* - \frac{\sum_{j\neq i} e_j^*}{N-1} = \frac{(N-1)e_i^* - \sum_{j\neq i} e_j^*}{N-1} = \frac{Ne_i^* - \sum_{i=1}^{N} e_j^*}{N-1} = \frac{N}{N-1}(e_i^* - m^*)$.

We consider three cases: $e_i^* < m^*$, $e_i^* = m^*$ and $e_i^* > m^*$. First suppose $e_i^* < m^*$. Then $\frac{\sum_{j \neq i} e_j^*}{N-1} > m^*$ implying $[e_i^* - \frac{\sum_{j \neq i} e_j^*}{N-1}]_+ = 0$ because $m^* = mean(\mathbf{e}^*)$. Since $[m^* - e_i]_+ = m^* - e_i$, the first-order condition for e_i^* is $\frac{w}{N} - \frac{e_i^*}{c_i} + k = 0$ or $e_i^* = c_i(\frac{w}{N} + k)$. This can be a local optimum only when $m^* > c_i(\frac{w}{N} + k)$ and the worker utility is increasing for all $e_i < m^*$ when $m^* \leq c_i(\frac{w}{N} + k)$,

Next suppose $e_i^* > m^*$. Then $[e_i^* - \frac{\sum_{j \neq i} e_j^*}{N-1}]_+ = e_i^* - \frac{\sum_{j \neq i} e_j^*}{N-1}$ and $[m^* - e_i]_+ = 0$. e_i^* has to satisfy

$\frac{w}{N}\{1 + g - \frac{\#\{j \neq i \mid e_j^* > m^*\}}{N-1} g\} - \frac{e_i^*}{c_i} = 0$ or $e_i^* = \frac{c_i w}{N}\{1 + g - \frac{\#\{j \neq i \mid e_j^* > m^*\}}{N-1} g\}$ where

$\#\{j \neq i \mid e_j^* > m^*\}$ is the number of worker i's teammates whose equilibrium effort levels are higher than the equilibrium team norm. $\#\{j \neq i \mid e_j^* > m^*\}$ can be found in the following way. Because we assume $c_1 < c_2 < ... < c_N$, there is i^* such that all of worker i^* through worker N choose to produce more than m^* and all of the other workers produce m^* or less. Such i^* satisfies the following inequalities: $\frac{c_{i^*} w}{N}\{1 + \frac{i^* - 1}{N-1} g\} > m^* \geq \frac{c_{i^*-1} w}{N}\{1 + \frac{i^* - 2}{N-1} g\}$. Then, given i^*,

$e_i^* = \frac{c_i w}{N}\{1 + \frac{i^* - 1}{N-1} g\}$ only for $i \geq i^*$. Again, the worker utility is decreasing for all $e_i > m^*$ when $i < i^*$.

When $\frac{c_i w}{N}\{1+\frac{i-1}{N-1}g\} \le m^* \le c_i(\frac{w}{N}+k)$, from the above analyses, it is straightforward that $e_i^* = m^*$. When $c_i(\frac{w}{N}+k) \le m^* \le \frac{c_i w}{N}\{1+\frac{i-1}{N-1}g\}$, there are two local optima $e_i^* = c_i(\frac{w}{N}+k)$ and $e_i^* = \frac{c_i w}{N}\{1+\frac{i^*-1}{N-1}g\}$.

■

Figure 1 and 2 illustrate the optimal choices of effort given the team norm for a team of six members. In Figure 1, workers are relatively homogeneous (*i.e.* $\frac{c_N w}{N}(1+g) < c_1(\frac{w}{N}+k)$) and g is small enough so that <<please fill in>> (*i.e.* $\frac{c_i w}{N}(1+\frac{i-1}{N-1}g) < c_i(\frac{w}{N}+k)$ for all *i*). In this case, all team members follow the team norm and choose the same effort level. Furthermore, there will be a continuous set of equilibria, namely any number between $\frac{c_N w}{N}(1+g)$ and $c_1(\frac{w}{N}+k)$ could be the equilibrium team norm (see the shadow area in Figure 1). Figure 2 illustrates more heterogeneous team in terms of skill level. Workers 1 and 2 are the least productive workers in the team and they continue to receive peer pressure to work harder. Workers 3 and 4 are mediocre workers who are productive enough to achieve the team norm but cannot provide additional collaborative efforts. They are motivated by piece rate and threat of peer pressure. Worker 5 and worker 6 are the most productive workers whose collaborative efforts are so effective that piece rate alone gives them additional incentives to choose effort levels that are higher than the team norm.

Now, we derive the steady-state team norm. Lemma 1 gives us the best response function from the team norm in period *t*, m_t to the workers' effort choices in the same period $\mathbf{e}_t^*$. Since the team norm in the next period is obtained by m_{t+1} = mean($\mathbf{e}_t^*$). This creates the mapping from the team norm in the current period to that in the next period. Let $M(m^*)$ be this mapping. The steady-state equilibrium can be found by solving $M(m^*) = m^*$.

Proposition 1 When $\frac{c_i w}{N}(1+\frac{i-1}{N-1}g) \le c_i(\frac{w}{N}+k)$ for all *i*, there always exists a steady-state equilibrium $(m^*, \mathbf{e}^*)$.

Proof: From Lemma 1,

$$e_i^* = \max\{\min\{c_i(\frac{w}{N}+k), m^*\}, \frac{c_i w}{N}(1+\frac{i-1}{N-1}g)\} + \frac{c_i w}{N}\frac{i^*-i}{N-1}g\ 1_{m^* < \frac{c_i w}{N}(1+\frac{i-1}{N-1}g)} \qquad (1.5)$$

where i^* is the minimum integer that satisfies $m^* < \frac{c_i w}{N}(1+\frac{i-1}{N-1}g)$ and 1_* is the indicator function. i^* becomes identical to *i* and the final term gets zero when m^* approaches $\frac{c_i w}{N}(1+\frac{i-1}{N-1}g)$ close enough from below. Note that, in the range where i^* is constant, e_i^* is a continuous function of m^*. But as m^* increases, i^* shifts up and generates discontinuous jumps in e_i^*. $M(m^*) = \sum_{i=1}^{N} e_i^*$ also has the same property. Because $M(m^*)$ is bounded and continuous almost everywhere with only finite upward jumps, the fixed point always exists. See Figure 3.

■

Note that $M(m^*)$ is discontinuous because skills are substitutable among those who can provide productive collaborative efforts, *i.e.*, your effort to coordinate activities and help others is less productive when there are more people who do so. As the team norm increases, the

number of teammates who can exert collaborative efforts decreases, generating jumps in incentives to supply such services.

The requirement that $\frac{c_i w}{N}(1+\frac{i-1}{N-1}g) \le c_i(\frac{w}{N}+k)$ for all i is only a sufficient condition. When $\frac{c_i w}{N}(1+\frac{i-1}{N-1}g) > c_i(\frac{w}{N}+k)$ for some i, which is more likely for the most productive workers, $M(m^*)$ exhibits a downward jump at m where the optimal effort choice shifts from $e_i^* = \frac{c_i w}{N}\{1+\frac{i^*-1}{N-1}g\}$ to $e_i^* = c_i(\frac{w}{N}+k)$. What is necessary for the existence of equilibrium in this case is that this jump does not happen around the 45 degree line. When $M(m^*)$ jumps across the 45 degree line without intersecting it as you see in Figure 4, there is no steady-state equilibrium. The team norm will vacillate around the crossing. In the rest of the paper, we only consider the case in which the steady-state equilibrium exists, *i.e.,* there is no i such that $c_i(\frac{w}{N}+k) \le m^* \le \frac{c_i w}{N}\{1+\frac{i-1}{N-1}g\}$ in the equilibrium.

The uniqueness of the equilibrium is hard to obtain because of the discontinuity of $M(m^*)$. To deal with multiple equilibria, *we focus on the most productive or the least productive equilibrium*. Let $\overline{m}^*$ and $\underline{m}^*$ be the highest and the lowest equilibrium team norm.

Impact of Demographic Diversity

Now, we analyze how heterogeneity affects the equilibrium. Let τ be the non-skill-related diversity measure of the workers.

Proposition 2 Suppose g and k are decreasing in τ. Then, $\overline{m}^*$ and $\underline{m}^*$ are decreasing in τ.

Proof: From (1.5), e_i^* is decreasing in τ. Hence, $M(m)$ shifts down as τ increases. As Figure 3 shows, $\overline{m}^*$ and $\underline{m}^*$ decrease as τ increases. ■

Impact of Skill Diversity

The impact of a change in skill heterogeneity is challenging to analyze because we have to assess the change in the profile **c** = $\{c_1, c_2, \ldots, c_N\}$. Since it is difficult to derive a general result for a particular dispersion measure of **c**, we only consider the following mean-preserving change in variance of $\{c_1, c_2, \ldots, c_N\}$. Suppose workers are heterogeneous enough so that not all workers choose the same effort level. Take *i* and *j* such that $c_i(\frac{w}{N}+k) < m^* < \frac{c_j w}{N}$. How will the incremental change from (c_i, c_j) to $(c_i - \Delta c, c_j + \Delta c)$ affect m^*? This change does not affect the average productivity of the same workers when they work separately because it is expressed by $\frac{\sum_i \underline{q}_i}{N} = w\frac{\sum_i c_i}{N}$. But how does it affect the team production? We take the derivatives of e_i^* and e_j^* with respect to Δc fixing m^* to assess this change.

$$\frac{\Delta e_i^*}{\Delta c} + \frac{\Delta e_j^*}{\Delta c} = -(\frac{w}{N}+k) + \frac{w}{N}(1+\frac{i^*-1}{N-1}g) = \frac{wg(i^*-1)}{N(N-1)} - k \qquad (1.6)$$

where i^* is the minimum integer *I* that satisfies $m^* < \frac{c_I w}{N}(1+\frac{I-1}{N-1}g)$ again.

This derivative implies that the impact of skill heterogeneity is indeterminate. This is because there are two countervailing effects: team norm erosion and enhanced value of collaboration. To contrast the two effects, first assume that there is no value in collaboration, *i.e.* $g = 0$. Then, the replacement of a low-productivity worker with even less productive one simply has more impact that the replacement of a high-productivity worker with even more productive one because the strength of the incentive mechanism is asymmetric (*i.e.* $\frac{w}{N}+k$ vs. $\frac{w}{N}$). On the

other hand, when there is no peer pressure functioning, *i.e.,* $k = 0$, more skill diversity should increase the value of collaborative effort by construction. This increased value of collaboration is especially higher the fewer the number of high-performers in the team controlling the average skill constant (*i.e.* i^* is large). Note that when $\frac{\Delta e_i^*}{\Delta c} + \frac{\Delta e_j^*}{\Delta c} > 0$, the change from (c_i, c_j) to $(c_i - \Delta c, c_j + \Delta c)$ raises the function $M(m^*)$ resulting in higher $\overline{m}^*$ and $\underline{m}^*$. We summarize the result in the next proposition.

Proposition 3 When w and g are large relative to k, and skill is concentrated in sufficiently small number of team members, the incremental change from (c_i, c_j) to $(c_i - \Delta c, c_j + \Delta c)$ described above raises $\overline{m}^*$ and $\underline{m}^*$.

Impact on Turnover

Next, we derive the implications for turnover. Let $\underline{u}_i$ be the outside option value available for worker i after she quits her team. Then, worker i should leave her team when $u_i - \underline{u}_i < 0$. It should be natural to assume that $\underline{u}_i$ is non-decreasing in c_i. Let's compare $u_i - \underline{u}_i$ among team members $i = 1, \ldots, N$. Remember that all team members receive the same team pay. Let it be w. Then,

$$u_i - \underline{u}_i = w - \frac{c_i}{2}(\frac{w}{N} + k)^2 - k[m^* - c_i(\frac{w}{N} + k)] + b_i - \underline{u}_i(c_i) \text{ when } m^* > c_i(\frac{w}{N} + k)$$

$$u_i - \underline{u}_i = w - \frac{c_i}{2} m^{*2} + b_i - \underline{u}_i(c_i) \text{ when } \frac{c_i w}{N}(1 + \frac{i-1}{N-1} g) < m^* < c_i(\frac{w}{N} + k)$$

$$u_i - \underline{u}_i = w - \frac{c_i}{2}\frac{w^2}{N^2}(1 + \frac{i^* - 1}{N-1} g)^2 + b_i - \underline{u}_i(c_i) \text{ when } m^* < \frac{c_i w}{N}(1 + \frac{i-1}{N-1} g)$$

If b_i is constant over i, the second and the third functions are decreasing in c_i while the first one may be increasing in c_i if k is large. This means that it is the most productive worker or the least productive one that would want to leave the team first. Team participation decisions will be less clear than separation decisions because workers with different skill levels may form different expectations about their income in teams. If their expectations are similar and peer pressure is not expected to be so large, our expectation would be that less productive workers should join teams first because they could free-ride on the work of more productive workers. Surprisingly, the results in Hamilton, Nickerson and Owan (2003) indicate that more productive workers tend to join teams first. This result may imply that k was expected to be high, which discouraged less able workers to join teams, or that psychological utility of joining a team b_i was systematically higher for more productive workers.

In this paper, we ask the question of who is more likely to switch teams when team characteriscs affect g and k, and workers may receive different psychological utility of joining a team b_i. Because demographic diversity may reduce the equilibrium payoff by lowering team productivity through lower g and k and reducing non-pecuniary benefits of working in team, greater demographic differences might also raise the team-member turnover. When team diversity in skills and ability is great, the most productive worker is more likely to switch teams because she will be able to enjoy a higher pay by switching teams. How skill diversity affects the turnover of least productive workers is less clear. On the one hand, the least productive worker is likely to experience disutility from strong peer pressure. But, on the other hand, the least productive worker benefits from the productivity gain derived from skill diversity.

To summarize, our formal model argues that diversity in skill level and ability enhances the team productivity if there is significant mutual learning and collaboration within the team. In

contrast, demographic diversity along such dimensions as age and ethnicity is likely to harm productivity by making learning and peer pressure less effective. Demographic diversity also should lead to increased levels of team-member turnover.

2. Production at Koret

Our empirical context for analyzing these predictions is weekly productivity reports from a Koret Corporation garment manufacturing facility in Napa, California. The facility produces "women's lowers" including pants, skirts, shorts, etc. These garments are mid-priced clothes purchased and distributed by department stores. Along with many other firms in the garment industry, a major reason for the introduction of team production over the 1995 – 1997 period at Koret is the demand by retailers that apparel companies make just-in-time deliveries. As noted by Berg et al. (1996), such demands required more flexible production systems, and pushed manufacturers like Koret to replace traditional individual production methods with more flexible teams. Because module production was expected to decrease costs through reductions in inventory, manufacturing space, supervisory and service functions, quality inspections, and rework, many apparel manufactures were willing to adopt a team system even if worker productivity fell.

Garment production at the plant is segmented into three stages. First, cloth is cut into pieces that conform to garment patterns. Finished garments may contain anywhere between 2 and 10 individual pieces including pockets, fronts, backs, waistbands, belt-loops, etc. Second, garments are constructed by sewing together pieces. Third, garments are finished by pressing, packaging, and placing them into a finished goods inventory where they await delivery to a storage warehouse or to customers. Our study focuses on the sewing operation.

Progressive bundling system production

Historically, the plant used a Taylorist progressive bundling system (PBS) (e.g., Dunlop and Weil (1996)) for production. In PBS production, sewing operations are broken down by management into a number of distinct and separate operations (usually totaling between 10 and 30) depending on the complexity of the garment. Management, in consultation with the union, assigns an expected sewing time or "standard" (in minutes) for each operation such that the amount of effort required to sew a standard minute is equivalent across tasks. The standard, which typically ranges between 0.5 and 2.0 minutes per operation, makes comparison of productivity across tasks and garments feasible and represents the central measure against which productivity is evaluated. Workers without any sewing background require little training (approximately 2 weeks of on-the-job training). Sewing stations with one worker sitting at each station are evenly spaced in a grid on the shop floor and one sewing operation is assigned to each station. Two floor supervisors assign sewing tasks and deliver batches of material (stored on movable carts that hold between 30 and 50 garments or pieces of cloth) to sewing stations. Workers take garments from an input cart, execute their single sewing operation and re-stack the garments on an output cart. These carts hold the work-in-process (WIP) and remove any possibility of production externalities.[3]

Seamstresses are paid based on individual piece rates according to the standard set for the operation they undertake. In addition to the piece rate standard, workers also receive an hourly wage, or variance pay, when work is interrupted. Variances include the lack of work, machine

[3] One exception to this independence is that workers may compete against each other to gain the favor of their supervisor so that they receive sewing tasks when production is slack. The supervisor acknowledged that an estimated 25% of the workers behave strategically to insure a steady supply of work during slow production periods (the supervisor called these interactions "greedy problems").

breakage, job transfer, extra handling other than specified in the prescribed method, rework for which the seamstress is not responsible, making samples, and jury duty.[4]

Quality inspections during sewing occur two times: when the garment is half completed and again when it is fully completed. Supervisors record the seamstress' name for each batch sewn to track the source of such problems. Quality is evaluated by randomly selecting six out of the 30 to 50 garments in a bundle. Quality problems include non-uniform stitching, crooked stitching, etc. Reworking garments due to one's poor quality is a variance that is unpaid—workers must correct their own quality problems without pay.

During the transition from PBS to module production, the plant manager used PBS production for garment orders with long lead times and large production volumes such as those before a selling season begins, in which quantities of greater than 50,000 units are common. Production time from receipt of order is approximately 5 weeks with materials in the sewing operation for approximately 2 weeks. Cumulative sewing time per garment is between 5 and 20 minutes depending on garment style. At any time, the sewing operation may have 10,000 garments in WIP.

Module Production

In the winter of 1994 the plant manager began experimenting with the use of flexible work teams known in the garment industry as module production. The general manager handpicked the first team. The manager began to rely on module production in earnest by setting

[4] During these interruptions, the union contract specifies that workers are paid either the minimum wage or an average wage, which is calculated for each worker based on their take home wage over the preceding 13 weeks. For the first two variances, workers receive a minimum wage for the first half-hour and average wage thereafter. Job transfers receive minimum or average wages depending on the situation. Extra handling, rework, and sample making are paid with an average wage. Jury duty is paid at the minimum wage less jury pay. Variance wages, on average, are approximately 10 to 11% of total garment standard (for a total of 111% when total garment standard is included). Also, supervision and management accounts for approximately 5% of total garment standard (for a total of 116%).

up eight teams in 1995. However, instead of hand picking teams, he asked for volunteers. After joining a team, seamstresses could return to PBS production if they preferred it or if other team-members voted a worker off the team. This option was available until mid-1996 when the manager decided to convert the entire plant to module production. When initially interviewed in the fall 1995, the manager had no plans to convert the entire plant to module production.

In module production at Koret each team typically is comprised of six or seven team-members[5] who work in a U-shaped work space approximately 12' x 24'. Contiguously located around the partitioned workspace are 10 to 12 sewing machines mounted on wheels so that the ordering of machines is easily changed.[6] Unlike seamstresses in floor production, module team-members sew standing up. Instead of storing WIP on carts, WIP is held on small dowels jutting out between each workstation. The dowel acts as a kanban[7] where team-members take pieces from the right and place sewn pieces into the left kanban. By rule, kanbans may hold no more than three to five garments, depending on the length of sewing operations (long operation times have smaller queues while short production times have larger queues). The use of a kanban introduces a production externality among workers as each worker's productivity depends on adjacent workers' output. The kanbans and close proximity of workers and machines reportedly facilitate team-members quickly identifying bottleneck operations and changes in worker productivity. Also, workers are cross-trained on all sewing machines and receive training on the use of the kanban production rule.

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[5]The manager stated that he experimented with the number of workers on a team. He believed that 10 workers were too many for the team to effectively make joint decisions and less than five was too few because cooperation broke down.

[6] A variety of different sewing machines, which are specialized for different types of operations, exist.

[7] Kanban is a Japanese production concept whereby a queue between workstations is kept low by rule. In the limit where only one item is allowed in the queue, the upstream worker is not to perform her task and place WIP in the queue until it is empty.

Modules are compensated with a group piece rate—the team receives a piece rate for the entire garment as opposed to a piece rate for each operation. The team's net receipts are divided equally. Group piece rates for modules have two additional differences from individual piece rates. First, each worker on the floor must unbundle and bundle the stack of garments when it arrives and leaves the workstation. Bundling and unbundling time accounts on average for five percent of the standard time for sewing an entire garment and is included in the PBS standard. With the module's kanban system, bundling and unbundling is not needed between operations—only when raw material bundles first arrive and finished goods bundles finally leave the work area. Thus, the standard for an entire garment is five percentage points lower for modules because of the elimination of intermediate unbundling and bundling steps, which means that teams should be able to increase garment production by 5%, ceteris paribus. However, worker productivity of PBS and module production is measured in comparison to standard minutes, not garments, meaning that worker productivity measures for each are directly comparable. Second, whereas floor workers receive variance wages averaging approximately 10 to 12% of standard, module team-members receive no such variance wages. Instead, team-members receive piece-rate wages approximately 11% above the module-adjusted standard, which provides a small increase in incentive intensity. Quality, which the plant manager stated was at least as good and perhaps better than quality provided by PBS production, is monitored upon completion of the garment using same inspection method found in PBS production.

Initially, module production was used in response to three trigger events: small order quantities or need to replenish inventories, special short-term deliveries for customers, or small volumes. The characteristics of these orders is that they have very short lead times and small volumes ranging from 100 to 10,000 garments with an average of approximately 2,000 garments.

The manager asserted that an important advantage of module production is that it can sew a batch of 300 garments within eight hours whereas conventional production would in the best scenario require at least two days of sewing and the efforts of up to two-dozen workers to sew the same number of garments. The plant manager also stated that just-in-time stocking by retailers had been a trend that had increased the need for small production runs with little forewarning.

While modules essentially use the same labor, capital, and material inputs as PBS production, modules differ in that the team is empowered to make an array of production decisions. Workers from one team described some of these decisions as well as the advantage and disadvantages of module production. Workers reported that they could produce faster with higher quality in modules. They claimed they learned all production tasks, had more information about production tasks, and were able to shift tasks, share tasks, and "figure our easier ways to sew" garments. They stated that they found working in a team to be more interesting and fun, they enjoyed the friendships they developed in the team, and they preferred standing to sitting because it avoided backaches. They reportedly pushed each other to work hard, which often involved joking around. They also stated that other team members quickly caught quality problems, which allowed the team to quickly identify and correct the source of quality problems. Team members claimed that the biggest difficulty of module production is that workers hold a "variety of attitudes", which can lead to "communication problems and misunderstandings". The manager added that workers were more aggressive than management at disciplining team-members.

3. The Koret Data

This paper utilizes a novel data set constructed from the personnel records of employees at Koret over the time period covering January 1, 1995 until December 31, 1997. The data consists of weekly information on worker pay, hours worked, and team membership for all individuals employed at Koret over this period. In addition, the ethnicity and birth date of each worker also was obtained, although further data on education, training, and so forth was not available to us. Finally, productivity is measured at the individual level when the worker is operating under the PBS system and at the team level for workers engaged in module production. The productivity variable is measured as efficiency relative to the standard described above, with values greater than 100 indicating performance above the standard level.

Figure 3 plots median weekly productivity at the plant from the first week of 1995 (week 0) to the last week in 1997 (week 156). In addition, the fraction of plant workers engaged in team production is also presented. The figure shows that median productivity at Koret increases after the bulk of Koret workers are working in teams after week 70. However, the plot also shows substantial cyclical variation in productivity, which is accounted for by the inclusion of month and year dummies in the subsequent regression analysis. Table 1 presents summary statistics for the team-week data, indicating substantial variation in weekly team productivity across teams and over the 1995-1997 period. These productivity differentials translate into substantial variation in worker pay. Comparing team productivity with the average productivity in individual production of the team members, both the 50th and 75th percentiles suggest that teams increased productivity, while the difference at the 25th percentile suggests that for at least some teams and/or weeks, teams were less productive. Finally, there appears to be substantial variation in the ethnic composition of teams over time.

Measuring Diversity in Teams

The model in Section I suggests that the most able worker on a team at Koret will have a strong influence on team productivity due to the help she can provide to other less able members. Similarly, the least able member may require substantial help to achieve the team norm level of output. Consequently, following Hamilton, Nickerson, and Owan (2003), we measure skill diversity within the team by the ratio of the maximum to the minimum average individual productivity levels of the team members. To measure the demographic diversity of the team, we use the standard deviation of the natural logarithm of the ages to measure age diversity. The standard deviation of ln(age) implies that percentage rather than absolute differences in the age of team members affect communication among individuals. For example, one might argue that communication may be more difficult between a 20 and 25 year old than between a 40 and 45 year old.[8] Our second measure of demographic diversity considers the ethnic/racial composition of the team. Nine ethnic/racial groups are represented at Koret.[9] 54% of the workers are Hispanic, followed by 12% who are Vietnamese. More importantly, the only ethnically homogenous teams are Hispanic, and virtually all the teams that have at least two-thirds of team members belonging to the same ethnic group are largely Hispanic. Given that this group shares a common language, Spanish, we measure ethnic/racial diversity of each team by the fraction of the team that is Hispanic.

Columns (1) – (4) of Table 2 summarize the skill and demographic characteristics of teams at the date of formation, including average worker productivity for individuals prior to joining the team and the level of skill and demographic diversity. The table describes four

[8] Leonard and Levine (2002) argue that the standard deviation of ln(age) provides a better measure of social distance than the standard deviation of age.

notable findings. First, column (1) shows that teams formed in 1994 and 1995 not only tend to be comprised of more able workers, but they also have greater diversity in skill, perhaps in an attempt to capture the benefits of mutual learning. By contrast, teams formed in 1996 and 1997, when team participation was less voluntary generally, have lower average skill and are less diverse in terms of ability. Second, later teams tend to be more diverse in terms of age, as evidenced by column (3). Again, the earlier teams may have been more able to reduce communication costs due to their ability to "hand-pick" their teammates. Third, column (4) provides relatively little evidence of substantial worker segregation across teams. Only team three is comprised completely of Hispanic workers, and 9 of 25 are comprised of two-thirds or more Hispanics. Moreover, with the exception of team 8, no team has over half of its members belong to one of the other ethnic/racial groups. Finally, comparison of columns (1) and (5) indicate productivity increases in 14 of the 23 teams for which we have valid pre- and post-team data. Teams formed in 1995 are the most likely to show a productivity increase, while teams formed in August 1996 and later (when team participation was less voluntary) experience declines. As discussed in Hamilton, Nickerson, and Owan (2003), it may be the case that workers with greater collaborative skills joined the early teams.[10]

4. The Impact of Diversity on Productivity

In this section, we investigate the impacts of skill heterogeneity and demographic diversity on productivity in teams at Koret. The theory outlined in Section I suggests that teams

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[9] These ethnic/racial groups include Hispanics, whites, blacks, Filipinos, Chinese, Japanese, Vietnamese, Indians, and Koreans.

[10] Table 2 shows that Team 21, which consisted primarily of new hires with no Koret experience, was highly productive. We suspect that this team was "hand-picked" by management, since it consisted of young workers in their early twenties from a range of ethnic backgrounds (as judged by the workers' names). Because no pre-team productivity data is available, Team 21 is excluded from the team regressions reported in Table 3 and 4 below.

with more diverse skills will be more productive, all else equal, when highly productive workers can substantially increase the production of the least able workers on the team by helping, teaching or coordinating activities (*e.g., g* is high enough relative to *k*). Conversely, our model suggests that if demographic diversity increases communication costs, more heterogeneous teams in terms of age and/or ethnicity should be less productive. A particular advantage of the Koret data is that we are able to observe individual productivity prior to team membership for many workers, and so we are able to distinguish between diversity in skill and diversity in demographic characteristics.

To examine the impact of team composition on team productivity, let y_{jt} be the natural logarithm of the productivity of team *j* in week *t* at Koret. A team's weekly productivity is modeled as:

$$y_{jt} = M_{jt}\alpha + D_{jt}\beta + X_{jt}\delta + \varepsilon_{jt}, \tag{4.1}$$

where the vector M_{jt} consists of measures of the productivity of team *j*'s members in week *t*, such as the average individual productivity level and the spread in individual abilities. The vector D_{jt} consists of measures of the demographic characteristics of team *j*'s members in week *t*, including the average ln(age), the standard deviation of ln(age), and indicators of whether the team consists of two-thirds Hispanic employees, or whether all the workers on the team were Hispanic. X_{jt} includes variables thought in the literature to affect team productivity: team size (*SIZE*); the length of time the team has been in operation (*TEAM TENURE*) and its square; the length of time the current members of the team have worked together (*LINEUP TENURE*) and its square; and whether the team includes a new hire with no previous Koret experience (*NEWHIRE*). To account for possible selection effects, a variable indicating that the team was formed in April <<do we mean April or August??>> 1996 or later (*LATER TEAM*) is also included. Figure 1

indicated that output at Koret exhibited substantial seasonal variation. To account for this factor, we obtained monthly data on U.S. women's retail apparel sales over the period from the Bureau of Economic Analysis. We include period t retail sales as well as sales up to 6 months in the future as regressors in the X_{jt} vector, since such future sales may translate into current period demand for Koret output. Because the retail sales variable is seasonally adjusted, month dummies are also incorporated into X_{jt} to account for cyclical factors. Finally, we do not have complete data on Team 1, and Team 21 initially consisted entirely of outsiders for whom we have no pre-team productivity data. Consequently, these two teams are not included in the regression analysis described below.

The first column of Table 3 present random effect estimates of equation (4.1), where the error term is specified as:

$$\varepsilon_{jt} = \theta_j + \eta_{jt}, \tag{4.2}$$

to account for correlation in ε_{jt} over time. The results in column (1) exhibit four notable features. Not surprisingly, teams with more able members, on average, are more productive. More striking is the finding that holding ability constant, teams with more diverse skills also tend to be more productive. This result holds in our median regression model shown in column (2) that is more robust to outliers in the dependent variable. The positive estimated relationship between the spread in skill and productivity is consistent with the case of high g in the model in Section I, which argued that a team with a greater spread in ability will be more productive when the value of collaborative effort is high. Moreover, Hamilton, Nickerson, and Owan (2003) suggest that the most skilled workers may be able to increase the team norm level of output by threatening to quit the team.

The coefficient estimate in the fourth row of column (1) indicates that teams with more diversity in age are significantly less productive. This finding is consistent with those of Leonard and Levine (2002), who find that retail stores with greater age diversity among its employees tend to be less profitable. However, Leonard and Levine are not able to determine the extent to which employees in their study firm work together in teams. A variety of studies in the Organizational Behavior literature find similar negative impacts of age diversity on alternative measures of team performance (see Reskin et al. (1999)). For example, Zenger and Lawrence (1989) find that age homogeneity enhances technical communication. However, these papers typically do not distinguish between the roles of diversity in skill versus heterogeneity in the demographic characteristics of team members.

Estimates of our second measure of demographic diversity, the team's ethnic composition, provides mixed support for the view that demographically homogeneous teams have lower communication costs that may lead to higher productivity. Column (1) shows that teams comprised entirely Hispanics are 10% more productive than more ethnically diverse teams at Koret. However, the magnitude and significance of this coefficient estimate falls in the median regression in column (2). Moreover, teams of two-thirds or more Hispanic members (e.g., a six person team with four or five Hispanic members) are no more productive than more diverse teams.

One concern about the estimates described above is that there are unobserved team characteristics correlated with the diversity measures that also affect productivity. For example, Hamilton, Nickerson, and Owan (2003) show that more able workers at Koret joined teams first, and the negative coefficient estimate for teams formed in 1996 or 1997 shown in Table 3 suggests that early teams may have had higher levels of collaborative skills. We take two

approaches to attempt to account for the potential confounding role of team-level unobserved factors. First, we estimate fixed effect models of equation (4.1), so that the impact of diversity on productivity is identified by within-team changes in team composition. After including team fixed effects in the regression, column (3) of Table 3 shows that increasing the average skill level of the team increases productivity, as was the case in the random effects and median regressions. Moreover, increasing the skill diversity of the team, holding the average constant, continues to positively affect team productivity, although the impact is moderated somewhat by the inclusion of the team fixed effects.

The coefficient estimates of the demographic diversity measures shown in column (3) do not appear to be robust to the inclusion of team fixed effects. The estimated impact of diversity in the age of team members becomes positive but insignificant, while the productivity of teams composed solely of Hispanics is not significantly different from that of more ethnically diverse teams. In fact, teams comprised of two-thirds or more (but not all) Hispanics are actually less productive than more diverse teams once team dummies are included in the model. <<Bart, with fixed effects aren't we estimating coefficients based on changes in team composition? Since we have only one team that is all Hispanic and the composition of other teams didn't change that much, should we be surprised that we do not find significant results with this estimation approach? Should we say something about the limitation of our data here?>> Overall, the results from Table 3 suggest that teams with more diverse skills and abilities are more productive at Koret, but the role of demographic diversity is less clear and may in fact not play a significant role in explaining productivity differences across teams.

The fixed effects specification assumes that unobservables affecting changes in team membership are uncorrelated with changes in productivity, which may be questionable. While

managers at Koret did not randomly choose team members, recall that membership in teams was voluntary in 1995, but became less voluntary as the firm changed to full-scale modular production in mid-1996. While workers could still choose to leave the firm in 1996 and later, team formation during this period appears to be closer to the ideal of a natural experiment in which team membership is randomly assigned. Consequently, we re-estimate the productivity regressions for the subset of teams formed between 1994 and March 1996, and those formed in April 1996 and later.

Comparison of columns (1) and (3) of Table 4 shows that diversity in skill continues to have a significantly positive impact on team productivity, regardless of when the team was formed. Demographic heterogeneity has a mixed impact on productivity. Teams with more diversity in age are less productive, although this finding is only significant for the teams formed later at Koret. Since we expect there is less bias caused by unobservable factors for these teams than those formed earlier, the result provides support for our hypothesis that diversity in age has a negative impact. In contrast, all Hispanic teams are no more productive than those that are ethnically diverse. Similar results are found in the median regressions. To summarize the results from this section, skill diversity raises team productivity as predicted by our model, and this finding is robust across specifications. There is evidence, although it is less robust, regarding the role that demographic diversity plays, since the results are sensitive to assumptions regarding unobserved factors that may be correlated with team formation.

5. The Impact of Diversity on Turnover

We now turn to the questions of whether more diverse teams suffer greater turnover, and whether individuals that are more "isolated" on teams are more likely to leave. To analyze the impact of diversity on turnover at Koret, we construct team employment spell data for 189

workers who spent at least one week on a team during 1995-1997. Some workers either switched teams or had more than one stint on a given team, yielding a total of 355 spells of team participation. Figure 4 shows the fraction of founding team members remaining on the team at the end of our sample period. Team membership is surprisingly stable. For example, five of the seven members of team 1, founded in 1994, are still on the team as of December 1997, as are five of the original seven members of team 8. On the other hand, there are a few teams that have experienced substantial turnover, such as teams 6 and 19, which have no original members. In some cases, workers from these teams left the firm altogether, while others joined another team at Koret, sometimes as a founding member.

To investigate worker turnover on teams more closely, we examine how the conditional probabilities of leaving the team over the course of the worker's team spell. To do this, we construct the empirical transition intensity for destination r, $\lambda_r(t)$, which describes the fraction of team spells that last exactly t weeks and end for reason r, given that the team spells are at least t weeks long.[11] We distinguish between two possible reasons for exiting the team: Leaving to join another team (denoted by $r = o$); and exit from the firm or a return to individual production (denoted by $r = e$). Very few workers leaving a team return to individual production, so the vast majority of $r = e$ exits represent an employee leaving the firm completely.

Figures 5 plots the empirical transition intensities for workers leaving their teams to join another team ($\lambda_o(t)$) or to leave Koret ($\lambda_e(t)$), over the first six months on the team. The figure indicates that the conditional probability of leaving a team for any reason is initially declines after the first few weeks on the team. One interpretation of the negative duration dependence

[11]The empirical transition intensity is defined as $\lambda_r(t)$ = (# of job spells lasting exactly t weeks and ending for reason r)/(# of job spells lasting at least t weeks).

observed in Figure 3 is that match quality or learning about teammates' attributes is important in forming a team. Poor matches of the individual worker with the team end relatively quickly. Of course, it may also be the case that a worker may temporarily participate on one team while waiting for a space on another team to open. However, this argument cannot explain why the conditional probability of leaving firm, as opposed to switching teams, declines roughly monotonically from week one.

To examine the impact of covariates on the conditional probability of leaving a team at Koret, we estimate an independent competing risks model. The transition intensity for worker *i* associated with leaving the team after *t* weeks for reason *r* follows the proportional hazards specification:

$$(5.1) \quad \lambda_r(t \mid M_{jt}, D_{jt}, X_{jt}, Z_{ijt}, W_t) = \exp(M_{jt}\gamma_r + D_{jt}\mu_r + X_{jt}\pi_r + Z_{ijt}\rho_r + W_t\omega_r)\lambda_{0r}(t), \quad r = e, o,$$

where M_{jt}, D_{jt}, and X_{jt} are time-varying covariate vectors defined as above. The vector Z_{ijt} includes worker *i*'s individual characteristics, in most cases measured relative to the team *j* average at time *t*.[12] Finally, over the course of the three year period under study, there were an increasing number of teams available for a Koret worker to switch to. To measure the impact of the changing team opportunity set for the individual, the vector W_t consists of dummy variables indicating whether week *t* of the spell occurred during particular periods defined by the number of teams in operation at the plant.[13]

The specification in equation (5.1) allows us to determine whether workers that differ from their teammates are more likely to leave the firm or switch teams. $\lambda_{0r}(t)$ represents the

[12] There may be some concern about the potential endogeneity of the M_{jt} and D_{jt} variables as they vary over the course of the spell. We re-estimated the models shown in Table 5 measuring the covariates included in M_{jt} and D_{jt} at the time the worker joined the team. This approach yielded very similar results to those reported in Table 5.

baseline transition intensity. Several parametric and non-parametric methods are available to estimate the baseline hazard (see Lancaster (1990)). We seek a flexible form for the baseline transition intensity since misspecification of $\lambda_{0r}(t)$ may lead to biased parameter estimates (Heckman and Singer (1984)). To avoid such problems, we adopt a Cox proportional hazard specification in which the baseline hazard is estimated non-parametrically. This approach allows us to capture the features of the empirical hazard functions for each risk as shown in Figure 5.

Table 5 presents the estimates for the duration model outlined above, where a positive coefficient indicates that an increase in the variable is associated with an increase in the transition intensity. The base specification estimates are shown in columns (1) and (4) for the conditional probability of leaving the team to exit the firm and switching teams, respectively. We first focus on the transition intensity associated with workers exiting the firm. Workers at Koret do not appear to exit the firm in response to participation in a more diverse team in terms of skill or age. With regard to ethnicity, there are no exits from the firm among individuals on all Hispanic teams, and membership on a two-thirds Hispanic team reduces the transition probability. It is the case that membership in a larger team significantly reduces the probability of exit, perhaps because team size is endogenously determined. Successful six-member teams are more likely to attract a new member than unsuccessful ones. With regard to the individual variables, following studies such as Leonard and Levine (2002), we measure individual isolation on the team as the absolute value of the distance between the worker's characteristics and the average of those for the team. We also distinguish in many cases whether the worker was above or below the team average, due to potential asymmetries in response implied by our theoretical

[13] From Table 2, we define a set of dummy variables indicating whether period t of the spell fell during: (a) weeks 32 to 67, when teams 1 – 9 were operating; (b) weeks 68 – 101, when teams 1 – 20 were operating; (c) weeks 102 – 135, when teams 1 – 23 were operating; (d) weeks 136 – 155, when all teams were operating at Koret.

model. The results in the bottom half of column (1) indicate that distance from a worker's teammates in terms of age or skill does not affect the decision to leave the team and the firm. Hispanics are less likely to leave the firm, although somewhat surprisingly this effect is moderated by being in the majority on a two-thirds Hispanic team.

More intriguing results are found in column (4) for the transition intensity associated with switching from one team at Koret to another. More highly skilled teams experience less switching, perhaps because, as shown in Table 3, such teams are more productive and hence more highly paid. All Hispanic teams also experience less switching. This could reflect either worker preferences for segregation, or recognition that such teams may have lower communication costs or greater ability to exert peer pressure, both of which may increase productivity. While the estimates of the individual variables in the bottom half of column (4) suggest that workers with above average skills on the team are more likely to switch, perhaps due to poaching, the estimate is not statistically significant. Age and ethnicity (outside of participation on an all Hispanic team) play an insignificant role in the decision to change teams.

The model in Section 1 suggested that workers may prefer to remain on teams that are more demographically homogeneous, both because of the reduction in communication costs that enhances the value of collaboration and hence output in team production, and because individuals like working with similar employees. In order to distinguish between these two explanations for turnover, our second specification of the transition intensities includes a covariate measuring lagged team productivity.[14] Holding this factor constant, the demographic variables are likely to reflect preferences toward working with similar individuals. In addition, although it is difficult to measure peer pressure within the team, it may be reasonable to assume

that peer pressure is related to the difference between the worker's individual productivity and the productivity of the team. Workers whose individual productivity was low may find it difficult to raise effort enough to meet the team norm, and so may face additional peer pressure that reduces the utility associated with remaining on the team.

Columns (2) and (5) present estimates of the transition intensities including measures of team productivity. Workers on more productive teams are less likely to switch to another team, although this finding is only moderately significant. Similarly, the significant coefficient found for the average productivity of team members in column (4) appears to reflect the fact that more skilled teams are more productive and earn higher wages. Workers on teams with more diverse skills are more likely to switch, although it is difficult to interpret this coefficient. It may be the case that other teams at Koret attempt to poach workers from more successful teams, which, from Table 3, tend to more diverse in terms of skill. We note that workers on all Hispanic teams continue to be significantly less likely to switch teams, suggesting that participating in a homogeneous workgroup yields some utility gain to these workers, as suggested by Becker (1957). Finally, we find little evidence that workers whose individual productivity is above or below the team level are more likely to quit the firm or switch teams. It remains unclear what role peer pressure plays in team turnover.

In our last specification, we assess the prediction from the model in Section 1 that the most productive member of the team will be more likely to switch teams in order to increase her income. Moreover, it may be the case that the most able team member is more subject to being poached away by other teams at Koret. For the least able member on the team, two factors may be at work. The worker will want to stay on the team because she gains substantial monetary

[14] The measure of lagged team productivity used in the duration model is the average productivity over the previous

benefit from team membership. However, she may be subject to intense peer pressure due and hence be more likely to leave the firm. In columns (3) and (6) of Table 5, we estimate the model including indicators of whether the worker was most skilled (Max on Team) or least skilled (Min on Team) on the team, interacted with the difference between the worker's production and the team average. The coefficient estimates indicate the most highly skilled worker is not significantly more likely to switch teams, either due to poaching or the desire to increase her income, and the least skilled worker is not significantly more likely to leave Koret. Overall, the results from this section suggest that there is relatively low cost to the firm in terms of turnover of diverse work teams, although support is found for the view that some workers prefer homogeneous groups.

6. Discussion and Conclusion

four weeks. The results are not sensitive to changes in the lag length.

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TABLE 1
DISTRIBUTIONS OF TEAM PRODUCTIVITY, PAY, AND COMPOSITION

Variable	Quantile		
	.25	.50	.75
Productivity	80.30	98.24	114.02
Weekly Earnings per Member	$219.04	$294.65	$361.52
Average Team Skill[1]	83.61	91.31	102.49
Average Team Age	33.4	35.7	39.2
Fraction Hispanic	0.33	0.50	0.80
Number of Team-Week Observations		2012	

[1] Average team skill measured as average productivity of team members under individual production.

TABLE 2
DATES OF TEAM FORMATION, INITIAL TEAM CHARACTERISTICS, AND AVERAGE WEEKLY TEAM PRODUCTIVITY

Team	Date of Team Formation	Mean Individual Productivity[1] (1)	Min/Max Individual Productivity (2)	S.D. of ln(Age) (3)	Fraction Hispanic (4)	Team Productivity (Weeks 21+)[2] (5)
1	Mar. 12, 1994	97.8	1.57	0.22	0.71	114.3
2	Jan. 7, 1995	82.9	4.36	0.09	0.71	122.6
3	Jan. 28, 1995	79.4	2.45	0.22	1.00	97.6
4	Jan. 28, 1995	94.0	2.09	0.26	0.36	106.0
5	Jan. 28, 1995	117.8	1.50	0.38	0.21	118.9
6	Jan. 28, 1995	89.4	2.40	0.18	0.42	88.3
7	Apr. 29, 1995	89.6	2.95	0.23	0.83	107.8
8	Oct. 7, 1995	122.6	1.79	0.23	0.00	115.6
9	Oct. 28, 1995	127.4	2.15	0.27	0.29	131.3
10	Apr. 13, 1996	85.6	1.46	0.32	0.44	83.6
11	Mar. 30, 1996	100.4	1.78	0.27	0.21	111.8
12	Apr. 13, 1996	87.3	2.10	0.25	0.48	109.3
13	Apr. 13, 1996	94.6	3.18	0.16	0.17	106.1
14	Apr. 13, 1996	85.6	1.64	0.19	0.37	91.2
15	May 18, 1996	78.3	1.25	0.33	0.67	76.8
16	June 22, 1996	81.1	3.17	0.43	0.67	82.6
17	July 20, 1996	81.7	1.41	0.26	0.80	122.9
18	Apr. 13, 1996	92.6	1.62	0.28	0.00	95.5
19	Apr. 13, 1996	86.1	1.95	0.38	0.60	79.7
20	Aug. 10, 1996	127.5	2.10	0.39	0.33	114.4
21	Dec. 7, 1996	-[3]	-	0.18	0.50	139.1
22	Jan. 18, 1997	94.0	1.50	0.35	0.57	80.0
23	Feb. 1, 1997	89.2	1.30	0.30	0.83	70.9
24	Mar. 15, 1997	92.1	1.85	0.20	0.80	61.2
25	Sep. 6, 1997	76.9	6.45	0.12	0.57	-

[1] Entries in column (1) are calculated by averaging the individual person-week productivity values of workers who subsequently join the particular team (individuals are weighted by the length of time they spent on the team).
[2] Team averages in column (5) calculated after excluding the first 20 weeks the team is in operation.
[3] Team 21 consisted of almost all new hires and so pre-team productivity data is not available.

TABLE 3
EFFECT OF TEAM COMPOSITION ON TEAM PRODUCTIVITY
Dependent Variable is ln(Productivity$_{jt}$) For Team in Each Week

Variable	Specification		
	Random Effects	Median	Fixed Effects
	(1)	(2)	(3)
Average Productivity	0.004	0.004	0.005
	(0.0008)	(0.0005)	(0.001)
Ratio of Max/Min	0.050	0.051	0.031
Productivity	(0.011)	(0.016)	(0.016)
Mean ln(Age)	0.113	0.203	-0.062
	(0.102)	(0.060)	(0.162)
S.D. ln(Age)	-0.360	-0.430	0.049
	(0.119)	(0.070)	(0.216)
All Hispanic	0.100	0.045	-0.032
	(0.044)	(0.026)	(0.082)
2/3 Hispanic	-0.021	-0.013	-0.149
	(0.028)	(0.016)	(0.049)
TEAM TENURE	0.0033	0.002	0.0015
	(0.0016)	(0.0006)	(0.0011)
TEAM TENURE^2	-0.0002	-0.0002	-0.0002
	(0.00007)	(0.00004)	(0.00007)
LINEUP TENURE	0.011	0.007	0.008
	(0.002)	(0.001)	(0.002)
LINEUP TENURE^2	-0.0015	-0.0010	-0.0011
	(0.003)	(0.0002)	(0.003)
SIZE	0.003	-0.002	0.003
	(0.011)	(0.006)	(0.014)
NEWHIRE	-0.006	-0.005	0.076
	(0.025)	(0.015)	(0.037)
LATER TEAM	-0.072	-0.108	-
	(0.038)	(0.022)	

Note: N = 2012 observations. Standard errors in parentheses. Robust standard errors for Random and Fixed Effect regressions. Standard errors for median regressions are block bootstrapped with 500 replications. Each regression also includes a constant, dummies for each month, and cyclical variables measuring women's retail garment sales.

TABLE 4
EFFECT OF TEAM DIVERSITY ON TEAM PRODUCTIVITY, BY YEAR OF TEAM FORMATION
Dependent Variable is ln(Productivity$_{jt}$) For Team in Each Week

Variable	Teams Formed Prior to April 1996		Teams Formed April 1996 and Later	
	Random Effects (1)	Median (2)	Random Effects (3)	Median (4)
Average Productivity	0.0027	0.0036	0.0090	0.0082
	(0.0015)	(0.0007)	(0.0012)	(0.0005)
Ratio of Max/Min Productivity	0.048	0.028	0.038	0.056
	(0.016)	(0.007)	(0.014)	(0.006)
Mean ln(Age)	-0.624	-0.289	-0.057	-0.146
	(0.205)	(0.090)	(0.127)	(0.056)
S.D. ln(Age)	-0.275	-0.468	-0.332	-0.412
	(0.197)	(0.086)	(0.152)	(0.066)
All Hispanic	0.047	-0.028	0.063	0.088
	(0.071)	(0.061)	(0.077)	(0.064)
2/3 Hispanic	0.061	0.023	-0.096	-0.040
	(0.048)	(0.041)	(0.045)	(0.040)

Note: Standard errors in parentheses. Robust standard errors for Random Effect regressions. Standard errors for median regressions are block bootstrapped with 500 replications. Each regression also includes a constant, dummies for each month, and cyclical variables measuring women's retail garment sales.

TABLE 5
TRANSITION INTENSITY ESTIMATES FOR LEAVING TEAM
Independent Competing Risks, Unrestricted Baseline Hazard

	Exit Event					
	Leaves Firm			Switches Teams		
	(1)	(2)	(3)	(4)	(5)	(6)
Team-Level Variables						
Avg. Prod.	-0.017	-0.009	-0.010	-0.018	-0.004	-0.001
	(0.012)	(0.012)	(0.011)	(0.008)	(0.011)	(0.011)
Ratio of Max/Min Prod.	-0.021	0.025	0.016	0.112	0.207	0.249
	(0.191)	(0.181)	(0.180)	(0.098)	(0.107)	(0.108)
Mean ln(Age)	0.375	0.044	0.081	-0.473	0.026	0.075
	(1.627)	(1.417)	(1.410)	(1.085)	(1.100)	(1.106)
S.D. ln(Age)	-0.385	0.104	0.141	0.977	0.820	0.779
	(2.978)	(3.025)	(3.007)	(1.543)	(1.577)	(1.574)
All Hispanic Team	-	-	-	-2.039	-1.913	-1.894
				(0.731)	(0.770)	(0.758)
2/3 Hispanic Team	-1.456	-1.321	-1.297	-0.726	-0.487	-0.494
	(0.698)	(0.656)	(0.659)	(0.502)	(0.532)	(0.531)
Team Prod.[1]		-0.012	-0.011		-0.013	-0.015
		(0.011)	(0.011)		(0.007)	(0.006)
Team Size	-0.354	-0.398	-0.403	0.079	0.058	0.058
	(0.154)	(0.140)	(0.152)	(0.104)	(0.113)	(0.115)
Team Formed April 1996 or Later	-1.242	-0.247	-1.131	0.619	0.553	0.540
	(0.631)	(0.421)	(0.747)	(0.453)	(0.469)	(0.467)
Individual Variables						
|Individual – Avg Prod.| Above Avg. Prod.	0.004			0.010		
	(0.011)			(0.007)		
|Individual – Avg Prod.| Below Avg. Prod.	0.009			0.003		
	(0.014)			(0.007)		
|Individual – Team Prod.| Above Team Prod.[2]		-0.003			0.006	
		(0.007)			(0.005)	
|Individual – Team Prod.| Below Team Prod.[3]		-0.001			0.003	
		(0.012)			(0.006)	
|Individual – Avg. Prod.| Max on Team			-0.006			0.004
			(0.010)			(0.007)
|Individual – Avg. Prod.| Min on Team			0.002			-0.006
			(0.013)			(0.007)
|Individual – Mean ln(Age)|	-0.480	-0.431	-0.439	-0.428	-0.352	-0.300
	(1.178)	(1.180)	(1.185)	(0.717)	(0.769)	(0.765)
Individual is Hispanic	-1.610	-1.480	-1.482	0.321	0.362	0.391
	(0.601)	(0.607)	(0.588)	(0.238)	(0.247)	(0.257)
Hispanic on 2/3 Hispanic Team	1.264	1.062	1.052	0.126	-0.024	-0.034
	(0.940)	(0.920)	(0.923)	(0.539)	(0.545)	(0.552)

Team Founder	-0.739	-1.135	-0.236	0.246	0.239	0.238
	(0.397)	(0.743)	(0.427)	(0.260)	(0.275)	(0.277)
Log-Likelihood	-164.1	-158.9	-158.9	-539.1	-491.6	-491.8

Note: Based on N = 355 Worker-Team Spells. Robust Standard Errors in Parentheses. Each model includes team tenure and team tenure squared, indicators for week during sample period as defined in footnote 13, month dummies, and cyclical variables measuring women's retail garment sales.

[1]Team productivity measured by average team productivity in previous four weeks.

[2]Variable is the value of Individual – Team Productivity if it is positive, zero otherwise.

[3]Variable is the (absolute) value of Individual – Team Productivity is negative, zero otherwise.

Figure 1: Optimal Effort Choice Given Team Norm m^*: Very Homogeneous Team with small g

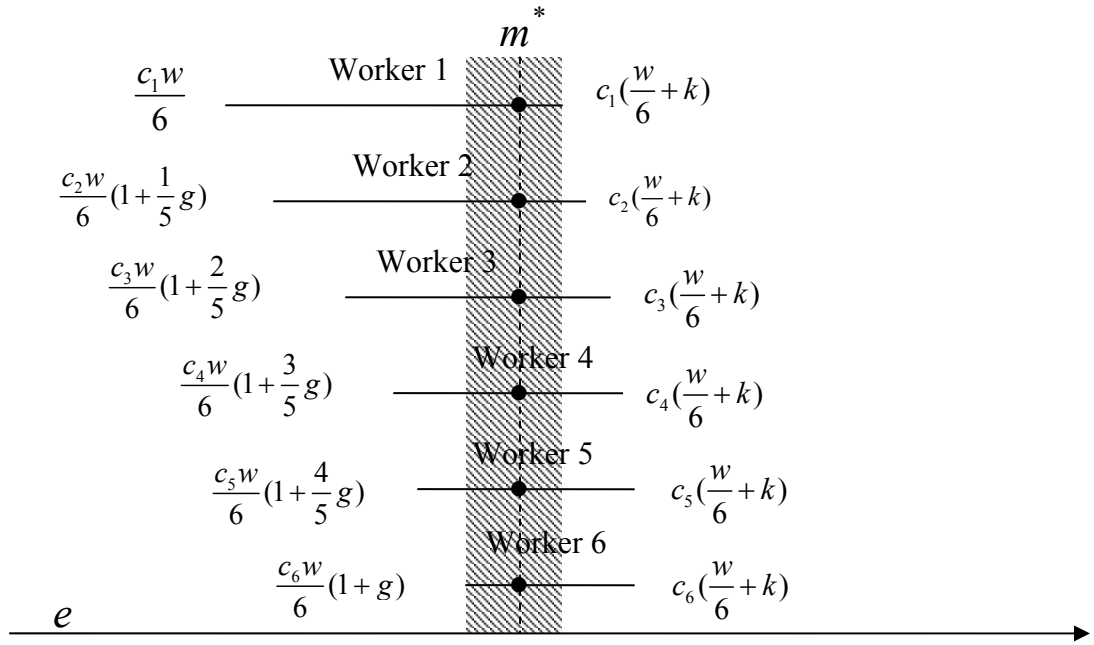


Figure 2: Optimal Effort Choice Given Team Norm m^*: Very Heterogeneous Team with large g

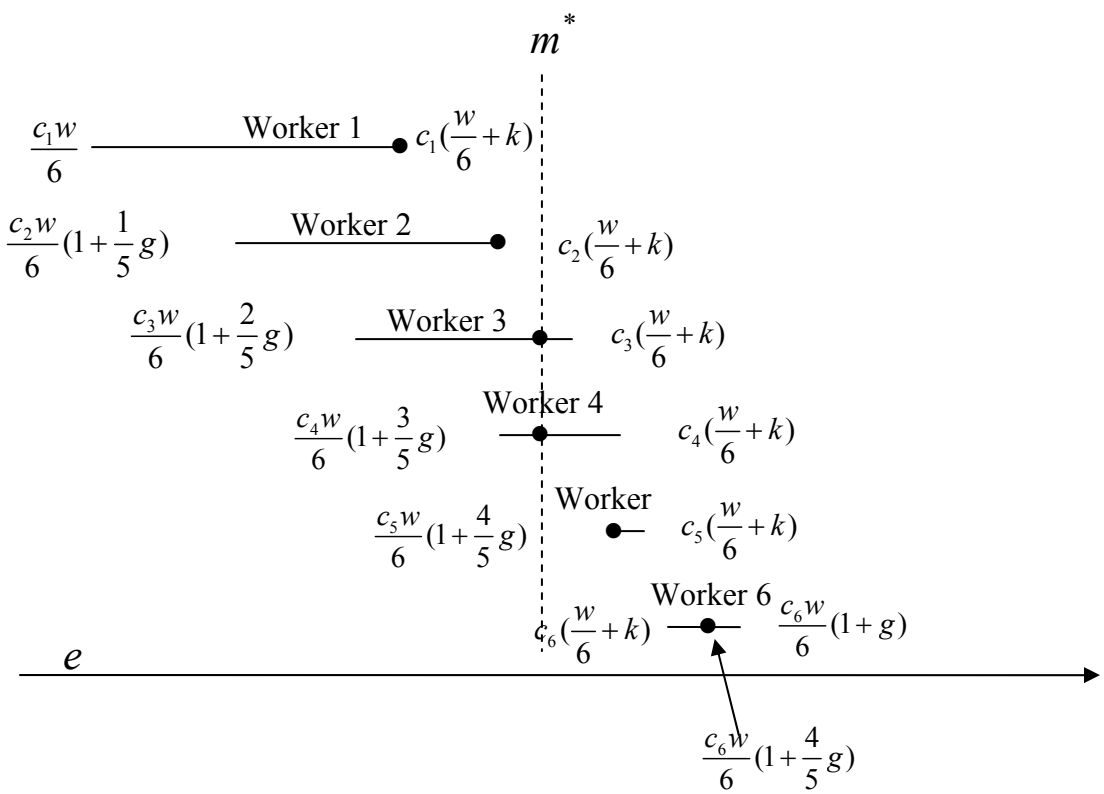


Figure 3: Existence of the Equilibrium

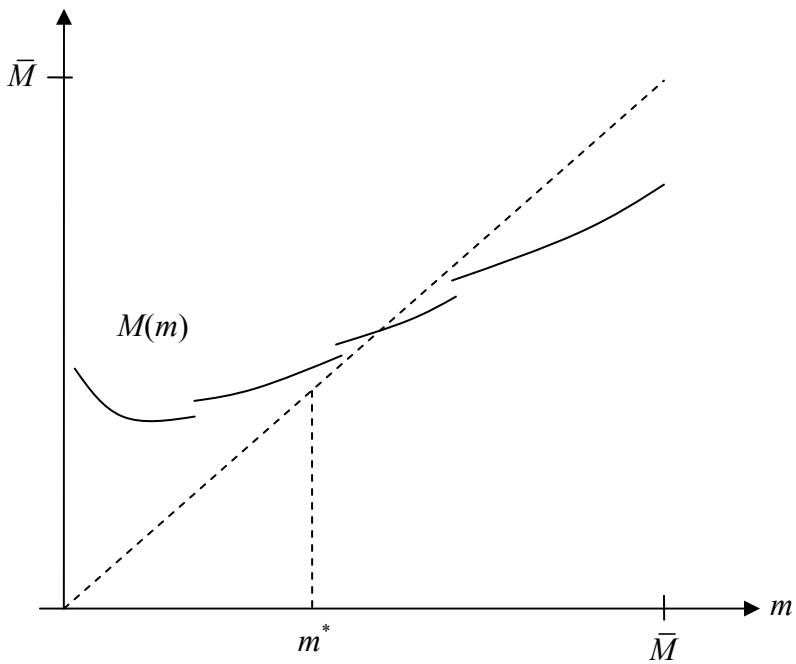
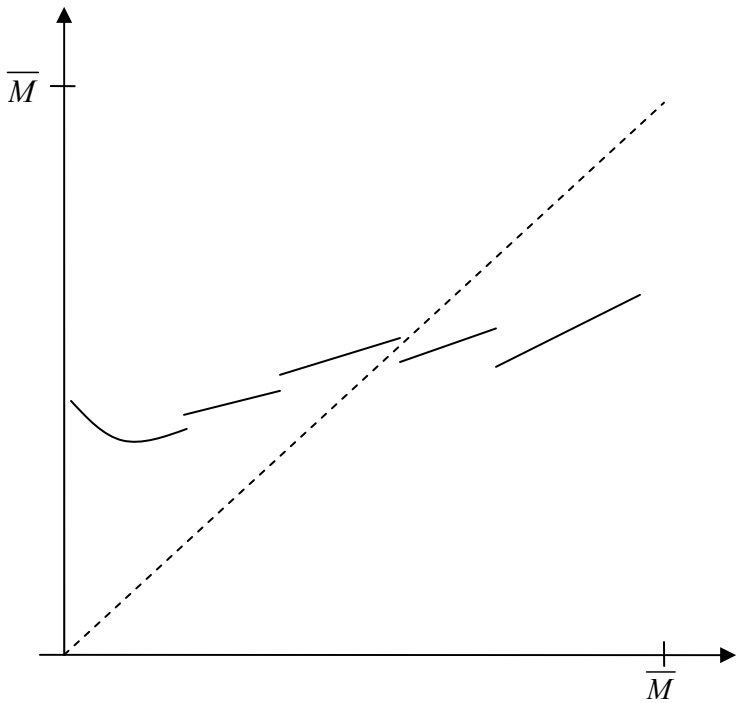


Figure 4: Existence of the Equilibrium



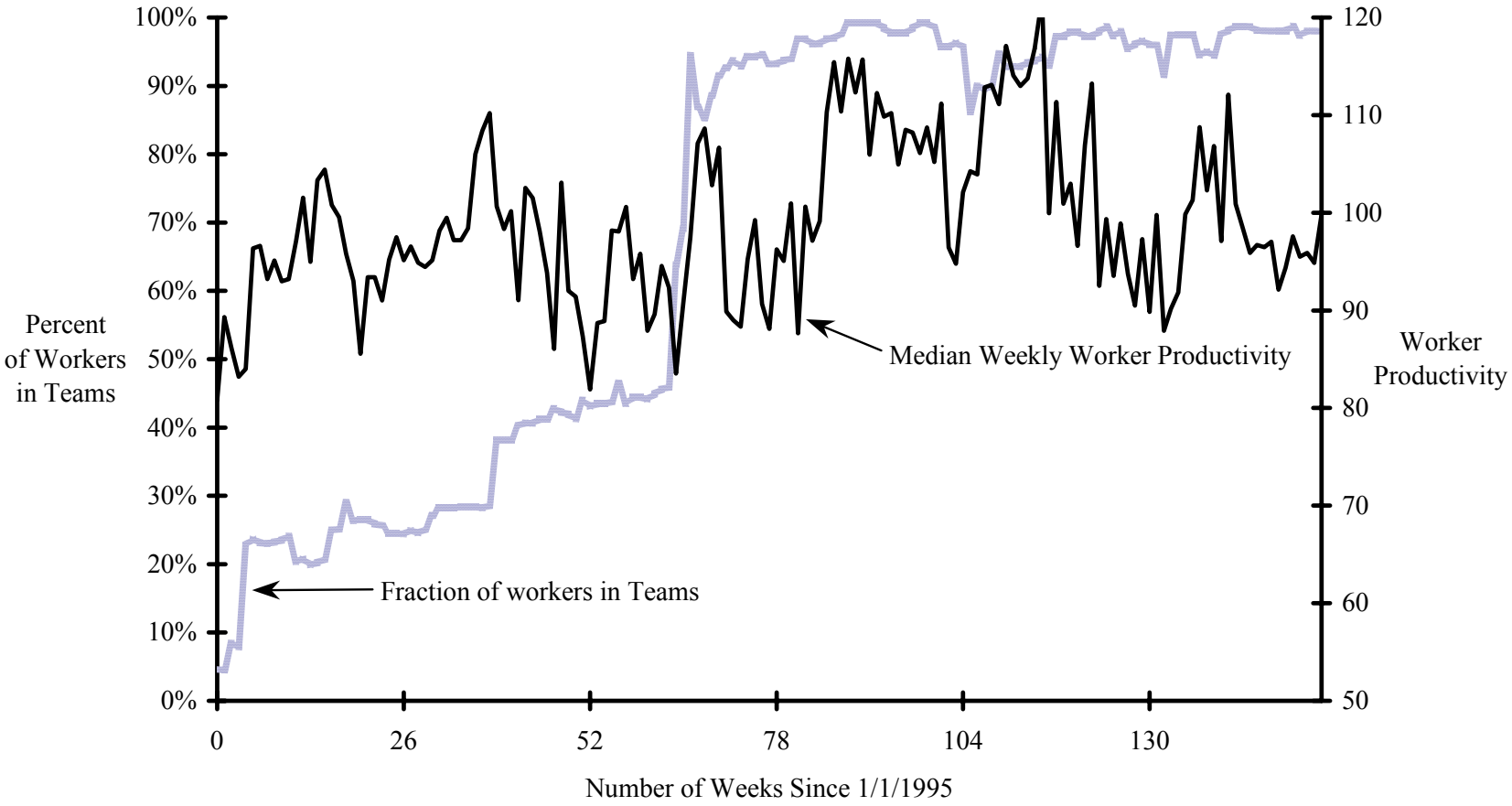


FIGURE 1: MEDIAN WORKER PRODUCTIVITY AND TEAM PARTICIPATION

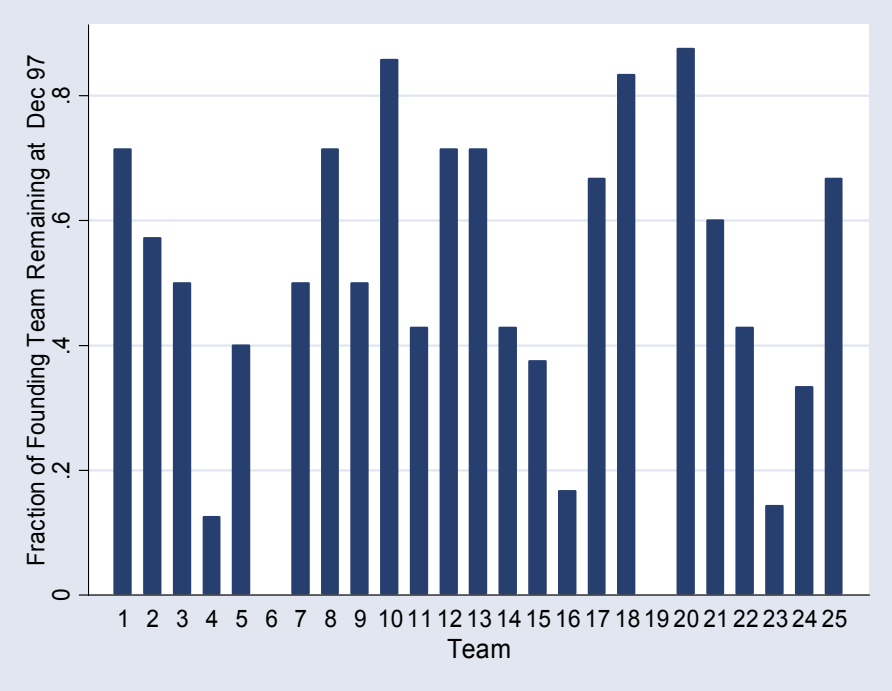


Figure 4: Fraction of Founding Team Members Remaining as of 12/31/97

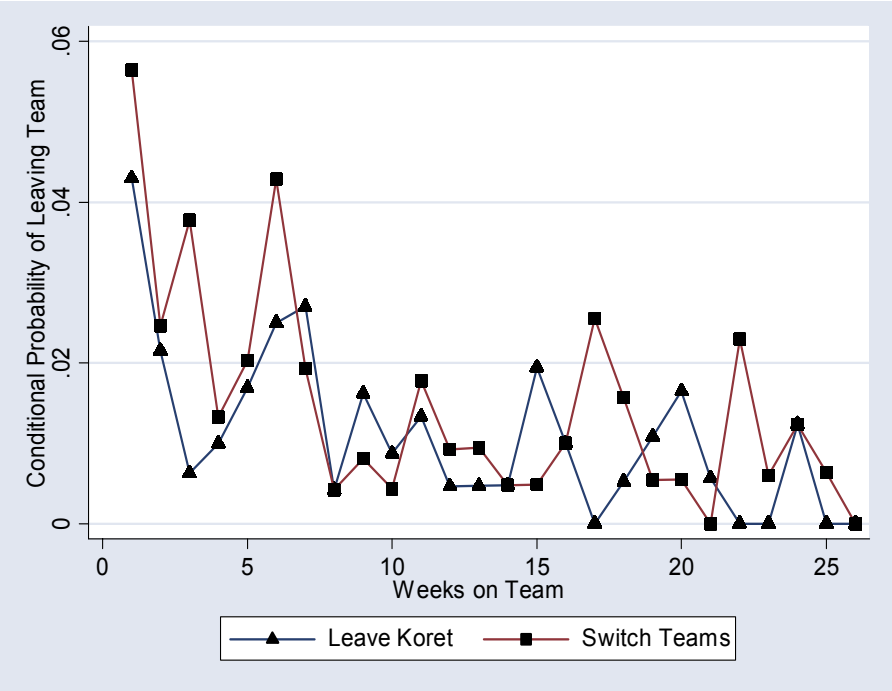


Figure 5: Empirical Transition Intensities