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Inventors' Working Autonomy; is it an incentive instrument?

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Abstract

Strategic management of human capital is critical in knowledge-intensive industries. Incentivizing knowledge workers is a challenge since their performance is not exactly verifiable, and their innovative output is uncertain, and thereby, not contractble. We aim to test if working autonomy in practice is an incentive instrument for managing knowledge workers. In this framework, we disentangle two distinct channels in which a firm may offer working autonomy to the worker; efficiency and incentive channel; an employer may delegate more autonomy to the worker to achieve higher productivity. At the same time, autonomy may be granted to better motivate the worker

Using the dataset of "Inventors Survey in Europe, the U.S. and Japan (Innovative S&T)? we investigate the determinants of working autonomy for the category of knowledge and ordinary workers. Our results confirm a uniform effect of autonomy through efficiency channel for knowledge and ordinary workers. However, the effect via incentive channel is not similar. We find strong evidence of using autonomy as a tool to motivate knowledge workers through the incentive channel. This effect is absent for the case of ordinary workers.

The results have implications for the strategic management of human capital, explaining the differences observed in the autonomy levels of employees in the organizations, based on the nature of the workers' activities and assets of the firm.

Keywords: working autonomy, knowledge workers, complementary assets, strategic management of human capital

JEL codes: M54, J24

Inventors' Working Autonomy

Is it an Incentive Instrument?

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INTRODUCTION

Human capital has a key role in the value creation process of knowledge intensive firms, and the effective management of key employees may be the ultimate determinant of organizational performance (Youndt, Snell, Dean Jr. & Lepak, 1996). This process poses many challenges though. Firms depend heavily on their employees' firm-specific knowledge and accumulated skills, which are not easily replaceable. To retain such employees, firms must negotiate away a big chunk of the value created unless they have strong complementary assets (Campbell, Ganco, Franco & Agarwal, 2012). Besides retention, also motivation can be problematic due to information constraints (Coff, 1997, 1999) that for example prevent the firm from observing the true characteristics of the employees as well as their contribute to production. Finally, firms may find it difficult to set up pay-for-performance schemes given that many knowledge outcomes are hardly verifiable.

Firms can use many instruments to manage effectively their key employees, but incentivizing and retaining knowledge workers are still open issues in the literature (Campbell et al., 2011). We aim to understand the use that firms make of "working autonomy" when attempting to retain and motivate their employees.[1] Although autonomy has long been mentioned as an important job dimension for knowledge workers (see Parzefall, Seeck & Leppänen (2008) for a review), its role has not yet been deeply investigated. In this paper, we empirically investigate the existence of two distinct channels that affect an employer's decision to grant autonomy to key employees. An employer firm may offer more autonomy to more skilled workers to achieve higher efficiency and productivity. Absent any incentive problems, the decision to delegate is only linked to efficiency considerations; we label this first role of autonomy the *efficiency channel*. On the other hand, autonomy can be a powerful instrument to motivate workers, i.e., to provide the right incentives. For example, more

autonomy can be used to induce workers to exert a greater effort, or to focus more on a given project. We label this the *incentive channel* of autonomy.

These two channels can lead to different choices. For example, as we also discuss in greater details below, when there are strong ties between the firm's resources (technical equipments, complementary assets, scientific environment, etc.) and a worker's skills and knowledge, the worker can obtain higher benefits from being involved in the firm's innovative activities. Therefore, a firm that owns large complementary assets and suitable resources can more effectively motivate a worker, yet by granting *lower* autonomy to her (Gambardella, Panico & Valentini, 2012).

Given these two channels for the choice of autonomy, we discuss the different implications for the effective management of two categories of workers: the ones that are directly involved in the innovation activities, that we name knowledge workers and those that are not hired primarily to deal with innovation, ordinary workers. We then offer a few testable hypotheses about the use that firms make of autonomy for these two groups, answering to the following questions: Is autonomy in practice an incentive instrument for managing knowledge workers? According to which mechanism? And when is it more effective? We argue that the efficiency channel must function equally for both knowledge and ordinary workers, whereas the incentive channel is particularly relevant for the former but not the latter category, because of additional limitations due to the problem of observing their efforts and measuring their outputs.

To disentangle the two channels of autonomy and test our hypotheses, we use extensive data drawn from the "*Innovative S&T indicators for empirical models and policies*" project. The dataset is based on a survey of inventors for *EPO* granted patents with priority dates in 2003-2005 in twenty European countries, US, Japan and Israel. The survey covers a

wide range of complementary indicators at the level of inventors, patents, companies, regions and technologies. An exceptional feature of the dataset is that it covers serendipitous inventions made by the workers who were not initially employed as knowledge workers. We exploit this feature to test our hypotheses and compare the effects of the efficiency and the incentive channel of autonomy.

Our results confirm a uniform effect of autonomy through the efficiency channel for both professional inventors and ordinary workers. However, the effect of autonomy via the incentive channel differs for the two categories; we find a negative significant relation between the provision of suitable resources by the employer and the autonomy level for the professional inventors. Also, controlling for the efficiency channel, knowledge workers receive lower autonomy when the employer provides a more attractive environment (scientifically or technically) for the knowledge worker. These relations are absent for the case of ordinary workers. We argue that this is consistent with the fact that autonomy is used indeed as an incentive tool for the inventors.

By connecting the firm's decision to grant more autonomy to its technological resources, our work contributes to the literature on strategic management of the human capital. Also, this study complements recent streams of literature that suggest a potential role for a firm's technological capabilities on its governance decisions (see Hoetker, 2005; Leiblein & Miller, 2003; Martin & Salomon, 2003; Mayer & Solomon, 2006). In addition, our results offer managerial implications for firms about when to use autonomy to retain and motivate employees according to the resources that they possess.

The remainder of this paper is organized as follows. Section 2 discusses the theoretical background and develops the corresponding hypotheses. The empirical setting, data and the

sample employed in the study are described in section 3. Section 4, reports and discusses the results.

Inventor's Working Autonomy as an Incentive Instrument

In this section, we discuss the determinants of autonomy of knowledge workers. We emphasize two distinct reasons why a firm may offer autonomy to a knowledge worker: for efficiency purposes, i.e., because a worker with higher skill can produce better outcomes, and for incentive reasons, i.e., to better motivate the worker. Next, we analyze the effect of each channel for two categories of workers, deriving a few theoretical implications. Finally, we provide testable hypotheses relevant to our analysis.

Efficiency channel of autonomy. It is widely accepted that job satisfaction is one of the key sources of worker's efficiency (e.g. Clark 2001; Freeman 1978; Hamermesh 1977; Lévy-Garboua, Montmarquette & Simonnet, 2007). Working autonomy is also mentioned among the prominent factors contributing to job satisfaction in the literature (Benz & Frey, 2008a; Nguyen, Taylor & Bradley, 2003; Sousa-Poza & Sousa-Poza, 2000). After all, studies about self employed workers have consistently found that their job satisfaction is higher than the one of wage workers (e.g. Benz & Frey, 2008a; Blanchflower & Oswald, 1998), a finding that is mainly attributed to the greater autonomy that these workers experience (Benz & Frey, 2008b; Frey, Benz & Stutzer, 2004). This suggests that greater autonomy in the workplace may lead to higher job satisfaction – and thereby job efficiency- of the workers, regardless of the nature and type of their task.

The effect of autonomy is more significant in the case of knowledge workers (Baylin, 1985), and its influence is not merely bounded through the job satisfaction channel. Typically,

employees with higher levels of knowledge appreciate and seek more autonomy in their workplace (Baylin, 1985; Raelin, 1991). Also, autonomy allows the employees to take credit for their decisions and assign achievements to their own (Gagne & Deci 2005, Sauermann & Cohen, 2010), which is more relevant for the case of knowledge workers. Also, empirical evidence supports the positive effect of autonomy on the employee's innovative behavior (Shalley, Gilson & Blum, 2000). These factors, suggest that knowledge workers may value autonomy more than ordinary workers.

Innovative activities generally involve complex technicalities that are difficult to understand for managers not involved in research. Thus, an inventor typically has superior knowledge over the project issues and is therefore more capable of making the right decisions involving the use of the project resources (Sauermann & Cohen, 2010). Therefore, because workers with higher levels of knowledge, skills or experience are expected to take better decisions for the innovative project, employers may decide to grant more autonomy to attain higher efficiency.

We label this channel the *efficiency channel of autonomy*. We expect the efficiency channel to be present and functioning for both knowledge and ordinary workers. Accordingly, we hypothesize:

Hypothesis 1. *Workers with higher project-level skills are more likely to receive higher levels of working autonomy in the project.*

Incentive channel of autonomy. There are important differences between managing human capital in knowledge intensive and in other organizations due to some special features of knowledge based activities (see e.g. Campbell et. al, 2011; Coff, 1997). The uncertainty of the outcome, the difficulty to measure the output, and observe the effort exerted by the

workers make it harder to compensate them for their contribute to production. Even when the output of the knowledge intensive activities takes a tangible form (e.g. patent), it generally takes time to perceive their market value. Also, it is extremely difficult to measure the exact share of an employee's contribution to a given output. And finally, some by-products of the knowledge workers such as learning or spillovers cannot be reasonably quantified. For the reasons above, standard pay-for-performance schemes are considered inappropriate, increasing the contractual hazards (Mayer and Solomon, 2006). So, firms may prefer to focus on managing the workers input rather than metering their output (Holmstrom & Milgrom, 1991).

Working autonomy and control over the firm's assets is an instrument that can be used to incentivize knowledge workers (Gambardella, Panico and Valentini 2012). A knowledge worker prefers greater working autonomy to carry out her preferred activities (e.g. invest more in generic knowledge to retain her options outside the firm). Yet, the firm may prefer a more commercial direction. Thus, the allocation of control over the firm's assets can change the direction of innovation activities - and the potential output- toward goals that hold greater interest for the firm (e.g., profits) or the worker (e.g., scientific curiosity, visibility). However, when there are strong ties between the firm's assets and the worker's skills and knowledge, the worker gains higher private benefits from participating in the project. So, the employer can afford offering lower working autonomy and control and still retain the worker. On the contrary, when the firm does not own suitable resources for the worker's knowledge and skills, it needs to grant greater autonomy to properly incentivize the worker. This suggests the use of working autonomy as an incentive instrument, and we label this the *incentive channel of autonomy*.

Following Gambardella, Panico & Valentini (2012), we expect the firm's provision of suitable technical and scientific environment and complementary assets to be key determinants of the working autonomy level in the case of knowledge workers. Through the incentive channel of autonomy –and the absence of efficiency channel- we expect firms with particularly strong complementary resources to offer lower autonomy to knowledge workers and retain more control. Testing this implication would enable us to understand if autonomy in reality is practiced as a means to incentivize the knowledge workers or not. In addition, we could explain the variations in the workers' autonomy across different activities within a firm, and among firms.

Hypothesis 2. *Controlling for the efficiency channel of autonomy, there is a negative relation between the firm's provision of complementary assets and the autonomy of a knowledge worker.*

In the light of the discussion above, we expect every dimension of the employer which can generate private benefits for a knowledge worker (e.g. scientifically stimulating environment of the organization) to have similar effect on their autonomy level.

Non measureable output and unobservability of input are the sources of contractual hazards in the case of knowledge workers. In the absence of these factors (e.g., for non-innovative tasks) the worker's *measurable* output can provide a simple tool to offer pecuniary incentives to exert effort. The employer, in this case, can always design a payment scheme, contingent on the output that generates greater profits for the firm (Holmstrom 1979). So, the employer can safely delegate control and autonomy to the worker up to the level that is efficient for the project. For this reason, we do *not* expect the incentive channel of autonomy in action for the case of ordinary workers.

METHOD

Data and Sample

Our empirical strategy is performed on a restricted-use, extensive data drawn from the "*Innovative S&T indicators for empirical models and policies*" project (hereafter *InnoS&T*). This dataset is based on a survey of inventors for the EPO granted patents with priority dates between 2003-2005 in twenty European countries, US, Japan and Israel. The survey covers a wide range of complementary indicators at the level of inventors, patents, companies, regions and technologies. At the inventor-level, the survey includes the inventors' personal characteristics (e.g., age, gender, education, etc.) and job dimensions at the time of invention. The survey also covers data on the serendipitous inventions besides the targeted outcomes of R&D projects. At the firm-level, the survey collects data on the characteristics of the organization such as company's type, age, size, governance and etc. More details about the survey project, methodology and the primary results are described in Gambardella et al. (2012).

For the purpose of our study, we focus on the inventors employed in the private firms and exclude the employees of academic institutions and non-profit organizations. Also, since the fit between the worker's research skills and employer's resources is a key factor in our analysis, we select the employees who have moved at least once from the beginning of their career. This assures that we have a more accurate measure of the worker-employer match for the following reasons; first, these workers can use their previous workplace as a reference to compare the fit between their skills and their current employer's resources. Without a reference point, it is more likely that the worker does not have a sense of potential matches for her skills in the job market. Secondly, freshly graduate job seekers may not have

specifically defined skills or research interests.[2] Therefore, it is likely that the first employer offers the job dimensions based on more general and observable signals (such as past educational performance). Also, from the worker's side and in the absence of well-defined skills, factors such as family, salary or job location are more likely to influence the first employment. Finally, by selecting the mobile workers, we address workers mobility dilemma, as one of the most salient issues in the strategic management of human capital (Coff, 1997, Campbel et al. 2011).

Key Measures

Working autonomy. By the autonomy in the workplace, we intend to capture the degree to which the job provides worker with independence in scheduling the work and in determining the procedures and related tasks. In our analysis, we measure this by employing a question in *InnoS&T* questionnaire asking respondents to rate their autonomy level, at the time of invention on a Likert scale from 1 ("no autonomy") to 6 ("very high autonomy") on the issues:

(a) *"selection of your tasks or projects"* and (b) "*allocation of your working time among different tasks or projects".* To build a unique measure of inventor's autonomy (AUTONOMY), we simply sum up the responses over the items above. Also, to check the robustness of our results, we include the items independently as proxies for autonomy in our regressions. Notice that these proxies correspond to the worker's *project-level* autonomy which is not necessarily granted at job-level.

Firm's provision of suitable assets and resources. We define this variable as the organization's ownership of proper technical equipments and complementary assets which generate private benefits for the worker. The measure we use in our analysis is built by a

question in the survey which the respondents were asked to rate their organization on a Likert scale from 1 ("completely disagree") to 5 ("completely agree") on the following items:

The organization had… (a) *"all the right instruments and technical equipment for this invention"* (b) "*all the complementary resources to make the invention a technical success"* (c) *"all the resources to turn the invention into something economically valuable."*

To have a unique measure for the firm's provision of suitable assts in the project (ASSET), we sum up the responses over the items.

Firm's provision of suitable scientific environment. By this variable, we tend to capture the non-tangible resources of the firm which generate private benefit for the worker. Factors such as scientific stimulating environment of the organization can be considered in this category. To have a measure for this variable (SCI_ENV), we take a question from the survey asking respondents to rate the level they 1 ("completely disagree") to 5 ("completely agree") with the following statement:

"… interactions with new colleagues had provided you with significant creative input for your inventive activities."

Worker's skill. To capture the efficiency effect, we need to build a measure for the worker's level of skill, relevant to the particular project she is involved. However, the skill for the innovative activities is different from ordinary activities. Therefore, we build a proxy for the worker's skill, based on the category of the worker. For this purpose, we use a question from *InnoS&T*, asking the respondent to indicate to which extent they agree or disagree with the following statements:

a.*"… the combination of your previous experience with the knowledge of your new employer was instrumental in enhancing the inventive activity at the new organization."*

b.*" … a significant part of your previous inventive experience was no longer applicable to the new organization's inventive activities."*

The first question considers the worker's previous experience while the second question focuses on the worker's previous *inventive experience*. We build the measure for the worker's skill level (SKILL) by the responses made on a 5 point scale to the fist question for ordinary workers and the mean of the responses for the first and second question for the knowledge workers.

Knowledge worker and ordinary worker. Although all the survey respondents are considered inventors in the sense that they are associated with patented inventions, however, not all of them were hired as knowledge workers at the time of invention. These are the cases of serendipitous inventions made by employees whose main jobs were not invention. On this basis, we define knowledge workers the ones whose working task is researching and inventing in the organization that they work. Differently, ordinary workers are the employees who their main defined task is not considered invention in their organization. Table 1, describes the details for building these categories.

Controls. We control for a range of variables at the level of individuals, companies, regions and technological areas. All the data regarding the controls are derived from the *InnoS&T* survey. At the individual level, we control for the gender, age and gross income of the worker. Moreover, we control for the inventor's level of education and rank in the firm's structure. At the firm level, we control for the size of the firm and the project. Finally, due to

geographical and technology-specific factors we include dummies for the location of the inventor and technological areas.

A brief variable definitions and summary of their statistics and correlations are presented in Tables 1 and 2 and 3.

Empirical Strategy

In the empirical analysis, we estimate the determinants of working autonomy for employees in our sample. Since our measure of working autonomy (AUTONOMY) is reported in levels, we postulate an ordered response model of the following form:

$$\mathbf{P}(AUTONOMY_i=j) = \Phi(\theta_j-\beta_1 SKILL_i -\beta_2 ASSET_i -\mathbf{X'}_i\gamma)- \Phi(\theta_{j-1}-\beta_1 SKILL_i -\beta_2 ASSET_i -\mathbf{X'}_i\gamma) \quad (1)$$

In the equation above, *j* is one of the J categorical levels of AUTONOMY for the inventor *i*. θ_j is a cutoff point estimated by the model (with $\theta_0=-\infty$ and $\theta_J=\infty$) and Φ is a logistic CDF. **X** in equation (1) is a vector of regressors and controls. The company and patent level controls are matched with the inventor, so can be controlled at the individual level. We estimate equation (1) for knowledge and ordinary workers independently. Also, we use different proxies for the AUTONOMY and ASSET.

In the setup above, β_1 accounts for the efficiency channel of autonomy. Our first hypothesis asserts β_1 to be positive and significant for both groups of employees. Also, if working autonomy is practiced as an incentive tool, we expect the coefficient β_2 to exert a negative sign for the case of knowledge workers (hypothesis 2).

RESULTS AND DISCUSSION

Table 4, presents the results of ordered logit estimates for equation (1) where dependent variable is the unique measure of autonomy (AUTONOMY). We report the determinants of working autonomy for the categories of knowledge and ordinary workers independently. All specifications in Table3 include geographical and technological controls. The coefficients of the ordered logit model can be interpreted as log odds-ratios.

In the specifications in Table 4, our key explanatory variables of interest are firm's provision of suitable assets (ASSET) and the worker's skill (SKILL). According to hypothesis 1, we expect the coefficient for the SKILL to be positive, both for knowledge and ordinary workers. Hypothesis 2, suggests the sign for ASSET to be negative for the knowledge workers.

To start, we focus on the first two columns as our base-line estimates. Columns (1) and (2) report the determinants of AUTONOMY for the category of knowledge and ordinary workers, respectively. Aligned with our expectations, variable SKILL exerts a significant positive sign in the estimates for both categories. This is in line with the first hypothesis suggesting a positive and uniform effect of autonomy via the efficiency channel for the workers.

Insert table 4 about here

The effect of asset provision, however, is not parallel for the two categories of workers. For knowledge workers; ASSET shows a negative and significant impact on the autonomy level. The sign is reversed and significant for the sample of ordinary workers. This may suggest that the efficiency channel of autonomy is in place, only for the knowledge workers.

Another interesting difference between the knowledge and ordinary workers is the effect of AGE. Worker's age relates positively to autonomy delegation for knowledge workers, while it

appears insignificant for ordinary worker's sample. Controlling for the skill of the worker, EDU does not seem significantly affecting the AUTONOMY for any categories of workers. Also, higher earning workers from both categories, enjoy higher autonomy in the workplace.

Worker's autonomy may be also dependent on the worker's rank in the firm's hierarchy. As a result, higher autonomy might reflect the worker's position in the organization's structure. To control for this factor, we estimate equation (1) including a measure of worker's rank (RANK) for both categories in columns (3) and (4). As expected, workers with higher position in the organization's hierarchy are granted higher autonomy level. However, the effect of SKILL and ASSET stay robust after controlling for this factor.

Since the firm's assets are likely to be correlated with its size, in the last two columns, we control for the size of the firm (FIRM_SIZE) and include an interaction between ASSET and FIRM_SIZE. As reported in the columns (5) and (6), the variable SKILL keeps the sign and significance after controlling for the FIRM_SIZE for both categories. These results provide support for hypothesis 1, suggesting a positive and uniform effect of skill on autonomy via efficiency channel. In addition, the negative and significant relation between firms' provision of assets and the autonomy level of knowledge workers holds after controlling for the size of the employer firm. The coefficient of the FIRM_SIZE, suggests that-controlling for the efficiency channel- knowledge workers receive less autonomy in larger organizations. However, for the ordinary workers, the firm size is insignificant. This may suggest that the size of the firm is roughly proxying for the assets of the employer and therefore –and in line with our theory- only affecting the knowledge workers. Also, since working in larger organizations is considered more prestigious and may promote the future career of the worker, the FIRM_SIZE may capture in the incentive channel for a worker to work in a lager firm. The positive sign of the interaction between ASSET and FIRM_SIZE suggests that the effect of efficiency channel is mediated by the size of the employer. As mentioned, this might

be due to the worker side utility from working in large organizations. For instance, a knowledge worker may not be incentivized by the high asset level of the firm in a project, if the employer firm is small.

In the next step, we check if the effects via efficiency and incentive channel are robust to alternative measures of autonomy. Columns (1) to (4) in table-5, report the determinant of autonomy in "*selection of tasks or projects*" while columns (5) to (8) report for autonomy in "*allocation of working time among different tasks or projects*". The results are similar for both measures of autonomy supporting our hypotheses. The variable SKILL always exerts a positive significant sign for both categories of workers. The effect of ASSET is negative and significant on knowledge worker's autonomy level, except for the column (5) which is negative but not significant. However, with the same measure of autonomy, ASSET gains significance after controlling for the FIRM_SIZE (column (7)). The effect of ASSET on the ordinary workers is again different for the two categories. In all the specifications in Table 5, the coefficient of ASSET for ordinary workers is positive and mostly significant.

Insert table 5 about here

Similar to the findings in Table4, higher earners enjoy higher levels of autonomy regardless of autonomy measure and their task. An interesting difference between the two measures is the effect of RANK. Worker's rank has a positive and significant effect on the autonomy in *selection of projects and tasks* for the both categories of workers. On the contrary, it seems insignificant for the worker's autonomy in *time allocation among the tasks*.

As we explained in the theoretical section, the rationale behind hypotheses 2 is based on the assumption that knowledge workers gain private benefits from being involved in the projects

that match their interest. Therefore, if an employer provides higher suitable assets and resources, it can incentivize the knowledge worker easier. In line with this rationale, we expect that every dimension of the job, which generates private benefit for the knowledge worker (and not necessarily for the ordinary workers), to show similar effect as ASSET. To test this as a robustness check, we include a measure for the scientific environment of the organization (SCI_ENV). Since this measure is based on the worker's perception on the innovative spillovers of interacting with the colleagues in the workplace, we only include knowledge workers in this analysis. The results are presented in table 6.

Insert table 6 about here

In all the specification, SCI_ENV exerts a negative significant effect on the autonomy level of knowledge workers. The result is robust to controlling for the worker's rank and the firm's size. We interpret this as another evidence of the use of autonomy as an incentive instrument for the case of knowledge workers. This also implies that, providing a scientifically stimulating environment besides ownership of suitable resources by a firm may enable firms to use autonomy as a more efficient incentive instrument.

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FOOTNOTES

[1] We denote working autonomy as ”the degree to which the job provides substantial freedom, independence, and discretion to the individual in scheduling the work and in determining the procedures to be used in carrying it out" (Hackman & Oldham , 1980).

[2] Even when the fresh job seeker has particular skills and knowledge, she may not have enough evidence (e.g. previous inventions, articles, well balanced resume) to signal to her first employer.

Table 1 Variable Definitions

Variable	Definition
Worker's autonomy level (AUTONOMY)	Sum of the score (b/w 2-12) to two *InnoS&T* questions regarding the respondent's autonomy level in (a) *selection of tasks or projects* (b/w 1-6), (b) *allocation of working time among different tasks or projects* (b/w 1-6)
Firm's provision of suitable assets (ASSET)	Sum of the score (b/w 3-15) to three *InnoS&T* questions on whether the organization in which the invention was made... (a) *had all the right instruments and technical equipment for the invention*, (b) *had all the complementary resources to make the invention a technical success*, (c) *had all the resources to turn the invention into something economically valuable.*
Scientific environment of the firm (SCI_ENV)	Sum of the respondent's score (b/w 1-5) to the InnoS&T question:*"... interactions with new colleagues had provided you with significant creative input for your inventive activities"*
Worker's skill (SKILL)	Sum of the respondent's score (b/w 1-5) to the InnoS&T question: "*... the combination of your previous experience with the knowledge of your new employer was instrumental in enhancing the inventive activity at the new organization.*"
GENDER	Dummy = 1 if the individual is female.
AGE	Age of the individual.
Worker's education (EDU)	Educational degree of the individual: 1= Secondary School or lower; 2= High School Diploma or equivalent; 3= Bachelor or equivalent; 4= Master or equivalent; 5= PhD or equivalent; 6= Post-doctoral degree.
Worker's gross annual income (INCOME)	Individual's approximate annual gross income in the year of the patent application: 1= Below 10,000 Euro; 2= 10,000-29,999 Euro; 3= 30,000-49,999 Euro; 4= 50,000-69,999 Euro; 5= 70,000-99,999 Euro; 6= 100,000 and more Euro

Firm size (SIZE)	Size of the employer firm: 1= 1-9 employees; 2= 10-19 employees; 3= 20-49 employees; 4= 50-99 employees; 5= 100-249 employees; 6= 250-499 employees; 7= 500-999 employees; 8= 1000-4999 employees; 9= 5000 and more employees.
Project ManMonth	Individual's response to the *InnoS&T* question: "*How many man-months did the invention process require in total?*" 1= less than 1 man-month; 2=1-3 man-months; 3= 4-6 man-months; 4=7-12 man-months; 5=13-24 man-months; 6=25-48 man-months; 7=49-72 man-months; 8=more than 72 man-months
RANK	Individual's rank in the firm's hierarchy, based on the number of people reported to the individual at the time of invention: zero= 0 people; 1= 1-5 people; 2= 6-20 3= 21 people and more.
Knowledge worker	Dummy =1 if, as stated in the formulation of the question in the survey a)"*the invention was the targeted achievement of a research project*"; b) "*the invention was an expected by-product of a research project, not directly related to the main target of the project"*; c) "*the invention was an unexpected by-product of a research project, not directly related to the main target of the project*"
Ordinary worker	Dummy = 1 if, as stated in the formulation of the question in the survey a) "*the idea for the invention was directly related to the inventor's normal job (which is not inventing), and was then further developed in a (research) project*"; b) *the idea for the invention came from pure inspiration/creativity or from your normal job (which is not inventing), and was not further developed in a (research or development) project (was patented without further research or development costs)*"
Technological Class	ISI-INPI-OST Technology Classes

Table 2 Descriptive Statistics

Variable	Knowledge Workers				Ordinary Workers			
	Mean	**Std. Dev.**	**Min**	**Max**	**Mean**	**Std. Dev.**	**Min**	**Max**
AUTONOMY (unique measure)	8.708101	2.43415	2	12	8.923571	2.499841	2	12
AUTONOMY (selection of projects)	4.116624	1.505903	1	6	4.307395	1.525856	1	6
AUTONOMY (allocating time among projects)	4.605382	1.247975	1	6	4.624186	1.290441	1	6
ASSET	11.22453	3.026234	3	15	11.02031	3.190411	3	15
SCI_ENV	3.765697	1.229241	1	5	3.636304	1.241034	1	5
SKILL	3.738809	1.036666	1	5	3.757655	1.264253	1	5
GENDER	1.050738	0.219473	1	2	1.04212	0.200889	1	2
AGE	49.11044	10.12423	14	91	50.77756	10.12567	25	91
EDU	3.839685	1.134582	1	6	3.532847	1.185508	1	6
INCOME	4.001125	1.178805	1	6	3.982969	1.198158	1	6
RANK	0.90929	0.875453	0	3	0.897497	0.912756	0	3
FIRM_SIZE	7.238411	2.383716	1	9	6.935948	2.600808	1	9
PROJ_MANMONTH	4.77343	1.983639	1	8	4.018318	1.935261	1	8

Table 3 Correlation Matrix

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	**AUTONOMY** (unique measure)	**1**													
2	**AUTONOMY** (selection of projects)	0.90*	**1**												
3	**AUTONOMY** (allocating time among projects)	0.86*	0.56*	**1**											
4	**ASSET**	0.06*	0.02*	0.10*	**1**										
5	**SCI_ENV**	-0.01	-0.02	0.02	0.14*	**1**									
6	**SKILL**	0.16*	0.14*	0.14*	0.05*	0.23*	**1**								
7	**GENDER**	-0.01	-0.03*	0.01	0.01	0.06*	-0.02	**1**							
8	**AGE**	0.20*	0.23*	0.11*	0.03*	-0.14*	0.10*	-0.10*	**1**						
9	**EDU**	0.08*	0.06*	0.08*	-0.03*	0.04*	0.06*	0.07*	-0.01	**1**					
10	**INCOME**	0.17*	0.16*	0.14*	0.13*	0.02	0.09*	-0.12*	0.38*	0.20*	**1**				
11	**RANK**	0.18*	0.18*	0.13*	0.06*	0.01	0.09*	-0.05*	0.22*	0.09*	0.36*	**1**			
12	**FIRM_SIZE**	-0.20*	-0.21*	-0.4*	0.14*	0.11*	-0.06*	0.02*	-0.19*	0.13*	0.05*	-0.04*	**1**		
13	**PROJ_MANMONTH**	0.11*	0.11*	0.08*	-0.04*	0.05*	0.07*	0.10*	0.03*	0.16*	-0.02*	0.10*	-0.05	**1**	
14	**KNOWLEDGE WORKER**	-0.04*	-0.06*	-0.01	0.03*	0.05*	-0.01	0.02*	-0.07*	0.13*	0.01	0.01	0.06*	0.17*	**1**

Table 4

Dep. Var: **AUTONOMY**	(1) Knowledge worker	(2) Ordinary worker	(3) Knowledge worker	(4) Ordinary worker	(5) Knowledge worker	(6) Ordinary worker
GENDER	0.44*	-0.37	0.45*	-0.38	0.51**	-0.16
	(0.246)	(0.360)	(0.253)	(0.364)	(0.254)	(0.362)
AGE	0.02***	0.01	0.02***	0.01	0.01**	0.01
	(0.005)	(0.009)	(0.005)	(0.009)	(0.006)	(0.010)
EDU	0.05	0.05	0.04	0.07	0.06	0.09
	(0.046)	(0.081)	(0.047)	(0.084)	(0.047)	(0.085)
INCOME	0.31***	0.34***	0.26***	0.35***	0.28***	0.40***
	(0.052)	(0.082)	(0.056)	(0.085)	(0.056)	(0.086)
PROJ_MANMONTH	0.05**	0.22***	0.05*	0.22***	0.03	0.19***
	(0.025)	(0.046)	(0.026)	(0.047)	(0.026)	(0.048)
SKILL	0.18***	0.16**	0.16***	0.18***	0.15***	0.16**
	(0.044)	(0.064)	(0.045)	(0.065)	(0.045)	(0.066)
ASSET	-0.03*	0.03	-0.03*	0.03	-0.09**	0.15**
	(0.015)	(0.026)	(0.016)	(0.027)	(0.039)	(0.068)
FIRM_SIZE					-0.31***	-0.04
					(0.063)	(0.112)
ASSET* FIRM_SIZE					0.02***	-0.01
					(0.006)	(0.010)
RANK			0.15**	0.12	0.16***	0.05
			(0.059)	(0.089)	(0.060)	(0.091)
Technological Controls	YES	YES	YES	YES	YES	YES
Geographical Controls	YES	YES	YES	YES	YES	YES
Observations	1,571	566	1,530	551	1,524	548
log likelihood	-3247.20	-1136.25	-3155.95	-1097.27	-3105.44	-1076.65
chi-square	254.58	119.63	249.27	128.67	322.35	157.50

Ordered logit estimations on the category of knowledge and ordinar workers.. Dependent variable: unique measure of autonomy (AUTONOMY). Standard errors in parentheses.

*** p<0.01
** p<0.05
* p<0.1

Table 5

Dep. Var: Autonomy in...	**selection of projects or tasks**				**time allocation among different tasks or projects**			
	(1) Knowledge worker	(2) Ordinary worker	(3) Knowledge worker	(4) Ordinary worker	(5) Knowledge worker	(6) Ordinary worker	(7) Knowledge worker	(8) Ordinary worker
GENDER	0.23	0.03	0.26	0.24	0.63**	-0.59*	0.70***	-0.48
	(0.257)	(0.359)	(0.259)	(0.363)	(0.264)	(0.352)	(0.265)	(0.349)
AGE	0.03***	0.02*	0.02***	0.01	0.01*	0.00	0.00	-0.00
	(0.006)	(0.009)	(0.006)	(0.010)	(0.005)	(0.009)	(0.006)	(0.010)
EDU	0.01	0.04	0.02	0.07	0.08*	0.09	0.10**	0.10
	(0.047)	(0.084)	(0.047)	(0.086)	(0.046)	(0.082)	(0.047)	(0.083)
INCOME	0.25***	0.36***	0.27***	0.42***	0.22***	0.22***	0.24***	0.25***
	(0.057)	(0.085)	(0.057)	(0.087)	(0.054)	(0.084)	(0.054)	(0.085)
PROJ_MANMONTH	0.05**	0.19***	0.04	0.16***	0.03	0.17***	0.01	0.14***
	(0.026)	(0.047)	(0.026)	(0.048)	(0.025)	(0.045)	(0.025)	(0.046)
RANK	0.13**	0.13	0.14**	0.07	0.10*	0.09	0.09	0.04
	(0.059)	(0.092)	(0.060)	(0.094)	(0.059)	(0.087)	(0.059)	(0.089)
SKILL	0.15***	0.14**	0.13***	0.12*	0.13***	0.21***	0.12***	0.20***
	(0.045)	(0.065)	(0.045)	(0.066)	(0.044)	(0.063)	(0.044)	(0.063)
ASSET	-0.03**	0.00	-0.09**	0.15**	-0.01	0.07***	-0.07*	0.15**
	(0.016)	(0.027)	(0.039)	(0.068)	(0.016)	(0.026)	(0.039)	(0.065)
FIRM_SIZE			-0.28***	0.04			-0.28***	-0.07
			(0.063)	(0.113)			(0.063)	(0.105)
ASSET* FIRM_SIZE			0.01**	-0.02*			0.01**	-0.01
			(0.006)	(0.010)			(0.006)	(0.010)

Technological Controls	YES	YES	YES	YES	YES	YES	YES	YES
Geographical Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,553	560	1,547	557	1,692	610	1,686	607
log likelihood	-2478.77	-866.29	-2439.03	-847.89	-2402.12	-839.30	-2363.40	-823.96
chi-square	256.28	117.32	316.00	144.37	166.12	112.09	221.90	133.47

Ordered logit estimations. Dependent variable: autonomy in selection of projects or tasks (columns 1-4) and autonomy in time allocation among different tasks or projects (columns 5-8). Standard errors in parentheses.

*** p<0.01

** p<0.05

* p<0.1

Table 6

Dep Var: **AUTONOMY**	(1) Knowledge worker	(2) Knowledge worker	(3) Knowledge worker
GENDER	0.36	0.36	0.38
	(0.242)	(0.249)	(0.250)
AGE	0.02***	0.02***	0.01**
	(0.005)	(0.005)	(0.006)
EDU	0.07	0.06	0.06
	(0.045)	(0.046)	(0.046)
INCOME	0.31***	0.25***	0.28***
	(0.051)	(0.055)	(0.055)
PROJ_MANTMONTH	0.06**	0.05**	0.03
	(0.025)	(0.025)	(0.025)
RANK		0.17***	0.17***
		(0.058)	(0.059)
SKILL	0.19***	0.17***	0.16***
	(0.044)	(0.045)	(0.045)
SCI_ENV	-0.08**	-0.07*	-0.36***
	(0.038)	(0.038)	(0.091)
FIRM_SIZE			-0.34***
			(0.054)
SCI_ENV* FIRM_SIZE			0.05***
			(0.013)
Technological Controls	YES	YES	YES
Geographical Controls	YES	YES	YES
Observations	1,630	1,586	1,581
log likelihood	-3388.26	-3289.50	-3239.36
chi-square	271.81	266.60	343.55

Ordered logit estimations on the category of knowledge and ordinary workers.. Dependent variable: unique measure of autonomy (AUTONOMY). Standard errors in parentheses.

*** p<0.01
** p<0.05
* p<0.1