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A Test of Garicano's Knowledge Model

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Abstract

Garicano's model has become one of the main models dealing with the analysis of the structure of information within organizations. It is used in many fields such as labor economics, international economics and strategic management. However, few papers have attempted to test the predictions of this model at the microeconomic level. In this paper we provide a test of two predictions of Garicano's model, using a French matched employer-employee database.

1. Introduction

Do cheaper communication technology and a change in the cost of acquisition and transmission of knowledge affect the organizational design of firms (number of production workers, number of managers, etc....)? Garicano (2000) provides answers to some of these issues. The starting point in Garicano's analysis is that production needs physical resources and knowledge. If there is communication, workers do not need the whole level of knowledge required to produce. Indeed, they will learn to meet the daily challenges of work and will ask a third party to help them in case of unusual problems. Hence production requires physical inputs and expertise. The organization must therefore decide who learns what and who to contact in case of problems.

According to Garicano, the acquisition of knowledge can be organized as "a knowledge-based hierarchy". In such a structure, solutions to the most common problems are found in the first level of the hierarchy whereas the solutions to the toughest problems or exceptional ones are found in higher levels of the hierarchy. In other words, the workers who face problems that they do not know how to solve transfer them to the next level of the organization, and the problems will therefore move until someone finds the solution.

The model also shows that a decrease in the cost of acquisition of knowledge reduces the need for specialized managers in organizations. Indeed, a cheaper knowledge acquisition such as the introduction of expert systems for example will mean that production workers have less need for specialized managers. This will reduce the number of hierarchical levels, reduce the time required to obtain solutions to problems and thereby reduce the frequency with which managers are involved in the production process. On the other hand, the implementation of this type of organization will ensure that production workers depend more on managers to solve their problems. Moreover, each specialized manager will have to solve the problems of a larger number of workers, which will increase the manager's power of control.

Garicano's 2000 model has been extended and/or adapted in order to explain some cases in economic fields like labor economics (Hubbard and Garicano 2003, 2009), management and organization (Garicano et al. 2010), inequality analysis (Garicano and Rossi-Hansberg 2004, 2006), growth theory (Garicano and Rossi-Hansberg 2012), etc. In international economics, for example, Antràs et al. (2006a, 2006b) study the decision to offshore or not production to a foreign country.

Despite its many extensions, the 2000 model remains the core of Garicano's analysis of the information and knowledge structure within organizations and the purpose of our paper is to test this model through two of its several and rich predictions. For instance, according to Garicano, the optimal organization satisfies four conditions: (1) only one class is scheduled for production, (2) the other classes are trained by managers to solve problems, (3) no solution can be known by two different classes, and (4) the organizational structure is pyramidal.

This result suggests a matching between a firm's knowledge structure, its structure of help and its hierarchical structure. Hence our first prediction derived from Garicano's model states that help is an increasing function of the number of hierarchical levels (**Prediction 1**).

Garicano's model also includes a parameter denoted λ that catches the complexity of the production process or equivalently its unpredictability, where a high λ means a more predictable production process. According to Garicano's proposition 7, the more unpredictable the production process, the more the employees will be confronted by unusual events and the more, they will need others to solve problems. Hence our second prediction derived from Garicano's model states a positive correlation between help and unpredictability of the production process **(Prediction 2)**.

Our short paper is organized as follows: section 2 deals with the empirical analysis, while section 3 concludes.

2. The empirical analysis

2.1. Data

To test the two predictions, we used the French Organizational Changes and Computerization (COI) 2006 survey [1]. The COI survey is a matched employer-employee dataset on organizational change and computerization created by researchers and statisticians from the National Institute for Statistics and Economic Studies (INSEE), the Ministry of Labor, and the Center for Labor Studies (CEE). It contains about 7,700 firms with at least 20 employees belonging to the private sector. It is a representative population of French firms from all industries except agriculture, forestry, and fishing. Each firm self-administers a questionnaire concerning the use of information technologies and organizational practices.

Within each surveyed firm, some employees are randomly selected and questioned about their socio-economic characteristics, as well as about their job characteristics within the firm (organization, training, etc.). The total number of employees is about 14,000. However, by deleting some missing variables, this number falls to 12,984 employees. Finally, for robustness purposes, we keep only the employees who do not supervise other employees. Our final data set includes 9,287 employees having at least one year of experience at the date of the survey.

2.2. Dependent and independent variables

2.2.1. Dependent variable: formal help received

To construct our "received formal help" variable, we use the following question taken from the employee section of the (COI) survey:

"If you have a temporary workload increase or if you have trouble doing a delicate, complicated task, are you helped by your hierarchical superior? (Yes/No)"

The "received formal help" variable is equal to 1 if the employee answers yes to the above question and 0 otherwise. According to table 1, 41% of employees declare that their hierarchical superiors help them when needed.

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1 www.enquetecoi.net.

Of course, several other forms of help between employees exist within firms. For instance there may be some informal help between workers. Recall however that Garicano's analysis focuses on help from hierarchical superior to subordinate.

2.2.2. The two main explanatory variables

Related to predictions 1 and 2, our two main explanatory variables are the *firms' number of hierarchical levels* (taken from the "employer part" of the COI survey) and the *unpredictability of the production process* (taken from the "employee part" of the COI survey). This means that the unpredictability of the production process is measured from the employees' standpoint. The "unpredictability" variable takes three values. The *highest value* corresponds to the case where the employee answers that his tasks are very different *every day*. The *medium value* corresponds to the case where the employee answers that his tasks are very different *every week*. Finally it takes the *lowest value* if the employee answers that he "less often or almost never" performs some tasks that are very different from each other.

The average number of hierarchical levels (see table 1) is about 4, while 46% of workers declare that their jobs do not include some unpredictable events.

2.2.3. Control variables

We use three groups of control variables, models 2, 3 and 4, corresponding to our three types of regression. The first group contains some employee-variables such as the working atmosphere among employees, the employees' degree of (horizontal) autonomy and whether wage increases depend on individual or team work. Here, job autonomy means that workers decide about the way they perform a task instead of following precise instructions from their supervisors. We expect a positive link between receiving help from supervisors and a good working atmosphere inside firms. This variable has been used by Grolleau et al. (2013) in analyzing the effect of working atmosphere on firms' innovation activities. Concerning the job autonomy variable, we can expect a positive link with receiving help from a supervisor since the more a worker receives precise instructions from supervisors about the way to perform the less he/she will ask for help from them. However we can also expect a negative link between job autonomy and receiving supervisor help since it may be the case that workers who are autonomous are also those who are able to tackle the unexpected difficulties of their task. The job autonomy variable has been used in several papers, especially in the literature concerning job quality (Green et al. 2013). The wage increase variable is related to firms' incentive schemes. Do these incentive schemes depend on individual work, group work, both or none of them (for instance, based on seniority)? Drago and Garvey (1998) develop and test a model (over an Australian data set) of how commonly-used incentive schemes affect workers' choices to help one another.

The second group includes the first group, plus the usual firms-control variables: size and business sector. Finally the third group contains the second group, plus some socio-demographic variables, such as age, being single or not, the level of education and the number of dependent children. One can expect a negative link between age and needing help from others (remembering that in order to be helped or not by this supervisor, a worker has first to be in a situation where he/she "asks" for help). Indeed, the higher his age, the more experienced a worker is, and the less he will be in a situation in which he needs help. But one can also expect a positive link since, with all things being equal, if a worker performs the same task as a younger worker, then it is likely that the younger worker is more productive. Hence, the younger worker is probably less likely to ask for help than the older worker. Moreover being single or not and the number of dependent children are a proxy of the out-of-

workplace constraints faced by a worker. Such constraints can be non-monetary (time constraints for instance). We expect that the number of dependent children will incite the agent to minimize the probability of getting fired and therefore to be more careful in performing his task. Hence, we expect a negative coefficient associated with this variable. However being single or not may (positively or negatively) affect a worker's labor supply, depending on his intra-household bargaining and resource allocation power (Chiappori 1992). Finally the level of education may affect the probability of needing help from the supervisor, either positively (if educated workers are associated with more complex tasks) or negatively (if educated workers are more productive, more adaptable, flexible-minded, etc. …).

Table 1: Descriptive statistics

Variables	Definition	Mean	SD	Min	Max
Dependent variables					
RECEIVED_FORMAL_HELP	This variable is constructed from the following question: "If you have a temporary workload increase or have trouble doing a delicate, complicated task, are you helped by your hierarchical superior? (Yes/No)" Dummy variable =1 if yes	0.41	0.49	0.00	1.00
Main explanatory variables					
NHL	The number of hierarchical levels in the firm	4.49	1.73	1.00	30.0
UNPREDICTABILITY OF TASKS	High	0.40	0.48	0.00	1.00
	Medium	0.14	0.34	0.00	1.00
	Low (ref)	0.46	0.49	0.00	1.00
Control variables					
GOOD WORKING ATMOSPHERE	The employee declares that there is a good atmosphere between workers (ref=no)	0.55	0.50	0.00	1.00
JOB AUTONOMY	The employee receives instructions about the way to perform his task (ref=no)	0.79	0.41	0.00	1.00
WAGE INCREASES	…are determined by *INDIVIDUAL WORK*	0.37	0.48	0.00	1.00
	…are determined by *TEAM WORK*	0.05	0.22	0.00	1.00
	…are determined by *BOTH INDIVIDUAL AND TEAM WORK*	0.12	0.32	0.00	1.00
	…are determined by *NONE OF THEM* (ref)	0.46	0.49	0.00	1.00
BUSINESS SECTORS	*CARS AND EQUIPMENT GOODS*	0.11	0.31	0.00	1.00
	CONSUMER GOODS (ref)	0.07	0.25	0.00	1.00
	SALES	0.18	0.38	0.00	1.00
	CONSTRUCTION	0.05	0.22	0.00	1.00

	FINANCE AND REAL ESTATE	0.08	0.27	0.00	1.00
	AGRIFOODS	0.07	0.25	0.00	1.00
	INTERMEDIATE GOODS AND ENERGY	0.16	0.37	0.00	1.00
	SERVICES	0.20	0.40	0.00	1.00
	TRANSPORTATION	0.08	0.27	0.00	1.00
SIZE	Firm's number of employees	1535.48	6267.18	10	111956
LEVEL OF EDUCATION	*BELOW "HIGH SCHOOL LEAVING CERTIFICATE"* (ref)	0.29	0.45	0.00	1.00
	"HIGH SCHOOL LEAVING CERTIFICATE"	0.32	0.47	0.00	1.00
	"YOUTH VOCATIONAL TRAINING CERTIFICATES"	0.10	0.30	0.00	1.00
	"TERTIARY STUDIES"	0.29	0.45	0.00	1.00
SINGLE	(ref=NOT SINGLE)	0.26	0.43	0.00	1.00
AGE	Employee's age	39.61	10.13	16	67
NDC	*NUMBER OF DEPENDENT CHILDREN*	1.04	1.28	0	9

Source: COI-ICT (2006)
Number of observations: 9 287

2.3. Results

The results of the estimates are presented in Table 2 and they clearly go in favor of Garicano's model. The number of hierarchical levels is positively correlated with the probability of a worker asking for and being helped by his supervisor. However this effect is actually not so high, since the associated coefficient is about 0.04. Moreover the unpredictability of the task has the expected sign and the associated coefficients are about four times higher than the coefficient associated with the number of hierarchical numbers. However, it seems that the relation between the probability of asking for and receiving help from a supervisor, and the unpredictability of task is non-linear. Indeed, if it is true (in accordance with Garicano) that workers whose tasks include some highly or mediumly unpredictable events have a higher probability (compared with workers with low unpredictability events) of asking for and receiving help from their supervisor, this probability is higher for medium unpredictability tasks than for high unpredictability tasks. This means that these latter workers either ask less for help or get less help from their supervisors.

Our estimates also include peripheral results concerning the control variables. For instance, the probability of a worker asking for and receiving help from a supervisor and being helped, is an increasing function of a good working atmosphere and of job autonomy.

Table 2: Determinants of received formal help (Logistic regression)

	Model (1)		Model (2)		Model (3)		Model (4)	
	Estimate	*SE*	*Estimate*	*SE*	*Estimate*	*SE*	*Estimate*	*SE*
Intercept	-0.82***	0.06	-1.45***	0.08	-1.69***	0.11	-1.17***	0.16
Number of hierarchical levels	0.06***	0.01	0.05***	0.01	0.05***	0.01	0.04***	0.01
Unpredictability of task (ref=Low)								

High	0.26***	0.04	0.21***	0.04	0.19***	0.04	0.15***	0.04
Medium	0.38***	0.06	0.31***	0.06	0.30***	0.06	0.24***	0.06
Good working atmosphere (ref= bad)			0.43***	0.04	0.43***	0.04	0.42***	0.04
Wage increases depend on individual/team work (ref= Neither individual nor team work)								
On individual work			0.36***	0.04	0.36***	0.04	0.31***	0.04
On team work			0.48***	0.09	0.46***	0.09	0.44***	0.09
Both on individual and team work			0.71***	0.07	0.70***	0.07	0.62***	0.07
Job autonomy (ref=No)			0.29***	0.05	0.29***	0.05	0.26***	0.05
Business sector (ref=Consumption goods)								
Cars and equipment goods					0.2*	0.1	0.19*	0.1
Sales					0.45***	0.09	0.39***	0.1
Construction					0.3**	0.12	0.33***	0.13
Finance & real estate					0.36***	0.11	0.28**	0.11
Agrifoods					0.45***	0.11	0.46***	0.11
Intermediate goods& energy					0.2**	0.1	0.22**	0.1
Services					0.22**	0.09	0.12	0.09
Transportation					-0.06	0.11	-0.05	0.11
Size					0.00	0.00	0.00	0.00
Age							-0.01***	0.00
Single (ref= Not single)							0.01	0.05
Level of education (ref=Below "High-school leaving certificate")								
High-school leaving certificate							0.11**	0.05
Youth vocational training certificates							0.2***	0.08
Tertiary studies							0.39***	0.06
Number of dependent children							-0.05*	0.02

Source: COI-ICT (2006).
Number of observations: 9 287
(*), (**), (***) indicate parameter significance at the 10, 5 and 1 per cent level, respectively.
AIC (Aikeke Information Criteria) are respectively: 12504.23, 12226.62, 12191.31 and 1208.34
Wald statistics are respectively: 85.5***, 351.51***, 403.2*** and 506.96***.

3. Conclusion

We provide in this paper a test of Garicano's knowledge model, through two predictions derived from this model. Using a French matched employer-employee data set, we find that the Garicano's model is accurate.

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