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PERFORMANCE, CAREER DYNAMICS, AND SPAN OF CONTROL

By

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INTRODUCTION

- A standard building block of hierarchical models of the firm such as Lucas (1978) and Rosen (1982) is the scale-of-operations effect, i.e., the idea that managerial decisions affect productivity of subordinates so there are large returns to managerial ability at the top levels of hierarchies.

- A basic prediction of the scale-of-operations effect is that higher ability managers should have larger spans of control, but this prediction has not previously been tested probably because of lack of appropriate datasets.

- In this paper we extend the theory of the scale-of-operations effect to incorporate symmetric learning about worker ability as in Gibbons and Waldman (1999, 2006) and then test the resulting predictions using a firm level dataset that contains detailed information about span of control.

- Our model which can be thought of as a synthesis of Lucas (1978) and Rosen (1982) on the scale-of-operations effect and Gibbons and Waldman (1999, 2006) on symmetric learning is characterized by the following.
  - Workers vary in terms of their innate ability levels, where higher schooling means higher innate ability on average.
  - Effective ability is a function of innate ability and general human capital which workers accumulate as they gain labor market experience.
  - Firms know a worker's schooling level upon labor market entry and there is symmetric learning during careers based on publicly observable output realizations.
  - There is a job ladder where managers supervise an endogenously determined number of lower level workers.
  - We assume the scale-of-operations effect so the return to managerial ability increases with the number of workers a manager supervises.

- In our basic analysis we consider two period worker lives, two job levels, and multiple schooling groups. But we also discuss what happens when workers have longer lives and there are three job levels.

- Our theoretical analysis finds a number of results concerning wages, wage changes, and probability of promotions.
  - Wages rise with job level, schooling, and performance.
  - Wage increases rise with performance and promotion.
  - The probability of promotion rises with performance holding schooling fixed, and rises with schooling holding performance fixed.

- And we also find results concerning span of control.
  - Span of control increases with performance holding schooling fixed, and increases with schooling holding performance fixed.
  - Changes in span of control increase with performance.

- Some of our results follow from the earlier models we build upon, while some follow from our synthesis of the scale-of-operations effect and symmetric learning.
  - In particular, our result concerning changes in span of control follows from this synthesis.

- Our empirical analysis is based on confidential performance and personnel data from a large EU “high tech” manufacturing firm that produces and sells globally, although our analysis is restricted to domestic (Denmark) workers.

- What distinguishes this dataset from datasets such as the one investigated in Baker, Gibbs, and Holmstrom (1994a,b) is that our dataset contains information about the firm’s chain of command, so we can calculate managerial span of control.

- We use this dataset to test predictions of our model concerning wages, wage changes, probability of promotion, span of control, and changes in span of control. And most of our empirical findings support the theoretical predictions.

- Overall, our theoretical and empirical analyses support the idea that the scale-of-operations effect and learning are both important determinants of the design of job hierarchies, including span of control.

OUTLINE

- Related Literature
- Model and Theoretical Analysis
  - The model
  - Equilibrium and testable implications
  - Extensions
- Data
- Empirical Tests
  - Wages, wage changes, and probability of promotion
  - Span of control
- Discussion
- Conclusion

RELATED LITERATURE

Related Theoretical Literature

- The paper contributes to the theoretical literature on the scale-of-operations effect such as Mayer (1960), Lucas (1978), Rosen (1982), Waldman (1984a), Garicano (2000), etc.
  - In our empirical analysis we do not try to distinguish between different approaches that might yield the scale-of-operations effect.

- There are also related theoretical approaches that do not capture the scale-of-operations effect such as the supervision approach of Calvo and Wellisz (1978, 1979) and Qian (1994) and tournament models of Lazear and Rosen (1981) and Rosen (1986).
  - We believe it should be possible to extend these models to yield the scale-of-operations effect, so we do not see our results as ruling out these approaches.

- The paper also contributes to the theory literature on symmetric learning such as Harris and Holmstrom (1982), Holmstrom (1982), and especially Gibbons and Waldman (1999, 2006).
  - But note that the Gibbons and Waldman (1999, 2006) models do not capture the scale-of-operations effect since in those models there is no chain of command and thus no span of control.

Related Empirical Literature

- The paper contributes to empirical studies of symmetric learning such as Farber and Gibbons (1996) and Altonji and Pierret (2001).
  - Our results are also consistent with symmetric learning but as discussed further in the Conclusion it is also possible that asymmetric learning as in Greenwald(1979, 1986) and Waldman (1984b) is important.

- Another related set of empirical studies are those concerning wage and promotion dynamics inside firms such as Lazear (1992) and Baker, Gibbs, and Holmstrom (1994a,b).
  - Some of our empirical findings are similar to findings in this literature, although previous papers in this literature did not look at the scale-of-operations effect.

- And there are also related papers that empirically estimate the Gibbons and Waldman (1999) model such as Lima and Pereira (2003), Lluis (2005), Dias da Silva and van der Klaauw (2011), and Hunnes (2011).

- The final empirical literature the paper contributes to is the literature on span of control such as Rajan and Wulf (2006), Smeets and Warzynski (2008), Guadalupe and Wulf (2010), Garicano and Hubbard (2007, 2009), Fox (2009), and Lazear, Shaw, and Stanton (2013).
  - But other than Smeets and Warzynksi (2008), these papers either do not test for the scale-of-operations effect or do not find evidence consistent with the effect.

MODEL AND THEORETICAL ANALYSIS

Preliminary Points

- Our model combines the scale-of-operations approach of Lucas (1978) and Rosen (1982) with the symmetric learning approach of Gibbons and Waldman (1999, 2006).
- We start by analyzing what happens when worker careers are two periods, there are two job levels, and there is a single schooling group.
- We then extend the analysis by considering how results change with the introduction of more schooling groups, longer careers, and a third job level.
- Some of our results follow from the scale-of-operations effect, some from the symmetric learning aspect of the model, and some from the combination of these two modeling components.

The Model

- Assumptions
  - Free entry into production with identical firms and the only input is labor.
  - Careers last two periods, where workers are called young in the first period and old in the second.
  - Worker i enters the labor market with schooling level s_i and there are S schooling levels.
  - In each cohort of workers schooling group s consists of z_s workers.
  - Worker i's innate ability is given by θ_i, $\theta_i \in (\theta_L, \theta_H)$, and worker i with schooling level s_i has a probability $p(s_i)$, $p' > 0$, that $\theta_i = \theta_H$.
  - Worker i's effective ability in period t is given by $\eta_{it} = \theta_i f(x_{it})$, where x_{it} is prior labor market experience.
  - $f(1) > f(0) > 0$ captures general human capital accumulation during a worker's career.
  - Everyone is risk neutral and no discounting.
  - Spot market contracting and fixed wages (no piece rates).
  - No hiring or firing costs.

- Production
  - A firm consists of two job levels and m divisions, where m is exogenously given.
  - In each division there is a single level 2 worker and an endogenously determined number of level 1 workers.
  - Worker i assigned to job 1 in period t produces

$$y_{i1t}=(1+v_{it})[c_1+c_2(\eta_{it}+\varepsilon_{i1t})],$$

    where ε_{i1t} is a noise term drawn from a normal distribution with mean 0 and variance σ_1^2.
  - $v_{it}=v>0$ if the worker was at the same firm in the previous period and 0 otherwise, so v captures firm specific human capital.
  - Only an old worker with previous experience at a firm can be employed in job 2 (which is another manifestation of firm specific human capital).
  - Old worker i with previous experience at firm k assigned to job 2 at division j in firm k in period t produces

$$y_{ijkt}=g(n_{jkt})(\eta_{it}+\varepsilon_{i2t}).$$

  - n_{jkt} is the number of level 1 workers employed in division j in firm k in period t and ε_{i2t} is a noise term drawn from a distribution with mean 0 and variance σ_2^2.
  - We assume $g(0)=G$, $g'>0$, and $g''<0$, where $g'>0$ captures the scale-of-operations effect.

- Information Assumptions
  - At the beginning of a worker's career, a worker with schooling level s is known to be of innate ability θ_H with probability p(s) and θ_L with probability(1-p(s)).
  - Learning takes place at the end of the worker's first period in the labor market when the worker's output is publicly observed.
  - Because of the noise term, learning is gradual.

- Timing of Game/Wage Determination
  - At the beginning of each period, all firms simultaneously offer each old worker a wage and the worker chooses to work for the firm that offers the highest wage.
  - If multiple firms are tied for the highest wage, the worker remains with the previous employer if that is one of the high wage firms and chooses randomly among the high wage firms if not.
  - Young workers are hired where each firm is sufficiently small that it is a price taker in the young worker labor market and the young worker wage for each schooling group equates supply and demand.

- Parameter Restrictions
  - $G>(1+v)c_2$, so old workers with the highest expected effective abilities are promoted.
  - v is sufficiently large so there is no turnover in equilibrium.

Equilibrium and Testable Implications

- Equilibrium when S=1 (one schooling group). Each firm k's behavior in each period t satisfies the following.
  - i) The firm promotes the m old workers it employed in the previous period who produced the highest outputs and assigns the remaining workers to job 1.
  - ii) The period t wage and the wage increase for old workers from t-1 to t are both strictly increasing in the worker's t-1 output.
  - iii) Promoted workers receive larger wage increases than workers who are not promoted.
  - iv) All young workers hired by the firm are assigned to job 1 and paid the same wage.
  - v) Managerial span of control (weakly) increases with the manager's t-1 output.

- Results i) through iv) are consistent with the Gibbons and Waldman framework with slot constraints added, while v) follows from the scale-of-operations effect.

- Equilibrium when S>1 (multiple schooling groups). Each firm k's behavior in each period t satisfies the following.
  - i) The firm promotes the m old workers it employed in the previous period with the highest values for expected effective ability and assigns the remaining workers to job 1.
  - ii) Within a schooling group, the old workers promoted are the ones who produced the highest t-1 outputs, but there can be pairs of workers where only one is promoted and this worker produced less in t-1 but has a higher education level.
  - iii) The period t wage and the wage increase for old workers from t-1 to t both increase with t-1 output holding education fixed, while the period t wage increases with education holding the t-1 output fixed.
  - iv) Within a schooling group, promoted workers receive larger wage increases than workers who are not promoted.
  - v) All young workers hired by the firm are assigned to job 1, where the young worker wage increases with education.
  - vi) Managerial span of control (weakly) increases with the manager's t-1 output holding education fixed and also (weakly) increases with the manager's education holding the t-1 output fixed.
- Results i) through v) are consistent with the Gibbons and Waldman framework with slot constraints added, while vi) follows from the scale-of-operations effect.

Testable Predictions

- Prediction 1: Wages increase with the schooling level.
- Prediction 2: Within a schooling group, promoted workers should be those who performed better prior to promotion.
- Prediction 3: Holding performance constant, promoted workers should be those with higher education.
- Prediction 4: Within a schooling group, performance should be positively related to subsequent wages and wage increases.
- Prediction 5: Wages rise with job level and promoted workers receive larger wage increases than those not promoted.
- Prediction 6: Managerial span of control should be positively related to prior performance holding the schooling level constant.
- Prediction 7: Managerial span of control should be positively related to the schooling level holding performance constant.

Extensions

- Extension 1: Careers last more than two periods (and single dimensional ability).
  - Prediction 8: Changes in span of control rise with the most recent performance.
  - Key Point: This prediction helps us distinguish between our model and a similar model without learning (if there is no learning, then expected effective ability does not vary with the performance level, so changes in span of control should be independent of performance).
  - Prediction 9: Learning effects decrease with labor market experience.

Extensions

- Extension 2: Careers last more than two periods (and multi-dimensional ability).
  - Prediction 9′: Learning effects decrease with job level tenure.
  - We feel the multi-dimensional assumption is more realistic, so in the empirical tests we will focus on Prediction 9′ rather than 9.
- Extension 3: A third job level.
  - New Result: Earlier results concerning wages, probability of promotion, and span of control should hold for higher job levels and not just for the first level above the bottom.

DATA

- Confidential performance data from one large EU “high tech” manufacturing firm that produces and sells globally. We are currently focusing on home country, Denmark, data.
- Data covers 2006 to 2011 where coverage increases in later years.
- Workers are evaluated on a 1-5 scale, where 1 denotes the lowest performance (“worker does not meet expectations”) and 5 the highest (“outstanding performance”).
- Most workers receive a 3 or 4, approximately six percent receive a 5, two to three percent a 2, and less than one percent a 1.

- We first combine the performance data with data from confidential personnel records to create a panel dataset for 2006 to 2011 that includes for each observation firm tenure, age, salary bonus, cost center category, job level, nationality, gender, schooling level, a promotion variable, and performance evaluation.

- What is distinctive about this dataset is that it also includes information about the firm's chain of command.
  - For each individual and each year we were given the names of all the individuals directly above the worker in the firm's hierarchy.
  - We use this information to construct a span of control variable for all workers above the lowest level.

- Some basic facts concerning span of control at our firm.
  - Average span of control has been changing over time where the direction of the change varies by level.

Table 1: Evolution of the performance distribution in Denmark (%)

Year	1	2	3	4	5	# obs.
2006	0.0	2.4	47.7	44.0	5.9	962
2007	0.2	2.3	48.2	43.1	6.4	2,749
2008	0.3	2.9	51.0	39.4	6.4	4,561
2009	0.3	3.1	52.6	37.4	6.7	5,174
2010	0.2	3.1	52.1	38.3	6.3	7,077

Figure 1: distribution of subjective performance ratings in Denmark, 2006- 2010 (in %)

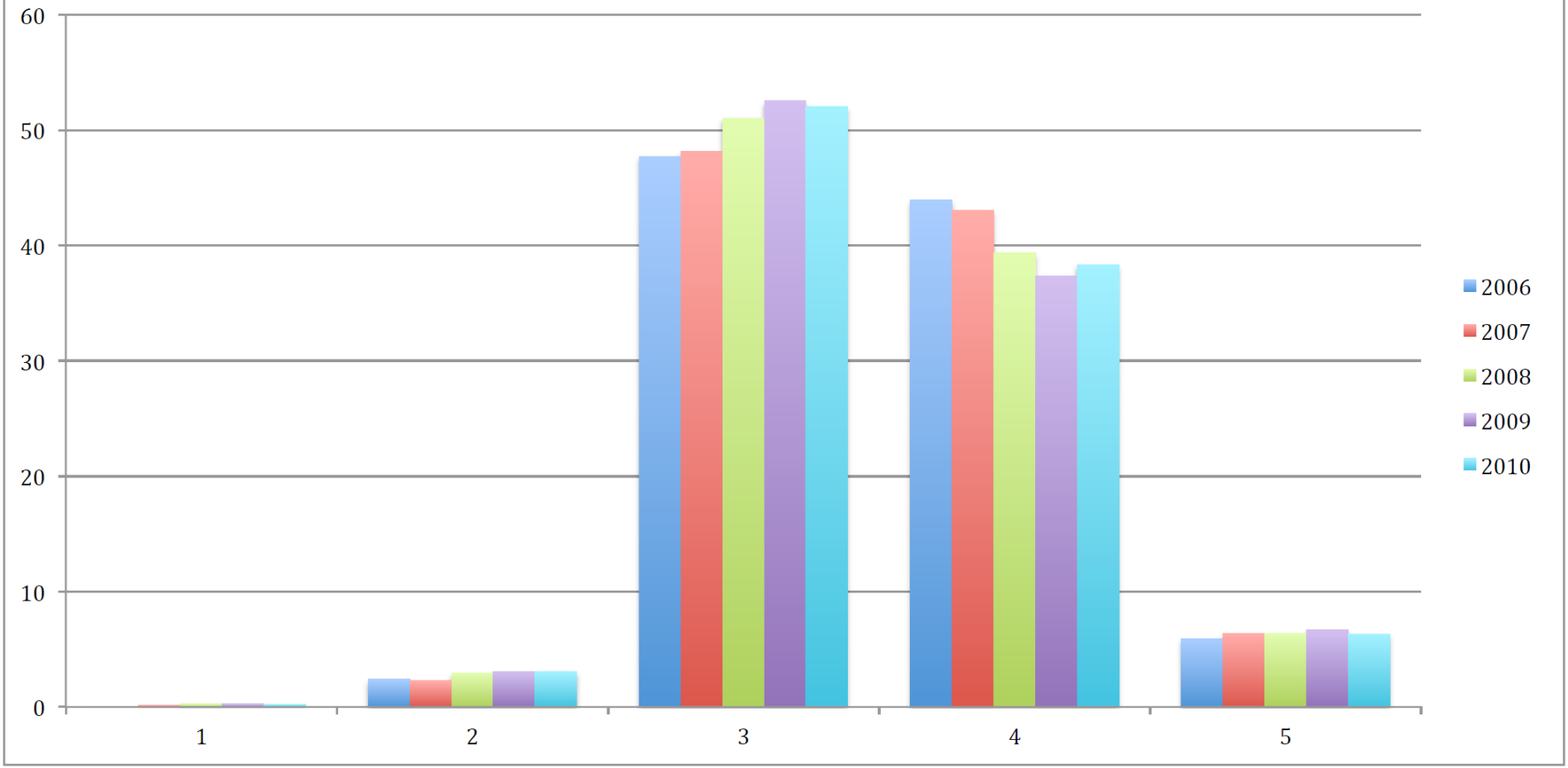


Figure 2: distribution of subjective performance evaluation ratings in 4 countries

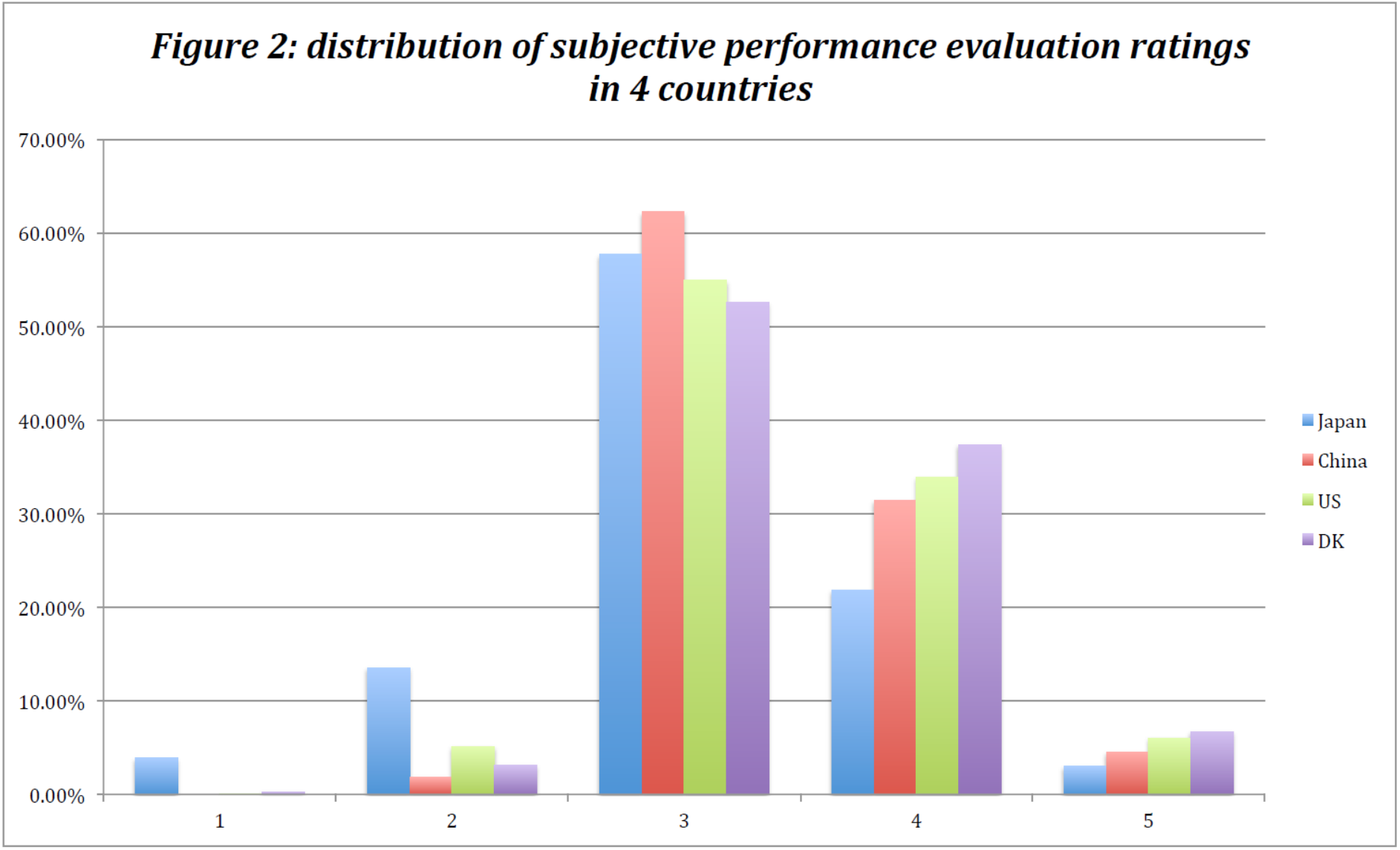


Figure 3a: evolution of span of control as team leader

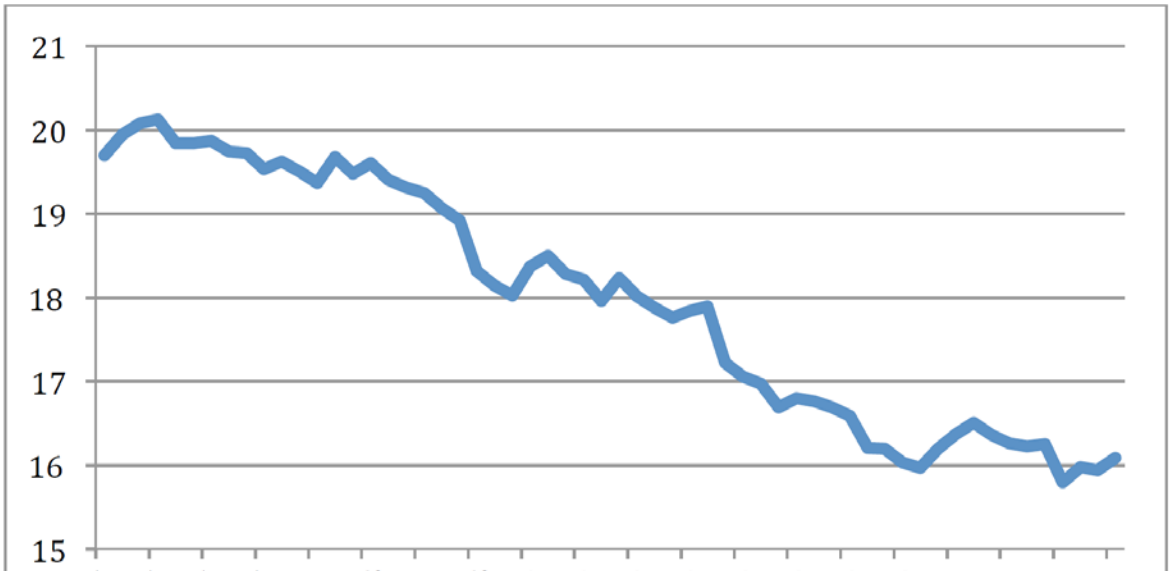


Figure 3b: evolution of span of control as manager

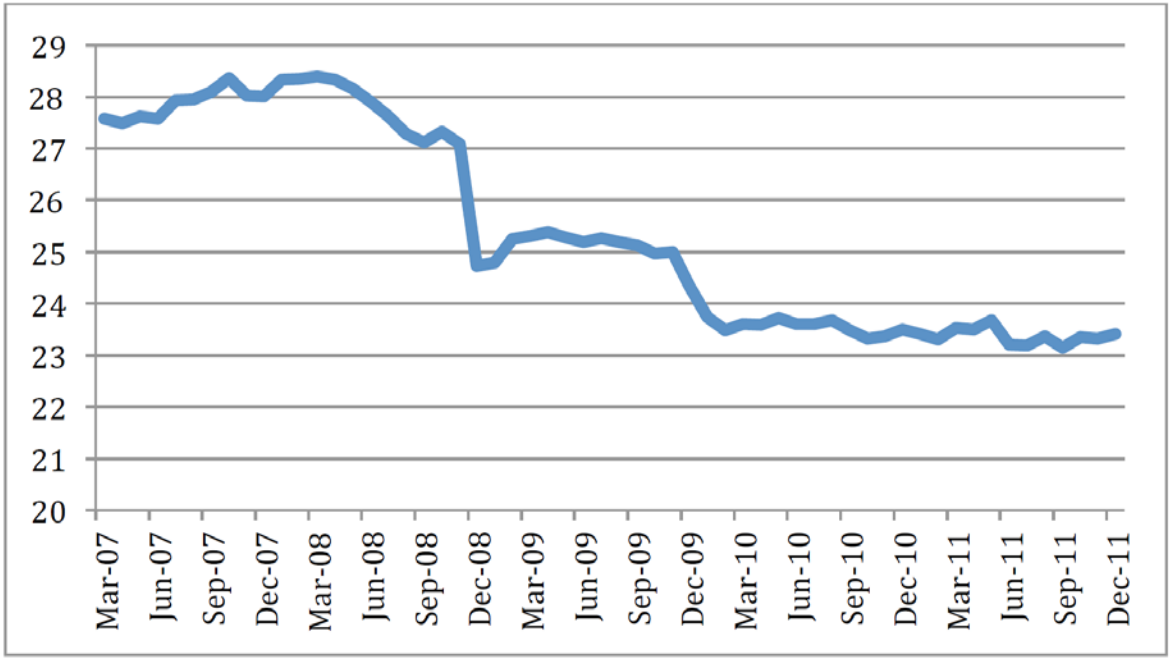


Figure 3c: evolution of span of control as VP

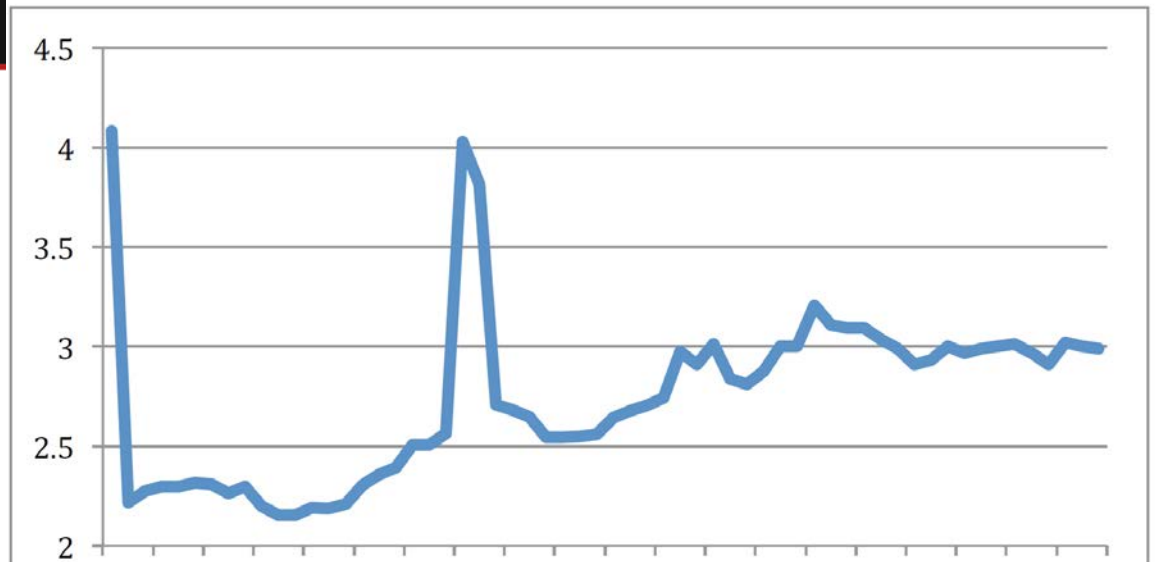
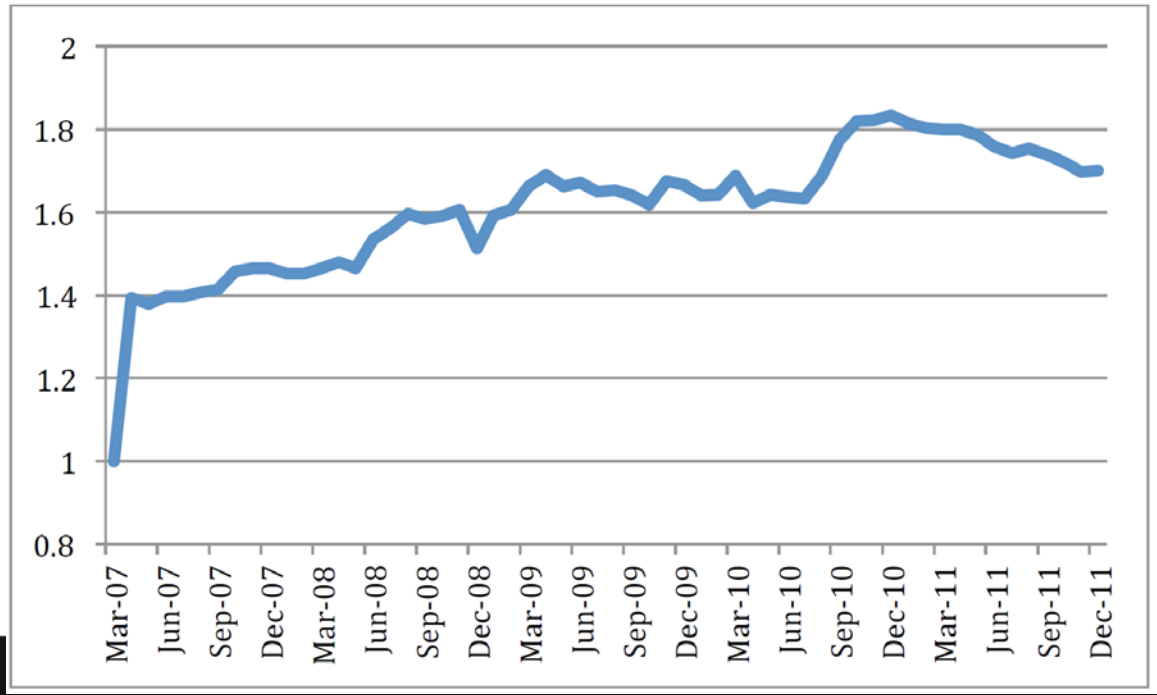


Figure 3d: evolution of span of control as CVP



EMPIRICAL TESTS

- Our tests concern wages, wage changes, probability of promotion, span of control, and changes in span of control, where our focus is the testable predictions derived in our theoretical analysis which I list in a shortened form below.

- Testable Predictions
  - Prediction 1: Wages rise with schooling.
  - Prediction 2: Wages and wage increases rise with performance.
  - Prediction 3: Probability of promotion increases with schooling and performance.
  - Prediction 4: Wages rise with job level and promoted workers receive large wage increases.
  - Prediction 5: Managerial span of control increases with schooling and performance.
  - Prediction 6: Changes in span of control are positively related to prior performance.
  - Prediction 7: Learning effects should decrease with job level tenure.

Table 2: Summary statistics

Variable	Worker	Team leader	Manager	Vice president	Corporate vice president
Tenure	9.35	9.38	10.68	13.21	14.69
Experience	21.01	19.37	20.52	23.17	24.61
Performance	3.41	3.48	3.69	3.83	4.05
Promotion probability	0.36%	6.17%	3.06%	19.15%	1.18%
Bachelor	0.19	0.22	0.22	0.17	0.13
Master and above	0.39	0.45	0.72	0.82	0.86
Average span	-	17.88	26.19	2.76	1.66
# worker-year data	12,869	1,302	1,872	425	328

Note: Tenure is the number of years working for the firm. Experience is defined as age minus the number of years of education minus 6. Performance of year t-1 is assessed by the direct supervisor in December of year t-1. Bachelor is a dummy equal to 1 if the individual has a bachelor degree and 0 otherwise. Master and above is a dummy equal to 1 if the individual has a MSc or PhD degree, and 0 otherwise. The average span of control is the average number of individuals reporting directly to their supervisor as observed in our dataset.

Table 3 : Wages, Human Capital and Performance

Log wage	(1)	(2)	(3)
Experience	0.018***	0.018***	0.016***
	(0.001)	(0.001)	(0.001)
Experience²/100	-0.029***	-0.029***	-0.025***
	(0.001)	(0.001)	(0.001)
Tenure	-0.0003	-0.0007*	-0.0015***
	(0.0004)	(0.0004)	(0.0006)
Tenure²/100	0.004***	0.005***	0.005***
	(0.001)	(0.001)	(0.0017)
Bachelor	0.208***	0.207***	0.187***
	(0.003)	(0.003)	(0.004)
Master and above	0.291***	0.291***	0.264***
	(0.003)	(0.003)	(0.004)
Team Leader	0.209***	0.205***	0.195***
	(0.004)	(0.004)	(0.005)
Manager	0.411***	0.403***	0.410***
	(0.003)	(0.003)	(0.004)
Vice President	0.638***	0.625***	0.618***
	(0.006)	(0.006)	(0.008)
Corporate Vice President	0.832***	0.810***	0.819***
	(0.007)	(0.007)	(0.008)
Performance in t-1	-	0.033***	0.022***
		(0.001)	(0.002)
Performance in t-2	-	-	0.015***
			(0.002)
Constant	10.166***	10.050***	10.081***
	(0.007)	(0.008)	(0.014)
Year dummies	YES	YES	YES
Cost center dummies	YES	YES	YES
Adj. R2	0.83	0.84	0.86
N	14,278	14,278	7,451

Table 4 : Wage Growth and Performance

Δ Log wage	(1)	(2)	(3)	(4)	(5)
Log wage	-0.012***	-0.013***	-0.016***	-0.017***	-0.024***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Performance in t-1	-	0.010***	0.009***	0.007***	0.008***
		(0.0004)	(0.0004)	(0.001)	(0.001)
Performance in t-2	-	-	-	0.003***	-
				(0.001)	
Promotion	0.021***	-	0.018***	0.014***	-
	(0.002)		(0.002)	(0.002)	
Performance in t-1 * (job level tenure=0)	-	-	-	-	0.003**
					(0.001)
Performance in t-1 * (job level tenure=1,2)	-	-	-	-	0.003***
					(0.001)
Performance in t-1* (job level tenure=3,5)	-	-	-	-	0.001
					(0.001)
Constant	0.169***	0.142***	0.178***	0.192***	0.027***
	(0.011)	(0.011)	(0.011)	(0.017)	(0.017)
Year dummies	YES	YES	YES	YES	YES
Cost center dummies	YES	YES	YES	YES	YES
Adj. R2	0.06	0.10	0.11	0.09	0.11
N	10,703	10,703	10,703	4,998	10,632

Table 5 : Promotion and Performance (marginal effects reported)

Promotion	(1)	(2)	(3)	(4)
Experience	0.0006	0.001	0.001	0.0005*
	(0.0004)	(0.0007)	(0.0007)	(0.0003)
Experience²/100	-0.001	-0.002	-0.0024	-0.0007
	(0.0009)	(0.0016)	(0.0017)	(0.0007)
Tenure	0.0005**	0.0007	0.0008	0.0006***
	(0.0003)	(0.0005)	(0.0005)	(0.0002)
Tenure²/100	-0.0005	-0.0002	-0.0004	-0.0009
	(0.0009)	(0.0014)	(0.001)	(0.0007)
Bachelor	0.034***	0.037***	0.043***	0.028***
	(0.009)	(0.015)	(0.016)	(0.008)
Master and above	0.034***	0.045***	0.049***	0.026***
	(0.005)	(0.008)	(0.008)	(0.005)
Performance in t-1	0.011***	0.011***	0.015***	0.005***
	(0.001)	(0.002)	(0.002)	(0.001)
Performance in t-2	-	0.008***	-	-
		(0.002)		
Performance in t-1 * (job level tenure=0)	-	-	-	0.004***
				(0.001)
Performance in t-1 * (job level tenure=1,2)	-	-	-	0.003***
				(0.001)
Performance in t-1* (job level tenure=3,5)	-	-	-	0.002***
				(0.001)
Team Leader	0.047***	0.028***	0.030***	0.030***
	(0.008)	(0.008)	(0.009)	(0.006)
Manager	-0.004**	-0.010***	-0.010***	-0.004**
	(0.001)	(0.002)	(0.002)	(0.001)
Vice president	0.016***	-0.009***	-0.010***	0.009***
	(0.006)	(0.002)	(0.002)	(0.004)
Year dummies	YES	YES	YES	YES
Cost center dummies	YES	YES	YES	YES
Pseudo R2	0.30	0.31	0.29	0.34
Log Likelihood	-928.86	-500.55	-512.93	-512.93
N	9,600	4,499	4,499	9,600

Table 6 : Span of Control and Performance

Log span	(1)	(2)	(3)
Experience	0.002	-0.003	-0.004
	(0.010)	(0.012)	(0.012)
Experience²/100	-0.026	-0.015	-0.015
	(0.021)	(0.025)	(0.025)
Tenure	0.031***	0.031***	0.032***
	(0.007)	(0.008)	(0.008)
Tenure²/100	-0.057***	-0.058**	-0.063**
	(0.022)	(0.025)	(0.025)
Bachelor	0.062	0.097	0.405***
	(0.053)	(0.063)	(0.102)
Master and above	-0.101*	-0.046	0.160*
	(0.052)	(0.062)	(0.097)
Performance in t-1	0.075***	0.058**	0.055**
	(0.022)	(0.027)	(0.027)
Performance in t-2	-	0.059**	0.052*
		(0.027)	(0.027)
Team leader	2.023***	2.070***	2.355***
	(0.061)	(0.069)	(0.122)
Team leader*BA/BSc			-0.572***
			(0.130)
Team leader*(Master and above)			-0.228*
			(0.119)
Manager	2.360***	2.381***	2.376***
	(0.052)	(0.056)	(0.056)
Vice President	0.503***	0.553***	0.545***
	(0.064)	(0.070)	(0.070)
Constant	0.144	-0.044	-0.218
	(0.168)	(0.217)	(0.224)
Year dummies	YES	YES	YES
Cost center dummies	YES	YES	YES
Adj. R2	0.62	0.64	0.64
N	2,837	2,133	2,133

Table 7 : Change in Span and Performance

Δ Log span	(1)	(2)	(3)	(4)	(5)
log span	-0.102***	-0.096***	-0.104***	-0.097***	-0.104***
	(0.009)	(0.010)	(0.009)	(0.010)	(0.009)
Performance in t-1	0.023**	0.027**	0.022**	0.027**	0.021***
	(0.010)	(0.012)	(0.010)	(0.012)	(0.011)
Performance in t-2	-	0.0002	-	-0.002	-
		(0.012)		(0.012)	
Performance in t-1 * (job level tenure=0)	-	-	-	-	0.003
					(0.006)
Performance in t-1 * (job level tenure=1,2)	-	-	-	-	-0.003
					(0.006)
Performance in t-1* (job level tenure=3,5)	-	-	-	-	0.005
					(0.005)
Team leader	0.236***	0.216***	0.232***	0.218***	0.233***
	(0.031)	(0.034)	(0.032)	(0.036)	(0.032)
Manager	0.254***	0.237***	0.255***	0.237***	0.257***
	(0.031)	(0.034)	(0.031)	(0.034)	(0.031)
Vice president	0.099***	0.101***	0.098***	0.101***	0.101***
	(0.029)	(0.030)	(0.029)	(0.030)	(0.029)
Bachelor	-	-	-0.002	-0.009	-0.004
			(0.023)	(0.027)	(0.023)
Master and above	-	-	-0.018	-0.009	-0.020
			(0.023)	(0.027)	(0.023)
Experience	-0.001	-0.0003	-0.001	-0.001	-0.001
	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)
Experience²	-0.002	-0.002	-0.001	-0.001	-0.001
	(0.009)	(0.011)	(0.009)	(0.011)	(0.009)
Tenure	0.003	0.004	0.002	0.004	0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Tenure²	-0.010	-0.015	-0.008	-0.015	-0.008
	(0.009)	(0.011)	(0.009)	(0.011)	(0.009)
Constant	-0.017	-0.029	0.015	-0.007	0.015
	(0.069)	(0.086)	(0.078)	(0.094)	(0.079)
Year dummies	YES	YES	YES	YES	YES
Cost center dummies	YES	YES	YES	YES	YES
Adj. R2	0.05	0.05	0.05	0.05	0.06
N	2,735	2,060	2,712	2,045	2,704

- In summary
  - Prediction 1: Wages rise with schooling.
    - Finding: yes
  - Prediction 2: Wages and wage increases rise with performance.
    - Finding: yes
  - Prediction 3: Probability of promotion increases with schooling and performance.
    - Finding: yes
  - Prediction 4: Wages rise with job level and promoted workers receive large wage increases.
    - Finding: yes
  - Prediction 5: Managerial span of control increases with schooling and performance.
    - Finding: yes, but a bit mixed on the schooling prediction
  - Prediction 6: Changes in span of control are positively related to prior performance.
    - Finding: yes
  - Prediction 7: Learning effects should decrease with job level tenure.
    - Finding: yes for two of the three sub-predictions

DISCUSSION

- Our results concerning Predictions 1-4 can be explained by the models investigated in Gibbons and Waldman (1999, 2006).

- But those models say nothing about span of control since in those models there is no sense in which a worker assigned to a higher level job supervise workers at a lower level. Thus, our results concerning span of control are not inconsistent with predictions of the Gibbons and Waldman models, but rather those models are simply silent concerning that issue.

- So to the extent our findings concerning span of control are consistent with the predictions of our model suggests that our extension of the Gibbons and Waldman framework provides a more complete picture of the operation of internal labor markets than the Gibbons and Waldman models.

- Our first finding concerning span of control is that span of control increases with schooling and performance, although the schooling result is a bit mixed.
  - This result is consistent with the scale-of-operations effect.
- Our second finding is that change in span of control is positively correlated with performance even after controlling for schooling.
  - This suggests that learning is important.
- Our third finding is that the effect of performance on change in span of control is not decreasing with job level tenure.
  - But this could be the result of a bias that arises due to the effect of performance on promotion probability decreasing with job level tenure.
- So overall our results are consistent the scale-of-operations effect, learning, and the interaction of the two all being important.

CONCLUSION

- In this paper we started with a theoretical analysis that combines the scale-of-operations effect as in, for example, Lucas (1978) and Rosen (1982) with the symmetric learning approach of Gibbons and Waldman (1999, 2006).

- We used this model to derive a number of testable predictions concerning the operation of internal labor markets that involve wages, wage changes, probability of promotion, span of control, and changes in span of control.

- We then used data from an EU “high tech” manufacturing firm to test these predictions and found evidence across the various outcome variables that, with a few exceptions, are consistent with the theory.

- Our conclusion is the scale-of-operations effect and learning are both important factors in the operation of internal labor markets and, further, that the interaction of the two which has not previously been explored is on its own an important factor.

- In term of future research, an interesting direction in which the analysis in the paper could be extended would be to introduce an element of asymmetric learning.
  - In this paper we have focused on symmetric learning similar to the approach taken, for example, in Harris and Holmstrom (1982), Holmstrom (1982), and Gibbons and Waldman (1999, 2006).
  - An alternative approach, first explored in Greenwald (1979, 1986) and Waldman (1984b), is asymmetric learning, i.e., current employers learn more about worker ability than alternative employers.
  - Papers such as Gibbons and Katz (1991), Schonberg (2007), DeVaro and Waldman (2012), and Kahn (2013) test for asymmetric learning and, on net, we believe the evidence supports the asymmetric learning approach.
  - Introducing asymmetric learning would thus be of interest from both theoretical and empirical perspectives.