《論　文》

Effects of Personnel Transfer on Engineer's Human Capital and Performance*

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personnel transfer, human capital accumulation, individual performance

Ⅰ. Introduction

In most Japanese companies, personnel transfers are primarily transfers to other workplaces within a company, i.e. lateral shifts to expand the breadth of employee experience. Other cases include vertical transfers associated with promotions, and changes of position made to effect a career change. Transfers between workplaces are often known as job rotations, and furthermore there are personnel transfers outside the company in what are termed "Shukko" or "Tenseki". Based on a series of previous researches by Koike, these kinds of personnel transfers in Japan have been above all performed as a part of on the job training (OJT), and have been emphasized as way to expand employee's work experience[1)].

What kind of effects do these personnel transfers have that focuses on an expansion of work experience? Previous researches in Japan mainly using interviews show that personnel transfers lead to an increase of skills related to the fulfillment of work duties by broadening work experiences, with the result of improved work output. However, there have not been sufficient researches to date regarding quantitative data analysis and issues other than the effectiveness of skill improvement. Therefore, this paper aims at clarifying that the broad effects of personnel transfers with regard to engineer's human capital and individual performance, based on the quantitative data in the survey. Our analytical target is engineers belonging to one of major Japanese manufacturing company groups.

The structure of this study is as follows. In the following section, we show our focuses by reviewing previous researches related to personnel transfers. Section 3 explains the data used in the analysis, after which an outline is provided of the features of personnel transfers in the purpose of this paper. Next, Section 4 validates our hypotheses presented in Section 2. Finally, in Section 5 we summarize our findings and concluding remarks.

Ⅱ. The focus of this paper

As discussed above, personnel transfer is something that causes the expansion of work experience, therefore in this part, we will review researches not only with transfers between workplaces but also work experience.

First of all, we look at its relationship with

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1) Koike (1988, 1991, 1994a, 1994b) and Koike and Inoki (1990)

work performance. Findings of researches centering on human capital theory show that personnel transfers contribute to improvement of work performance. The researches of Koike mentioned above also correspond to this context. Koike's works point out that personnel transfers accompanying a shift between workplaces expand the breadth of an employee's experience, and leads to the improvement of intellectual skills. These intellectual skills are defined as skills used to overcome uncertainty, and past experience in dealing with the varied problems at work heighten the skills, which are problem-finding and solving abilities, used to resolve uncertainty in the employee's current work, as a result improving an employee's output. In many studies based on human capital theory, greater work experience has been clearly shown to heighten a worker's individual output (Maranto and Rodgers 1984, McEnrue 1988, Avolio, Waldman and McDaniel 1990, Jung and Magrabi 1991, Dolton and Kidd 1998, Toda 2011). There are also many studies in the field of psychology concerning the effects of work experience and transfers between different work duties, and a positive relationship has been shown between work experience and job performance.(McDaniel, Schmidt and Hunter 1988, Quinones, Ford, and Teachout 1995, Kolz, Mcfarland and Silverman 1998, Tesluk and Jacobs 1998)

Furthermore, related domestic researches targeting Japanese engineers regarding transfers between research and development (R&D) has shown that individuals experience broad work duties in their own technical field, and form skills critical to dealing with problems through these kinds of transfers to different work duties (Japan Productivity Center 1990; 1991, Murakami 2003). The aforementioned debate is applicable to engineers in Japan as well. We set the following hypotheses for validation.

Hypothesis 1: The individual performance of engineers is heightened through personnel transfers.

In this paper we will proceed with the following discussion paying heed to the effects on individual performance in human capital theory. Then, in what manner is human capital accumulated through personnel transfers? The human capital theory focuses on the increase of work performance ability like technical skills and knowledge by OJT including personnel transfers, so one can expect this ability improvement brings high work performance. Therefore, the following validation hypothesis can be set forth.

Hypothesis 2-1a: An engineer's work performance ability is heightened by personnel transfers.

Koike's researches note in particular the heightening of skills to deal with problems, so we shall also examine problem-finding and solving ability, which is an element of work performance ability.

Hypothesis 2-1b: An engineer's problem-finding and solving ability increases with personnel transfers.

Next, according to Becker's work, the accumulation of human capital does not rest solely on the knowledge, technical skills and other abilities which are improved by education and training, rather it is pointed out that information search activities such job searches also increase the value of human capital. In other words, the human capital investment by companies making personnel transfers can be viewed as information searches that seek

suitable duties in order to best make use of an employee's skills and characteristics. In the more suitable work, employee can make more effective use of his or her work performance abilities, thus heightening individual performance. We can pose the following hypothesis.

Hypothesis 2-2: Current highly suitable work can be found with personnel transfers.

Finally, researches in recent years based on network theory have shown that when there is a human network advising an individual with the necessary knowledge and information related to work duties, that individual's performance improves. By supplementing an individual's work performance abilities, this kind of advice network can be seen as enabling a higher degree of human capital accumulation. Personnel transfers can be thought of as providing opportunities to meet new people and to broaden one's network for exchanging and gathering information. Therefore, we can pose the following hypothesis.

Hypothesis 2-3: It is possible to construct a broad advice network with personnel transfers.

Based on previous researches, we see that the heightening of an individual's work performance through personnel transfers can be seen as a result of the progress made in the accumulation of human capital, i.e. building up work performance abilities, finding suitable jobs, and building a broad advice network.

Ⅲ. Engineer's personnel transfer in our data

Let us first explain the data used in this paper. A questionnaire survey was implemented in 2012 regarding ways in which to create innovation, targeting companies belonging to a manufacturing group and engineers working in the group companies. We use 1,807 engineers personal data (1421 union members (ordinary employees) and 387 management personnel) gathered from 35 companies.

First, when investigating areas of work duty categories of the engineers, we found 4.5% work in survey and research, 63.1% in development and design, 22.5% in production technology, 3.5% in technology patent management, 2.5% in quality assurance, 2.0% in information processing and software development, 0.7% in sales and technology services, and 3.1% in other areas. Therefore we confirmed that the majority is responsible for development and design work[2] (See Table 1).

Next, with regard to experience with personnel transfers, 51.7% of employees have experienced personnel transfers one or more times (See Table 2). Most such personnel transfers are transfers within the company, but the above figure also includes those having experienced transfers to workplaces outside the company. Also, the average number of personnel transfers experienced

Table 1. Distribution of current work duty

	frequancy	%
survey and research	82	4.5
quality assurance	46	2.5
development and design	1141	63.1
production technology	406	22.5
technology and patent management	63	3.5
information processing etc	36	2.0
sales and tech-services	13	0.7
ohters	56	3.1
total	1843	101.9

Note: M.A. N=1807, % is share in N.

2) Multiple responses were allowed. Out of the valid replies from 1,807 people, the total number of responses was 1,843 and approximately 2% of the total was multiple responses.

was 1.3, and the average age at which an individual first experienced a personnel transfer was 29.1. The state of transfers between different work duties is not clear, but the result is that there are many transfers between research and development, and approximately half of engineers in both the U.S. and Japan have experienced working in both areas, which conforms to the findings of previous research[3].

Regarding this personnel transfer, the number of transfers experienced can be expected to increase the longer one is employed, so let us also examine the relationship to years of employment. The number of years employed is also used as an index of specific human capital accumulation in companies, so it may be possible to think of personnel transfers as reflecting the breadth of specific human capital, while the number of years employed reflects its depth. Therefore, it is important to consider the mutual relationship between them. In Figure 1, we have divided the number of years worked and employee age into 5-year intervals, and calculated the average values for each layer. It is possible to confirm that as the number of years employed and age increase, the number of personnel transfers experienced also increases. However, that increase is not linear. Rather, a trend can be seen in which, as the number of years employed and age increase, increases in personnel transfers gradually diminish. In other words, the implication is that personnel transfers are generally conducted among the younger generation that has relatively little work experience. This conforms to the approach of human capital theory, which says that companies generally conduct skill development among the young generation.

Ⅳ. The effects of personnel transfers

1. The effects on individual technical achievement

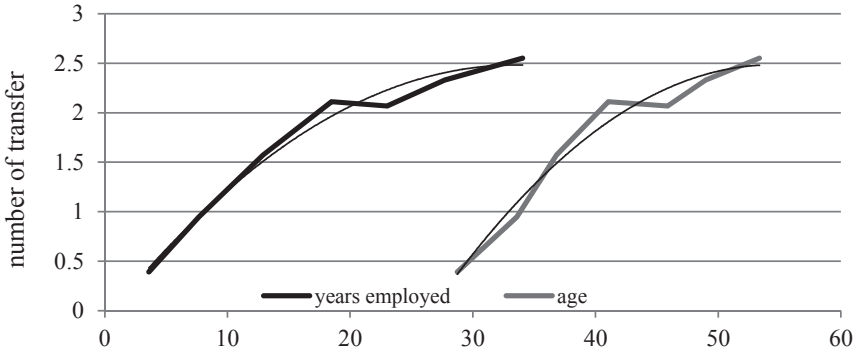
Here we will validate Hypothesis 1. Firstly,

Table 2. Statistical indices on personnel transfer

		N
share of engineers experienced transfer (%)	51.7	1807
average times	1.3	1807
ave. age in first transfer	29.1	967

Note: Ave. age is calculated in engineers experienced transfer.

Figure 1. Personnel transfer, years employed, and age



3）Japan Productivity Center（1991）

in the survey of engineers, four questions were asked regarding individual technical achievements made in the past three years: "number of patent applications"; "total cash amount of bonuses related to patents granted to the individual"; "number of internal technical reports"; and "number of external technical reports". Bonuses depend on issues such as the company's size and bonus system, and are expected to differ greatly among companies, so we use three items except bonus data and create a composite index of individual technical achievement[4]. We set this to be the explained variable for technical achievement. With regard to explanatory variables, for personnel transfers we next use the number of personnel transfers experienced in the past, which we noted in Section III. We control sex (reference group; male), academic degree (university), number of years employed, type of hiring (graduate recruitment), current work duties (development and design), and company size as other variables in this analysis (OLS)[5].

The results of the analysis are shown in Table 3. Looking at the control variables, when arranged by academic degree the technical achievement of engineers who are only high

Table 3. Results of effects on individual technical achievement (OLS)

explained variable	technical achievement index			
explaratory variables	coefficient	s.e.	s.c.	
female	-0.070	0.152	-0.012	
high school	-0.190	0.097	-0.057	+
collage	-0.101	0.111	-0.024	
graduate	0.009	0.062	0.004	
mid-career	-0.066	0.071	-0.026	
leader	0.052	0.067	0.024	
manager	0.139	0.101	0.052	
general manager	0.111	0.164	0.021	
survey and research	0.361	0.121	0.075	***
quality assurance	-0.125	0.158	-0.020	
production technology	-0.146	0.065	-0.059	**
technology and patent management	-0.301	0.139	-0.054	**
information processing etc	-0.293	0.181	-0.040	
sales and tech-services	-0.391	0.306	-0.032	
ohters	-0.041	0.150	-0.007	
firm size	-2.24E-06	0.000	-0.050	+
years employed	0.002	0.005	0.015	
num of personnel transfer	0.036	0.018	0.058	**
sample size	1617			
adjusted R-square	0.03			
F-value	3.672			

Note: ***p<.001, **p<.05, +p<.01. Explaratory variables are dummy variables except firm size, personnel transfer and years employed. s.e. and s.c. is standard error and standardized coefficient respectively.

4) This composite index is a first component score by a principle component analysis. This first component can be seen as overall individual technical achievement.

5) Control variables are dummy variables except number of years employed and company size.

school graduates is lower compared to university graduates. When arranged according to work duties, survey and research engineers achieve more easily than development and design engineers, while production technology and technology management engineers find it more difficult to achieve. The number of years worked is shown not to have an impact on an individual technical achievements. In addition, we found evidence that personnel transfers have a positive effect on the individual achievements of engineers, and that breadth of work experience contributes to the improvement of individual achievement. In other words, these findings conform to those of previous researches, and support Hypothesis 1.

2．The effects on the human capital accumulation

Next, let us clarify the manner in which personnel transfers heighten human capital and increase technical achievements.

1）Work performance ability

First, we will examine the effects on work performance ability. To do so, we will define work performance ability. In our survey of engineers, we have asked them about the state of maintenance of twelve subjective abilities and characteristics comprising work performance ability that are personally possessed by engineers themselves. These twelve abilities and characteristics are wide ranging, from intellectual abilities to work attitudes, and include: "sense of responsibility", "problem-finding ability", "leadership", "problem-solving ability", "ability to plan and propose projects", "logical and systematic thinking", "ability to negotiate", "consciousness in training one's juniors", "tenacity", "willingness to take up challenges", "time management ability" and "communications skills". The survey sought evaluation of the degree to which the individual possesses each of these abilities and characteristics, allowing four levels of intensity from "lacking" to "sufficiently possessing" them. In other words, it is necessary to understand that the data used does not reflect possession of objective abilities or characteristics, but rather are subjective evaluations[6].

In this paper, we have extracted features from these twelve abilities and characteristics, and implemented principal component analysis in order to gather deeply related elements from them. According to the results of this analysis, only one feature from among these twelve abilities and characteristics could be extracted as only one component, and the resulting primary component score was used as an indicator showing possession of overall work performance ability. Therefore, the analysis of Hypothesis 2-1a is based on the relationship between this index and personnel transfers. Also, one can expect the ability to deal with problems to improve through personnel transfer, so we created an index called "problem-finding and solving ability" by combining two of the twelve abilities and characteristics, namely "problem-finding ability" and "problem-solving ability".[7] The analysis of Hypothesis 2-1b is based on the relationship between this index and personnel transfer. Now, let us perform multiple regression

6）Dunning and Kreuger (1999) point out that it is difficult to recognize one's own unskilled and incompetence, as a result, self-evaluation by unskilled workers tends to be overestimated in the subjective evaluations. There are no objective indicators of workers' abilities in our data. We use subjective indicators based on the recognition of this problem.

7）Here the combination of indices was calculated by taking a weighted average from the component score coefficient found for the primary component. "Problem-finding ability" was 0.784 and "problem-solving ability" was 0.778.

analysis (OLS) using as the explained variable this overall combination of work performance ability and the problem-finding and solving ability. Note that the explanatory variable is the same as that used in validating technical achievement.

The analytical results are shown in Table 4. When we look at where the control variables showed effects, compared to men, women have the same level of work performance ability overall, but are slightly weaker than men in the problem-finding and solving ability. Next, engineers recruited in mid-career had high overall work performance ability compared to other engineers, but no difference was seen with regard to the problem-finding and solving ability. In viewing data in light of academic degree, high school and junior college graduates were lower than university graduates, and, on the basis of official responsibilities, leaders and management class engineers were higher than other engineers in general. Furthermore when looking at job positions, trends were confirmed showing that engineers responsible for duties such as quality assurance and production technology were lower, and that if limited to examining only the problem-finding and solving ability, engineers responsible for surveys and research were higher, compared to development and design. The number of years employed

Table 4. Results of effects on work performance ability (OLS)

explained variable	overall work performance ability				problem-finding & solving ability			
explaratory variables	coefficient	s.e.	s.c.		coefficient	s.e.	s.c.	
female	-.210	.129	-.037		-.276	.123	-.051	**
high school	-.254	.084	-.078	***	-.292	.080	-.096	***
collage	-.198	.096	-.047	**	-.215	.091	-.055	**
graduate	.049	.054	.024		.042	.052	.022	
mid-career	.233	.062	.095	***	.245	.059	.105	***
leader	.449	.056	.214	***	.347	.054	.175	***
manager	.506	.087	.191	***	.324	.083	.130	***
general manager	.826	.141	.156	***	.458	.135	.091	***
survey and research	.159	.106	.033		.223	.100	.050	**
quality assurance	-.243	.140	-.039	+	-.399	.131	-.068	**
production technology	-.091	.056	-.037		-.047	.054	-.020	
technology and patent management	-.251	.122	-.046	**	-.330	.117	-.063	***
information processing etc	.191	.157	.027		.082	.150	.012	
sales and tech-services	-.237	.273	-.019		.048	.261	.004	
ohters	-.181	.128	-.031		-.058	.122	-.011	
firm size	7.6E-06	.000	.174	***	7.2E-06	.000	.175	***
years employed	.023	.005	.197	***	.027	.004	.244	***
num of personnel transfer	.005	.015	.008		-.007	.015	-.011	
sample size	1700				1715			
adjusted R-square	.197				.172			
F-value	24.22				20.79			

Note: ***p<.001, **p<.05, +p<.01.

showed a positive effect regarding both indices, and it was shown that the length of experience in a company improves not only the ability to find and solve problems, but also overall human capital such as work performance ability. On the other hand, no effects were detected with either index in regards to the effect of personnel transfers. These findings reject the Hypotheses 2-1a and 2-1b.

2）Job suitability and advice networks

Here we shall clarify what kind of relationship job suitability matching and advice networks have with personnel transfers. With regard to the job suitability matching of Hypothesis 2-2, the following three items were used as indices indicating whether an individual is in a job of high suitability. We used responses to three questions, of which the first was, "Do you think your job is interesting," the second was, "Do you enjoy your job," and the third was, "In your current job are you able to make the best of your abilities." The responses to these questions were four levels for goodness of fit, therefore, used as explained variables in an ordered logit model analysis. Next with regard to Hypothesis 2-3, in the survey of engineers we asked about the extent of exchange of ideas and meetings with others related to work. Here subjects were asked to select from seven possible choices regarding the extent of their exchanges of ideas: "engineers at the same workplace"; "engineers in the same technical field but of a different workplace in the company"; "engineers in a different technical field and different workplace in the company"; "non-engineering staff in the company"; "engineers, researchers, etc. in other domestic companies"; "engineers, researchers, etc. in other overseas companies"; and "customers." In other words, the number of targets with which information was exchanged was used as an explained variable. Note that the explanatory variable is the same as that of the analysis of individual technical achievement.

The results are shown in Table 5. These results suggest that personnel transfers do not affect job suitability matching, nor do they have a negative effect. In other words, there is a possibility that job suitability matching weakens with increasing personnel transfers, thus Hypothesis 2-2 was not supported by the results. However, personnel transfers were shown to have a positive relationship with advice networks, and we were able to confirm that increasing numbers of personnel transfers lead to a broader network for information exchange. In other words, Hypothesis 2-3 was supported.

Finally, when we look at the three points that stimulate human capital accumulation and their relationship with individual technical achievement, a statistically significant and strong positive correlation was discovered between the achievement index and each of the three items of work performance ability, job suitability matching, and advice networks. From these findings, it was discovered that in this corporate group the effect of personnel transfers is primarily that of expanding human networks, and improving an individual human capital through information exchange and advice necessary for one's work. This forms a route leading to much technical achievement.

Ⅴ. Conclusion

This paper used individual data from engineers belonging to a Japanese manufacturing group, and analyzed the effects of personnel transfers on

Table 5. Results of effects on job suitablity and advice network (Model 1-3; orderd logit model, Model 4; OLS

	Model 1		Model 2		Model 3		Model 4		
	coefficient	s.e.	coefficient	s.e.	coefficient	s.e.	coefficient	s.e.	s.c.
female	0.508	0.283 +	0.300	0.278	-0.707	0.288 **	-0.006	0.233	-0.001
high school	-0.044	0.178	0.126	0.176	-0.350	0.185 +	-0.225	0.152	-0.041
collage	-0.273	0.201	-0.045	0.199	-0.399	0.209 +	-0.255	0.173	-0.036
graduate	0.259	0.110 **	0.323	0.109 ***	0.362	0.116 ***	0.146	0.098	0.041
mid-career	-0.058	0.130	0.022	0.129	0.064	0.137	-0.234	0.112	-0.056 **
leader	0.345	0.120 ***	0.446	0.119 ***	0.670	0.127 ***	0.294	0.104	0.082 ***
manager	1.172	0.183 ***	1.080	0.181 ***	1.269	0.194 ***	0.678	0.159	0.150 ***
general manager	1.530	0.301 ***	1.049	0.297 ***	1.529	0.323 ***	0.979	0.258	0.109 ***
survey and research	0.126	0.224	0.343	0.222	0.493	0.239 **	-0.435	0.191	-0.054 **
quality assurance	-1.295	0.291 ***	-0.884	0.291 ***	-0.710	0.302 **	-0.142	0.252	-0.013
production technology	-0.099	0.115	-0.153	0.114	-0.215	0.120 +	-0.090	0.102	-0.021
technology and patent management	-0.397	0.255	0.009	0.253	-0.287	0.267	-0.428	0.220	-0.046 +
information processing etc	0.005	0.333	0.201	0.329	-0.069	0.347	-0.252	0.283	-0.021
sales and tech-services	-1.187	0.527 **	-0.200	0.526	-0.584	0.552	0.178	0.493	0.008
ohters	-0.397	0.278	-0.294	0.275	-0.154	0.295	-0.694	0.231	-0.071 ***
years eployed	-0.011	0.010	-0.010	0.010	-0.002	0.010	-0.011	0.008	-0.054
num of personnel transfer	-0.021	0.032	-0.057	0.031 +	-0.021	0.034	0.069	0.028	0.066 **
sample size	1694.0		1692.0		1691.0		1700		
pseudo R-square	0.070		0.052		0.086				
χ-square	4578.8		4593.3		4533.6				
adjusted R-square							0.098		
F-value							10.755		

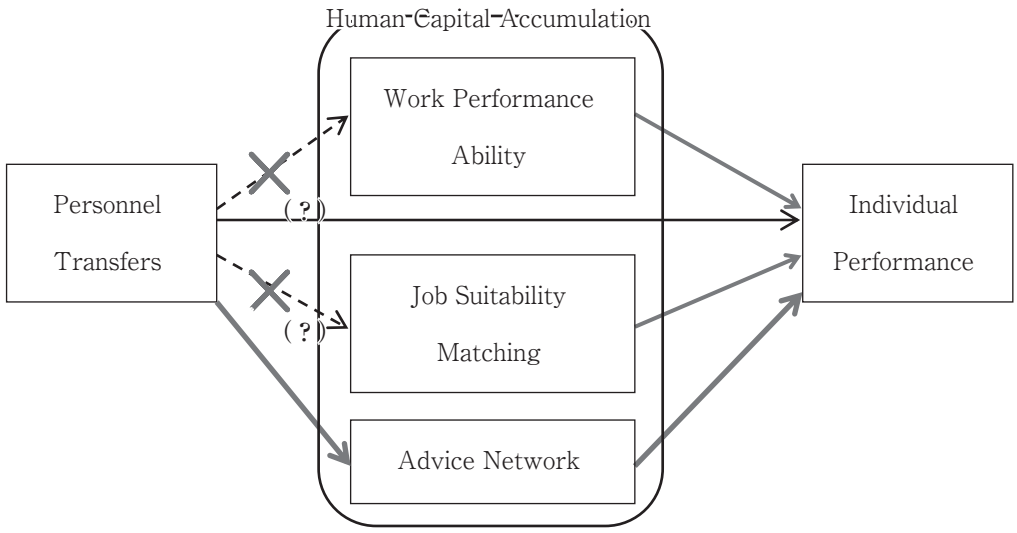
Note: ***p<.001, **p<.05, +p<.01. With regard to explained varibles, Model 1 is "Do you think your job is interesting", Model 2 is "Do you enjoy your job", and Model 3 is "In your current job are you able to make the best of your abilities", and Model 4 is the number of contacts to exchange information.

the accumulation of human capital and individual performance. The main findings from this study are as follows.

First, as expected, a positive relationship was discovered between improved individual performance, which is used as an indicator of technical achievement, and increased experience with personnel transfers. Next, when the correlation between personnel transfers and individual performance was considered from the three standpoints of work performance ability, job suitability matching and advice networks, no effect was seen concerning work performance ability centering on the ability to find and solve problems, or on job suitability matching. However, human networks for information exchange were shown to expand as experience with personnel transfers increases, and are implied as an intermediary between personnel transfer and individual achievement.

Here we would finally like to state some of important issues this study raises, and offer our concluding remarks. In this paper, one is the problem of reverse causality. Our study has discussed on the assumption of a causal relationship of personnel transfer that increase workers' human capital and improve their work performance. However, in our factor analysis of personnel transfer, there is also a fact that workers, who accumulate high human capital like high education background and job responsibility, are selected to personnel transfer. In other words, it is possible that our results simply show the latter relationship between personnel transfer and human capital. Second, the personnel transfer of engineers was captured in the number of transfers experienced. Despite that, however, the qualitative side concerning company's purpose of personnel transfers is important, though not considered as part of this study. Also, we considered work performance ability, primarily the ability to find and solve problems. But from an engineer's perspective, ingenuity or creativity may be what is truly important. Effective work performance development from this kind of perspective must also be considered. The above issues are topics which will be examined in our future studies.

Figure 2. Relationship between personnel transfer and individual performance



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Appended table 1. Descriptive statistics

	N	average	s.d.	min	max
Explaratory variables:					
female	1802	.03	.172	0	1
high school	1801	.11	.312	0	1
collage	1801	.06	.242	0	1
university	1801	.47	.499	0	1
graduate	1801	.36	.479	0	1
mid-career	1803	.21	.406	0	1
ordinary employee	1798	.44	.496	0	1
leader	1798	.35	.476	0	1
manager	1798	.18	.381	0	1
general manager	1798	.04	.189	0	1
survey and research	1807	.05	.208	0	1
quality assurance	1807	.03	.158	0	1
development design	1807	.63	.483	0	1
production technology	1807	.22	.417	0	1
technology and patent management	1807	.03	.183	0	1
information processing etc	1807	.02	.140	0	1
sales and tech-services	1807	.01	.085	0	1
ohters	1807	.03	.173	0	1
firm size	1748	22670	23055	100	69125
years eployed	1796	12.116	8.566	0.00	44.00
num of personnel transfer	1807	1.262	1.634	0.00	10.00
Explained variables:					
technical achievement index	1716	.00	1.00	-.33	19.58
overall work performance ability	1779	.00	1.00	-3.54	2.59
problem-finding & solving ability	1796	4.473	0.940	1.58	6.32
Model 1	1804	2.850	0.776	1	4
Model 2	1801	2.493	0.784	1	4
Model 3	1799	2.705	0.657	1	4
Model 4	1807	3.085	1.698	0	7