INNOVATION, EMPLOYMENT AND PUBLIC DEBT ACROSS EUROPEAN COUNTRIES

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Abstract. This paper here analyzes, across European countries, the relationship between labour and technological innovation determinants also considering the interaction with the structural indicator of the public debt. The main findings are: the fruitful effect of education public expenditure and R&D spending on employment rate, whereas an increase of general government consolidated gross debt has a negative effect for employment rate as well as for technology proxies. Empirical evidence provides some elements to discuss main economic policy implications from relationships between observed facts.

Keywords: Employment, R&D, Technological Innovation, Education, Public Debt, European Growth.

JEL classification: J01; J08; I20; H63; O30; O33

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Biographical Note

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Contents

Introduction

The aim of this paper is to answer to the following question:

- How do R&D intensity and spending on human resources affect the employment of countries, also considering the critical macroeconomic indicator of the public debt?

In order to understand, within current economic systems, the impact of driving technological forces on employment, it is important to analyze how technological determinants and employment variables interact with public debt. In fact, the macroeconomic variable of the public debt of countries affects, within the framework of the political economy of growth, the government spending in R&D and for human resources that plays a vital role to spur employment growth.

Economic literature is abundant of studies that analyze the role of technology, employment and economic growth (*cf.* Addison and Teixeira, 2001; Corley *et al.*, 2002; Michie *et al.*, 2002; Antonucci and Pianta, 2002; Mastrostefano and Pianta, 2009; Bogliacino and Pianta, 2010). In particular, as technological progress is a main determinant of economic growth and technical knowledge is the engine of technological innovations, modern economic growth

theory is focused on endogenous growth approach that considers the accumulation of physical and human capital (Lucas, 1988; Caballé and Santos, 1993) and R&D-based models (Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1992). The critical role of R&D and spending in human resource for employment is consistent with the recent empirical literature which emphasizes the fruitful effect of some innovations for employment growth of firms, industries and countries (Pini, 2005; Goel *et al.,* 2007*;* Grossman, 2007). Several works have provided many valuable insights into the theory of technological innovation, although, how public debt of countries can affect national spending in R&D and in human resources for supporting employment growth has not been accurately explored by economists of technical change. The study here investigates this main economic issue in order to contribute to the debate on the relationship between innovation and employment, considering the interaction with the public debt. In fact, sovereign debt plays a critical role for economic stability and steady-state pattern of economic growth of countries; in addition, the high/low level of public debt can make available economic and financial resources to design apt political economy of growth (Amaral and Jacobson, 2011). For this reason modern economic literature considers, more and more, the effects of public debt and balanced-budget rules into the political economy of countries because they can affect long-run patterns of employment and economic growth (Schmitt-Grohé and Uribe, 1997, Stockman, 2001; Sargent, 2012). The findings of this research can provide main results to understand the critical interaction of key variables for economic growth and to support best-practices on innovation and education in order to minimize the unemployment over period of turbulence of business cycles. The paper is laid out as follows: section 2 describes the theoretical framework of the study, section 3 presents data source and method of research, section 4 shows the main results of empirical analysis and section 5 discusses the empirical evidence and concludes.

Related works

Europe has been experiencing high level of unemployment since 1990s (Michie *et al.* 2002, p. 253ff; Addison and Teixeira, 2001, p. 191, Sapir *et al.*, 2004)[1]. This issue of low employment has been increasing with the fiscal rules of the Maastricht treatise, the background for Euro currency, since several member-countries have been designing economic policies that focus on austerity packages and balanced-budget rules to support their stability, creating friction effects for economic growth into the Eurozone. The relationship between innovation and employment of countries has been widely investigated by economic models coupled with empirical evidence, and in the economic literature is accepted that technical knowledge and investments in R&D play a vital role for employment growth (*e.g.* Bogliacino and Pianta, 2010). A first problem to deal with is the difficulty of measuring the innovation with accuracy; scholars mainly use R&D expenditure, patents, spending for human resources, etc., to analyze the directions of technological change and assess the impact on economic variables such as employment, productivity, GDP per capita, and so on (Autant-Bernard *et al.*, 2010). According to Acemoglu (2002, p. 7): "technical change favors more skilled workers, replaces tasks previously performed by the unskilled, and exacerbates inequality". In fact, technological choices by countries can affect wage inequality because of different incentives created by labor-market institutions (Acemoglu, 2002, p. 14). In addition, "skill-bias technological change" can generate friction effects on TFP due to imbalance composition of R&D (Acemoglu, 2002, p. 12). Addison and Teixeira (2001, p. 191) analyze the role of the technology as a factor that has been rising unskilled worker unemployment and consider as long-run solution the improvements of educational system. In particular, the increase of educated workers in employment is a main determinant of "relative demand shifts in their favor" (Addison and Teixeira, 2001, p. 192). In fact, "technological proxies such as R&D expenditures …

[1] Cf. the special issue of *International review of applied economics*, vol.16, n. 2, 2003.

have been found to have a positive and statistically significant effects on the employment … of non-production/skilled workers in country and cross-country studies alike" (Addison and Teixeira, 2001, p. 214). In addition, it is important to also note that the effects of innovation on employment change according to technological pathways of industries and countries that can affect the structure of employment. Mostrostefano and Pianta (2009, p. 729ff.), analyzing the relationship innovation-employment, show that the product innovations, driven by R&D, foster employment at firm level when is associated to a sustainable demand, while process innovations tend to reduce employment and productivity growth because of the substitution of labour with capital (cf. also Bogliacino and Pianta, 2010, p. 805). Negative effects of innovation process on employment have been also stressed by Pini (1995, pp.208-209) into its model.

As far as industries are concerned, in this case a main role is played by structural change of the economic system, and low employment growth and/or reduction is associated to low demand, low product innovations and introduction of "labour saving process innovation" (Mastrostefano and Pianta, 2009, p. 729). Mastrostefano and Pianta (2009, p. 737) show that high-tech industries are mainly dominated by product innovations with fruitful effects for employment, whereas low-technological industries have a negative impact of innovation on employment because of the prevalence of process innovations. Corley *et al.* (2002, p. 265ff) claim that to spur employment in high-tech sector it is required an investment in R&D, physical and human capital. These main results support the analysis by Antonucci and Pianta (2002, p. 306) that argue how the high level of European unemployment in comparison with US economic system is due to manufacturing sector based on industries with low product innovations and more process innovations. In fact, this specificity of European industrial structure, also affected by economic turbulence and low demand growth, can have continuous negative effects for patterns of employment and economic growth. Pini (1995, p. 208) finds

that within European countries the innovation process (as input) has a main effects on employment, whereas as output has not a "compensation effects through growth in exports".

Funke and Strulik (2000) present a model with different theories of growth (neoclassical, endogenous growth by physical capital and human capital accumulation and R&D-based growth model). They show the main role of education and training because "perpetual growth of ideas . . . requires the accumulation of knowledge" (Funke and Strulik, 2000, p. 512) as well as the knowledge positive spillover plays a main role to support long-run technological progress. Instead, Bogliacino and Pianta (2010, p. 805) investigate how technological change affects in different ways employment across industries, analyzing a revised Pavitt taxonomy. They describe the best performer industries: *a)* science based industries, based on product innovations and low significant effect of process innovation, and *b)* specialized supplier industries where the employment is affected by low positive effect of product innovation and a high negative impact of new labour saving processes.

In addition, their empirical evidence shows a declining employment in scale and information intensive sectors and supplier dominated industries mainly because of innovation process and a "strategy of cost competitiveness". Hence, the vital role of innovations for employment growth is widely displayed within the economic literature, which shows as different innovations have different impacts on industries, as well as different types of research spending can generate different effects on economic growth and labour force (cf. David *et al.*, 2000). Other scholars, such as Goel *et al.* (2008, p. 247) claim that R&D spending has higher social returns with fruitful effects on employment and show the higher association between economic growth and federal R&D, rather than non-federal R&D. Instead, Grossman (2007, p. 893) suggests that public R&D spending should be targeted to the supply of education and skills to promote R&D-based growth. In particular, this strategy plays a critical role for innovations and performances of firms (productivity growth) and does not affect income distribution

(Grossman, 2007, p. 905). It is also important to note that: "the optimal structure of public education spending . . . depends on the relative effectiveness of the education sector across fields and its interaction with technological characteristics of firms' R&D and production activity" (Grossman, 2007, p. 905).

These and other studies confirm that the relationship between employment and innovation has attracted much scholarly attention and it deserves new investigations, in period of economic turbulence that increases unemployment level, also considering other critical structural indicators, such as the public debt that can affect a comprehensive political economy aimed to support employment growth.

In fact, Ogawa (2007, p. 404), focusing on Japanese manufacturing sector, analyses how outstanding debts affect R&D investment and technological progress of firms. Results show as the ratio debts to total assets has a significant and negative impact on R&D investment and opportunity of growth. As the impact of technological indicators changes according to firms and industries, the study here focuses on national data of European countries, considering how a main structural indicator, the public debt, interacts with R&D expenditures and spending for human resources and, as consequence, employment growth. In fact, the role of the public debt is important because it affects the capacity of spending in research and education that are main determinants of employment growth. This analysis can provide main results that should be assessed in association with austerity packages and balanced-budget rules of countries in order to avoid aggregate instability and chaotic equilibria of economic systems with negative repercussions on employment and pattern of economic growth (*cf.* Schmitt-Grohé and Uribe, 1997, Stockman, 2010).

Research method

The purpose of this paper is to investigate, at aggregate level across European countries, the

relationship between employment and innovation, also considering the impact of the public debt. The study is based on 27 European countries that represent a homogenous sample over the 1995-2009 period.

Models consider the following assumption and hypotheses.

Assumption: A balanced national system of innovation (in broad terms) [2] and economic system (with low public debt) support the national employment growth.

Two critical hypotheses (Hp) are:

Hp 1: *Spending in education and research has a fruitful effect for employment of countries.*

Hp 2: *Public debt reduction improves the level of employment of the economic system.*

The empirical methodology has the aim to see whether statistical evidence supports these hypotheses, in order to understand the interlinked economic and technological processes that support employment growth of countries. In particular, the research strategy analyzes the relationship between employment, innovation and their interaction with public debt. As far as employment and public debt are concerned, there are univocal metrics (see table 1), whereas the accurate measurement of the innovation variable is a difficult task. In economics, to analyze the technological innovations and assess their impact on economic variables, the following metrics are used: R&D expenditures, R&D intensity (R&D/GDP), patents, total public expenditure on education, etc. This research applies the following main technological prox-

[2] The national system of innovation (NSI) refers to the complex network of agents, policies, and institutions supporting the process of technical advance in an economy (Lundvall, 1992). The narrow definition of NSI would include the subsystem research sector represented by universities, research laboratories, while the broad NSI includes many subsystems such as finance, firms, government, and so on. The efficiency of this broad NSI supports economic growth patterns.

ies: R&D expenditures as percentage of GDP and public expenditure on education (*cf.* Addison and Teixeira, 2001). Strulik (2005, p. 131), following Jones within the semi-endogenous growth model, considers the economic growth associated to the growth rate of effort in R&D, supporting the interpretation that people became skillful scientists by education and that few skilled scientists produce more knowledge than non-skilled ones. The technological proxies of technological innovation, employment and public debt variables are described in table 1.

Table 1 – Variables

Variables /Period	**Short Description**
Employment rate *2000-2009* EMP2000-2009	The employment rate is calculated by dividing the number of persons aged 15 to 64 in employment by the total population of the same age group. The indicator is based on the EU Labour Force Survey. The survey covers the entire population living in private households and excludes those in collective households such as boarding houses, halls of residence and hospitals. Employed population consists of those persons who during the reference week did any work for pay or profit for at least one hour, or were not working but had jobs from which they were temporarily absent.
Gross domestic expenditure on R&D (GERD) - *Percentage of GDP* *1995-2004* GERD1995-2004	The indicator provided is GERD (Gross domestic expenditure on R&D) as a percentage of GDP. "Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to devise new applications" (Frascati Manual, 2002 edition, § 63). R&D is an activity where there are significant transfers of resources between units, organizations and sectors and it is important to trace the flow of R&D funds.
Spending on Human Resources *Total public expenditure on education as a percentage of GDP* *1995-2004* SPENDING HR 1995-2004	Generally the public sector funds the education either by bearing directly the current and capital expenses of educational institutions (direct expenditure for educational institutions) or by supporting students and their families with scholarships and public loans as well as by transferring public subsidies for educational activities to private firms or non-profit organizations (transfers to private households and firms). Both types of transaction together are reported as total public expenditure on education.
General government consolidated gross debt as a percentage of GDP *1997-2006* DEBT1997-2006	EU definition: the general government sector comprises the subsectors of central government, state government, local government and social security funds. GDP used as a denominator is the gross domestic product at current market prices. Debt is valued at nominal (face) value, and foreign currency debt is converted into national currency using end-year market exchange rates (though special rules apply to contracts). The national data for the general government sector are consolidated between the sub-sectors. Basic data are expressed in national currency, converted into euro using end-year exchange rates for the euro provided by the European Central Bank.

Source: Eurostat (2012)

Original data have been subjected to a process of horizontal and vertical cleaning, eliminating outliers. The normal distribution of variables is checked by Curtosi and Skewness coefficients, as well as by the normal Q-Q plot to ensure the correct estimates of parameters.

First of all, the data have been analyzed by bivariate correlations and partial correlation controlling the variable public debt. After that, the econometric modeling has been applied considering the following two model setting.

1.1 Econometric modeling without interaction

The functional relationship is:

Employment $_{i,\,t}$ = *f* (R&D intensity, Expenditure in Education, General government consolidated gross debt) $_{i,\,t-n}$

The specification is based on a multiple regression model with three explanatory variables:

$$EMP_{\,i,(2000\text{-}2009)} = \lambda_0 + \lambda_1 Spending\ HR_{i,(1995\text{-}2004)} + \lambda_2 GERD_{i,(1995\text{-}2004)} + \lambda_3 DEBT_{i,(1997\text{–}2006)} + u_{i,t} \qquad [1]$$

where the *i* subscript indicates the country and *t* the time

$u_{i,t}$ = error term

This is an apt model to analyze the effects of two critical technological variables and one main economic structural indicator on employment growth. This equation is estimated by ordinary last squares method, stepwise method (Criteria: Probability-of-*F*-to-enter ≤ 0.050, Probability-of-*F*-to-remove ≥ 0.100), applying the statistics software SPSS (Statistical Package for the Social Sciences).

1.2 Econometric modeling with interaction

The second modeling considers the interaction terms, in particular,

INTER 1= DEBT × SPENDING IN HR

INTER 2= DEBT × GERD

INTER 3= GERD × SPENDING IN HR

The specification of the econometric modeling is:

$$EMP_{i,(2000\text{-}2009)} = \lambda_0 + \lambda_1 Spending\ HR_{i,(1995\text{-}2004)} + \lambda_2 GERD_{i,(1995\text{-}2004)} + \lambda_3 DEBT_{i,(1997\text{-}2006)} + \\ + \lambda_4 INTER1 + \lambda_5 INTER2 + \lambda_6 INTER3 + \varepsilon_{i,t} \quad [2]$$

where the *i* subscript indicates the country and *t* the time.

$\varepsilon_{i,t}$= error term.

This equation of multiple regression is also estimated by ordinary last squares method, step-wise method (Criteria: Probability-of-*F*-to-enter ≤ 0.050, Probability-of-*F*-to-remove ≥0.100).

Empirical results

First of all, the descriptive and correlation analyses are presented (tab. 2-3-4).

Table 2. Descriptive Statistics

Variables	Mean	Std. Deviation	Skewness	Kurtosis
EMP 2000-2009	64.77	6.80	0.002	-0.537
GERD 1995-2004	1.317	0.85	0.956	0.379
SPENDING HR 1995-2004	5.30	1.13	0.717	0.606
DEBT 1997-2006	48.68	23.26	0.489	0.617
INTER 1: DEBT × SPENDING IN HR	258.20	131.04	0.268	–0.471
INTER 2: DEBT × GERD	68.24	53.80	0.749	–0.317
INTER 3: GERD × SPENDING IN HR	7.47	6.07	1.425	1.639

Table 3. Bivariate correlations

		EMP (2000-2009)	GERD (1995-2004)	SPENDING HR (1995-2004)	DEBT (1997-2006)
EMP (2000-2009)	Pearson Correlation	1	.590**	.616**	-.103
	Sig. (2-tailed)		.000	.000	.125
	N		225	225	225
GERD (1995-2004)	Pearson Correlation		1	.509**	.209**
	Sig. (2-tailed)			.000	.002
	N			225	225
SPENDING HR (1995-2004)	Pearson Correlation			1	.006
	Sig. (2-tailed)				.933
	N				225
DEBT (1997-2006)	Pearson Correlation				1

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4. Partial correlations

Control Variables			EMP (2000-2009)	GERD (1995-2004)	SPENDING HR (1995-2004)
DEBT (1997-2006)	EMP (2000-2009)	Correlation	1	.628	.620
		Significance (2-tailed)		.000	.000
		df		222	222
	GERD (1995-2004)	Correlation		1	.519
		Significance (2-tailed)			.000
		df			222
	SPENDING HR (1995-2004)	Correlation			1

Results of econometric modeling [1], without interaction terms, are in tables 5-8.

Table 5. Models [a] and variables entered

Model	Variables Entered	Method
1	SPENDING HR 1995-2004	Stepwise (Criteria: Probability-of-F-to-enter ≤ 0.050, Probability-of-F-to-remove ≥ 0.100).
2	GERD1995-2004	Stepwise (Criteria: Probability-of-F-to-enter ≤ 0.050, Probability-of-F-to-remove ≥ 0.100).
3	DEBT 1997-2006	Stepwise (Criteria: Probability-of-F-to-enter ≤ 0.050, Probability-of-F-to-remove ≥ 0.100).

a) Dependent Variable: EMP 2000-2009;

Table 6. Coefficients of model[a] [1]

Model		Unstandardized Coefficients			
		B	Std. Error	t	Sig.
1	(Constant)	45.175	1.714	26.353	.000
	SPENDING HR 1995-2004	3.697	.316	11.689	.000
2	(Constant)	47.280	1.601	29.535	.000
	SPENDING HR 1995-2004	2.559	.336	7.609	.000
	GERD 1995-2004	2.979	.448	6.643	.000
3	(Constant)	50.308	1.721	29.227	.000
	SPENDING HR1995-2004	2.401	.328	7.328	.000
	GERD1995-2004	3.410	.447	7.632	.000
	DEBT 1997-2006	-.057	.014	-4.029	.000

a. Dependent Variable: EMP 2000-2009

Table 7. Model Summary[d] of model [1]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.616[a]	0.380	0.377	5.369
2	0.695[b]	0.483	0.478	4.915
3	0.720[c]	0.518	0.512	4.755

a. Predictors: (Constant), SPENDING HR 1995-2004

b. Predictors: (Constant), SPENDING HR 1995-2004, GERD1995-2004

c. Predictors: (Constant), SPENDING HR 1995-2004, GERD1995-2004, DEBT1997-2006

d. Dependent Variable: EMP 2000-2009

Table 8. ANOVA[d] of model [1]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3939.196	1	3939.196	136.640	0.000[a]
	Residual	6428.887	223	28.829		
	Total	10368.082	224			
2	Regression	5005.305	2	2502.652	103.601	0.000[b]
	Residual	5362.778	222	24.157		
	Total	10368.082	224			
3	Regression	5372.276	3	1790.759	79.218	0.000[c]
	Residual	4995.806	221	22.605		
	Total	10368.082	224			

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	Total	10368.082	224			

a. Predictors: (Constant), SPENDING HR 1995-2004

b. Predictors: (Constant), SPENDING HR 1995-2004, GERD 1995-2004

c. Predictors: (Constant), SPENDING HR 1995-2004, GERD 1995-2004, DEBT 1997-2006

d. Dependent Variable: EMP 2000-2009

Econometric modeling [2], with interaction terms, considers as predictors: GERD 1995-2004; SPENDING HR 1995-2004; DEBT 1997-2006; INTER 1 DEBT-GERD, INTER 2 DEBT-SPENDING HR, INTER 3 GERD-SPENDING HR. The Stepwise method (Criteria: Probability-of-F-to-enter ≤ 0.050, Probability-of-F-to-remove ≥ 0.100) considers the variables of table 9.

Table 9. Models and variables entered

Model	**Variables Entered** [a)]
1	INTER GERD-SPENDING
2	SPENDING HR 1995-2004
3	GERD 1995-2004
4	INTER DEBT-GERD

Note: a) Dependent Variable: EMP 2000-2009; Method Stepwise (Criteria: Probability-of-F-to-enter ≤ 0.050, Probability-of-F-to-remove ≥ 0.100).

The coefficients of estimated relationship [2] are in table 10, adjusted R^2 and its standard error of the estimate are in table 11, ANOVA is in table 12.

Table 10. Coefficients of model[a] [2]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	59.526	.563		105.821	.000
	INTER GERD-SPENDING	.702	.058	.627	12.004	.000
2	(Constant)	50.384	1.855		27.156	.000
	INTER GERD-SPENDING	.430	.077	.384	5.622	.000
	SPENDING HR 1995-2004	2.108	.410	.351	5.144	.000
3	(Constant)	37.925	3.118		12.161	.000
	INTER GERD-SPENDING	-1.174	.339	-1.048	-3.466	.001
	SPENDING HR 1995-2004	4.268	.592	.712	7.206	.000
	GERD 1995-2004	9.865	2.034	1.234	4.850	.000
4	(Constant)	36.280	2.953		12.288	.000
	INTER GERD-SPENDING	-1.445	.323	-1.290	-4.474	.000
	SPENDING HR 1995-2004	4.475	.559	.746	8.003	.000
	GERD 1995-2004	15.153	2.151	1.895	7.044	.000
	INTER DEBT-GERD	-.064	.012	-.509	-5.403	.000

a. Dependent Variable: EMP 2000-2009

Table 11. Model Summary[e] of model [2]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.627[a]	.393	.390	5.3145
2	.676[b]	.457	.452	5.0348
3	.714[c]	.509	.503	4.7974
4	.753[d]	.567	.559	4.5179

a. Predictors: (Constant), INTER GERD-SPENDING

b. Predictors: (Constant), INTER GERD-SPENDING, SPENDING HR 1995-2004

c. Predictors: (Constant), INTER GERD-SPENDING, SPENDING HR 1995-2004, GERD 1995-2004

d. Predictors: (Constant), INTER GERD-SPENDING, SPENDING HR 1995-2004, GERD 1995-2004, INTER DEBT-GERD

e. Dependent Variable: EMP 2000-2009

Table 12. ANOVA[e] of model [2]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4069.656	1	4069.656	144.089	.000[a]
	Residual	6298.427	223	28.244		
	Total	10368.082	224			
2	Regression	4740.515	2	2370.258	93.503	.000[b]
	Residual	5627.567	222	25.349		
	Total	10368.082	224			
3	Regression	5281.808	3	1760.603	76.499	.000[c]
	Residual	5086.274	221	23.015		
	Total	10368.082	224			
4	Regression	5877.617	4	1469.404	71.990	.000[d]
	Residual	4490.465	220	20.411		
	Total	10368.082	224			

a. Predictors: (Constant), INTER GERD-SPENDING

b. Predictors: (Constant), INTER GERD-SPENDING, SPENDING HR 1995-2004

c. Predictors: (Constant), INTER GERD-SPENDING, SPENDING HR 1995-2004, GERD 1995-2004

d. Predictors: (Constant), INTER GERD-SPENDING, SPENDING HR 1995-2004, GERD 1995-2004, INTER DEBT-GERD

e. Dependent Variable: EMP 2000-2009

Discussion and political economy implications

Europe since 1990s has been experiencing a "secular rise of unemployment" (Addison and Teixteira, 2001, p. 191). This European unemployment, recently, has been intensifying the effects due to economic downturn of 2007-2010 and succeeding crisis of sovereign debts of countries that has generating turmoil within the Eurozone. As Europe has to design an apt political economy to support new pattern of employment growth, this paper investigates the relationship between employment and technological variables, considering the interaction with the structural indicator of public debt that affects, more and more, government policies of European countries. First of all, the study here shows a high positive association among employment, GERD and Spending in Human Resources, significant at the 0.01 level (table 3). In addition, if the relationship between Employment, GERD and spending in human resources is

analyzed by partial correlation, controlling -*ceteris paribus*- the public debt of countries (tab. 4), the coefficients of partial correlation are higher: $r_{Employment,\ GERD|\ Debt}$=62.8%, $r_{Employment,\ Spending\ in\ HR|\ Debt}$=62.0%, respectively (sign.0.00). The paper also analyzes the interaction of variables on employment by multiple regression models. The first thing to be said about these estimated relationships [1] and [2] is that the significance of coefficients of the equations is high and the explanatory power of the equation is good. In fact, table 7 shows that final model [1] explains more than 51% variance in the data-, whereas final model [2] explains about 56% (see adj. R^2 in table 11). ANOVA shows for both models the significance of *F*-test (table 8 and 12). In particular, the estimated relationship (model 3 in table 6, without interaction among variables) shows an expected employment rate increase of approximately 2.4% for a spending in human resources increase of 1% (*ceteris paribus* GERD and public debt) and an expected employment rate increase of approximately 3.4% for a GERD increase of 1% (*ceteris paribus* spending in human resources and public debt), whereas the moderate negative impact of public debt is showed by the third coefficient: an expected employment rate reduction of approximately 0.06 for a public debt increase of 1% (*ceteris paribus* spending in human resources and GERD). The final model 4 in table 10, with interaction of variables, finds some highly significant variables through stepwise method based on probability-of-*F*-to-enter ≤ 0.05, Probability-of-F-to-remove ≥ 0.1. This model shows the higher impact of R&D intensity and spending in human resources on employment rate of countries, as well as it shows the negative interaction between GERD and spending in human resources, public debt and R&D intensity (GERD). In short, these models [1] and [2] show the fruitful impact of gross domestic expenditure as percentage of GDP and total expenditure on education (as percentage of GDP) on employment rate of European countries. This statistical analysis provides main results to social planner, mainly of advanced countries, to design policies of employ-

ment increase, considering technological determinants and in particular sovereign debt implications.

Modern economic literature attempts to explain the determinants of growth considering R&D and knowledge creation that have main effects on technological change with positive spillover for employment and productivity gains of countries (*cf.* Romer, 1990). In fact, high growth and employment in US and Europe are driven by investments in machinery and equipment, but also by intangible assets, represented by Research and Development (R&D) and human capital investment. R&D leads to technological innovations that skilled human capital can absorb to spur economic growth of economies (*cf.* Corley *et al.*, 2002, p. 266ff).

The study here also shows the negative impact of general government consolidated gross debt (as percentage of GDP) on employment rate as well as on technological indicators (GERD and spending in human resources by interaction effects). In fact, Sargent (2012) argues the risk of high sovereign debt for some Europe countries, driven by government policies, which contributes to maintain persistently high European unemployment.

In order to spur employment, it is important to increase R&D intensity and spending in human resource, but these research policies are affected by austerity packages in presence of high consolidated gross debt and negative budget deficit by countries, *e.g.* in Greece, Spain, Italy, etc. In fact, Bajo-Rubio *et al.* (2010) re-examine the long-run sustainability of budget deficits in Spain, and show that fiscal authorities would cut deficits only if they are large, which would assure in turn their long-run sustainability (p. 263).

Economic growth is the engine of employment rate increase, and innovation is a main determinant of employment and economic growth. A vital trade-off that policy makers have to deal with, in period of economic turmoil, is whether either to support R&D spending in order to spur employment and economic growth or to apply government policy based on balanced-

budget rules to reduce public debt that, as consequence, decrease government spending included R&D intensity.

First of all, it is important to note that government policy has to be applied considering the phase of business cycle. If it is considered European orientation, a social planner should apply a balanced budget rule and public debt reduction to improve the stability of the economic system and spur economic growth and employment. Economic literature shows that whether the government strictly applies a balanced-budget rule to reduce public deficit and public debt, the amplitude of business cycle increases by fostering aggregate demand during booms via tax cuts and higher public expenditures and by lowering demand during recessions through a fiscal contraction (Schmitt-Grohé, 1995, p. 976 and 977, *passim*). In particular, balanced-budget rule can be a source of economic instability and this result is confirmed in presence of (high) public debt that should remain constant over time. Several models do not suggest for governments a balanced-budget rule on average, since affects (narrows) the political economy of driving surplus and deficits, by borrowing and lending, to smooth taxes, thereby a balanced-budget rule is not an optimal policy. In addition, "the welfare consequences of decreasing ratio of debt/output at the exogenous growth rate are negligible" (Stockman, 2001, p. 439). Maastricht treatise in 1992 has established fiscal rules to restrict the ratio of the annual government deficit to gross domestic product (GDP) at max 3%[3] and the ratio of gross government debt to GDP that must not exceed 60%. This is considered a sub-optimal policy (cf. Stockman, 2001) such that several European countries with the fluctuations of business cycles have not improved the patters of employment and economic growth[4]. A balanced-budget rule, with a (high) public debt, inhibits the possibility by government to smooth taxes, and according to reputation model by Stockman (2004, p. 382, p.

[3] European summit held at Bruxelles in December 2011 has suggested to reduce this value at 0.5%, except in periods of recessions.

[4] Pros of this fiscal rule are the reduction of government spending, cons are the inhibition of stabilization fiscal policy that can increase the fluctuations of business cycle. Stockman (2001, p. 440) argues: "in Europe, …without strict fiscal guide-

383 and 384) predicts default (*i.e.* incapacity of governments to honor its debt obligations), although other main mechanisms works as incentive to have a reputation as a reliable borrowed. Stockman (2010) also shows the possibility of chaotic equilibria under a balanced-budget rule and critical role is played by endogenous labor tax.

In short, the study here confirms the driving role of innovation on employment growth, but innovation as engine of growth is affected in negative way by public debt that has also a low negative impact on employment rate. As innovation has a high positive effect on employment, whereas public debt has a negligible impact on employment, a government policy could support innovation by public debt, *ceteris paribus* other structural indicators. Public debt of European countries, after the economic downturn of 2008-2010, has sharply increased trajectory, since governments have supported the financial system, and applied fiscal stimulus and dropped in tax revenue (Corsetti *et al.*, 2010). Tabellini and Alesina (1990, p. 37ff) argue that most governments choose, *a priori*, a non-optimal debt policy by budget deficits, because of disagreement between current and future majorities such as in Italy ("time inconsistency in the dynamic social choice problem that determines the size of budget deficits", p. 37). Public debt is a complex economic issue (Barro, 1979) and government should limit government spending[5] but political pressures by European institutions to reduce public debt in the short-run should be assessed with accuracy since can generate more negative socio-economic effects than benefits for employment and economic growth. Although it is a desirable target, reduction of sovereign debt of some European countries is not an easy task and should be pursued by long-run government policies, considering the fluctuations of business cycle, to support steady-state patterns of economic growth. In particular, the Europe has focused on downsizing of the ratio of public debt to GDP and of the fiscal deficit as percentage of GDP

lines, there will be excessive deficits (perhaps politically motivated) that are not consistent with long-term solvency". In fact, nowadays in several European countries there is the problem of sovereign debt such as in Greece, Italy, etc.

[5] Corsetti *et al.* (2010, p. 45) argue: "consolidation efforts are likely to include not only tax increases but also sizeable spending cuts. . . . analysis suggests that such prospective spending cuts generally *enhance* the expansionary effect of current fiscal stimulus" (original emphasis).

as well as on balanced-budget rules for members. If these targets have to be achieved in the short run, at any price with austerity packages, under political pressure of European Institutions and recurrent shocks of business cycles, can generate negative effects for long-run patterns of employment and economic growth, shaking stability of countries to its foundations. Antonucci and Pianta (2002, p. 306) also claim that: "macroeconomic constraints of Economic and Monetary Union in Europe have put a serious limit on the economic dynamics of national economies, and of manufacturing industries in particular". Modern economic research shows that some of these rules are not optimal policy considering the initial level of the public debt and they can generate aggregate instability (Schmitt-Grohé and Uribe, 1997; Stockman, 2010). According to Stockman (2004, p. 383): "The ability to borrow is desirable because debt serves as a buffer to help smooth distortionary taxes over time resulting in higher economic welfare". As a matter of fact, fiscal guidelines of the Monetary European Union, since Maastrict treatise, have deteriorated the economic dynamics and structure of countries in presence of the global financial crisis over 2007-2010 and economic turmoil over 2011-2012. European policy makers should have the awareness that to support employment and economic growth by Lisbon strategy (*i.e.* increasing R&D intensity of countries, *cf.* Room, 2005), the strict fiscal rules, public debt downsizing, balanced-budget rules stressed in the short run for different economic structures of European countries can reduce the common patterns of economic growth and trigger European instability and economic shocks in the interlinked relationships among countries.

In order to spur employment growth by innovation into the European countries, it is important to design effective and efficient lung-run political economy, considering the respective structural indicators, to allow the economic system to dry out slowly public debt without inserting frictional effects for patterns of economic and employment growth. Although other socio-demographic-economic factors are important for a systematic analysis of this critical

relationship (Sahin *et al.*, 2009), models discussed here, focusing on key critical variables, provide interesting results to understand basic vital interactions that support, or are friction processes for pattern of technological innovation and employment growth. This study, of course, is a starting point for further investigations based on more complex and comprehensive models.

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