Safety and productivity in the agricultural sector. Panel analysis for Italian regional data

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The aim of this paper is to analyze the link between safety at work and productivity in the agricultural sector in Italy . To this end, we proceed with two-stage analysis conducted on Italian regional data for the years 1976-2004. The first phase of the analysis shows that in the Italian agricultural sector productivity Granger-causes occupational diseases and accidents at work, and not vice versa (**ODA**). The results of the econometric estimates in the second stage of the analysis show that the introduction of technological *innovation* has in the short-term the effect of an increase in accidents at work leading to temporary disability; however, they tend to decrease in the long run, after the learning phase (Saari, 1982c); the increase in the unemployment rate is the main cause of the increase in more serious ODA, whose consequence is an increase in permanent disability (Starrin et al., 1989). In addition, we test how the propensity of individuals to report accidents at work is encouraged by pro work legislation and by the insurance for workers against accidents at work.

KEYWORDS: labour accidents; severe and fatality injuries; sick leave; panel data
JEL SECTORS: J28, J81, C23

1. Introduction

The statistics of many countries and regions show that the agricultural sector has higher rates of accidents compared to the industrial sector. The causes of accidents and diseases affecting agricultural workers are different. In developed countries, tractors and other machinery are the major cause of accidents and deaths that occur on the job, the percentage of accidents varies between 30 and 70%.

A known risk, but little considered, is represented by repetitive actions and poor body postures which result in various forms of disability. In a study on 1155 Italian tractor driver, more than 80% appeared to be suffering from back disorders due to vibration of the tractor and poor posture acquired during driving (Bovenzi and Betta, 1994). Only recently attention has been given to the economic costs of temporary and permanent disability of farm workers. The cost takes various forms: costs related to medical treatment, loss of workers, loss of income or reduction of agricultural productivity. The severity of accidents can have a greater economic impact than the frequency of accidents (Litchfield, 1999).

In particular, the study of the link between on the job safety and productivity becomes important to derive information for the choice of appropriate policies, which actually contribute to improving the health, safety at work and economic development of a given area (Schultz, 2010). Diseases caused by work or an unsafe work environment may make individuals less productive, even though it is difficult to measure this effect.

The problem has been investigated in the industrial sector: The economic consequence on productivity of improving health and safety in the work environment, , is intuitively positive, therefore generating a negative link between productivity and ODA but empirical estimates of these benefits could be affected by possible problems of simultaneity existing between the variables involved (Strauss, 1986; Deolalikar, 1988 , Thomas and Strauss, 1996; Schultz and Tansel, 1997). In fact instead of analyzing the impact of accidents on productivity in the industrial sector, Fabiano et al. (1995, 2001) study the opposite relationship. i.e. the influence that production pressure may

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exerts on the accident at work rate In short, they analyze the fluctuations in the frequency of accidents recorded in the Italian industrial sector and their connection with the fluctuations in the industrial production. The authors verify the existence of a positive relationship between accidents and production, therefore an increase in pressure production will produce an increase in accidents.
Blank et al. (1996, 1997) use productivity as one of the control variables to investigate the relationship between technological development and occupational accidents in the Swedish manufacturing sector. Productivity is *interpreted* as an indirect measure of technological development (Blank et al. 1996). The authors verify the existence of a negative relationship between the accidents and a measure of technological innovations. In addition, this relationship is weakened by the inclusion of control variables in the econometric estimation.

It is clearly difficult to define the causal relation between health, safety at work and productivity, and to determine the direction of causality, which is important especially when taking into account the incidence of the health and safety sectors on public expenditure in many countries. A further difficulty arises from the complexity of accident, as Blank et al. (1996) argue,: << accident occurence has both social and economic determinants as well as technological ones>>. This becomes even more complicated when the field of investigation is the agricultural sector. In fact, econometric works analyzing the relationship between accidents and productivity in the agricultural sector are non-existent In this paper, we propose as a main objective to investigate the causal relationship between productivity and safety at work. As it is well known, from an econometric point of view when the causal relationships are *bidirectional*, unidirectional models are misspecified and the results derived from the recursive statistical models, typically used to test unidirectional theories, may be incomplete and incorrect (Thornberry and Christenson, 1984).
In studies of accidents in the workplace, productivity has been used as a proxy for technological innovation.. In fact, it is very difficult to define the effect that technological innovation may have on the risk of accidents at work. In addition, the effect of short and long-run of technological innovation of production on ODA is not well known (Laflamme, 1993). Among other things, the effects seen in the literature are different and at odds with each other. Some authors argue that technology has the effect of reducing the risk of accidents (Asogwa, 1988, Laflamme and Cloutier, 1988), others argue the opposite (Novek et al, 1990). In fact, both results are defensible (Saari, 1982c) as new technology could have the initial effect of an increase in the level of risk that would tend to decline only gradually after a learning process (Saari, 1982c). An adjustment period (Asogwa, 1988) is necessary to allow workers to adequately perform their tasks, in work environments that change due to the introduction of new technology.
Therefore, it is our goal to investigate the impact that technology has in the short and long term on accidents recorded in the agricultural sector. The estimation of an equation with error correction will allow us to separate the two effects and to verify their sign and impact.
Based on this premise, our goal is: to investigate the causal relation, by a Granger causality test for panel data, between safety at work and productivity in the agricultural sector; to verify the existence of a long-term relationship between the endogenous and the explanatory variable (cointegration). Finally, to proceed to the estimation of *the* long run equation . The analysis will be conducted on regional Italian data for the years 1976-2004.
Furthermore, in order to verify the robustness of the results we will consider other variables considered important by the specific literature (Blank et al., 1996, 1997). In particular, we will refer to human factors (experience and workers' training as a deterrent to accidents at work) and socio-economic factors (unemployment rate, changes in the legal system that regulates safety at work) (Blank, Laflamme, Andersson , 1997; Fabiano et al, 2008).

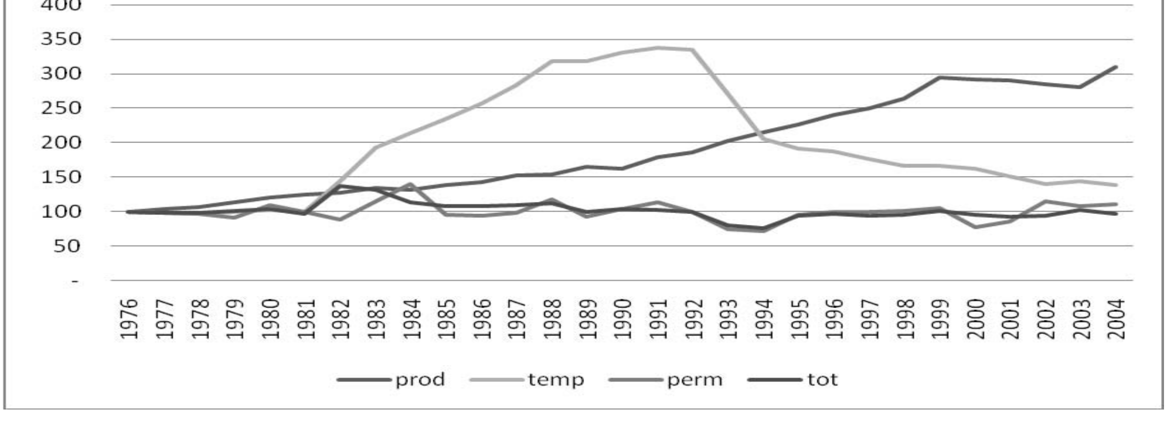
The paper is organized as follows: section 2 presents a preliminary analysis of the data, Section 3 presents the analysis methodology. Section 4 comments the results. Paragraph 5 concludes.

2. Data analysis

The present study deals with the data of the twenty Italian regions, corresponding to the European NUTS-2 level in the official classification of the European Union. The analysis is based on the number of occupational diseases and accidents (ODA) recorded in each year and defined with compensation by INAIL (National Institute for Insurance against Accidents at Work); and of the value added at 1995 prices. The data on ODA in the agricultural sector are provided by INAIL[2], the value added in the agriculture sector is provided by CRENoS (Centre for North South Economic Research).
Occupational diseases are all those diseases caused by own work by the action of physical, biological or chemical agents and they manifest themselves, over time, with symptoms more or less perceptible; professional illnesses are not immediately perceived and manifest themselves over time, with more or less clearly perceptible symptoms. The accidents, to be compensated, must derive from own work, and must be characterized by a violent cause.
In our work we consider the number of: permanent ODA, when the ability to work fails completely or is permanently reduced by more than 15%; temporary ODA, when the impediment to work lasts longer than three days; total ODA, the sum of permanent and temporary ODA.
Both the number of ODA and the value added are divided by the number of annual work units of the agricultural sector (AWU)[3].The data cover the period 1976-2004.

In Graph 1 the fixed-base index (1976 = 100) shows an increasing trend for temporary ODA (temp) at least until 1992, then it undergo a sharp decrease that continues until the last year of the series but always remaining above the permanent and total ODA series (respectively *tot* and *perm*). In particular, we note that the trend of these two series appears unchanged from the base year (1976), almost as if they had reached a balance. The productivity index (*prod*) follows an upward trend, showing a clear positive relationship with temporary ODA until 1992; since 1992, the relationship is reversed indicating an improvement of on the job safety over the years. The relationship with total and permanent ODA is much more complicate, and no relationship appears to emerge between productivity and total and permanent ODA; infact we observe a constant trend in the first two series and a growing trend in the productivity of the agricultural sector.

GRAPH 1 – FIXED-BASE INDEX (1976=100) OF PRODUCTION AND ODA. YEARS 1976-2004

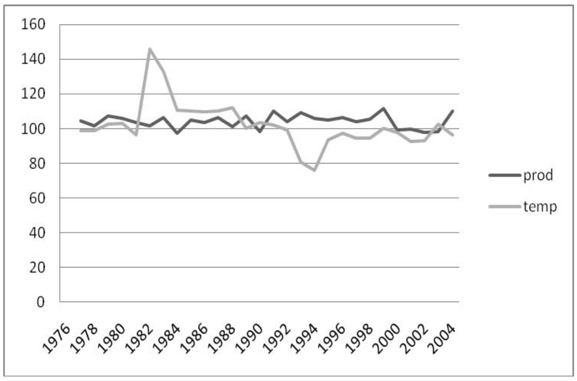


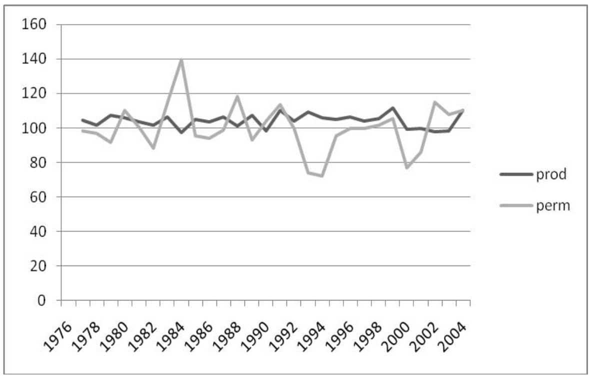
[2] INAIL provides only the aggregate regional level of occupational accidents and diseases.
[3] The AWU represents the amount of work offered in the year by a full-time employee, or the equivalent amount of work provided by part-time workers or workers who hold more than one jobs.

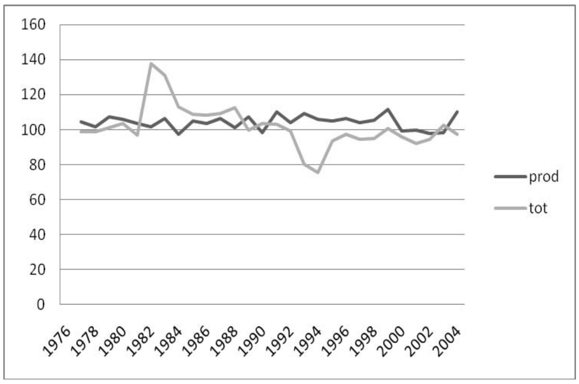
We conclude this preliminary analysis with concatenated indexes that allow us to highlight short-term changes through the changes that occur in a series between the current period and the next (Vitale, 2002). These indexes have been used by Fabiano et al. (1995, 2001) to test the influence of production pressure on the rate of industrial accidents. Fabiano et al. (1995, 2001) observe, plotting concatenated indexes of industrial production and of accidents occurring in industry, that cycles of expansion of production are accompanied by cycles of expansion of accidents.
For the agricultural sector, Graph 2 shows how the different ODA indexes do not fully follow the production cycle, on the contrary, we see that most often expansions in the production cycles are accompanied by a reduction of the ODA index and for a few years only an increase in production is accompanied by an increase in ODA; in particular this is true in the first years of the series for temporary and total ODA. Also, we note a similar pattern of concatenated indexes for temporary and total ODA.

This allows us to suggest that in the agriculture sector there appears to be no production pressure on the development of ODA but rather that the growth of production generates no pressure, as it could be caused by an improvement in working conditions or even by a reduction of the production pressure itself that would result in a reduction of on the job accidents and illnesses. This could suggest a double relation of causality that we are going to investigate later.

GRAPH 2 –CONCATENATED INDEXES OF PRODUCTION AND ODA (*temp, perm, tot, prod*). YEARS 1977-2004







3. Methodology

Panels with a significant temporal dimension are subject to spurious relationships, especially because macroeconomic variables are usually characterized by non-stationarity. The extension of

the methods of time series to panel data allows us to control for non-stationarity and to verify the existence of cointegration relationships (Kao and Chiang, 2000; Pedroni, 2000). The analysis of cointegration develops in three steps: verification of the presence of unit root through the appropriate tests, the test for a cointegration relationship and the estimation of a long-term relationship.
However, before proceeding in the analysis of cointegration we will evaluate the exogeneity of the variables through the Granger test (1969). The Granger test verifies the power_ of a variable to predict another one (Hamilton, 1995), *i.e.* to check whether y is Granger caused by x. In other words, we regress y on its lagged values and those of x and test whether the set of coefficients associated with x are statistically different from zero.

3.1 Granger causality test for panel data

The procedure used to test the causal relationship in a panel data set was proposed by Holtz-Eakin et al (1988). The Granger causality test for panel data is presented as follows:

$$y_{it} = \alpha_0 + \sum_{j=1}^{m} \alpha_j y_{it-j} + \sum_{j=1}^{m} \delta_j x_{it-j} + f_i + u_{it} \qquad (1)$$

Where *i = 1,…,N* are the observation units and *t = 1,…,m* is the time index. The model in differences allows us to eliminate the fixed effects (f_i)

$$y_{it} - y_{it-1} = \alpha_0 + \sum_{j=1}^{m} \alpha_j \left(y_{it-j} - y_{it-j-1}\right) + \sum_{j=1}^{m} \delta_j \left(x_{it-j} - x_{it-j-1}\right) + \left(u_{it} - u_{iy-1}\right) \qquad (2)$$

This specification introduces a simultaneity problem because the error term is correlated with $y_{it} - y_{it-j-1}$. In this case a consistent estimate can be obtained using the two-stage instrumental variables method (2SLS).
In order to verify if x causes y it will be necessary to test the joint hypothesis $H_0 : \delta_1 = \delta_2 = ... = \delta_m = 0$. If the null hypothesis is rejected then x Granger causes y.

3.2 Auto regressive distributed lag models: long-term analysis

In our analysis we assume that the long run function is the following:

$$Y_{it} = \theta_{0i} + \theta_{1i} X_{it} + \theta_{2i} G_{it} + u_{it} \quad \text{per } i = 1,..., N \text{ e } t = 1,..., T \qquad (3)$$

Where Y is the logarithm of the dependent variable, X is the logarithm of the principal regressor, which will be defined on the basis of the Granger test, and G is the logarithm of the control variables (socio-economic and human factors that we will list later).
The first phase of the analysis will consider only the relationship between the two main variables: ODA and productivity; the second phase, in order to verify the robustness of the relationship, will also involve the control variables.

Once we have verified that the variables involved in the analysis are *I (1)* and cointegrated such that the error term, *u*, is a process *I (0)* $\forall i$, we proceed to consider an autoregressive distributed lag model with a number of lags equal to one, *ARDL (1,1,1)*.

The equation with error correction is:

$$\Delta Y_{it} = \phi_i \left(Y_{it-1} - \theta_{0i} - \theta_{1i} X_{it} - \theta_{2i} G_{it} \right) - \delta_{11i} \Delta X_{it} - \delta_{21i} \Delta G_{it} + \varepsilon_{it} \qquad (4)$$

Where: ϕ_i is the parameter that measures the speed of adjustment, θ_1 and θ_2 represent the coefficients of the long run.

In the estimation of equation (5), both the fixed effects estimator and the causal effects ones are biased for $T \to \infty$ *and* for $N \to \infty$.

Pesaran, Shin and Smith (1999) propose two estimators to solve the problem of heterogeneity induced by the slope parameter in dynamic panel models. The models in question are the mean group estimator (MP) and the pooled mean group estimator (PMG).

Under some regularity assumptions, the parameters estimated by this model are consistent and asymptotically normal both in the presence of stationary regressors and of non-stationary regressors integrated of order one (Pesaran, Shin and Smith, 1999). Pesaran, Shin and Smith (1999) suggest the Hausman test to choose between MG and PMG. Under the null hypothesis both estimators are consistent but only the PMG is efficient. If the assumption of homogeneity (poolability) is not valid, the PMG estimates are not consistent (the null hypothesis is rejected).

4. Results

4.1 Granger causality test

The Granger causality analysis conducted for ODA (temporary, permanent and total) and productivity shows a causal relationship in which productivity Granger-causes ODA (table 1),this in line with the studies for industrial sector (Fabiano et al., 1995 and 2001; Blank et al., 1996 and 1997).

TABLE 1. GRANGER CAUSALITY TEST[4]

Regression 1 **Dependent variable: D.prod**		**Regression 2** **Dependent variable: D.temp**	
D2.prod	-.2077 (-1.53)	*D2.prod*	.1990*** (3.04)
D3.prod	.8253*** (6.63)	*D3.prod*	-.2319*** (-3.65)
D2.temp	.0543 (0.57)	*D2.temp*	1.4218*** (5.95)
D3.temp	-.0748 (-0.81)	*D3.temp*	-.4906** (-2.18)
dummy temporal	Yes	*dummy temporal*	Yes
GRANGER TEST	0.93	***GRANGER TEST***	14.09***
HANSEN J STATISTIC	4.284[5] [0.2324]	*HANSEN J STATISTIC*	2.749 [0.4320]
Regression 3 **Dependent variable: D.prod**		**Regression 4** **Dependent variable : D.perm**	

[4] The analysis is conducted for a different number of lags. Here we report the results in which the regressors are significant.

[5] We use, in all estimates, the lags of the dependent variable as instruments (Hsiao, 1986).

D2.prod	-.2064* (-1.65)	*D2.prod*	.1975** (2.08)
D3.prod	.8213*** (6.96)	*D3.prod*	-.1876** (-2.02)
D2.perm	.0386 (0.96)	*D2.perm*	.4601 (1.60)
D3.perm	-.0429 (-1.11)	*D3.perm*	.2331 (1.07)
dummy temporal	Yes	*dummy temporal*	Yes
GRANGER TEST	1.29	***GRANGER TEST***	6.11**
HANSEN J STATISTIC	4.233 [0.2374]	*HANSEN J STATISTIC*	10.561 [0.1589]
Regression 5 Dependent variable: D.prod		**Regressione 6 Dependent variable: D.tot**	
D2.prod	**-.2033 (-1.49)**	*D2.prod*	**.1996*** (3.39)**
D3.prod	**.8234*** (6.58)**	*D3.prod*	**-.2313*** (-4.00)**
D2.tot	**.0669 (0.69)**	*D2.tot*	**1.3212*** (6.52)**
D3.tot	**-.0851 (-0.91)**	*D3.tot*	**-.3864** (-2.08)**
dummy temporal	**Yes**	*dummy temporal*	**Yes**
GRANGER TEST	**1.02**	***GRANGER TEST***	**16.84*** **
HANSEN J STATISTIC	**4.287 [0.2321]**	*HANSEN J STATISTIC*	**3.896 [0.2729]**

****, **, *: 1, 5, 10%; (): t-stat; []: p-value. With D. D2. e D3. we indicate, respectively, first, second and third differences of variables.*

4.2 Long term analysis

In what follows we investigate first the presence of unit roots in the series and if they are cointegrated; subsequently we estimate the long term equation in order to test the link between productivity and ODA.

The unit root tests were designed to evaluate the integration order of variables[6]. If the variables are integrated of order one we use cointegration tests to address the problem of non-stationarity of the series[7].

Almost all tests reject the hypothesis of the unit root only for permanent ODA; productivity is not stationary for both the Hadri and the Pesaran tests; temporary and total ODA are not stationary for almost all tests (table 2).

TABLE 2. UNIT ROOT TESTS FOR PANEL DATA: VARIABLES IN LEVELS

VARIABLES	**LLC t***	**IPS W-t-bar**	**Fisher**		**Breitung λ**	**Hadri Z**	**Pesaran**	
			Adf-Pm	PP-Pm			t-bar	z
Prod	-4.2357***	-4.5668***	4.0255***	15.9928***	-3.1279***	6.6171***	-2.334	-0.118
Temp	-2.0010**	0.7219	0.1394	-1.7407	1.0500	13.6974***	-2.796**	-2.339**
Perm	-3.5011***	-1.7285**	1.2488	2.2644**	-1.0603	10.5999***	-2.625*	-1.517*
Tot	-1.8879**	0.8299	0.2871	-1.9602	1.0821	13.6357***	-2.809**	-2.401**

****, **, *: 1, 5, 10%*

[6] All tests, except Hadri test , are characterized by a null hypothesis which postulates a unit root.

[7] Among the first generation test we have: LLC tests (Levin et al (2002), IPS (Im et al, 2003) and Fisher's nonparametric tests (Maddala and Wu, 1999; Choi, 2001). These tests assume that data are independent and identically distributed across individuals. This assumption creates problems of distortion which leads to reject the null hypothesis of unit root in the presence of non-stationary (Banerjee et al, 2005). By contrast, second-generation tests allow us to explicit cross-sectional dependence. The tests in this second category are represented by the Pesaran, Breitung and Hadri test (Pesaran, 2007).

The hypothesis of non-stationarity of the series is rejected for the variables in first differences, except for the Hadri test which rejects the hypothesis of no unit root (table 3). The integration tests accept the alternative hypothesis of stationarity in first differences so that all series are integrated of first order.

TABLE 3. UNIT ROOT TESTS FOR PANEL DATA: VARIABLES IN FIRST DIFFERENCES

VARIABLES	LLC t*	IPS W-t-bar	Fisher		Breitung λ	Hadri Z	Pesaran	
			Adf-Pm	PP-Pm			t-bar	z
Prod	-17.4621***	-22.2848***	12.5437***	101.3119***	-6.4997***	4.5998***	-3.035***	-3.487***
Temp	-14.9749***	-15.2823***	5.3697***	39.5196***	-4.7473***	2.7193**	-3.086****	-3.730***
Perm	-14.6206***	-17.4248***	8.8322***	64.1846***	-5.8797***	2.6602**	-3.249***	-4.513***
Tot	-15.0386***	-15.5298***	5.2897***	40.1487***	-4.6939***	2.8702**	-3.075***	-3.678***

****, **, *: 1, 5, 10%*

Among the many tests of cointegration (Pedroni, 1999; Kao, 1999) we propose the four tests of Westerlund (2007. These tests allow us to control for a high degree of heterogeneity The four tests evaluate the null hypothesis that the error correction term in a conditional ECM (Error Correction Models) is zero (no cointegration hypothesis). The tests are derived under the null hypothesis of no cointegration.
The cointegration tests rejecting the null hypothesis of no cointegration suggest that the variables are cointegrated and are linked by a long-term relationship (table 4).
In the agricultural sector, the results of the estimates show a long-term relationship only between ODA and productivity (table 5). By contrast, the coefficient associated with the impact of short-term is always statistically insignificant except in the case of the MG estimates for permanent ODA. In terms of long-term impact, we observe that if productivity increases by 1% total and temporary ODA decline more than proportionally_(respectively, a coefficient of -2.20 and -2.96 for the PMG and MG estimates for temporary ODA and -2.11 and -2.69 for total ODA). In the case of permanent ODA, the impact of productivity is less than proportional (respectively, a coefficient of -0.54 and -0.52 for the PMG and MG estimates). The Hausman test rejecting the null hypothesis in the case of temporary and total ODA leads us to prefer the MG to the PMG model; the Hausman test prefers the PMG model in the case of permanent ODA.
The negative impact of productivity on ODA can be due to technological *innovation* in the agricultural sector, making the production process more efficient and safer[8]. This result is in line with the idea that new technology would have the initial effect of an increase in the level of risk (short run) that will tend to decline only gradually after a learning process (long run) (Saari, 1982c). To allow workers to perform adequately the new tasks, in work environments that change due to the introduction of new technologies, it is necessary an adjustment period (Asogwa, 1988).

TABLE 4. COINTEGRATION TEST

	statistics	*prod temp*	*prod perm*	*prod tot*
WESTERLUND	*Gt*	-3.069***	-3.074***	-3.090***
	Ga	-18.720***	-18.267***	-18.905***
	Pt	-19.355***	-19.879***	-19.429***
	Pa	-26.307***	-25.401***	-26.482***

****, **, *: 1, 5, 10%*

[8] In several studies that have considered the technological innovation and occupational accidents, the productivity and the consumption of electricity have been used as a measure of technological innovation (Saari, 1982a, 1982b).

TABLE 5. RESULTS OF the ESTIMATES

Regression 1 *Dependent variable: **D.temp***	PMG	MG
constant	1.1552***	1.1346***
	(16.53)	(7.58)
D.prod	.0599	.0490
	(0.86)	(0.68)
ϕ_i	-.0634***	-.0727***
	(-14.74)	(-6.77)
long run		
prod	-2.2007***	-2.9650***
	(-3.70)	(-4.83)
HAUSMAN TEST		13.15***
Regression 2 *Dependent variable: **D.perm***	PMG	MG
Constant	-.0465	-.2972
	(-1.16)	(-1.09)
D.prod	.1743	.2160*
	(1.41)	(1.88)
ϕ_i	-.2357***	-.2976***
	(-6.47)	(-7.87)
long run		
prod	-.5492***	-.5284***
	(-8.00)	(-4.33)
HAUSMAN TEST	0.04	
Regression 3 *Dependent variable: **D.tot***	PMG	MG
Constant	1.0757***	1.0565***
	(16.97)	(7.97)
D.prod	.0787	.0714
	(1.30)	(1.15)
ϕ_i	-.0617***	-.0721***
	(-15.10)	(-7.21)
long run		
prod	-2.116***	-2.6977***
	(-3.72)	(-4.93)
HAUSMAN TEST		36.39***

****, **, *: 1, 5, 10%; (): t-stat. We indicate with D. the first differences, while (-1) denote the lag of the dependent variable.*

It is much more complex especially when you consider that the effect of a technological innovation on occupational accidents depends on a number of different factors (Blank, Laflamme, Andersson, 1997). For example, the way in which technological innovation is implemented, the manner in which workers are prepared (trained or informed) and other factors that may moderate the main effect of technological innovation on the occurrence of accidents, both before and after. Among the main factors considered in empirical studies, we find: the environment, the work organization, the work task, the human factors, the socio-economic status (Blank, Laflamme, Andersson, 1997, Fabiano et al , 2008). In particular, we consider the socio-economic factors: unemployment rate, changes in legislation regulating the work and safety at work (Saari, 1982). We consider the total unemployment rate[9] (td) as a factor that can influence the intensity of production (Starrin et al, 1989, Blank et al, 1996) and the dummies will allow us to grasp the changes that have occurred in legislation which protects the workers and their health in the workplace from 1976 to 2004. Specifically, we will refer to a dummy for the Legislative Decree 626/1994 (decree). The introduction of this variable will allow us to grasp the influence that the legislation, which protects

[9] We consider the total unemployment rate and not specific to the agricultural sector because it is not available (Blank et al, 1996).

the worker, has to prevent or reduce accidents at work With this decree the matter of prevention is no longer static but dynamic (evolution of technology, production methods, updating security measures), it also allows to switch from an objective safety model, whose purpose is to ensure a technologically safe working environment, to a safety model based on the behavior of workers subjectively safe. In particular, we consider as a proxy for the educational level of workers formation represented the employment rate of graduates (*tod*) and non-graduates (*tond*) in agriculture. In this way we test the impact that training has in the determination of the accidents and occupational diseases in the Italian agricultural sector.
We verify, even for these variables, the presence of unit roots and we implement the cointegration test to verify a long-term relationship.

TABLE 6. UNIT ROOT TESTS FOR PANEL DATA: VARIABLES IN LEVELS

VARIABLES	**LLC t***	**IPS W-t-bar**	**Fisher**		**Breitung λ**	**Hadri z**	**Pesaran**	
			Adf-Pm	PP-Pm			t-bar	z
Td	-4.3577***	-3.5486***	5.4253***	1.1841	1.8098	9.0819***	-2.124	0.892
Tod	-4.2454***	-3.0766***	0.9616	3.0005***	-2.3430**	5.2101***	-2.069	1.159
tond	-4.0532***	-3.3274***	1.6780**	3.4130***	-1.5891*	5.8029***	-2.016	1.412

****, **, *: 1, 5, 10%*

TABLE 7. UNIT ROOT TESTS FOR PANEL DATA: VARIABLES IN FIRST DIFFERENCES

VARIABLES	**LLC t***	**IPS W-t-bar**	**Fisher**		**Breitung λ**	**Hadri z**	**Pesaran**	
			Adf-Pm	PP-Pm			t-bar	Z
Td	-12.9630 ***	-12.9402***	4.8945***	40.7450***	-5.0372***	1.6049*	-2.522	-1.018
Tod	-14.2642***	-15.2881***	6.5459***	49.0451***	-7.3284***	3.9219***	-2.836***	-2.531***
tond	-15.3944***	-16.4736***	5.2025***	48.3205***	-7.0929***	5.0434***	-2.947***	-3.061***

****, **, *: 1, 5, 10%*

TABLE 8. COINTEGRATION TEST

	statistics	*prod temp td tod tond*	*prod perm td tod tond*	*prod tot td tod tond*
WESTERLUND	*Gt*	-3.282**	-3.477***	-3.309**
	Ga	-18.579***	-17.708***	-18.580***
	Pt	-30.844***	-29.402***	-30.643***
	Pa	-39.983***	-32.896***	-39.388***

****, **, *: 1, 5, 10%*

Tests conducted on the variables in levels (Table 6) show the possible presence of unit root problems. Tests conducted on the variables in first differences, rejecting the null hypothesis, conclude that all series are integrated of first order. The cointegration tests suggest that the variables are linked by a long-term relationship (Table 8).

The Hausman test leads to always prefer the MG estimates to the PMG ones. The only case in which productivity appears to be significant in the short and long term is related to the temporary ODA. We note that in the short run the influence of productivity is found to be positive, so if productivity is seen as a proxy of technological change, the introduction of a new technology will result in an increase in the level of risk; the risk will tend to decrease after a process of learning referred to the new technology. This we verify when we consider the effect of long-run productivity on temporary ODA (Saari, 1982c). Productivity has no effect on permanent ODA, while it is significant only in the short term, with positive sign, in the case of total ODA.

The socio-economic factors can affect not only the probability of accidents but also the probability that such accidents are reported to the authorities. In other words, the probability that accidents are reported tends to decline when the economic climate is unfavourable and the threat of unemployment is high (Blank et al., 1996, 1997). Conversely, the propensity of individuals to sue could be encouraged by legislation and by the insurance for workers against accidents at work. This we find in our results. In fact, in all estimates the effect of the introduction of Legislative Decree 626/1994 has the effect of reducing the risk of accidents and occupational diseases in both the short and long run. The biggest impact occurs mainly in the long run. The unemployment rate has an impact only on the permanent risk with negative sign in the short run and positive sign in the long run. The positive long-term relationship is justified by the hypothesis that an increase in overtime and work intensity are simultaneous to an increase in the rate of unemployment (Starrin et al., 1989). In particular, the threat of becoming unemployed leads workers to work harder and make fewer demands on working and environment conditions (Starrin et al, 1989). Effects of this type could be a possible explanation for the increase of accidents at work (Blank et al., 1996).

In addition, we observe that the employment rate of graduates in the agricultural sector in the short term have a negative impact on the risk of ODA and a positive impact in the long run. We observe this result for all three cases examined. The positive impact is justified in the repetitiveness of the work in the agricultural sector, which would result in various accidents leading to disability (Litchfield, 1999). Since this variable captures the effect of school education, it could be connected to the idea that educated people, for long, may feel the work in the fields unsatisfactory and perform it with little attention. This will increase the probability of being injured at work. For the employment rate of non-graduates in agricultural sector, we find a situation reversed. The relationship appears to be not significant in the short run, while in the long run it has a negative sign and is statistically significant only in case of permanent accidents and occupational diseases. The negative impact of long-term variables finds its justification in the manual and repetitive action of gesture that require more experience, attention and not so much education. It seems evident that non-graduate workers are more focused on their work than graduates ones.

TABLE 9. RESULTS OF ESTIMATES

Regression 1 *Dependent variable: **D.temp***	PMG	MG
constant	-.7637*** (-7.29)	3.1295 (1.58)
D.prod	-.0183 (-0.24)	.18830** (2.02)
D.td	-.1771* (-1.89)	-.1477 (-1.23)
D.tod	-.1231 (-1.63)	-.2154** (-2.32)
D.tond	-.1831* (-1.74)	.0947 (0.57)
decree	158.702*** (7.59)	-.3043*** (-3.94)
ϕ_i	-.2703*** (-7.60)	-.3734*** (-6.82)
long run		
prod	.0551 (0.39)	-2.646* (-1.67)
td	.8537*** (12.91)	-.0440 (-0.04)
tod	.5040*** (3.43)	2.1540* (1.81)
tond	-1.1314*** (-6.79)	-5.8699*** (-2.75)
decree	-588.1211*** (-7.10)	-1.3709*** (-3.77)
HAUSMAN TEST		104.26***
Regression 2 *Dependent variablee: **D.perm***	PMG	MG
Constant	-3.8563*** (-18.30)	-3.4465*** (-2.88)
D.prod	.0381 (0.30)	.1798 (1.34)
D.td	-.1683 (-1.34)	-.2821** (-2.63)
D.tod	-.1600 (-1.53)	-.2322** (-2.07)
D.tond	.1602 (1.15)	.0571 (0.35)
decree	-.1228*** (-2.87)	-.5297*** (-7.78)
ϕ_i	-.4853*** (-15.98)	-.7067*** (-16.87)
long run		
prod	.3069** (2.52)	-.0178 (-0.10)
td	.3215*** (5.09)	.5768*** (4.85)
tod	.1337 (0.93)	.4976** (2.34)
tond	-.3418* (-1.92)	-.3897 (-1.63)
decree	-.6260*** (-4.48)	-.8179*** (-6.95)
HAUSMAN TEST		35.72***
Regression 3 *Dependent variablee: **D.tot***	PMG	MG
constant	-.8722*** (-7.46)	2.5393 (1.45)
D.prod	.0050 (0.08)	.1770** (2.16)
D.td	-.1847** (-2.22)	-.1478 (-1.37)
D.tod	-.1304* (-1.93)	-.2066** (-2.66)
D.tond	-.1400 (-1.44)	.0930 (0.62)
decree	3.2244*** (7.27)	-.3084*** (-4.79)
ϕ_i	-.2812*** (-7.79)	-.3705*** (-7.40)
long run		
prod	.0864 (0.65)	-1.9180 (-1.17)
td	.8185*** (13.32)	.2421 (0.27)
tod	.4860*** (3.54)	1.770* (1.68)
tond	-1.0653*** (-6.70)	-7.004*** (-3.01)
decree	-12.4845*** (-7.23)	-1.9543** (-2.35)
HAUSMAN TEST		97.98***

****, **, *: 1, 5, 10%; (): t-stat.. We indicate with D. the first differences, while (-1) denote the lag of the dependent variable.*

5. Concluding remarks

The aim of this study was to analyze the relationship between workplace safety and productivity for the twenty Italian regions for the years 1976-2004 in the agricultural sector. The Granger causality test for panel data has shown that productivity Granger-causes ODA.

The second stage analysis has shown that productivity appears to be significant, in the short and long run, only for temporary ODA. The influence of productivity is found to be positive in the short run while it is negative in the long run. Therefore, if productivity is seen as a proxy for technological change, the introduction of a new technology will result in an immediate increase in the level of risk. The risk will tend to decrease only after a process of learning associated with the new technology (Saari, 1982c). In terms of policy, prevention should be recommended against the occurrence of the accidents that, even though not very severe, tend to occur mainly during the early period of introduction of technological innovation. According to . Litchfield (1999) such prevention would be most cost effective, both in terms of direct costs such as medical care, rehabilitation, etc., and of indirect costs such as reduction and replacement of personnel, reduction of productivity, agricultural rent, etc..)

Regarding the control variables, we have tested the relevance of the legislative decree 626/1994 by introducing an appropriate control variable. The negative impact of this variable on the number of accidents at work is a sign of how the propensity of individuals to sue is encouraged by legislation and by the insurance for workers against accidents at work. This result allows us to emphasize the key role played by the legislation on accident prevention, training and "education" of workers in the workplace.

The positive impact of unemployment rate on permanent ODA is justified by the hypothesis of simultaneity between the increase in overtime and unemployment rate. In particular, the threat of becoming unemployed would induce workers to work harder and make fewer demands on working and environment conditions (Starrin et al, 1989). Effects of this type could be a possible explanation for the increase of accidents at work (Blank et al., 1996).

Finally, we observe that the employment rate of graduate workers in the agricultural sector in the short term have a negative impact on the risk of ODA where as in the long run the impact is positive. The connection between level of education and long and short term effects on ODA requires further investigation. Here we offer a very preliminary interpretation of our findings: the positive impact is justified in the repetitiveness of the work in the agricultural sector, which would result in various forms of accidents leading to disability (Litchfield, 1999). Since this variable captures the effect of school education, it could be connected to the idea that educated people, for long, may consider agricultural work unsatisfactory and perform it with little attention. This will increase the probability of injury at work. In this regard, Blank et al. (1995) attribute the increased risks in the workplace to the nature of the work, the type of work task and the loss of qualification. Our future goal is to investigate the composition of employment of agricultural workers with different levels of education, this is to better understand the link between accidents and education.

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