The Signaling Role of Promotions: New Evidence from European Firms*

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Abstract

Using large-scale, nationally-representative, worker and firm-level panel datasets from Finland and Germany, and inferring time-varying, job-specific worker performance measures from bonus data, we provide new empirical evidence supporting the signaling role of promotions. Controlling for performance, promotion probabilities are increasing in educational attainment whereas wage increases from promotion are decreasing in educational attainment for some educational groups, with both results stronger for first than for subsequent promotions. Women have lower promotion probabilities than men, though this difference dissipates after first promotions. Evidence of promotion signaling is stronger for within-firm than for across-firm promotions.

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1 Introduction

In this paper we provide new empirical evidence on the signaling role of promotions. The idea that promotions serve as signals of worker ability was first developed in Waldman (1984) and has significantly influenced the subsequent theoretical literature.[1] The theory is based on asymmetric learning (about worker ability) by employers in a labor market. In most employment relationships, the party who possesses the most accurate and complete information concerning a worker's ability is that worker's own employer. The information possessed by other employers in the labor market is typically less complete. This means that promoting a worker to a higher rank conveys new (and positive) information to other employers concerning the worker's ability, and those employers update their beliefs (and wage offers) accordingly. The current employer must therefore increase the promoted worker's compensation to a sufficient extent to prevent the worker from being bid away by a competitor.

Extending the model of Waldman (1984) to incorporate a worker characteristic that is publicly observed by all firms in the labor market and that is correlated with ability gives rise to testable implications. In DeVaro and Waldman (2012) that worker characteristic was the level of educational attainment.[2] Promotion of a highly-educated worker releases little new information to the market (since other employers already saw the person as having high ability) whereas a promotion of a less-educated worker is more of a surprise to other firms. This greater surprise leads to a big positive update in the beliefs of competing firms about the worker's ability and, hence, a big increase in the wage these employers are willing to offer the worker. To avoid the resulting bidding war, the employer of this less-educated worker may be inclined to withhold a promotion from the worker, even if such a promotion would be justified on productivity grounds. The result is that promotion rates are inefficiently low for less-educated workers, holding job performance constant. By similar logic, the wage increase occurring at the time of promotion should decrease with educational attainment, again holding job performance constant. Furthermore, both of these predictions should hold more strongly for first promotions than for subsequent promotions. The reason is that because a promotion releases significant information about a worker's ability to other firms in the market, each successive promotion a worker receives reduces the information asymmetry between the worker's current employer and other employers in the labor market. The preceding testable implications were derived formally in DeVaro and Waldman (2012) and serve as the primary basis for the present paper.

We empirically test the predictions from DeVaro and Waldman (2012), using large-scale,

[1] Other papers in this area include Milgrom and Oster (1987), MacLeod and Malcolmson (1988), Ricart i Costa (1988), Waldman (1990), Bernhardt (1995), Gibbs (1995), Zábojník and Bernhardt (2001), Owan (2004), Golan (2005, 2009), Ghosh and Waldman (2010), DeVaro and Waldman (2012), DeVaro, Ghosh, and Zoghi (2012), and Zábojník (2012).

[2] See Bernhardt (1995) for a related theoretical analysis that also differentiated workers by level of educational attainment.

nationally-representative, worker and firm-level panel data from Finland and Germany. The Finnish dataset is a linked employer-employee panel with more than 5 million observations across 5000 firms spanning the 30 years from 1981 to 2010, drawn from the records of the Confederation of Finnish Industries (EK), which is the central organization of employer associations in Finland. The German dataset is the German Socio-Economic Panel (GSOEP), an annual panel of households that began in 1984 and that continues to the present (2012).[3] The panel consists of 17,134 households, 55,471 individuals, and a total of 497,087 person-year observations. The advantages of focusing on two distinct countries in the same empirical analysis are highlighted in the following statement from Hamermesh (2007): "If our theories are intended to be general, to describe the behaviour of consumers, firms, or markets independent of the social or broader economic context, they should be tested using data from more than just one economy." Following DeVaro and Waldman (2012) we differentiate workers by their level of educational attainment, and we address the aforementioned testable implications related to the probability of promotion and to the wage increases conditional on promotion. We find that the signaling role of promotions is supported in both Finland and Germany in that the predictions from DeVaro and Waldman (2012) hold for certain educational groups.

We also investigate whether and how the signaling role of promotions differs between men and women. A potential theoretical explanation for gender differences in the extent to which promotions signal worker ability can be found in Milgrom and Oster (1987). In that framework there are two types of workers (Visibles and Invisibles). Visibles are workers whose abilities are readily observed by all employers in the labor market, whereas Invisibles are workers whose abilities are difficult to observe by employers other than the worker's current employer. Women (men) are likely to have disproportionately large representation in the Invisibles (Visibles) group. The argument is that for various reasons, such as lack of "old boys club" connections, women are less well connected to the outside labor market. This provides a theory of gender discrimination in the labor market, because employers with private information about their highly talented (but Invisible) workers can "hide" these workers from competing firms by failing to promote them. The strategy would not work for Visibles, because withholding promotion from a highly talented Visible would lead a competing firm to steal that worker away. One implication is that, holding worker performance constant, promotion probability should be lower for women than men.[4] Furthermore, again holding performance constant, the preceding gender difference should be larger for first promotions than for subsequent promotions, for the following reason. Since a promotion releases significant information about ability to competing firms, the informational asym-

[3] Our analysis uses the International Scientific Use Version, which is a 95% subsample of the full panel.

[4] Lazear and Rosen (1990) offer an alternative explanation for why, holding worker performance constant, promotion probability should be lower for women than men. That explanation is not based on the signaling role of promotion but rather on the idea that differential movement along job ladders entails comparative advantage, and women are assumed to be more productive than men in non-market labor such as household work.

metry is reduced and "Invisible" women start to look more "Visible" to outside firms. A related implication of the Milgrom-Oster framework is that the wage increase attached to promotion should be larger for women than men, controlling for worker performance, with this result more pronounced for first than for subsequent promotions.

The empirical literature on gender differences in promotion probabilities and in the wage changes attached to promotion has yielded mixed results, though in most cases the empirical models in that literature have not controlled for time varying, job specific measures of worker performance.[5] Some studies find a positive gender gap in promotion probabilities, others find a negative gap, and others find no gap. One study that included a control for worker performance was Blau and DeVaro (2007), which found a lower promotion probability for women than men of 2 to 3 percentage points. That same study found essentially no gender difference in the wage change attached to within-firm promotion.[6] Drawing on the Milgrom-Oster framework, we can evaluate whether women have lower promotion probabilities than men after controlling for performance, and whether the gender gap diminishes after the first promotion is received. Similarly, we can evaluate whether women experience larger wage increases than men after controlling for worker performance and whether this gender difference is stronger for first than for subsequent promotions. In both Finland and Germany we find evidence of gender differences in promotion probabilities that are of comparable magnitude to those found in Blau and DeVaro (2007), and we also find evidence in both countries that this gender gap dissipates after the first promotion. In the Finnish data the point estimates reveal larger wage increases attached to within-firm promotion for women than men, with this difference larger for first than for subsequent promotions, though these gender differences are statistically insignificant at conventional levels. In the German data we find a positive but statistically insignificant wage increase from within-firm first promotions for men, whereas the corresponding increase for women is considerably larger and statistically significant at the one percent level. In the case of subsequent promotions, neither gender experiences a statistically significant wage change. This pattern of results is consistent with the signaling role of promotions being stronger for women than men, and diminishing after first promotion, consistent with the Milgrom-Oster framework.

A unique feature of our analysis is that we distinguish between within-firm and across-firm promotions. The theoretical literature on promotions and wage dynamics frequently focuses on a unique equilibrium that is characterized by no turnover, so that a worker's initial employer always raises a promoted worker's wage (or a non-promoted worker's wage) to a sufficient extent to prevent that worker from being bid away by a rival firm. Testable implications are then based on this zero-turnover equilibrium, which is seen as a justification

[5]See Blau and DeVaro (2007) for a survey.

[6]Examples of studies that found the same result but without controlling for worker performance include Olson and Becker (1983), Gerhart and Milkovich (1989), and McCue (1996). Other studies found evidence of a gender gap in one direction or the other, though in the absence of a control for worker performance. The gender gap favored men in Hersch and Viscusi (1996), Barnett et al. (2000), and Booth et al. (2003), whereas it favored women in Cobb-Clark (2001).

for conducting empirical work that focuses only on workers who remain with the firm. The focus on within-firm promotions is convenient, given that in single-firm personnel datasets there is typically no information on workers after they separate from the firm. However, in the real world, turnover regularly occurs, and previous research suggests it is an important aspect of careers (e.g. Topel and Ward 1992, Farber 1994, Booth et al. 1999, Munasinghe and Sigman 2004, and Parrado et al. 2007).[7] The data in the present study allow us to consider both within-firm and across-firm job changes (and the resulting wage changes). Our results suggest that theoretical predictions concerning the signaling role of promotions are more strongly supported for within-firm promotions than for across-firm promotions.

Three recent papers provide empirical evidence related to this study. The first of these, DeVaro and Waldman (2012), is the most closely related to the present study. That analysis uses data on white males from the single, large American firm in the financial services industry that was first studied in the classic internal labor market analyses by Baker, Gibbs, and Holmström (1994a,b). DeVaro and Waldman (2012) find that across all education groups, after controlling for worker performance the probability of promotion is increasing in the level of educational attainment, and this result is stronger for first promotions than for subsequent promotions. Furthermore, for first promotions the authors find that the wage increase due to promotion (measured as either a change in levels or a change in logs) is smaller for those with masters degrees than for those with bachelors degrees, whereas this relationship is not found for subsequent promotions. In contrast, they do not find the predicted relationships between education and wage growth for high school educated workers and those with Ph.D.s. Overall the results support signaling being important for workers with BA and MA degrees, whereas the evidence concerning the importance of signaling for high school graduates and Ph.D.s is mixed.[8]

Second, DeVaro, Ghosh, and Zoghi (2012) use data from the American firm analyzed in Gibbs and Hendricks (2004) to investigate four empirical predictions from a theoretical model that extends the Milgrom-Oster framework. As in Milgrom and Oster (1987), consider two groups of workers (Invisibles and Visibles) where the former consists of workers who are traditionally thought to be disadvantaged in the labor market (e.g. women or racial minorities) and the latter consists of workers who are traditionally thought to be advantaged (e.g. men or whites). Suppose that job hierarchies vary in the degree to which job tasks differ across hierarchical levels. DeVaro, Ghosh, and Zoghi (2012) show that four

[7] Noting the connection between career progression and turnover, Waldman (2007) has called for more empirical work on this subject to guide the development of theories that connect wage and promotion dynamics to turnover. Building on Gibbons and Waldman (1999), Ghosh (2007) provides a theoretical analysis predicting that the probability that a worker switches firms decreases with labor market experience. See also DeVaro and Morita (2012) which provides a theoretical and empirical analysis of internal promotion versus external hiring, with predictions concerning the probability that a firm's manager departs for another firm when getting promoted.

[8] Belzil and Bognanno (2010) report related results in the context of a study of fast-track promotions using a panel of 30,000 American executives, though their data do not include time-varying, job-specific worker performance ratings to be used as controls.

testable implications emerge. First, controlling for worker performance, promotion probabilities are lower for Invisibles than Visibles, and second, this difference is mitigated in job hierarchies that exhibit significant variability of tasks across job levels. Third, the wage growth attached to promotion is higher for Invisibles than Visibles, and fourth, this difference decreases when tasks become more variable across hierarchical levels. The authors conduct the empirical tests focusing on race, where Invisibles are nonwhite workers and Visibles are white workers. However, in principle the tests could also be applied in the case of gender. The empirical evidence supports the first three of these predictions, and the authors discuss some potential reasons for the lack of support of the fourth. Given that three of the four predictions are empirically supported the authors interpret the evidence as broadly suggestive of a signaling role of promotions.

Third, like the present study, Bognanno and Melero (2012) seek to empirically test the signaling role of promotions in panel data spanning many firms. They use the British Household Panel Survey (BHPS) to investigate whether promotions that reveal more information to the outside market (e.g. those for young workers or for workers with low education levels) are accompanied by greater percentage increases in the wage. Bognanno and Melero find results in accordance with their hypotheses regarding the effect of both age and education on the increase in log-wages attached to promotions, though the statistical significance of their estimates hinges on the definition of promotion. Apart from the fact that their paper covers Britain whereas ours covers Finland and Germany the focus of the two studies differs in a number of ways. For example, our paper considers theoretical predictions concerning both promotion probability and wage increases conditional on promotion, whereas theirs only considers the latter; our paper distinguishes between first promotions and subsequent promotions, following the theoretical predictions from DeVaro and Waldman (2012), whereas theirs does not; and their paper does not consider gender differences or distinguishing between within-firm to across-firm promotions, whereas these are important points of focus in our analysis.

All theoretical predictions in a promotion signaling framework, whether concerning promotion probabilities or the wage increases attached to promotion, include the qualifying phrase "holding worker performance constant". As an example illustrating why this is so important, consider the theoretical prediction that promotion probability is increasing in the level of educational attainment. Absent a control for worker performance, an empirical finding that promotion probability is increasing in education would be no surprise. Workers with more education are, on average, more productive than those with less education. Thus, it should be expected that workers with more education are more likely to be promoted. The requirement that the worker's pre-promotion job performance be held constant poses a considerable challenge for empirical tests given that performance measurements are rarely available in the few datasets that contain all the other requisite information (e.g. promotions, wages, measures of job hierarchy, and educational attainment).

There are three potential approaches for dealing with the performance measurement problem. One approach is to rely on single-firm personnel datasets that often contain supervisor-reported worker performance measurements which are inherently job-specific and time varying. Such measures are typically unavailable in datasets spanning many firms, and even if they were available the comparability of the ratings across firms would be questionable (e.g. the ratings might be measured in different units and on different scales). Examples of the single-firm approach to solving the performance measurement problem are DeVaro and Waldman (2012) and DeVaro, Ghosh, and Zoghi (2012). However, this approach has three important limitations, all of which derive from the nature of the data. First, as noted in Baker and Holmström (1995), it is unclear to what extent the results of single-firm case studies generalize to broader classes of employers. Second, workers who switch firms disappear from the sample, so there is no way to know whether they switched to a new firm, or to unemployment, and in the case of switching firms their new job level and wage are unobservable. Given that many workers come and go in the typical firm, particularly over a long time horizon, dropping all of the "leavers" from an analysis is problematic and could bias the results of an analysis of promotion and wage dynamics. Third, such data do not allow the researcher to investigate whether the signaling role of promotions differs between within-firm versus across-firm promotions. A second approach is to use large-scale, multi-firm panels that mitigate the limitations of single-firm studies, but at the expense of forgoing controls for worker performance. This is the approach taken in Bognanno and Melero (2012). A third and new approach, taken in the present paper, is to exploit large-scale, worker-firm panel data while inferring a job-specific, time-varying worker performance measure by estimating the idiosyncratic component of individual performance bonuses. The approach of inferring a measure of individual performance from bonus data has been used before for different purposes in Pekkarinen and Vartiainen (2006) and Gittings (2012a,b). Since lack of crucial data on worker performance has prevented researchers from exploiting rich, large-scale, worker-firm panels to empirically test the predictions of theories concerning careers, our approach opens the door for future work in this literature to move beyond single-firm case studies. Our empirical tests are not subject to any of the aforementioned limitations of single-firm studies.

In the remainder of the paper we devote two sections to the Finnish analysis and two to the German analysis before summarizing and concluding.

2 Data and Measures: Finland

The Finnish data are drawn from a large, worker-firm-linked panel from 1981 to 2010. The source of the annual survey data is the records of the Confederation of Finnish Industries (EK), which is the central organization of employer associations in Finland. EK-affiliated firms represent over two thirds of the Finnish GDP and over 90 percent of exports, so that the data represent a significant share of the Finnish economy.[9] The data are of high quality given that they are based on firms' administrative records, and since participation in the survey is compulsory except for the smallest firms, the response rate is nearly 100 percent. The data include over 5 million observations in total, of which 35.9 percent represent women. The number of individual workers is 639,712, with 38.2 percent women. The data allow us to follow individual workers' careers for up to 30 years, to distinguish within-firm from across-firm promotions and to incorporate a large set of controls for worker and firm characteristics.

Apart from the performance measurement problem discussed in the introduction, moving from single-firm data to multi-firm data poses a second empirical challenge. Defining promotions across firms is difficult because job hierarchies are not easily measured in a comparable way across firms.[10] This problem can be resolved in the Finnish data given that all firms use the same 56 job titles and four hierarchical levels, which makes the classification comparable across firms. We can therefore define a promotion as a transition across hierarchical levels (either within or across firms).

2.1 Variables and Data Selection: Finland

We restrict our analysis to all workers who appear in the data after 2001, since in this subsample we can distinguish more cleanly between workers receiving their first promotion and those receiving subsequent promotions.[11] The theoretical argument for making this distinction is given in DeVaro and Waldman (2012).[12]

We restrict attention to white-collar jobs in manufacturing because complexities in the occupational classification system for blue-collar jobs make it difficult to allocate those jobs across hierarchical levels. We also restrict our analysis to full-time workers (defined as regularly weekly working hours exceeding 30), though this restriction is of little practical consequence given that the share of part-time workers is small for white-collar jobs (about 2 percent in 2006).

The two dependent variables in this analysis are a binary indicator for whether a promotion was received and the annual wage change (measured in both levels and logs). We measure promotions based on changes in job titles. In manufacturing, these titles are comprised of two parts. The first is a three-digit code describing the field (e.g. R&D,

[9] See Kauhanen and Napari (2012a) for a more detailed description of the data and of the wage-setting process in Finland, and see Asplund (2007) and Vartiainen (1998) for descriptions of the Finnish bargaining system.

[10] A small number of papers have addressed this issue. Frederiksen et al. (2010) use occupation codes to distinguish between executive and non-executive ranks, while Da Silva and Van der Klaauw (2011) use Portuguese matched employer-employee data that contain a hierarchy definition that is comparable across firms.

[11] This is because in 2001 there was a change in the way job titles were coded, and it is difficult to compare codes consistently before and after this change.

[12] Even in our "first-promotion subsample" it is possible that some workers were in fact promoted earlier. This could happen if, for example, the firm first appears in the data in 2002. In this case 2002 would be the first observation for a given worker, but that person might have been promoted in the firm at an earlier date.

production, sales and marketing), of which there are 56. The second describes the organizational level, and it has four categories. For the wage change analysis, following DeVaro and Waldman (2012) the annual wage change does not include bonuses. In our analysis, excluding bonuses from the construction of the dependent variable avoids an endogeneity problem, given that we use the bonus data to infer individual performance, which is a key control variable required by the theory.

The independent variable in this analysis is educational attainment. As discussed in DeVaro and Waldman (2012), given that a higher observed level of schooling serves as a signal that the worker belongs to a higher productivity group, in models of promotion probability and of the wage growth attached to promotion it is preferable to focus on the receipt of a degree rather than on years of education. For example, taking five years to complete a BA degree does not signal higher quality than taking four, and taking three years to complete an MBA does not signal higher quality than taking two. In the absence of direct measures of degree receipt, DeVaro and Waldman had to define their four education dummies for degrees indirectly (and possibly with error) based on years of education. An advantage of the Finnish data is that we directly observe five categories of education levels, which we aggregate to the following four educational groups (upper secondary, lowest-level tertiary, BA, and GRAD), where BA is lower-degree-level tertiary education and GRAD is higher-degree-level tertiary education or doctoral (or equivalent-level tertiary) education. We aggregate from five categories to four because of an extremely small sample size in the highest-level category.[13]

2.2 Worker Performance Measures: Finland

Data on time-varying, job-specific, individual worker performance measures are needed to test the promotion-as-signal hypothesis. Such data are absent in the Finnish dataset, as in most other datasets that span many firms, including the British BHPS data used in Bognanno and Melero (2012). The difficulty of obtaining such performance data necessitated using personnel records from single-firm cases in DeVaro and Waldman (2012) and DeVaro, Ghosh, and Zoghi (2012). To overcome the problem in the present study, we infer measures of worker performance from the amount of performance-related-pay the worker received, following a similar approach to those used in Pekkarinen and Vartiainen (2006) and Gittings (2012a,b). About 58 percent of workers in the data received performance-related-pay.

We begin by estimating a regression in which the dependent variable is the amount of performance-related-pay that worker i receives in year $t+1$, and the independent variables (including job title dummies, job level dummies, year dummies, and industry dummies) are measured in year t. The reason for leading the dependent variable is that payments for

[13] Like the Finnish data, the British data used in Bognanno and Melero (2012) also contain direct measures of degree receipt. In that study the authors use those dummies to construct an inferred "years of education" measure on which they base their analysis, thereby assuming that the effect of an additional year of education on wage growth is the same, regardless of the education level.

performance in year t are typically paid in year $t + 1$. We then use the residuals from the regression as measures of worker performance. Thus, each worker's performance is measured by how much performance-related-pay the worker received compared to other workers in the same job title, same job level, and same industry, in a given year.

A feature of actual (as opposed to inferred) worker performance ratings is that they tend to be positively autocorrelated, with the strength of the correlation diminishing with the order of the autocorrelation. This is the case, for example, in Table 10 of DeVaro and Waldman (2012), which reports the bivariate correlation matrix of the workers' actual annual performance ratings and their first three lagged values, using data from a single American firm in the financial services industry. That table is reproduced in Panel A of Table 1 in the present paper. As shown in Panel B of that table, we find exactly the same pattern in the Finnish data, using the performance measure we inferred from bonus data. The correlation matrix is strikingly similar to that of the DeVaro-Waldman analysis.

3 Empirical Analysis: Finland

The following two subsections present the analyses of promotion probability and the wage change conditional on promotion, respectively.[14] Descriptive statistics for all variables in the subsequent analysis appear in Table 2.

3.1 Promotion Probability: Finland

We estimate a multinomial probit model with a trivariate dependent variable in which the baseline outcome, 0, is no promotion, outcome 1 is promotion within the firm, and outcome 2 is promotion across firms. The dependent variable refers to the outcome for worker i in year t, whereas all right-hand-side variables are measured in year $t - 1$. The independent variables of interest are the dummies for educational attainment. The control variables include worker performance (as defined in the preceding section), age, age squared, job tenure (in years) at the firm, job tenure (in years) at the firm squared, job level dummies, and job title dummies.

Table 3 displays average marginal effects, where the omitted educational group is BA, which is the second highest of the four groups. The table reveals that the overall probability of within-firm promotion for all workers combined is 6.2 percent. The probability of a within-firm first promotion is a bit higher, at 6.6 percent, whereas the probability of a within-firm subsequent promotion (conditional on having received an earlier promotion) is 3.8 percent. The probability of across-firm promotion is extremely small in the white-collar Finnish manufacturing data, at less than 1 percent. Although most promotions in the Finnish data occur within firms, the sample size is large enough to support analysis of

[14] Our approach is similar to that used in DeVaro and Waldman (2012), and we refer readers to that study for more detailed discussions of the underlying theoretical motivation for the empirical models we estimate.

across-firm promotions. Six interesting results emerge from Panel A, which combines men and women.

First, as seen in column 1, the probability of within-firm promotion is increasing in the level of educational attainment, holding worker performance constant. This is the same result found in DeVaro and Waldman (2012) which considered only white, male stayers and within-firm promotions in a single firm.

Second, the incremental effects of the education variables are smaller in column 5 than in column 3. This suggests that the first result is stronger for within-firm first promotions than for within-firm subsequent promotions, as theory predicts. This result also matches what was found in DeVaro and Waldman (2012), which provided the following theoretical rationale. As other employers in the labor market learn more about a worker's abilities (as a consequence of observing the promotion record) education carries less informational content, and its importance diminishes. We suspect that our evidence in favor of this second result, here and throughout the paper, is understated given that our method of distinguishing between first and subsequent promotions likely produces some misclassifications that would blur the distinction between columns 3 and 5.

Third, as seen in column 2, the result that promotion probability is increasing in the level of educational attainment (controlling for pre-promotion performance) also holds in the rare case of across-firm promotions just as it did for within-firm promotions.

Fourth, as seen by comparing the incremental effects of education in column 4 to those in column 6, the result that the across-firm promotion probability is increasing in the level of educational attainment is stronger for first promotions than for subsequent promotions. These third and fourth results concerning across-firm promotions parallel those that were found, theoretically and empirically, in DeVaro and Waldman (2012) for within-firm promotions. The result that these patterns of evidence are also true for across-firm promotions is new to the literature.

Fifth, as seen in columns 1, 3, and 5 concerning within-firm promotions, the marginal effect of pre-promotion performance has the anticipated positive sign. However, as seen in columns 2, 4, and 6, the sign flips to negative in the rare event of across-firm promotions. One possible explanation for the negative sign is adverse selection in the labor market as discussed in Greenwald (1986). However, we see that explanation as unlikely given that, as we show in Table 4, across-firm moves (whether promotions or not) are on average accompanied by large wage increases. We think that a more likely explanation for the negative sign derives from the definition of our performance measure, which is inferred from individual bonus data. Low measured performance in the pre-promotion year means the worker's bonus was low, and in such cases the worker may be more open to advancing the career at a different firm, whereas if last year's bonus was extremely high the worker might find it hard to leave.

Sixth, the probability of promotion (within and across firms) is lower for women than men. The lower promotion probability for women in this dataset was documented in Kauhanen and Napari (2012b). However, like most studies in the literature, that study did not control for pre-promotion, job-specific worker performance. As noted earlier, one study that controlled for such pre-promotion job performance (measured as the supervisor's subjective rating on a 0-100 scale) was Blau and DeVaro (2007), which also found evidence of lower within-firm promotion probabilities for women than men, for recent hires in an American establishment-level cross section. In that study, the magnitude of the marginal effect of gender was in the neighborhood of 2 to 3 percentage points, depending on the specification, just as it is in columns 1 and 3. When a prior promotion has occurred, there is no evidence in the Finnish data that the likelihood of a future promotion (within or across firms) is different for women versus men. This is consistent with the argument developed in Milgrom and Oster (1987) based on the Invisibility Hypothesis. At earlier career stages before a first promotion has been received, the labor market finds it harder to learn the abilities of (Invisible) women than (Visible) men. However, when a promotion occurs a considerable amount of information is revealed to the market concerning worker ability, so the visibility of women improves relative to men, explaining why the gender difference diminishes for the probability of subsequent promotion.

Panels B and C of Table 3 repeat the preceding analyses for the subsamples of men and women, respectively. The first five results just stated largely hold for both men and women, with few noteworthy differences between these two subsamples. All of the preceding results are insensitive to controlling for an additional lag of worker performance.

3.2 Wage Growth and Promotion: Finland

The promotion-as-signal hypothesis implies that the wage increase that accompanies a promotion should decrease with the level of educational attainment, controlling for pre-promotion performance. The intuition is that when highly-educated workers are promoted, employers are unsurprised since they already viewed these workers as being highly capable. There is therefore less positive updating in beliefs about the abilities of promoted workers, and consequently less of an increase in the wage competing employers are willing to offer. This in turn means that the worker's original employer need not offer a large wage increase to retain the worker. A further prediction of the theory is that the result just noted should be stronger for first promotions than subsequent promotions. Theoretical predictions involving wage growth in this literature are more often stated in wage levels than in log-wages. We consider both in this paper, as in DeVaro and Waldman (2012).[15]

To analyze the relationship between educational attainment and the wage increase that accompanies promotion, we first construct four dummies capturing within-firm promotions,

[15] As noted in the introduction, Bognanno and Melero (2012) also test this empirical prediction and find supporting evidence for it depending on how promotions are defined, though they only consider differences in log wages, they do not control for pre-promotion worker performance, and they do not distinguish first promotions from subsequent promotions.

across-firm promotions, within-firm non-promotions, and across-firm non-promotions. In OLS regressions for each of two dependent variables (annual change in wage level, and annual change in log-wage), we include three of the preceding four dummies (excluding the indicator for within-firm non-promotions) as main effects and also interacted with each of the education dummies. Our use of OLS regressions is consistent with the approach of DeVaro and Waldman (2012). Bognanno and Melero (2012) take an alternative approach that accounts for individual worker heterogeneity via random effects (or fixed effects in their models that include worker age but exclude years of education). Given that those authors were unable to control for pre-promotion performance, their decision to incorporate individual effects into the analysis was well advised. Note that most of the unobserved worker characteristics (some time varying, others not) that researchers are worried about in a wage growth model relate to and ultimately predict worker performance. Examples include worker attitudes, levels of motivation, effort levels, unobserved components of ability, unmeasured mental and physical health, etc. These unobserved factors affect wages via their effect on job performance, so most unobserved factors that one would be interested in absorbing via individual effects are already subsumed in measures of worker performance. These worker performance controls are included in our analysis as they were in DeVaro and Waldman (2012). Nonetheless, as a robustness check we also estimated our models accounting for individual worker heterogeneity via random effects and found results very similar to those we report here, which again is unsurprising given that the main unobserved components one hopes to absorb in an individual effect should already be embedded in our control for worker performance. Note that in random effects and fixed effects models the individual effect cannot be interpreted as fully accounting for worker performance, because some important determinants of worker performance tend to be time-varying (e.g. worker effort).

Table 4 displays the results for men and women combined (Panel A), men (Panel B), and women (Panel C). Several points are worth highlighting.

First, as seen in columns 1 and 4 of Panel A, whether considering changes in wage levels or changes in log wages, in the case of within-firm promotions (which comprise the vast majority of all promotions) the results are consistent with the theoretical prediction for the lowest-level education group. That is, the coefficient of the interaction between the within-firm promotion dummy and the lowest-level education dummy is positive and statistically significant. For the case of the highest-level education group, the coefficient on the interaction term has the wrong theoretical sign but is statistically significant only in the case of wage levels. The fact that the prediction fails to hold for the highest-level educational group was also true in the case of white men in the firm analyzed in DeVaro and Waldman (2012).

Second, as seen in columns 2, 3, 5, and 6 of Panel A, the evidence of promotion signaling for the lowest-level education group is stronger for first promotions than for subsequent promotions, consistent with theory.

Third, for the rare cases of across-firm promotions the theoretical prediction concerning wage growth fails to hold in Panel A, and distinguishing first from subsequent promotions does nothing to change matters.

Fourth, comparing Panels B and C reveals that both in level and logs, for all workers and for first promotions, within-firm promotions are associated with larger wage increases for women than men, though the reverse is true for subsequent promotions. However, none of these gender differences are statistically significant at conventional levels. For across-firm moves (whether promotions or not), both in levels and in logs, wage increases from first promotion are higher for men than women (a difference that is statistically significant at conventional levels), but there is no statistically significant gender difference in the wage increases attached to subsequent promotions.[16] The Milgrom-Oster framework offers a potential explanation for the fact that across-firm job transitions are associated with larger annual wage increases for men than women, whereas there is no gender difference in the wage changes attached to within-firm promotion. More precisely, whatever mechanisms might be causing annual wage increases to be higher for men than women are weakened in the case of within-firm promotions for the following reason. Since promotions of (Invisible) women are more of a surprise to competing firms than promotions of (Visible) men, there is a larger positive update in the beliefs about womens' ability, and hence a larger wage increase attached to promotion. In fact, although the gender differences are statistically insignificant, the point estimates reveal a large wage increase for women than men for within-firm promotion, and this difference is even larger for first promotions and absent for subsequent promotions. This pattern of evidence is consistent with a potential signaling role of promotions that is stronger for women than men.

Finally, as has been well documented in the literature, Panel A reveals that within-firm promotions are associated with wage increases. If the promotion involves a change in firms, this wage increase is even larger. Even job transitions that occur across firms but that do not involve promotion are associated with big wage increases, relative to remaining in the original firm without a promotion. Across all models in wage levels, unsurprisingly, last year's performance is positively related to annual wage increases. In contrast, last year's performance has essentially no effect in the models in logs.

The patterns of results in Panel B (for men) and Panel C (for women) essentially mirror those for Panel A.

[16]Kauhanen and Napari (2012b) also find that wage increases from across-firm promotions are higher for men than women but they do not separate first and subsequent promotions, nor do they control for performance.

4 Data and Measures: Germany

The German Socio-Economic Panel (GSOEP) is an annual panel survey of German households. The survey began in 1984, and as of 2012 there have been seven new waves added to the initial sample, including an East German sample starting in 1990. In addition to household information the panel contains a personal survey component which includes many employment-related questions. The data permit a definition of hierarchy and promotion that is consistent across firms. Workers are asked their occupational status, which can be interpreted as their hierarchical rank within the firm.[17] We describe the hierarchical assignment procedure in more detail in the Appendix. Using the response to the question about occupational status, we allocate workers to one of four hierarchical levels: Lower, Middle, Upper and Executive.

As noted earlier, defining promotions consistently across firms poses a potential challenge in datasets spanning many firms. In the German data we measure promotions by a worker-reported survey indicator that a promotion has occurred. This type of measure resolves the issue of defining an across-firm promotion since the definition does not hinge on a particular definition of the job hierarchy. Furthermore, since this survey question is asked independently of the worker's occupation, we need not rely on occupation codes to define the hierarchy as has been done in previous work.[18] The disadvantage of using transitions across occupation codes to define promotions is that promotions more commonly occur within occupations than across occupations.[19]

4.1 Variables and Data Selection: Germany

Our analysis focuses on full-time workers between the ages of 20 and 65.[20] We focus only on white-collar, blue-collar, and civil service workers, dropping self-employed workers and apprentices. These selection criteria result in a total of 112,412 observations for which we can assign a worker to a job level. We drop observations for which wages are below 4800 Euros a year,[21] as well as outlying yearly bonuses of over 50,000 Euros. We also drop absolute net yearly wage changes between years that exceed 24,000 Euros per year. In total, we lose 1168 observations due to wage or bonus data cleaning. Missing occupation, industry, and firm size data further reduce our sample by 5560. We lose 499 observations

[17] Lluis (2005) and Cassidy (2012a) also use this GSOEP question for this purpose. See the Appendix for an example of this question in the 1985 survey year.

[18] See, for example, Frederiksen, Halliday and Koch (2010), which uses occupation codes to group workers into executive and non-executive ranks, so that a promotion or demotion necessarily requires a change in occupation.

[19] For example, in the National Longitudinal Survey of Youth (NLSY), Cassidy (2012b) finds that roughly 60 percent of promotions occur within occupations. Furthermore, in the single-firm personnel data analyzed in DeVaro, Ghosh, and Zoghi (2012), the fraction of promotions occurring within-occupation is 93 percent using two-digit occupation codes and 92 percent using three-digit occupation codes.

[20] We identify full-time workers using the GSOEP-generated Labor Force Status variable and further restrict our attention to workers employed for over 30 hours per week on average.

[21] Income is denominated in 2009 Euros. We use net yearly labor income, as opposed to gross income.

due to missing education, tenure, and experience data. Since a worker in the highest job level cannot be promoted, we exclude 5437 observations where the worker is in the Executive level in the initial period.

We define a promotion to occur when a worker's job level increases from one year to the next. Following DeVaro and Waldman (2012), we do not distinguish between single-level versus multiple-level promotions, e.g. from Lower to Middle versus from Lower to Upper (bypassing the Middle level). The self-reported nature of the worker's job level introduces the possibility of spurious level changes. To mitigate this problem, Lluis (2005) uses a job change question in conjunction with level change and wage change to determine promotions and demotions; in that study, a promotion occurs if: a) the worker reports both a job change and a level increase; or b) the worker reports only a level increase, but with a wage gain of at least 5%. Demotions are analogously defined, but in case (b), occur only for workers whose real wage decreases. Using endogenous wage information to determine level changes would be problematic for our analysis since we use wage changes as a dependent variable. For this reason, we clean the data by assuming that if a worker changes level between period 1 and period 2, but returns to the initial level in period 3, the level change was mismeasured. In this case, we assign the period 1 (and period 3) level to period 2. This approach is similar to the method used in Yamaguchi (2010) for occupation codes, but where the intervening period is a single year, instead of the worker's entire firm tenure.[22] Our correction procedure reduces the yearly promotion rate from 10.7% to 5.7%.[23]

We define a categorical variable based on the worker's number of years of education, labeling respondents with fewer than 13 years of schooling as having a high school degree or less (HS), those with 13 to 16 years as having a bachelor's degree (BA), and those with 17 years or more as having a graduate degree (GRAD).[24] Firm size appears in the survey as a categorical variable with the following four size groups: 1-19, 20-199, 200-1999 and 2000+ workers. Industry classification is at the two-digit level, following the NACE classification system, and occupation classification uses the three-digit ISCO-88 system. Job tenure and worker experience are both worker-reported, where only full-time experience is used.[25]

We partition the sample into first-promotion and subsequent-promotion subsamples, where the first-promotion subsample includes workers who have either not yet received

[22]In that study, if a worker changes occupations but eventually changes back to the original occupation while at the same firm, Yamaguchi assumes that the intervening spell was mismeasured and imposes the original occupation code for the intervening period.

[23]Although this procedure probably mislabels some genuine promotions, the average wage change experienced by promoted workers increases from 3.7% to 4.6% after we impose the correction. For workers who are promoted based on the non-corrected procedure but not promoted after the correction, average wage change is only 2.6%. This is suggestive that many corrected "promotions" are, in fact, spurious.

[24]This approach of inferring indicators for levels of educational attainment from data on years of education was taken in DeVaro and Waldman (2012). As discussed earlier, an advantage of the Finnish data is that levels of educational attainment are directly observed and need not be inferred.

[25]Ignoring part-time experience is unlikely to be a problem, given that the mean part-time and full-time experience are roughly 2 years and 15 years, respectively.

a promotion, or who have just received their first promotion in that year.[26] All other observations are included in the subsequent-promotion sample. We note that in some cases our approach might misclassify a subsequent promotion as a first promotion. This issue arises because in the GSOEP, since many of the workers in the survey are only observed starting from a later age,[27] we do not observe the early part of the labor market history for many workers. Thus, for some workers in the survey the first promotion received may not be their true first promotion.[28]

4.2 Worker Performance Measurement: Germany

As in our Finnish analysis, we infer a measure of individual, job-specific performance from data on individual performance bonuses. The GSOEP asks workers for the amount of the bonus received in the previous year, divided into Christmas, vacation, profit sharing and "other" bonus. We aggregate all four types into a single bonus amount (setting missing bonus data to zero for each type) and use this to impute performance. A large fraction (75%) of workers received a bonus, and the average annual bonus amount is 1470 Euros.

The imputation procedure for the GSOEP is similar to the procedure used for the Finnish data. We measure performance as the residual of an OLS regression of bonus pay on firm size, industry and occupation dummies, the worker's blue-collar/white-collar status, hierarchical level, and year dummies. The bonus variable we use is observed in year $t + 1$ but refers to bonuses earned during year t; thus, we use year-t independent variables in the regression. Panel C of Table 1 displays the autocorrelation matrix for the performance measure. As in DeVaro and Waldman (2012) using actual performance (Panel A), and as in the Finnish data using imputed performance (Panel B), in the German data the imputed performance measure is highly autocorrelated, and the strength of the relationship declines with time.

5 Empirical Analysis: Germany

The empirical analysis using German data parallels the analysis using Finnish data as closely as possible, and the structure of this section parallels the corresponding structure from the Finnish analysis. Table 5 displays descriptive statistics for all variables used in the analysis.

[26] In our sample, 78% of promotions are "first" promotions.

[27] The mean worker is first observed in the sample at age 33.

[28] A similar concern pertains to DeVaro and Waldman (2012). In that analysis, the single-firm personnel records did not capture the entire hierarchy of the firm but rather only the managerial portion of it. So when a worker first appears in that sample, it is impossible to know whether the worker entered from outside the firm or was promoted up from the non-managerial ranks of the firm. In the latter case, a worker who appears to be promoted for the first time (in the sample) would in fact have experienced earlier promotions in the firm, unbeknownst to the researcher.

5.1 Promotion Probability: Germany

We estimate the same multinomial probit model for promotions described earlier in the Finnish analysis. Again the dependent variable is trivariate, where the baseline outcome, 0, is no promotion, outcome 1 is promotion within the firm, and outcome 2 is promotion across firms. The dependent variable refers to the outcome for worker i in year t, whereas all right-hand-side variables are measured in year $t-1$. The independent variables of interest are the dummies for educational attainment, where the middle category (BA) is the reference group. The control variables include worker performance (as defined in the preceding section), age, age squared, experience (in years), experience (in years) squared, job tenure (in years) at the firm, job tenure (in years) at the firm squared, one-digit industry codes, one-digit occupation codes, occupation group (white collar, blue collar, or civil service), and worker's hierarchical level.

Table 6 displays average marginal effects. Panel A reveals a within-firm promotion rate of 5 percent, which is slightly less than the corresponding rate of 6.2 percent from the Finnish data. As in the Finnish data, most promotions are within-firm, and the probability of across-firm promotion is less than 1 percent. This pattern is true for both men and women, though as in the Finnish data promotion rates are higher for men than women. Six interesting results emerge from Panel A, which combines men and women.

First, as seen in column 1, the probability of within-firm promotion is increasing in the level of educational attainment, holding worker performance in the pre-promotion period constant. This result is the same as that found in DeVaro and Waldman (2012), which considered only white, male stayers and within-firm promotions in a single firm, and it matches the result from the Finnish analysis.

Second, the incremental effects of the education variables are smaller in column 5 than in column 3, suggesting that the previous result is stronger for first promotions than for subsequent promotions. These results are consistent with first promotions having a stronger signaling role than subsequent promotions, as theory predicts and as found in the Finnish analysis. This result also matches what was found in DeVaro and Waldman (2012). We suspect that our evidence in favor of this second result is understated given that our method of distinguishing between first and subsequent promotions likely produces some misclassifications that would blur the distinction between columns 3 and 5.

Third, as seen in column 2 and as found in the Finnish analysis, the result that promotion probability is increasing in the level of educational attainment (controlling for pre-promotion performance) holds for across-firm promotions just as it did for within-firm promotions.

Fourth, as seen by comparing the incremental effects of education in column 4 to those in column 6, it is unclear whether the previous result concerning across-firm promotions is stronger for first promotions than for subsequent promotions. On the one hand, moving from column 4 to column 6, the incremental effect of HS shrinks in magnitude and becomes statistically insignificant. But on the other hand, the incremental effect of GRAD increases in magnitude.

Fifth, as seen in columns 1, 3, and 5 concerning within-firm promotions, the marginal effect of pre-promotion performance has the anticipated positive sign, though it is statistically insignificant in column 5. However, as seen in columns 2, 4, and 6, the sign flips to negative in the case of across-firm promotions. The same pattern of results occurred in the Finnish analysis. As noted there, although one possible explanation for the negative sign for across-firm promotions is adverse selection in the labor market as discussed in Greenwald (1986), we see that explanation as unlikely given that, as will be shown in Table 7, job transitions that occur across firms (whether promotions or not) are associated with wage increases. As noted earlier, we think that a more likely explanation for the negative sign derives from the definition of our performance measure, which is constructed from individual bonus data.

Sixth, the probability of promotion (within and across firms) is lower for women than men. The gender difference in within-firm promotion probabilities (controlling for pre-promotion performance) is three percentage points, which is similar in magnitude to the results from the Finnish analysis and from Blau and DeVaro (2007), both of which control for worker performance. As in the Finnish analysis, the gender gap is larger for within-firm first promotions than for within-firm subsequent promotions. This result is consistent with first promotions releasing considerable information about the ability of "Invisible" women (using terminology from Milgrom and Oster 1987), thereby diminishing the gender gap in information about abilities.

Panels B and C of Table 6 repeat the preceding analyses for the subsamples of men and women, respectively. The first five results just stated apply both to men and women, though there are two noteworthy differences between these two subsamples. First, the effect of education on promotion differs somewhat between men and women, with education having a larger impact on promotion receipt for women than for men. For the overall sample within firms (column 1), for women a GRAD degree increases the probability of promotion by 2.4% over the baseline education level (BA), whereas for men it increases the probability by only 1.0%. A HS degree reduces the probability of promotion for both men and women almost equivalently (1.9% and 2.0% for men and women, respectively); however, since the within-firm promotion rate for women is 0.7% lower overall than for men, these differences in coefficients understate the effects. This result is consistent with the Milgrom and Oster (1987) argument concerning Visible and Invisibles, in which the education signal is more valuable for women than men. Second, for men, performance is positively related to within-firm promotion receipt in the first-promotion sample, but not in the subsequent-promotion sample, whereas for women performance is even more relevant for subsequent promotions than for first promotions.

5.2 Wage Growth and Promotion: Germany

Results for OLS regressions of the wage growth attached to promotions appear in Table 7, which has the same structure as Table 4 from the Finnish analysis. First consider Panel A. In contrast to promotion signaling theory, the results in column 1 suggest that the level of educational attainment does not influence the magnitude of the annual wage increase attached to promotions. However, graduate degree holders who switch firms (but without receiving a promotion) experience bigger wage increases than do workers with less education who make the same job transition. Unsurprisingly, last year's performance is positively related to annual wage increases. Annual wage changes are lower for women than men. For our purposes, the most important point to take away from the education-related results in column 1 is that (given that the education variables do not influence the wage changes attached to promotion) there is no empirical support for promotion signaling. This state of affairs does not change when we separate first promotions (column 2) from subsequent promotions (column 3). The promotion-as-signal hypothesis implies that the wage increase from promotion should be decreasing in the level of educational attainment to a greater extent in column 2 than in column 3, whereas in fact there is no evidence of such a pattern in any of columns 1, 2, or 3. Finally, column 1 also reveals some other points. As has been well documented in the literature, within-firm promotions are associated with wage increases. If the promotion involves a change in firms, this wage increase is even larger. Job transitions that occur across firms but that do not involve promotion are also associated with big wage increases, relative to remaining in the original firm without a promotion.

If the dependent variable is the change in log-wages (columns 4, 5, and 6) the preceding observations from Panel A continue to hold for within-firm promotions, i.e. there is no evidence of a signaling role of promotions. However, for across-firm promotions there is evidence of signaling except in the case of high school graduates. For that educational group, the interaction with across-firm promotions should be positive according to the theory, whereas it is negative in columns 4, 5, and 6 (though statistically significant only in column 4). The results in DeVaro and Waldman (2012) also failed to support the wage-related predictions of the promotion-as-signal hypothesis for workers with high school degrees. As seen in column 4 and consistent with theory, workers with graduate degrees experience smaller raises upon promotion than do workers with the same job performance but only a college degree. Furthermore, again consistent with theory, this effect is present for first promotions and disappears for subsequent promotions. In summary, Panel A of Table 4 exhibits evidence of promotion signaling for changes in log-wages (with the exception of high school graduates) but not for changes in wage levels.

Comparing the results for men (Panel B) and women (Panel C) reveals some further results. For men, the wage increase (in levels) attached to within-firm first promotions is positive but statistically insignificant, whereas the corresponding result for women is considerably larger in magnitude and statistically significant at the one percent level. For within-firm subsequent promotions, on the other hand, neither gender experiences a statistically significant wage increase. The preceding results also hold in logs, with the only difference being that women continue to experience a positive raise even in the case of within-firm subsequent promotions, though it is still smaller than the raise women receive from within-firm first promotions. This pattern of results is consistent with the Milgrom-Oster framework that predicts larger wage increases from promotion for women than men, with this gender difference dissipating after first promotion.[29]

Further evidence suggesting support for the Milgrom-Oster framework can be found by comparing the education coefficients in Panel B to those in Panel C. In the case of men, the education-related results do not support the promotion signaling model for either dependent variable. In contrast, in the case of women, whether the dependent variable is changes in wage levels or changes in log-wages, and whether promotions are within firms or across firms, the education-related results are clearly consistent with promotion signaling except for high school graduates. In particular, the interactions of either promotion dummy with the dummy for receipt of a graduate degree exhibit the same pattern of results, namely a negative and statistically significant coefficient in the case of first promotions and a positive and insignificant coefficient in the case of subsequent promotions. The fact that the evidence of asymmetric learning is stronger for women than men is consistent with the argument in Milgrom and Oster (1987) that the abilities of women are less visible to the outside labor market than are the abilities of men. This can be true for a variety of reasons, one of which may be that women benefit less from networking in an "old boys club". Our evidence suggests that this informational disadvantage faced by women is mitigated following the public release of information about abilities that accompanies a first promotion. The basis for this conclusion is that the gender gap (in both promotion probabilities and the wage change conditional on promotion) is present for first promotions but not for subsequent promotions. The evidence suggests that there is significant information content in a first promotion. Prior to that, women may be at a disadvantage relative to men in that their skills are less easily observed by other employers in the labor market. But the positive public signal released when a woman is first promoted tends to level the informational playing field, and thereafter asymmetric learning may be less relevant.

6 Summary and Conclusion

Our Finnish and German analyses of promotion probabilities and of the wage growth conditional on promotion include controls for worker performance, which are crucial in empirical models designed to test the signaling role of promotions. Since such worker performance measures are typically absent in the large-scale panel datasets that span many firms, previ-

[29]In the case of across-firm promotions both men and women experience positive and statistically significant wage changes from first promotion but no statistically significant wage change from subsequent promotion.

ous evidence on the signaling role of promotion has had to rely either on single-firm data, as in DeVaro and Waldman (2012) and DeVaro, Ghosh, and Zoghi (2012), or on multi-firm panel data that do not control for worker performance, as in Bognanno and Melero (2012). We overcame this difficulty by constructing a measure of worker performance from individual bonus data, finding that (for both Finland and Germany) its autocorrelation structure was quite similar to that of the actual performance ratings from the single-firm personnel dataset used first in Baker, Gibbs, and Holmström (1994a,b) and later in DeVaro and Waldman (2012).[30]

To summarize the Finnish analysis, the results from both the promotion probability analysis and the wage growth analysis (for both men and women) are consistent with a signaling role of promotion and corroborate the findings in DeVaro and Waldman (2012). That is, for the most relevant case of within-firm promotions, and controlling for pre-promotion worker performance, promotion probability is increasing in the level of educational attainment, and the wage increase conditional on promotion is decreasing in the level of educational attainment for the lowest-level educational group. These results are stronger for first than for subsequent promotions. The fact that the predictions concerning wage-growth are unsupported for the highest-level education group echoes the results from DeVaro and Waldman (2012). Furthermore, controlling for pre-promotion worker performance, women experience lower promotion probabilities than men and higher wage growth attached to within-firm promotion than men, but only in the case of first promotions. These results are consistent with the promotion signaling framework in Milgrom and Oster (1987), though only the gender differences in promotion probability are statistically significant and not the gender differences in the wage increases attached to within-firm promotion. Finally, evidence of promotion signaling is weaker in the rarer case of across-firm promotions.

To summarize the German analysis, the probability of promotion is increasing in the level of educational attainment, holding performance in the pre-promotion job constant. This result holds for both within-firm and across-firm promotions, for both men and women, and it is stronger for first promotions than for subsequent promotions. These results are consistent with the signaling role of promotion and the evidence in DeVaro and Waldman (2012). For women (with the exception of high school graduates) the theoretical predictions related to wage changes are also supported. Controlling for performance in the pre-promotion job, the wage change accompanying promotions is decreasing in the level of educational attainment, both for within-firm and across-firm promotions, and whether the wage change is measured in levels or logs. Furthermore, consistent with the theory, these results are present for first promotions but not subsequent promotions. The fact that the predictions

[30] The correlation matrix from DeVaro and Waldman (2012) was matched somewhat more closely by the Finnish matrix than by the German matrix, though here it should be recalled that the German data include white-collar, blue-collar, and civil service workers, whereas the Finnish data include only white-collar workers as in DeVaro and Waldman (2012). Restricting the German analysis to white-collar workers results in a correlation matrix more closely matching that from DeVaro and Waldman (2012).

concerning wage-growth are unsupported for high school graduates echoes the results from DeVaro and Waldman (2012). For men, however, the theoretical predictions concerning wage changes are unsupported. The fact that evidence of asymmetric learning is stronger for women than men is consistent with the arguments in Milgrom and Oster (1987) in which the abilities of women are less visible to employers than are the abilities of men, though our results suggest that this informational disadvantage of women diminishes or vanishes following the first promotion. Further support for the Milgrom-Oster framework is found in the result that, for within-firm first promotions, the wage increase for men is positive but statistically insignificant whereas the corresponding increase for women is considerably larger and statistically significant at the one percent level, whereas for both genders there is no statistically significant wage change associated with within-firm subsequent promotions.

Overall, we see the results from both countries as broadly consistent with a signaling role of promotions, and given the considerable breadth of the Finnish and German samples we see the results as important in establishing the applicability of the promotion-as-signal hypothesis across a wide range of employer types, particularly given that our evidence comes from two distinct economies.

We conclude the analysis with some remarks on the current state of the employer learning literature and how it might fruitfully evolve in the future.[31] Although our focus in this paper is on asymmetric learning about worker ability in the labor market, a second important perspective in the literature concerns symmetric learning. Under symmetric learning, all employers in the market learn about a worker's abilities at the same rate, so that promotions convey no new information to competing firms.[32] Our impression is that most employment relationships are characterized by at least some asymmetric learning, which would be an argument for preferring that modeling approach. On the other hand, the asymmetric learning model tends to be less analytically tractable than the symmetric learning model, and therefore more difficult to extend and enrich in various dimensions the researcher may wish to explore. Thus, although the asymmetric learning model may offer a more realistic description of the nature of the employer learning that occurs in the labor market, as long as the symmetric learning model offers a reasonable approximation it might be preferable on grounds of tractability. Which of the two perspectives is more appropriate ultimately depends on the production context. These considerations highlight the need for empirical work aimed at discerning the importance of asymmetric learning in promotions, and our work is a step in that direction.

The current empirical evidence suggests that asymmetric learning plays a role, but this same evidence does not rule out the possibility of symmetric learning, nor does it suggest anything about the relative importance of the two types of learning. Empirical studies have generally tended to focus either on tests of symmetric learning (e.g. Farber and Gibbons

[31] We are grateful to Mike Waldman for numerous discussions that shaped our thinking on this subject.

[32] Examples of theoretical promotions models based on this assumption are Gibbons and Waldman (1999, 2006), Ghosh (2007), and DeVaro and Morita (2012).

1996, Altonji and Pierret 2001, and Lange 2007) or of asymmetric learning (e.g. Schönberg 2007, Kahn 2009, Pinkston 2009, DeVaro and Waldman 2012, and DeVaro, Ghosh, and Zoghi 2012). Collectively, the empirical work in this literature suggests that asymmetric learning plays a role and that symmetric learning also plays a role. What it does not yet do is to provide a clear sense of the relative importance of both types of learning, either overall or in a given production context. A promising next step for the literature, therefore, might be developing theoretical frameworks and corresponding empirical frameworks that nest both types of learning so that their relative importance is reflected in estimable parameters. Ideally these frameworks would be developed for application on large-scale, worker-firm matched datasets such as the Finnish data we analyze in this paper. However, such an approach would require attention to what variables are typically included (and excluded) from such datasets. For example, such datasets typically lack anything resembling an AFQT score, which is a crucial input to the current NLSY-based framework for studying symmetric learning, as developed by Farber and Gibbons (1996), Altonji and Pierret (2001), and Lange (2007). We think that development of a structural empirical framework that nests both types of learning and that does not necessitate data on AFQT scores (so that analysis could move beyond the NLSY to datasets like the Finnish data) would be a significant step forward in this literature. The relative importance of the two types of learning could then be assessed both within and across different job types.

Table 1: Autocorrelation Matrix for Worker Performance

Panel A: Actual Performance Ratings in One American Firm

	Performance	Performance$_{t-1}$	Performance$_{t-2}$	Performance$_{t-3}$
Performance	1.000			
Performance$_{t-1}$	0.581*	1.000		
Performance$_{t-2}$	0.394*	0.590*	1.000	
Performance$_{t-3}$	0.249*	0.398*	0.610*	1.000

Panel B: Inferred Performance Ratings in Finnish Panel Data

	Performance	Performance$_{t-1}$	Performance$_{t-2}$	Performance$_{t-3}$
Performance	1.000			
Performance$_{t-1}$	0.518*	1.000		
Performance$_{t-2}$	0.382*	0.518*	1.000	
Performance$_{t-3}$	0.296*	0.381*	0.509*	1.000

Panel C: Inferred Performance Ratings in German Panel Data

	Performance$_{t-1}$	Performance$_{t-2}$	Performance$_{t-3}$	Performance$_{t-4}$
Performance$_{t-1}$	1.000			
Performance$_{t-2}$	0.644*	1.000		
Performance$_{t-3}$	0.565*	0.619*	1.000	
Performance$_{t-4}$	0.497*	0.547*	0.606*	1.000

Sources: Panel A: DeVaro and Waldman (2012), Table 10, based on single-firm personnel data from Baker, Gibbs, and Holmström (1994a,b); Panel B: Finnish EK data, 2002-2010; Panel C: German SOEP, 1984-2009.
* Statistically significant at the 1% level.

Table 2: Descriptive Statistics, Finland

	All Workers		Men Only		Women Only	
	Mean	s.d.	Mean	s.d.	Mean	s.d.
Female	0.337	0.473				
Promotion	0.067	0.250	0.066	0.249	0.068	0.252
Firm change	0.042	0.201	0.043	0.202	0.042	0.200
Demographics						
Upper secondary	0.301	0.458	0.312	0.463	0.278	0.448
Lowest level tertiary	0.111	0.315	0.093	0.290	0.148	0.355
BA	0.348	0.476	0.359	0.480	0.326	0.469
GRAD	0.240	0.427	0.236	0.425	0.247	0.431
Age	33.994	7.894	34.052	7.810	33.879	8.055
Tenure	2.119	2.056	2.168	2.086	2.021	1.995
Occupation						
Hourly wage	17.866	5.729	18.630	5.749	16.369	5.382
Management	0.032	0.176	0.037	0.188	0.022	0.148
Professional	0.213	0.409	0.240	0.427	0.158	0.365
Expert	0.550	0.498	0.595	0.491	0.460	0.498
Clerical	0.206	0.404	0.127	0.333	0.360	0.480
Firm Size						
0-50	0.106	0.308	0.107	0.309	0.106	0.307
51-100	0.083	0.275	0.078	0.268	0.091	0.288
101-200	0.125	0.331	0.122	0.327	0.130	0.337
201-500	0.199	0.400	0.198	0.398	0.203	0.402
501-1000	0.115	0.319	0.127	0.332	0.093	0.290
1001-2000	0.092	0.289	0.083	0.276	0.110	0.312
2000+	0.280	0.449	0.286	0.452	0.268	0.443
Observations	269,559		178,728		90,831	

Source: Finnish EK data, 2002-2010.

Table 3: Multinomial Probit, Promotion Within and Promotion Across Firms, Finland

Panel A: All Workers

	All Workers		First Promotion		Subsequent Promotion	
	(1) Within	(2) Across	(3) Within	(4) Across	(5) Within	(6) Across
Upper secondary	-0.011***	-0.002***	-0.013***	-0.002***	-0.002	-0.001
	(-6.28)	(-3.23)	(-6.40)	(-3.08)	(-0.54)	(-0.48)
Lowest level tertiary	-0.014***	-0.001	-0.016***	-0.002*	-0.001	0.003
	(-4.78)	(-1.35)	(-5.20)	(-1.76)	(-0.12)	(1.18)
GRAD	0.036***	0.005***	0.037***	0.005***	0.024***	0.004***
	(19.67)	(7.88)	(17.63)	(7.52)	(6.51)	(2.99)
Performance t-1	0.007***	-0.004***	0.007***	-0.004***	0.006***	-0.002***
	(14.41)	(-12.36)	(13.41)	(-11.28)	(8.35)	(-4.01)
Female	-0.022***	-0.002***	-0.026***	-0.003***	-0.002	-0.001
	(-12.94)	(-4.05)	(-13.27)	(-4.38)	(-0.69)	(-0.46)
Pr(Y=k)	0.062	0.006	0.066	0.007	0.038	0.005
Observations	118,984	118,984	101,502	101,502	17,482	17,482

Panel B: Men

	All Workers		First Promotion		Subsequent Promotion	
	(1) Within	(2) Across	(3) Within	(4) Across	(5) Within	(6) Across
Upper secondary	-0.014***	-0.003***	-0.016***	-0.003***	0.000	-0.001
	(-6.33)	(-3.48)	(-6.63)	(-3.19)	(0.05)	(-0.85)
Lowest level tertiary	-0.012***	-0.002	-0.014***	-0.002	0.002	0.001
	(-3.23)	(-1.48)	(-3.58)	(-1.58)	(0.27)	(0.45)
GRAD	0.031***	0.005***	0.032***	0.005***	0.018***	0.004***
	(14.39)	(6.19)	(12.93)	(5.94)	(4.17)	(2.87)
Performance t-1	0.006***	-0.004***	0.006***	-0.005***	0.005***	-0.002***
	(11.93)	(-10.84)	(11.27)	(-9.92)	(6.79)	(-4.16)
Pr(Y=k)	0.061	0.006	0.066	0.007	0.034	0.004
Observations	81,776	81,776	69,472	69,472	12,304	12,304

Panel C: Women

	All Workers		First Promotion		Subsequent Promotion	
	(1) Within	(2) Across	(3) Within	(4) Across	(5) Within	(6) Across
Upper secondary	-0.009***	-0.000	-0.009**	-0.001	-0.012	0.002
	(-2.75)	(-0.41)	(-2.43)	(-0.46)	(-1.43)	(0.82)
Lowest level tertiary	-0.013***	-0.000	-0.016***	-0.001	-0.003	0.005
	(-2.89)	(-0.10)	(-3.10)	(-0.51)	(-0.30)	(1.14)
GRAD	0.041***	0.005***	0.040***	0.005***	0.034***	0.004
	(11.88)	(4.49)	(10.16)	(4.30)	(4.69)	(1.63)
Performance t-1	0.011***	-0.003***	0.011***	-0.003***	0.013***	-0.003***
	(11.88)	(-6.11)	(11.95)	(-5.53)	(8.03)	(-2.97)
Pr(Y=k)	0.063	0.006	0.066	0.006	0.047	0.006
Observations	37,208	37,208	32,030	32,030	5,178	5,178

Notes: Cell entries are average marginal effects from a multinomial probit, with t-statistics in parentheses. Base Outcome 0: no promotion; Outcome 1: promotion within firm ("Within"); Outcome 2: promotion across firms ("Across"). Row "Pr(Y=k)" refers to the probability of the column's outcome. Base education category is the second-highest education level, BA. All right-hand-side variables are measured in year t-1, and the dependent variable is measured in year t. All specifications include age, (age) squared, job tenure at the firm, (job tenure at the firm) squared, job level dummies, job title dummies, and an intercept term. Source: Finnish EK data, 2002-2010.
* Statistically significant at the 10% level.
** Statistically significant at the 5% level.
*** Statistically significant at the 1% level.

Table 4: OLS Estimates, Changes in Wage Levels and Log-Wage, Finland

Panel A: All Workers

	Wage Levels			Log-Wages		
	(1) All Workers	(2) First Promotion	(3) Subsequent Promotion	(4) All Workers	(5) First Promotion	(6) Subsequent Promotion
Upper secondary	0.081***	0.075***	0.087***	0.007***	0.007***	0.005***
	(8.16)	(7.10)	(3.07)	(10.72)	(9.73)	(3.51)
Lowest level tertiary	0.008	0.003	0.030	0.002***	0.002**	0.003
	(0.60)	(0.23)	(0.72)	(2.74)	(2.48)	(1.13)
GRAD	0.128***	0.135***	0.113***	0.003***	0.003***	0.003**
	(12.26)	(11.60)	(4.83)	(5.47)	(5.41)	(2.54)
Promotion-Within	0.623***	0.600***	0.867***	0.034***	0.033***	0.042***
	(15.25)	(13.49)	(10.00)	(16.72)	(15.17)	(9.19)
× Upper Secondary	0.150**	0.174***	-0.030	0.009***	0.011***	-0.004
	(2.45)	(2.72)	(-0.17)	(2.63)	(2.83)	(-0.44)
× Lowest level tertiary	0.045	0.086	-0.390	0.001	0.005	-0.049
	(0.45)	(0.83)	(-0.87)	(0.16)	(0.98)	(-1.16)
× GRAD	0.141**	0.132**	0.209	0.001	0.001	0.003
	(2.32)	(1.99)	(1.45)	(0.35)	(0.24)	(0.41)
Promotion-Across	1.603***	1.564***	1.833***	0.085***	0.085***	0.089***
	(10.59)	(9.65)	(4.41)	(10.22)	(9.40)	(4.06)
× Upper Secondary	0.215	0.286	-0.507	0.016	0.018	-0.017
	(0.90)	(1.14)	(-0.63)	(1.14)	(1.25)	(-0.43)
× Lowest level tertiary	-0.746**	-0.853**	0.304	-0.039**	-0.044**	0.005
	(-2.27)	(-2.42)	(0.33)	(-2.16)	(-2.23)	(0.11)
× GRAD	0.883***	0.882***	0.938	0.025**	0.024*	0.035
	(3.55)	(3.27)	(1.51)	(2.12)	(1.88)	(1.14)
No Promotion-Across	0.698***	0.679***	0.745***	0.038***	0.038***	0.036***
	(10.77)	(9.04)	(6.05)	(12.14)	(10.60)	(5.57)
× Upper Secondary	0.041	0.034	0.110	0.005	0.005	0.006
	(0.45)	(0.34)	(0.55)	(1.08)	(0.95)	(0.54)
× Lowest level tertiary	-0.197	-0.149	-0.499	-0.011*	-0.010	-0.018
	(-1.38)	(-0.95)	(-1.48)	(-1.69)	(-1.42)	(-1.11)
× GRAD	0.031	0.025	0.054	-0.004	-0.004	-0.002
	(0.32)	(0.23)	(0.26)	(-0.95)	(-0.91)	(-0.22)
Performance t-1	0.010***	0.009***	0.015***	-0.000**	-0.000**	-0.000
	(4.40)	(3.72)	(2.61)	(-2.54)	(-2.26)	(-0.77)
Female	-0.091***	-0.097***	-0.064***	-0.003***	-0.003***	-0.001
	(-10.18)	(-9.88)	(-2.88)	(-4.69)	(-4.64)	(-1.14)
Observations	122,152	103,317	18,835	122,150	103,315	18,835
R^2	0.061	0.060	0.083	0.058	0.058	0.078

Panel B: Men

	Wage Levels			Log-Wages		
	(1) All Workers	(2) First Promotion	(3) Subsequent Promotion	(4) All Workers	(5) First Promotion	(6) Subsequent Promotion
Upper secondary	0.085***	0.077***	0.097***	0.007***	0.007***	0.007***
	(6.96)	(5.90)	(2.87)	(9.45)	(8.29)	(3.57)
Lowest level tertiary	-0.001	0.001	-0.014	0.002	0.002	0.002

	(1)	(2)	(3)	(4)	(5)	(6)
	(-0.06)	(0.03)	(-0.25)	(1.58)	(1.61)	(0.44)
GRAD	0.127***	0.129***	0.133***	0.003***	0.003***	0.003***
	(9.96)	(8.96)	(4.74)	(4.49)	(3.97)	(2.79)
Promotion-Within	0.606***	0.582***	0.898***	0.032***	0.031***	0.043***
	(11.88)	(10.52)	(8.25)	(12.67)	(11.46)	(7.66)
× Upper Secondary	0.146**	0.172**	-0.025	0.009**	0.010**	-0.003
	(1.97)	(2.21)	(-0.12)	(1.96)	(2.17)	(-0.28)
× Lowest level tertiary	0.010	0.102	-1.183	-0.002	0.006	-0.111
	(0.07)	(0.67)	(-1.49)	(-0.20)	(0.77)	(-1.25)
× GRAD	0.136*	0.124	0.279	0.001	0.001	0.004
	(1.74)	(1.46)	(1.59)	(0.31)	(0.22)	(0.56)
Promotion-Across	1.757***	1.813***	1.381***	0.094***	0.098***	0.067***
	(10.68)	(9.93)	(4.28)	(10.35)	(9.68)	(4.17)
× Upper Secondary	0.304	0.281	0.282	0.020	0.018	0.022
	(1.09)	(0.96)	(0.30)	(1.28)	(1.07)	(0.50)
× Lowest level tertiary	-0.835*	-0.908*	-0.071	-0.046*	-0.051*	-0.001
	(-1.83)	(-1.86)	(-0.17)	(-1.80)	(-1.87)	(-0.05)
× GRAD	0.732**	0.665**	1.221*	0.017	0.013	0.047
	(2.46)	(2.03)	(1.93)	(1.21)	(0.83)	(1.57)
No Promotion-Across	0.771***	0.753***	0.825***	0.042***	0.042***	0.040***
	(9.16)	(7.65)	(5.65)	(10.60)	(9.14)	(5.42)
× Upper Secondary	0.047	0.054	0.025	0.005	0.006	-0.001
	(0.41)	(0.42)	(0.11)	(0.88)	(0.92)	(-0.07)
× Lowest level tertiary	-0.286	-0.222	-0.753	-0.015	-0.012	-0.033
	(-1.48)	(-1.07)	(-1.39)	(-1.63)	(-1.30)	(-1.29)
× GRAD	-0.010	0.020	-0.125	-0.007	-0.006	-0.010
	(-0.08)	(0.15)	(-0.49)	(-1.36)	(-1.03)	(-0.92)
Performance t-1	0.007***	0.007***	0.007	-0.000***	-0.000**	-0.001*
	(2.89)	(2.68)	(0.97)	(-2.59)	(-2.03)	(-1.91)
Observations	84,282	70,926	13,356	84,280	70,924	13,356
R^2	0.059	0.058	0.081	0.060	0.060	0.078

Panel C: Women

	Wage Levels			Log-Wages		
	(1) All Workers	(2) First Promotion	(3) Subsequent Promotion	(4) All	(5) First Promotion	(6) Subsequent Promotion
Upper secondary	0.062***	0.059***	0.080	0.006***	0.006***	0.003
	(3.76)	(3.42)	(1.54)	(4.88)	(4.80)	(1.16)
Lowest level tertiary	0.009	-0.006	0.087	0.002*	0.002	0.004
	(0.45)	(-0.32)	(1.47)	(1.79)	(1.40)	(1.23)
GRAD	0.109***	0.128***	0.051	0.002**	0.003***	0.000
	(6.08)	(6.43)	(1.19)	(2.33)	(2.97)	(0.16)
Promotion-Within	0.639***	0.617***	0.804***	0.037***	0.037***	0.040***
	(9.35)	(8.20)	(5.50)	(10.62)	(9.65)	(5.00)
× Upper Secondary	0.162	0.189*	-0.007	0.012*	0.013**	-0.003
	(1.53)	(1.68)	(-0.02)	(1.96)	(2.04)	(-0.24)
× Lowest level tertiary	0.085	0.063	0.150	0.004	0.004	-0.002
	(0.64)	(0.45)	(0.31)	(0.52)	(0.48)	(-0.09)
× GRAD	0.157*	0.154	0.115	0.001	0.001	0.001
	(1.66)	(1.51)	(0.46)	(0.25)	(0.17)	(0.04)
Promotion-Across	1.167***	0.861***	2.835**	0.061***	0.047***	0.136**

	(3.49)	(2.64)	(2.54)	(3.32)	(2.58)	(2.28)
× Upper Secondary	0.096	0.431	-2.095	0.010	0.026	-0.095
	(0.21)	(0.94)	(-1.39)	(0.38)	(0.91)	(-1.20)
× Lowest level tertiary	-0.406	-0.461	-0.271	-0.018	-0.017	-0.029
	(-0.81)	(-0.93)	(-0.17)	(-0.65)	(-0.59)	(-0.37)
× GRAD	1.336***	1.525***	0.352	0.049**	0.057**	0.011
	(2.92)	(3.28)	(0.25)	(2.12)	(2.42)	(0.15)
No Promotion-Across	0.499***	0.473***	0.567**	0.027***	0.027***	0.026**
	(5.88)	(5.34)	(2.46)	(5.83)	(5.46)	(2.10)
× Upper Secondary	0.003	-0.037	0.298	0.005	0.002	0.020
	(0.02)	(-0.26)	(0.76)	(0.54)	(0.22)	(0.83)
× Lowest level tertiary	0.035	0.070	-0.144	-0.001	-0.002	0.001
	(0.18)	(0.32)	(-0.45)	(-0.15)	(-0.18)	(0.06)
× GRAD	0.168	0.092	0.444	0.005	0.002	0.015
	(1.01)	(0.51)	(1.13)	(0.60)	(0.24)	(0.83)
Performance t-1	0.021***	0.018***	0.042***	0.000	-0.000	0.001***
	(4.89)	(3.75)	(4.30)	(0.58)	(-0.23)	(3.20)
Observations	37,870	32,391	5,479	37,870	32,391	5,479
R^2	0.075	0.074	0.121	0.060	0.059	0.108

Notes: Dependent variables are change in: 1) hourly wage levels (columns 1-3); and 2) hourly log-wages (columns 4-6), 2009 Euros. All right-hand-side variables are measured in year t-1, and the dependent variable is measured in year t. Base education category is the second-highest education level, BA. All specifications include age, (age) squared, job tenure at the firm, (job tenure at the firm) squared, job level dummies, job title dummies, and an intercept term. t-statistics are shown in parentheses. Source: Finnish EK data, 2002-2010.
* Statistically significant at the 10% level.
** Statistically significant at the 5% level.
*** Statistically significant at the 1% level.

Table 5: Descriptive Statistics, Germany

	All Workers		Men Only		Women Only	
	Mean	s.d.	Mean	s.d.	Mean	s.d.
Female	0.322	0.467				
Promotion	0.057	0.232	0.060	0.237	0.052	0.223
Firm Change	0.051	0.219	0.051	0.220	0.050	0.217
Demographics						
HS	0.730	0.444	0.749	0.434	0.692	0.462
BA	0.174	0.379	0.155	0.362	0.213	0.410
GRAD	0.096	0.294	0.096	0.295	0.095	0.293
Age	39.970	10.522	40.547	10.347	38.758	10.782
Tenure	11.122	9.523	11.740	9.811	9.822	8.746
Experience	17.382	10.777	18.662	10.864	14.691	10.076
Occupation						
Net Income	21,618	9,323	23,602	9,760	17,447	6,613
Lower Level	0.274	0.446	0.245	0.430	0.336	0.472
Middle Level	0.496	0.500	0.493	0.500	0.504	0.500
Upper Level	0.229	0.420	0.263	0.440	0.160	0.366
Blue-Collar	0.438	0.496	0.532	0.499	0.242	0.428
White-Collar	0.489	0.500	0.385	0.487	0.707	0.455
Civil Servant	0.073	0.259	0.083	0.275	0.051	0.220
Firm Size						
0-19	0.168	0.374	0.157	0.363	0.193	0.395
20-199	0.288	0.453	0.284	0.451	0.296	0.457
200-1999	0.265	0.441	0.258	0.438	0.280	0.449
2000+	0.279	0.448	0.301	0.459	0.231	0.421
Observations	99,748		67,595		32,153	

Source: German SOEP, 1984-2009.

Table 6: Multinomial Probit, Promotion Within and Promotion Across Firms, Germany

Panel A: All Workers

	All Workers		First Promotion		Subsequent Promotion	
	(1) Within	(2) Across	(3) Within	(4) Across	(5) Within	(6) Across
HS	-0.019***	-0.004***	-0.021***	-0.005***	-0.012***	-0.002
	(-8.91)	(-5.22)	(-8.82)	(-5.24)	(-2.95)	(.)
GRAD	0.015***	0.005***	0.019***	0.004***	0.010*	0.008
	(5.14)	(4.50)	(5.53)	(2.90)	(1.76)	(.)
Performance t-1	0.140***	-0.112***	0.174***	-0.121***	0.064	-0.092
	(4.90)	(-5.60)	(5.18)	(-4.91)	(1.18)	(.)
Female	-0.030***	-0.005***	-0.033***	-0.005***	-0.018***	-0.005
	(-17.05)	(-7.16)	(-16.40)	(-6.20)	(-5.14)	(.)
Pr(Y=k)	0.050	0.008	0.051	0.008	0.045	0.007
Observations	99,748	99,748	75,796	75,796	23,952	23,952

Panel B: Men

	All Men		First Promotion		Subsequent Promotion	
	(1) Within	(2) Across	(3) Within	(4) Across	(5) Within	(6) Across
HS	-0.019***	-0.003**	-0.024***	-0.003**	-0.009*	-0.002
	(-6.84)	(-2.44)	(-7.32)	(-2.30)	(-1.66)	(-0.91)
GRAD	0.010***	0.003**	0.014***	0.003	0.007	0.004*
	(2.80)	(2.29)	(3.22)	(1.60)	(0.98)	(1.78)
Performance t-1	0.132***	-0.118***	0.182***	-0.119***	0.008	-0.122***
	(4.09)	(-5.17)	(4.83)	(-4.28)	(0.13)	(-2.99)
Pr(Y=k)	0.052	0.008	0.053	0.008	0.048	0.007
Observations	67,595	67,595	50,507	50,507	17,088	17,088

Panel C: Women

	All Women		First Promotion		Subsequent Promotion	
	(1) Within	(2) Across	(3) Within	(4) Across	(5) Within	(6) Across
HS	-0.020***	-0.006***	-0.020***	-0.007***	-0.019***	0.001
	(-6.33)	(-4.71)	(-5.62)	(-5.02)	(-3.13)	(0.17)
GRAD	0.024***	0.008***	0.026***	0.006***	0.018**	0.014***
	(4.93)	(4.58)	(4.66)	(2.88)	(1.97)	(3.50)
Performance t-1	0.196***	-0.113**	0.167**	-0.153***	0.278**	-0.023
	(2.96)	(-2.57)	(2.07)	(-2.77)	(2.55)	(-0.36)
Pr(Y=k)	0.045	0.007	0.047	0.007	0.039	0.006
Observations	32,153	32,153	25,289	25,289	6,864	6,864

Notes: Cell entries are average marginal effects from a multinomial probit, with t-statistics in parentheses. Base Outcome 0: no promotion; Outcome 1: promotion within firm ("Within"); Outcome 2: promotion across firms ("Across"). Row "Pr(Y=k)" refers to the probability of the column's outcome. All right-hand-side variables are measured in year t-1, and the dependent variable is measured in year t. Base education category is the middle education level, BA. All specifications include age, (age) squared, tenure, (tenure) squared, experience, (experience) squared, one-digit industry and occupation codes, firm size, occupation group (white-collar, blue-collar or civil service), worker's hierarchical level controls, and an intercept term. Source: German SOEP, 1984-2009.
* Statistically significant at the 10% level.
** Statistically significant at the 5% level.
*** Statistically significant at the 1% level.

Table 7: OLS Estimates, Changes in Wage Levels and Log-Wage, Germany

Panel A: All Workers

	Wage Levels			Log-Wages		
	(1) All Workers	(2) First Promotion	(3) Subsequent Promotion	(4) All Workers	(5) First Promotion	(6) Subsequent Promotion
HS	-111.823**	-122.117**	-56.636	-0.006**	-0.006**	-0.002
	(-2.04)	(-1.98)	(-0.48)	(-2.48)	(-2.36)	(-0.40)
GRAD	54.411	74.292	-108.263	0.003	0.002	0.001
	(0.52)	(0.61)	(-0.52)	(0.86)	(0.58)	(0.14)
Promotion-Within	356.575*	414.499*	145.385	0.019**	0.024**	-0.003
	(1.72)	(1.76)	(0.35)	(1.99)	(2.17)	(-0.19)
X HS	-9.493	-24.430	80.290	-0.000	-0.004	0.017
	(-0.04)	(-0.10)	(0.18)	(-0.04)	(-0.34)	(1.02)
X GRAD	173.770	7.257	1,018.507	0.009	0.003	0.039
	(0.43)	(0.02)	(1.23)	(0.53)	(0.14)	(1.47)
Promotion-Across	1,631.125***	1,709.914***	1,320.766	0.105***	0.100***	0.127**
	(3.50)	(4.02)	(0.79)	(4.79)	(4.45)	(2.00)
X HS	-698.260	-734.895	-540.639	-0.047*	-0.037	-0.089
	(-1.28)	(-1.38)	(-0.30)	(-1.77)	(-1.30)	(-1.30)
X GRAD	-327.320	-1,294.186	2,385.697	-0.088**	-0.120**	-0.010
	(-0.34)	(-1.18)	(1.13)	(-2.22)	(-2.49)	(-0.14)
No Promotion-Across	667.940**	877.126***	96.593	0.028**	0.040***	-0.003
	(2.53)	(3.00)	(0.17)	(2.39)	(2.81)	(-0.12)
X HS	-18.922	-60.740	20.125	0.014	0.014	0.008
	(-0.07)	(-0.19)	(0.03)	(1.06)	(0.90)	(0.34)
X GRAD	1,190.279**	1,179.855**	1,044.982	0.049**	0.050**	0.034
	(2.44)	(2.34)	(0.83)	(2.31)	(2.14)	(0.75)
Performance t-1	3,494.490***	2,649.726**	5,983.949***	0.092***	0.058	0.192***
	(3.12)	(2.01)	(2.83)	(2.85)	(1.57)	(2.98)
Female	-93.420**	-96.641**	-82.228	0.002	0.002	0.001
	(-2.34)	(-2.18)	(-0.87)	(0.83)	(0.88)	(0.25)
Observations	99,748	75,796	23,952	99,748	75,796	23,952
R^2	0.014	0.016	0.015	0.017	0.020	0.014

Panel B: Men

	Wage Levels			Log-Wages		
	(1) All Men	(2) First Promotion	(3) Subsequent Promotion	(4) All Men	(5) First Promotion	(6) Subsequent Promotion
HS	-130.829	-130.743	-103.391	-0.006*	-0.006*	-0.003
	(-1.64)	(-1.46)	(-0.61)	(-1.91)	(-1.66)	(-0.56)
GRAD	61.874	128.431	-271.252	0.005	0.007	-0.005
	(0.46)	(0.82)	(-1.04)	(1.15)	(1.26)	(-0.63)
Promotion-Within	161.032	248.553	-68.499	0.004	0.010	-0.015
	(0.56)	(0.76)	(-0.12)	(0.38)	(0.82)	(-0.79)
X HS	211.609	167.001	297.909	0.013	0.009	0.028
	(0.69)	(0.48)	(0.48)	(1.16)	(0.68)	(1.24)
X GRAD	690.430	537.784	1,386.588	0.039**	0.036	0.054
	(1.27)	(0.88)	(1.19)	(2.03)	(1.62)	(1.51)
Promotion-Across	1,634.093**	1,816.310***	1,041.300	0.100***	0.091***	0.131
	(2.32)	(2.89)	(0.47)	(3.61)	(3.49)	(1.64)

X HS	-510.106	-690.711	77.464	-0.039	-0.028	-0.075
	(-0.65)	(-0.94)	(0.03)	(-1.19)	(-0.84)	(-0.88)
X GRAD	365.783	-657.838	4,186.491	-0.078	-0.091	-0.020
	(0.24)	(-0.41)	(1.32)	(-1.37)	(-1.38)	(-0.22)
No Promotion-Across	747.292**	874.235**	419.341	0.029**	0.036*	0.011
	(2.00)	(1.98)	(0.59)	(1.97)	(1.93)	(0.50)
X HS	-94.079	-6.096	-426.407	0.011	0.017	-0.014
	(-0.23)	(-0.01)	(-0.54)	(0.68)	(0.83)	(-0.51)
X GRAD	1,478.215**	1,648.970**	716.771	0.051*	0.062**	0.000
	(2.17)	(2.35)	(0.40)	(1.90)	(2.07)	(0.00)
Performance t-1	3,334.793***	2,065.990	6,947.137***	0.087**	0.044	0.213***
	(2.64)	(1.39)	(2.92)	(2.42)	(1.04)	(3.00)
Observations	67,595	50,507	17,088	67,595	50,507	17,088
R^2	0.015	0.018	0.017	0.018	0.021	0.016

Panel C: Women

	Wage Levels			Log-Wages		
	(1) All Women	(2) First Promotion	(3) Subsequent Promotion	(4) All Women	(5) First Promotion	(6) Subsequent Promotion
HS	-99.850	-141.044*	16.265	-0.007*	-0.009**	0.002
	(-1.58)	(-1.95)	(0.12)	(-1.84)	(-2.09)	(0.24)
GRAD	61.800	-29.359	222.757	-0.002	-0.009	0.009
	(0.44)	(-0.20)	(0.65)	(-0.36)	(-1.24)	(0.53)
Promotion-Within	757.386***	743.799***	801.378	0.049***	0.052**	0.032*
	(3.00)	(2.62)	(1.58)	(2.62)	(2.36)	(1.72)
X HS	-465.965*	-414.165	-559.380	-0.028	-0.029	-0.009
	(-1.67)	(-1.33)	(-0.94)	(-1.35)	(-1.23)	(-0.36)
X GRAD	-848.145*	-1,018.776*	139.508	-0.052*	-0.060*	0.001
	(-1.67)	(-1.72)	(0.17)	(-1.92)	(-1.89)	(0.03)
Promotion-Across	1,606.741***	1,534.203***	1,987.719	0.110***	0.109***	0.101
	(3.23)	(2.95)	(1.49)	(3.08)	(2.84)	(1.28)
X HS	-1,093.126	-872.084	-2,839.386*	-0.060	-0.047	-0.160*
	(-1.48)	(-1.10)	(-1.93)	(-1.28)	(-0.91)	(-1.89)
X GRAD	-1,360.703	-2,527.693***	376.596	-0.095*	-0.159***	0.025
	(-1.63)	(-2.71)	(0.25)	(-1.90)	(-2.85)	(0.28)
No Promotion-Across	538.081	826.258**	-657.084	0.027	0.042**	-0.033
	(1.63)	(2.57)	(-0.71)	(1.41)	(2.08)	(-0.71)
X HS	78.801	-159.518	1,051.676	0.019	0.010	0.056
	(0.22)	(-0.44)	(1.06)	(0.88)	(0.45)	(1.11)
X GRAD	545.951	266.325	1,829.439	0.046	0.035	0.106
	(1.01)	(0.45)	(1.41)	(1.40)	(0.95)	(1.44)
Performance t-1	4,216.925*	4,804.066*	2,013.188	0.117	0.117	0.145
	(1.72)	(1.67)	(0.46)	(1.58)	(1.41)	(0.90)
Observations	32,153	25,289	6,864	32,153	25,289	6,864
R^2	0.022	0.026	0.031	0.022	0.025	0.029

Notes: Dependent variables are change in: 1) net yearly wage levels (columns 1-3); and 2) net yearly log-wages (columns 4-6), 2009 Euros. All right-hand-side variables are measured in year t-1, and the dependent variable is measured in year t. Base education category is the middle education level, BA. All specifications include age, (age) squared, tenure, (tenure) squared, experience, (experience) squared, two-digit industry and occupation codes, firm size, occupation group (white-collar, blue-collar or civil service), worker's hierarchical level controls, and an intercept term. t-statistics are shown in parentheses. Source: German SOEP, 1984-2009.
* Statistically significant at the 10% level.
** Statistically significant at the 5% level.
*** Statistically significant at the 1% level.

Appendix: Occupational Position

In this appendix we describe the procedure we use to assign job levels in the GSOEP. The basis for the assignment is the skill level of the worker's main job. Note that the worker is not asked about his or her own skill level but rather the skill level requirement or task complexity of the job. Fortunately, the wording of the occupational status question has remained essentially unchanged throughout the entire GSOEP panel history, so that consistent hierarchical assignment across time is possible. The occupational status question for the 1985 survey for blue-collar, white-collar, and civil servants is as follows:[33]

What position do you have at the moment? If you have more than one job at the moment, please answer the following in reference to your main job.

Blue-collar worker:

unskilled worker **(1)**

trained worker **(2)**

semi-skilled and skilled worker **(3)**

foreman **(4)**

White-collar worker:

industry and works foreman in nontenured employment

employee with simple duties (e.g. salesperson, clerk, stenotypist) **(1)**

employee with qualified duties (e.g. official in charge, technical drawer) **(2)**

employee with highly qualified duties or managerial function(e.g. scientific worker, attorney, head of department) **(3)**

employee with extensive managerial duties (e.g. managing director, manager, head of a large firm or concern) **(4)**

Civil servant (including judges and professional soldiers):

lower level **(1)**

middle level **(2)**

upper level **(3)**

executive level **(4)**

Note that the worker can only answer yes to one of the preceding options, and his or her response to the question determines blue-collar, white-collar or civil service status. The number in parentheses after some of the responses indicates the level to which a worker responding with that answer is assigned. Following Lluis (2005), we do not assign the "industry and works group" in the white-collar category to a level, as it is unclear where these employees should be placed.

[33] Since self-employed workers and trainees are dropped from our sample, their sections of the question are omitted.

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