EMPLOYMENT IMPACT OF FIRMS' INNOVATION: WHAT IS THE ROLE OF REGIONAL INSTITUTIONS? EVIDENCE FROM ITALY

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Abstract

Employment effect of firms' innovation is a widely studied topic at both cross-country and national level, while still few contributions deals with the local dimension. Moreover, the role of the institutional factors is still unexplored. In this manuscript, the author estimates the impact of private firms' R&D spending, institutional quality and their interaction on the employment rate of the Italian regions. To accomplish his task, the author proposes two dynamic panel models and computes them through the Ordinary Least Squares (OLS), Fixed effects (FE) and System Generalized Method of Moments (GMM-SYS) regression tecniques. The obtained results suggest that the employment impact of firms' innovation is negative, while the ability of the regional institutions to attract, support and cooperate with the innovative companies and the R&D investment programs jointly financed by regional governments and private firms positively affect the employment rate. The author has deduced appropriate policy implications from the provided evidence.

Keywords: *Employment impact of firms' innovation, R&D activity, Regional Economics*
JEL classification: O30, R10, R11

1. Introduction

Employment impact of firms' innovation is important for both economists and policy makers who are concerned about the so-colled "fourth industrial revolution". In fact, the debate on the economic consequences of innovation is deadlocked over the questions "How does firms' innovation affect the employment rate?" and "What are the best strategies to maximize the positive externalities of firms'innovation on labour market and to minimize the negative ones?". In the past centuries, many primary economic thinkers focused on the relationship between technological innovation and labour market. For example, according to Adam Smith, innovation contributes to the economic growth of nations through division of labour. David Ricardo, instead, pointed out that the introduction in the production process of new machineries can be detrimental for workers, but it is better to support technological innovation because contrasting it can induce firms to move abroad with even worse aftermath on national labour market. Finally, Schumpeter highlighted that entrepreneurs exploit innovation to allocate the production factors in more and more efficient ways. His main insight is that innovation is responsible for job destruction just as a result of this constant riallocation process of existing resources. However, from an historical point of view and in particular looking at the three global industrial revolutions, it seems that innovation generally leds to a drop in employment in the short-run, but to a permanent increase in the long-run (Kapeliushnikov, 2019).

Today, the academic community is divided between those ones who believe that technological innovation does not reduce the employment rate and those ones claiming that innovation implies "technological unemployment" ("this means unemployment due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour" (Keynes, 1931)). However, it is a very challanging debate as the evidence on the technological unamployment are mixed for two main reasons. The first one is the fact that this phenomenon is shaped by an eterogeneous and complex set of microeconomic and macroeconomic variables (such as labour and physical capital marginal productivity, stock of human capital, companies' functional specialization, companies' settlment structure, systemic shocks and so on) changing country by country. The second one is the existence of many different kinds of innovation. General guidelines for both researchers and practitioners on the measurement of scientific, technological and innovation activities

have been provided by the Organization for Economic Cooperation and Development (OECD) only starting from 2005 through the well-known Oslo Manual. The fourth and last editon of this handbook (Oslo Manual 2018) defines business innovation as:

"[…] *a new or improved product process (or combination thereof) that differs significantly from firms' previous products or business processes and that has been introduced on the market or brought into use by the firm*"

and lists 8 types of business innovation activities: *i*) R&D activities; *ii*) engigneering, design and other creative work activities; *iii*) marketing and brand equity activities; *iv*) intellectual property (IP) related activities; *v*) employee training activities; *vi*) software development and database activities; *vii*) activities relating to acquisition or lease of tangible assets; *viii*) innovation management activities. Further, business innovation is split into two broad categories: product innovation, namely goods or services providing significant improvements compared to goods and services previously introduced into the market, and business process innovation, i.e. a new business process for one or more business function differing from the firms' previous business processes and that has been brought into use in the firm.

2. Research aims

Currently, there are two ways in which it is possible to contribute to the literature on the employment impact of firms' innovation. The first one consists in widening the local, and in particular regional, dimension of the phenomenon. In fact, actually most of the contributions on the link between firms' innovation and employment rate provide evidence at national or cross-national level (more precisely on the "Triad": USA, Europe and Japan), while those ones analyzing sub-national economies are still few. The second way, is focusing on a factor to which little attention has been paid in this literature until now, namely institutional quality. In fact, it would be fundamental to assess the role played by institutions, given that today innovation is considered a complex process coming from the interaction between public bodies and private firms (van Waarden, 2001; Coriat and Weinstein, 2002) and that regional government R&D spending itself have proved to be insufficient to stimulate employment growth in the advanced economies (Moutinho et al., 2015). Many cases of Regional Systems of Innovation (Cooke et al., 1997; Doloreux, 2002), joint initiatives between institutions and private companies (Korres and Kokkinou, 2011; Kafouros et al., 2015; Hussen and Çokgezen, 2022), R&D by candidate entrepreneurs (Batabyal and Jick Yoo, 2018) and R&D policy schemes on the innovation activities of firms (Almus and Czarnitzki, 2003) have been documented and studied in order to understand whether they are able to favour economic growth and absolute and relative convergence process among regions, but their impact on employment remains almost entirely unexplored. This manuscript aims at filling these two gaps by providing new evidence on the effect of companies' innovation on the employment rates of the twenty Italian regions taking into account the regional institutional quality. More in particular, this paper tries to provide an answer to the following question: "Is the employment effect of firms' innovation shaped by the local institutional quality? Are good quality regional institutions able to attract, support and cooperate with private innovative companies in such a way to mitigate (magnify) the negative (positive) effects of their activities on employment? Have the investment programs in innovation jointly financed by private firms and regional institutions a positive impact on employment rate?"

Here, the terms *institutions* refers to both formal and informal institutions. More in particular, the first ones include public institutions such as regions, provinces, municipalities, branches of public administration operaring at regional and sub-regional level and judicial authorities (police, courts, magistrature and anti-corruption bodies and so on), while the second ones comprise tertiary sector (non-profit organizations, associations, foundations and so on). Innovation, instead, has been measured through firms' R&D spending, a kind of business innovation activity according to the classification of the latest version of the Oslo Manual.

To accomplish his task, the author carried out a multivariate analysis on the twenty Italian regions: Aosta Valley, Piedmont, Trentino Alto-Adige, Friuli Venezia-Giulia, Lombardy, Veneto, Liguria, Emilia Romagna, Marche, Umbria, Tuscany, Latium, Abruzzo, Molise, Campania, Puglia, Basilicata, Calabria, Sicily and Sardinia. The author has employed as proxy of institutional quality of the Italian regions the Institutional Quality Index (IQI) calculated by Nifo and Vecchione (2014). This is a popular measure among the scholars of regional economics dealing with the Italian regions because it captures different qualitative aspects of the formal and informal institutions listed above. More precisely, it is articulated into five pillars:

1) *Control of corruption*, a summary of the crimes committed against the public administration;
2) *Government effectiveness*, accounting for the endowment of social and economic structures in Italian provinces and the administrative capacity of provincial and regional governments in relation to policies concerning health, waste management and the environment;
3) *Regulatory quality*, comprising the degree of openess of the economy, business environment and the capability of the local institutions to attract and support businesses;
4) *Rule of law*, a summary of data on crime against persons or property, on magistrate productivity, trial times, the degree of tax evasion and the shadow economy;
5) *Voice and Accountability*, including electoral participation, number of associations, number of social cooperatives and proxies of cultural liveliness.

Another good motive for considering this particular measure of institutional quality in this manuscript is that, in a recent contribution of them, D'Ingiullo and Evangelista (2020) have demonstrated that it represents a social filter that can foster the innovation across the Italian provinces. Then, in the Italian case, the IQI seems to be very suitable for the economic researches on the nexus between innovation and institutional quality at local level.

The reason for the choice of the Italian regions as territorial units, instead, is that Italy presents large regional gaps in employment rate, institutional quality and private companies' R&D spending. These differences are due to the economic backwordness of Southern regions compared to the Center-Northern ones. a well-known and widely studied issue (the so-colled *Mezzogiorno Question*) puzzling both economists and policy makers since 1880s. Consequently, it could be interesting to assess whether part of the variability in the employment rate of the Italian regions can be explained by both firms' R&D expenditure and the interaction between local institutions and firms' R&D activity, namely the ability of the institutions to attract, support and cooperate with private innovative firms. If so, increasing the institutional quality of the lagging regions and improving the way in which they interact with the innovative firms could be a good strategy for the Italian policy makers to contrast the technological unemployment and boost the employment rates at local level.

3. Literature review

As hinted in the previous paragraph, literature provides many evidence on the relationship between firms' innovation and employment rate and they are mixed, also because of the the fact that many different measures of innovation exist (Vivarelli, 2014; Calvino and Virgilito, 2016). However, the most common one among them is the firm level R&D capital stock. Of course, scholars pay greatest attention to the employment effect of innovation at cross-national level (Hall and Heffernan, 1985; Brouwer et al., 1993; Antonucci and Pianta, 2002; Mastrostefano and Pianta, 2009; Bogliacino and Pianta, 2010; Lucchese and Pianta, 2012; Bogliacino, 2014; Harrison et al., 2014). Among the contributions at international level, very significant is that one by Aldieri and Vinci (2017), as it considers 879 international corporations located in the so-colled "Triad" (USA, Japan and Europe) between 2002-2010, distinguishing between technological level of firms. The selected sample period allows the authors to capture the reallocation process of the labour factor among high-tech and low-tech industries due to the recession of 2008. They proxy innovation through R&D capital stock of firms. Their results indicate that the own innovation generally has a negative destruction rate, but some relevant differences from the baseline result rises looking at the the external

spillover. In fact, the latter one negatively affected the employment rate before the beginning of the crisis and positively after 2006. These findings are similar to those ones presented in Agovino et al. (2016), who also consider USA, Japan and Europe. Other recent evidences at international level are presented by Matuzeviciute et al. (2017). They look for effect of firms' innovation on employment and unemployment rate using panel data relating to 25 European countries between 2000 and 2012 and triadic patent families per million inhabitants as measure of innovation. They find that firms' innovation has no predictive effect neither on employment rate nor on unemployment rate. Feldmann (2013), instead, studies 21 industrial countries using the same proxy of innovation of Matuzeviciute and his co-authors and discrovers that in the short-run (three years) the introduction of new patents boosts unemployment rate, while, in the long run, any negative effect disappears. In other words, technological unemployment is only a temporary consequence of a transition process. Postel-Vinay (2002) writes down a theoretical model of frictional unemployment that arrives at the opposit conclusions of the Feldmann's estimations, namely that, in the short term, technological change has a positive impact on employment but, in the long term, the equilibrium level of employment goes down because of job obsolescence. Even if all the evidences above are quite different, overall they seems to confirm the schumpeterian theory of creative distruction. Other authors have studied the nexus between innovation and employment at national level, again with heterogeneous results (Vivarelli et al., 1996; Klette and Førre, 1998; Greenhalgh et al., 2001; Piva and Vivarelli, 2005; Lachenmaier and Rottmann, 2011; Coad and Rao, 2011; Mitra and Jha, 2015; Van Reenen, 2015; Ciriaci and Moncada-Paterno-Castello, 2016). Instead, among manuscripts treating the argument under scrutiny at regional level, the manuscripts Capello and Lenzi (2013) and by Aldieri et al. (2019) deserves attention. The first one consists in an empirical contribution on the nexus between process and product innovation and employment growth in the regions of 27 European countries (Nomenclature of Territorial Units for Statistics- NUTS2). Its authors show that the effect of these kinds of innovation on employment depend mainly on the regional structural characteristics, or better on the regions' functional specialization and settlment structure: in the regions having larger presence of production functions, product innovations have an average positive effect, while the effect of process innovation is negative in metropolitan areas. In the third one, instead, the authors are interested to understand how the R&D expenditure (measure of technological innovation) and the knowledge spillover shape the employment rate of the Finnish regions differentiating the effects on the basis of the skill level of the workers. Their outcomes suggest the existence of positive effects of both innovation and spillover for high-skilled employees at local level between 2000 and 2013, while only innovative activities have a significant (and negative) effect for the low-skilled ones in the same sample period. Finally, as concerns the nexus among employment rate, firms' innovation and institutional quality, the only contribution on this argument is that one by Goos et al. (2015), which proves that, over the past decades, high-tech employment have increased across the European regions during the period 2005-2015 mainly thanks to the local job multipliers generated by the high-tech companies, altough many institutional obstacles related to innovation impede a proper convergence process between developed and lagging regions.

4. Employment, institutional quality and firms' R&D: a descriptive analysis

In this section, the author provides a simple descriptive analysis of the employment rate, firms' R&D spending and Institutional Quality Index (IQI) and shows their territorial distribution. The data relating to the IQI come from Nifo and Vecchione (2014), while the data on the other two variables have been collected from the public available database of the Italian Statistical Office (ISTAT)[1]. The summary statistics for these three variables in the year 2018 are reported in Table 2 below:

[1] http://dati.istat.it/

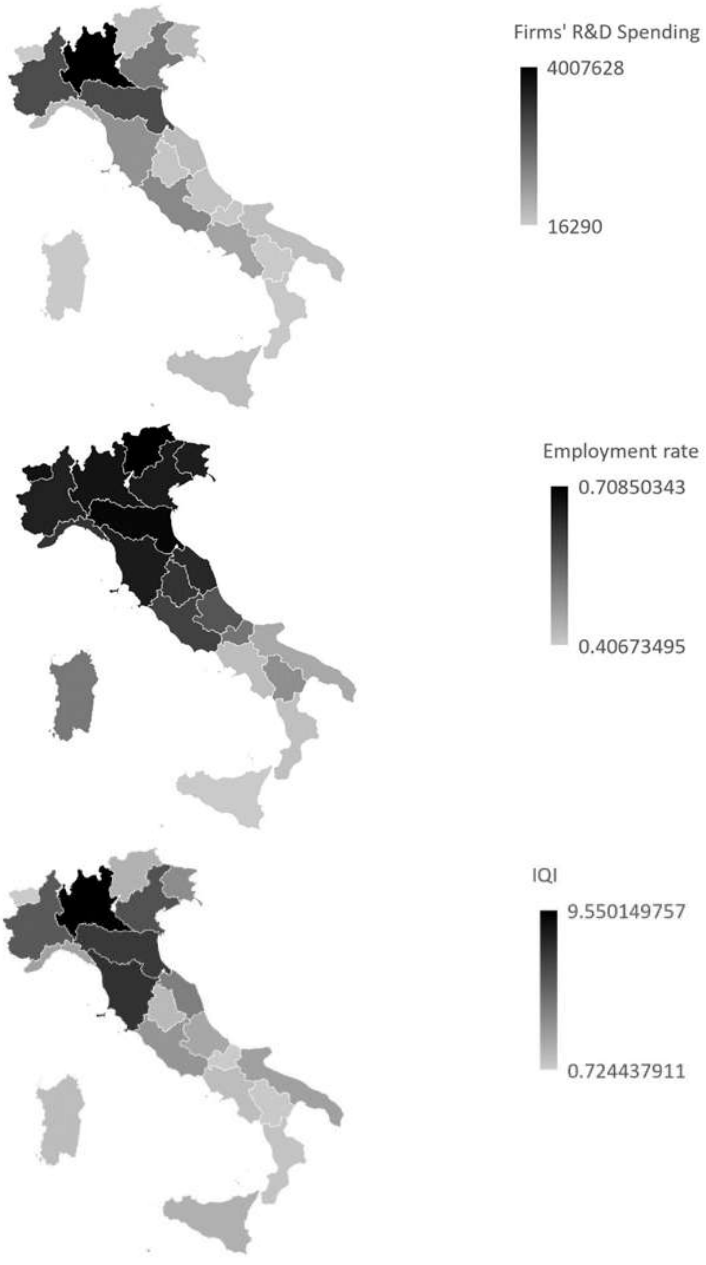
Table 1: Summary statistics for Employment rate, Firms' R&D spending and IQI

Variable	Mean	Median	Standard deviation	Min.	Max.
Employment rate	57.12	62.07	9.891	38.91	70.85
Firms' R&D spending	66200000.00	25860000.00	90760000.00	3181	400800000.00
IQI	3.226	2.378	2.545	0.3621	9.897

Source: author's elaboration

Both the standard deviation and the range (the difference between the maximum and the minimum value) indicate a high variance in the employment rate, IQI and firms' R&D spending. This high variability is due to the gap between the Center-Northern regions and the Southern ones. In fact, as highlighted in the Figure 1 below, in 2018 the Center-Northern regions present higher employment rates and institutional quality than the Southern ones. At the same time, the firms'R&D expenditure is mainly concentrated in few Center-Northern regions, i.e. Lombardy, Piedmont, Emilia Romagna, Veneto and Latium:

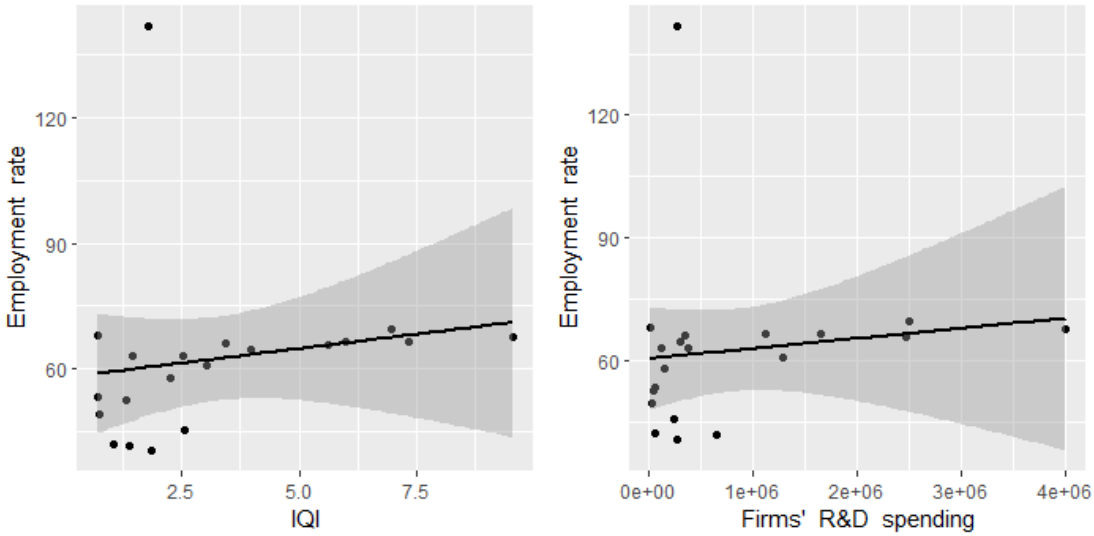
Figure 1: Territorial distribution of Firms' R&D spending, employment rate and IQI



Source: author's elaboration

Finally, the author has plotted both the IQI and the firms' R&D spending towards the employment rate and calculated the Pearson's correlation index between both employment rate and firms'R&D spending and employment rate and IQI in the year 2018 (the last of the considered sample period). The two scatterplot are reported in Figure 2 below:

Figure 2: Territorial distribution of Firms' R&D spending, employment rate and IQI



Source: author's elaboration

As can be noted fromthe graph above, there is a positive and very significant linear correlation between the employment rate and the IQI and between the employment rate and the Firmsì R&D spending. In fact, the correlation indexes between the Employment rate and between the employment rate and the firms' R&D spending are, respectively, equal to 0.55 and 0.43. Then, it is appropriate to carry out a multivariate regression analysis in order to search for the existence of the relating causal relationships.

5. Research methods

In order to assess the impact on the employment rate of the firms' R&D spending, institutional quality and their interaction, the author, following Lachenmaier and Rottmann (2011), has written down the two dynamic panel models below:

$$n_{i,t} = \sum_{i=1}^{2} \beta_i n_{i,t-i} + \sum_{i=3}^{5} \beta_i s_{i,t-i+3} + \beta_6 IQI_{i,t} + \beta_7 (IQI_{i,t} * s_{i,t}) + \gamma X' + \eta_i + \varepsilon_{i,t} \quad (1)$$

and:

$$n_{i,t} = \sum_{i=1}^{2} \beta_i n_{i,t-i} + \sum_{i=3}^{5} \beta_i s_{i,t-i+3} + \beta_6 IQI_{i,t} + \beta_7 (IQI_{i,t} * s_{i,t} * U_{i,t}) + \gamma X' + \eta_i + \varepsilon_{i,t} \quad (2)$$

where:

$n_{i,t}$ is the employment rate of people aged 15-64;

$s_{i,t}$ is the firms' R&D spending;

$IQI_{i,t}$ is the institutional quality index;

$U_{i,t}$ is the regional governments spending;

X is a vector of additional control variables containing GDP per capita, forms' gross fixed investment, labour income; resident population; value added per employee, regional governments tax revenue and human capital (for a complete description of the controls see the Appendix);

η_i is an unobserved region-specific time-invariant effect that can be correlated with the independet variable;

$\varepsilon_{i,t} \sim iid(0, \sigma_\varepsilon^2)$ is an error term;

γ and β_i are sets of parameters to be estimated;

i and t indicate, respectively, the i-th territorial unit (Italian region) and the t-th time unit.

The two coefficients β_1 and β_2 capture the dynamic adjustment of the employment rate over time, while β_3, β_4 and β_5 account for the effect of contemporaneous and delayed effects of the firms' R&D spending on the current employment rate. All these lagged variables reflect the short-run dynamics due to adjustment costs (i.e. the costs borne by firms to change their level of output), expectations formation and decision process of firms. For example, when firms face high hiring and firing costs (just as in the Italian case), the actual employment will deviate from the equilibrium level and so a dynamic estimation equation is better than a static one.

Indeed, specifications like the two ones above are very common in manuscripts dealing with the topic under scrutiny and employing panel data. The novelty here compared to the previous contributions are two. The first one is the coefficient β_6 that estimates the impact of the regional institutional quality on the employment rate. The second one, instead, is given by the interaction term and the double interaction term present, respectively, in the equation (1) and in the equation (2). More in particular, the interaction term in the equation (1) represents the effect on the actual employment rate of the ability of the regional institutions of attracting, supporting and cooperating with the private innovative firms, while the double interaction term in the equation (2) indicates the effect on the current employment rate of the R&D programs jointly financed by the innovative companies and the regional governments, taking into account the administrative quality of the latter ones.

Estimating the equation (1) and the equation (2) poses two significant endogeneity problems. The first one comes from the correlation between the lagged values of the dependent variables (employment rate) and the the cross-section specific effect. The second one, is due to the fact that, probably, firms choose their labour stock and R&D investment at the same time and then the simultaneous causality issue arises. Consequently the Ordinary Least Squares (OLS) estimator is biased and inconsistent. Currenlty, two alternatve estimators are used in this literature to compute models like those ones considered by the author: the GMM-difference proposed by Holtz-Eakin et al. (1988) and Arellano and Bond (1998) that, as suggested by its name, employs first-differenced variables, and the GMM system (GMM-SYS) developed by Blundell and Bond (1998), that can be run either on first-differenced or in level variables. More in particular, the GMM-difference uses all (or most of the) level values of the dependent variables as instruments for the relating lagged variables, while the instrument matrix of the GMM-SYS includes first-differences. Using the GMM-SYS instead of the GMM-difference is highly recommended with short sample period and high persistence of variables over time. In fact, Blundell and Bond (1998) have demonstrated that the GMM-difference estimated coefficients are biased downwards, namely in the same direction of the within group estimator. Here, the author has estimated his two dynamic panel models through an OLS regression with heteroskedasticity and autocorrelation consistent standard errors (HAC), a Fixed effects linar regression with time dummies (a method able to account for all those factors varying over time and constant among units and vice versa) and a GMM-SYS on the variables in level with time dummies. In this context, the time dummies capture the macroeconomic and financial shocks common to all the Italian regions and the economic policy decisions taken from the central Italian government and the European institutions during the considered sample period.

The author preferred the GMM-SYS to the GMM-difference just because both the employment rate and the firms' R&D spending exhibit high serial correlation and his sample period is quite short, as consists of only 6 years (2012-2018). Finally, the author has carried out a Ramsey RESET test on his OLS regression to assess the suitability of the linear specification of his two models and a Sargan test on his GMM-SYS in order to assess the exogeneity of the instruments.

The data on the IQI, as previously hinted, come from Nifo and Vecchione (2014), while the data relating to all the other variables entering the model have been collected from the

public available database of the Italian statistical office (ISTAT)[2]. The author's panel dataset comprises six years only because the ISTAT database includes statistics on the firms' R&D innovation only in the period 2012-2018.

6. Estimation output with a techinical comment

The estimation outcomes of the equation (1) obtained through the three estimators indicated in the previous section (OLS, Fixed effects regression and GMM-SYS) are reported in Table 4 below. All the variables entering the two theoretical model (except the employment rate and the IQI) are in natural logarithm (lin-log):

Table 4: Estimation output of the equation (1)

Control variables	OLS	FE regression	GMM-SYS
$Const$	-	-750.853*** (239.132)	-
$Employment\ rate_{i,t-1}$	0.708494*** (0.129326)	0.116275 (0.0746085)	0.679152 (0.116342)
$Employment\ rate_{i,t-2}$	0.178771 (0.127251)	-0.398698* (0.203407)	0.0509181 (0.0863360)
ln $(GDP\ per\ capita_{i,t})$	-2.21694 (2.16468)	7.32403 (7.51497)	-1.02606 (2.77682)
ln $(Firms'fixed\ investment_{i,t})$	0.663887 (1.44305)	-6.35619*** (2.03463)	-0.706123 (0.885241)
ln $(Labour\ income_{i,t})$	4.76742 (5.43914)	16.3182 (10.5569)	4.09051 (4.93626)
ln $(Human\ capital_{i,t})$	2.20619*** (0.762165)	6.40979*** (2.03750)	3.33608*** (1.17811)
ln $(Reg.gov.spending_{i,t})$	-0.579167 (1.07003)	5.54531 (3.82124)	-0.433485 (1.04359)
ln $(Reg.tax\ revenue_{i,t})$	-0.188970 (0.242083)	0.487948 (4.19932)	-0.217613 (0.216701)
$IQI_{i,t}$	0.00659705 (0.0996435)	-1.81107** (0.701557)	0.00314823 (0.0924068)
ln $(IQI_{i,t}$ $* Firms'R\&D\ spending_{i,t})$	0.708494*** (0.129326)	1.61187 (1.87359)	1.57221** (0.717833)
ln $(Res.pop._{i,t})$	-3.55360 (2.56153)	26.6747 (15.5014)	-6.62479* (3.49254)
ln $(Value\ added_{i,t})$	0.970327 (1.10018)	9.32778** (4.29196)	3.60267** (1.72367)
ln $(Firms'R\&D\ spending_{i,t})$	-0.957997* (0.463278)	-1.30640 (2.23337)	-1.81977** (0.861726)
ln $(Firms'R\&D\ spending_{i,t-1})$	-0.351041 (0.692994)	0.138699 (0.524387)	-0.0774210 (0.372706)
ln $(Firms'R\&D\ spending_{i,t-2})$	0.218288 (0.660917)	0.269937 (0.662955)	0.0405291 (0.328436)
Adjusted R-squared:	0.995119	-	-
Ramsey RESET test:	0.083978 [0.92]	-	-

[2] http://dati.istat.it/

Control variables	OLS	FE regression	GMM-SYS
Sargan test	-	-	17.198 [0.2093]
Time dummies	YES	YES	YES

Robust standard errors (HC3) in round brackets.
p-values associated to the statistical test in squared brackets.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: author's elaboration

Here, some technical considerations can be useful. First of all, it is important to note that the two estimated coefficients associated to the lagged employment rate change greatly among the three considered estimators, both in dimension and standard errors. For example, the estimated coefficient relating to the one-year lagged employment rate is very significant in the OLS regression, while it becomes not statistically different from zero in the FE regression and in the GMM-SYS. This is due to the endogeneity problems previously discussed, namely reverse causality and correlation of the lagged dependent variables with the unobserved region-specific time-invariant factors. Also the other estimated coefficients vary a lot among the three estimators, because of the other endogeneity problems affecting panel data.

Consequently, only the GMM-SYS estimates can be considered reliable, as the other two estimators are unable to rule out the endogeneity issues proper of the dynamic panel models.

As concerns the regression diagnostic, the adjusted R-squared and the Ramsey RESET test sugges that, respectively, the variables included into the equation (1) explain almost all the variability in the employment rate and that a linear specification fits better the data than a polynomial one with squares and cubes. Further, the Sargan test indicates that the instruments exploited by the GMM-SYS satisfy the exogeneity property.

The estimation results relating to the equation (2) have been put in the following Table 5:

Table 5: Estimation output of the equation (2)

Control variables	OLS	FE regression	GMM-SYS
$Constant$	-	-750,853*** (239,132)	-
$Employment\ rate_{i,t-1}$	0,708494*** (0,129326)	0,116275 (0,0746085)	0,679152*** (0,116342)
$Employment\ rate_{i,t-2}$	0,178771 (0,127251)	-0,398698* (0,203407)	0,0509153 (0,0863364)
ln $(GDP\ per\ capita_{i,t})$	-2,21694 (2,16468)	7,32403 (7,51497)	-1,02610 (2,77683)
ln $(Fixed\ investment_{i,t})$	0,663887 (1,44305)	-6,35619*** (2,03463)	-0,706109 (0,885245)
ln $(Labour\ income_{i,t})$	4,76742 (5,43914)	16,3182 (10,5569)	4,09022 (4,93628)
ln $(Human\ capital_{i,t})$	2,20619*** (0,762165)	6,40979*** (2,03750)	3,33613*** (1,17812)
ln $(Reg.gov.spending_{i,t})$	-1,46984 (1,29181)	3,93344 (5,00885)	-2,00565 (1,25104)
ln $(Reg.tax\ revenue_{i,t})$	-0,188970 (0,242083)	0,487948 (4,19932)	-0,217600 (0,216702)
$IQI_{i,t}$	0,00659705 (0,0996435)	-1,81107 (0,701557)	0,00315114 (0,0924073)

Control variables	OLS	FE regression	GMM-SYS
ln ($IQI_{i,t}$ $* Firms' R\&D\ spending_{i,t}$ $* Reg.gov.spending_{i,t}$)	0,890674** (0,296423)	1,61187 (1,87359)	1,57224*** (0,717836)
ln ($Res.pop._{i,t}$)	-3,55360 (2,56153)	26,6747 (15,5014)	-6,62508* (3,49255)
ln ($Value\ added_{i,t}$)	0,970327 (1,10018)	9,32778** (4,29196)	3,60278** (1,72368)
ln ($Firms' R\&D\ spending_{i,t}$)	-0,957997* (0,463278)	-1,30640 (2,23337)	-1,81980** 0,861730
ln ($Firms' R\&D\ spending_{i,t-1}$)	-0,351041 (0,692994)	0,138699 (0,524387)	-0,0774201 (0,372708)
ln ($Firms' R\&D\ spending_{i,t-2}$)	0,218288 (0,660917)	0,269937 (0,662955)	0,0405357 (0,328438)
Adjusted R-squared:	0,995119	-	-
Ramsey RESET test:	0,083978 [0,919561]	-	-
Sargan test	-	-	17,1978 [0,2458]
Time dummies	YES	YES	YES

Robust standard errors (HC3) in round brackets.
p-values associated to the statistical test in squared brackets.
$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$
Source: author's elaboration

Here, technical comments very similar to those ones above could be made. The author skips them to avoid lengthening this section unnecessarily. The estimated coefficients and the standard errors in the two estimated equations are very near each other. In other words the author's dynamic panel models are robust: changing the interaction term does not imply relevant variations in the estimation output.

7. Economic discussion of the econometric results

Based on the technical comments of the previous Section, the economic interpretation of the author's results has to be carried out taking into account the estimated coefficients of the GMM-SYS, while those ones of the OLS and FE regression can be neglected. The estimated coefficients associated to the lagged values of the employment rate indicate that the year-on-year firms' adjustment costs, expectations formation and decision processes affect the actual employment rate, while the two-year dynamics plays no role. The estimated coefficients relating to the current and lagged values of the firms' R&D spending, instead, point out that the actual companies' innovation activity reduces the current employment rate (an increase in the firms' R&D expenditure causes an average decrease of the employment rate of 0.189%), whil there are not delayed effects of innovation spending. This result is in line with that stream of literature claiming a negative impact of innovation on employment rate discused in Section 3, but, unfortunately, the lack of contributions focusing on the economic consequences of R&D expenditure on the employment rate of the Italian regions makes it impossible to operate an appropriate comparison with similar evidence and better contextualize this outcome. However, from the microeconomic point of view, it can be deduced that the firms' labour stock is a production factor substitutable with R&D capital. In other words, the marginal rate of substitution between R&D capital and labour force of the firms operating at regional level in Italy is negative. The estimation of the equation 1 seems to suggest that also the marginal rate of substitution between physical capital and labour stock is negative.

It is interesting to note that the institutional quality itself has no predictive power, as this evidence is in contrast with the previous literature on the roots of the *Mezzogiorno Question*

according to which the labour market participation in the Italian regions is shaped by this variable (Agovino, 2019).

The interaction term between the firms' R&D spending and the institutional quality and the interaction term among the firms' R&D spending, the institutional quality and the regional governments' expenditure are highly significant and positive: an increase in this variable implies an average increase in the employment rate equal to 0.157%. This result represents the novelty of this manuscript and it means that the ability of the regional institutions to attact, support and cooperate with innovative firms as well as the R&D investment programs jointly financed by regional governments and private companies give a positive contribution to the local employment rates. Put differently, the involvment of the regional institutions in the firms' R&D activity can make positive the negative firms' innovation impact on employment and help the lagging Italian regions to contrast the phenomenon of long-run low employment puzzling them. The relating policy implication is that implementing forms of cooperation in innovation between private innovative firms and regional governments can be a good strategy for the Italian policy makers to boost the regional employment rates.

The positive and highly significant value associated to the human capital can appear intuitive, but it is not in the case of the Italian regions. In fact, Di Liberto (2008) and Odoardi and Muratore (2019) find out that the Italian regions do not benefit from the accumulation of human capital due to the difficulties to employee the high-skilled workers at territorial level.

8. Concluding remarks

In this manuscript, the author has studied the employment impact of firms'innovation in the Italian regions taking into account an element neglected in the previous literature on this topic, namely the institutional quality. More in particular, he has estimated the impact of firms' R&D spending, institutional quality and their interaction on the actual employment rate. The research method used by the author, namely a multivariate regression analysis on panel data, complies with the literature on the subject under scrutiny and seems to be able to address the endogeneity concerns posed by the estimation of dynamic panel models.

The obtained results prove that the firms' R&D spending has a negative impact on the regional employment, but it becomes positive when the innovative companies interact with the regional institutions. In other words, the ability of the regional institutions to attract, support and cooperate with the firms investing in research and development fosters the local employment rates. The policy implication arising from this evidence is that the regional governments can overcome the issue of technological unemployment and foster the employment growth in their territories by undertaking R&D activities with the innovative private companies.

A natural cue for future research on the topic treated in this paper can be identifying the transmission mechanism of institutional quality to employment rate, namely what are the components of the institutional quality (of the IQI, in the author's case) affecting the regional employment rates. Another possible development could be considering alternative types of firms' innovation listed in the Oslo 2018 manual, such as process and product innovation.

Altough it focuses on the regions of a single country (Italy), the author hopes that his manuscript can rise the interest also of non-Italian scholars, as technological unemployment is expected to become increasingly worrying over time and good solutions for this problem have not been proposed yet.

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Appendix

Table 2: Description of the variables[3]

Variable name	Source	Description
Employment rate	ISTAT	Employment rate of people aged 15 to 64.
GDP per capita	ISTAT	Nominal GDP per capita.
Gross fixed investments	ISTAT	Gross fixed capital formation. It accounts for firms' investments.
Resident population	ISTAT	Number of residents of the region on 01/01/2018. It accounts for demographic factors.
Human capital	ISTAT	Percentage of inhabitants with higher education (degree or more). It is a measure of human capital.
Labour income	ISTAT	Nominal compensation per employee. Wage is used as control also by Lachenmaier and Rottmann (2011).
Regional government spending	Conti Pubblici Territoriali	Nominal tax expenditure of the regions.
Regional tax revenue	Conti Pubblici Territoriali	Nominal tax revenues of the regions, including fiscal transfers from the central government.
Value added per employee	ISTAT	Nominal value added of firms per employee. This variable often is used as a control for labour productivity[4] (Boglianico and Pianta, 2010).
IQI	Nifo and Vecchione (2014).	Composite index of regional institutional quality.

Source: ISTAT and Conti Pubblici Territoriali

[3] Here, all the variables are taken at current prices because there are no available data on the Consumer Price Index (CPI) or GDP implicit deflator allowing to turn the data in real terms

[4] https://www.oecd-ilibrary.org/sites/5f7b09d6-en/index.html?itemId=/content/component/5f7b09d6-en