Do Labour Markets and Educational and Training Systems Shape Innovation Style? A multi-level analysis for the EU-27[1]

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1. Introduction

One of the most novel aspects of research on the varieties of capitalism (VoC) is the analysis of the way labour markets and vocational training systems shape differences in innovation style across nations. In their seminal work, Hall and Soskice (2000) argued that nations with relatively fluid labour markets and vocational training systems favouring the development of a general over industry or company-specific skills will be relatively specialised in the more radical forms of innovation. Subsequently, a variety of evidence has been presented that refutes this hypothesis. Some critics have concluded on this basis that domestic institutions do not matter much for the innovation style and performance of enterprise located there.

In this paper, drawing upon and extending research that Bengt-Aake Lundvall and I have undertaken together, and in cooperation with other colleagues, over the last decade, I develop a defence of the view that institutions do matter for innovation style and performance. The analysis presented here, however, does not support the notion of institutional complementarities that underlies the VoC thesis that liberal market economies (LMEs) will be relatively specialised in radical innovation and that coordinated market economies (CMEs) will be relatively specialised in incremental innovations.

After reviewing the VoC hypothesis regarding innovation style and summarising the evidence going against the following secton, in Section 3 I present a multilevel logistic analysis of the institutional determinants of innovation mode for EU-27 member

[1] This paper draws upon and extends idea I have developed and published together with Bengt-Aake Lundvall and other colleagues over the last decade. Key contributions include: Johnson, Lorenz and Lundvall (2002); Lorenz and Lundvall (2006); Jensen et al. (2007); Arundel et al. (2007) Lorenz and Lundvall (2010); and Holm et al. (2010). I would also like to express my gratitude to Keith Sequeira of Unit 1 - Innovation Policy Development, DG Enterprise and Industry, European Commission, for providing me with access to the micro data from the 2007 Innobarometer Survey.

nations. Not only do the results show that institutions supportive of radical innovation are not distributed across EU-member in accordance with the distinction between LMEs and CMEs, they also show that institutions supportive of radical innovation are bundled in a way that is not consistent with the VoC notion of institutional complementarities. With respect to the latter point, the results show a positive, though of borderline statistical significance, relation between high levels of labour market mobility and the capacity of enterprises for forms of innovation requiring a high in-house capacity for knowledge exploration. They show a stronger, and highly statistically significant, positive relation between these forms of innovation and the development of institutional rich systems of life-long learning. Further, the results are consistent with the presence of complementarities between these two institutional dimensions.

Following this, in Section 4 I argue that the problems which the VoC hypothesis in correctly specifying the institutional arrangements that support differences in innovation style across nations is linked to a misunderstanding of the nature of the skills and the forms of internal enterprise governance that promote radical forms of innovation. The paper concludes by briefly alluding to the implications of the analysis for the EU 2020 strategy and for innovation policy in particular.

2. The VoC perspective on labour market institutions and innovation style

The VoC perspective draws a broad distinction between liberal market economies (LME) such as the US and the UK, and coordinated market economies (CME) such as Germany and Japan. A central idea developed in the VoC approach is that of 'comparative institutional advantage', and Hall and Soskice (2001, pp. 38-40) in argue that the institutional arrangements of different national systems will be more or less suited to different styles of innovation, with CMEs excelling in incremental innovation and LMEs excelling in more radical innovation. Drawing inspiration from Aoki's (1990) analysis of the Japanese firm and Streeck's (1991) analysis of the strategies of diversified quality production adopted by German enterprises, Hall and Soskice argue that incremental innovation thrives in corporate settings where workers are skilled and autonomous enough to contribute to continuous improvements in products and processes and secure enough in their tenures to take the risk of promoting changes that might alter their job situation. These relational requirements for incremental innovations are more likely to be achieved under the institutional arrangements characteristic of CMEs, including corporate governance arrangements favouring long-term employment tenures, well developed systems of vocational training providing an appropriate mix of firm and industry-specific skills, and industrial relations systems characterised by works councils and consensus decision making.

LMEs, on the other hand, will have a comparative advantage in radical innovation because the lack of restrictions on hiring and firing in such nations combined with weak initial vocational training systems will favour investments in general over industry-specific skills. This will result in comparatively fluid labour markets making it easier for companies to rapidly reconfigure their knowledge bases in order to develop new product lines. Further, the hierarchical structure of companies in LMEs, with power concentrated at the top, will make it easy for senior management to implement new business strategies in comparison to management in CME enterprises who are constrained by the requirements of consensus decision-making (Hall and Soskice, 2001, pp. 40-41).

These conclusions of the VoC approach regarding the comparative advantage of LMEs and CMEs in different styles or modes of innovation have recently been subject to some criticism and debate. Focusing on the biotech industry, Herrmann (2008) and Lange (2009) observe that German companies perform better than the VoC perspective would allow in market segments of the industry, such as therapeutics discovery, characterised by radical technological change. The authors don't contest the basic claim of the VoC approach that the institutions of CMEs are unsupportive of radical innovation. Rather, they criticise the idea that corporate strategy and performance can be read off from the national institutional configuration by arguing that German biotech companies have displayed a capacity for circumventing the disadvantages of their domestic institutional setting, notably by tapping into the international markets for technical labour and finance.

While the evidence of Herrmann (2008) and Lange (2009) would appear to be at odds with the VoC notion of comparative institutional advantage, the validity of the VoC hypothesis should not hinge on evidence concerning the performance of a limited number of companies in a single sector of activity. Hall and Soskice (p. 43-44) support their argument on the basis of patent data comparing patterns of technological specialisation between the US and Germany for the periods 1983-84 and 1993-94. Taylor (2004) and Akkermanns et al. (2009) have undertaken more general tests of the VoC hypothesis on the basis of patent data for larger populations of LMEs and CMEs. Using the NBER patent database Taylor presents evidence that refutes the basic proposition on the basis of a series of tests using indices of patent specialisation[2] across six LMEs (Australia, Canada, Great Britain, Ireland, New Zealand, and the US) and ten CMEs (Austria, Belgium, Denmark, Finland, Germany, Japan, Netherlands, Norway, Sweden, and Switzerland). For example, he observes that for the period 1983-84, also examined by Hall and Soskice, the population of LMEs have higher degrees of patent specialisation in three industries that are characterised by Hall and Soskice as incremental (mechanical elements, basic materials, polymers) while the CMEs have greater specialisation in two radical industries (new materials and audiovisual technology). Taylor also observes that the US stands out as a clear outlier in terms of specialisation in sectors that are characterised as radical and when the US is removed from the population of LMEs the success of the VoC hypothesis in accounting for international patterns of patent specialisation is substantially reduced.

Akkermanns et al. (2009), also using the NBER data set, arrive at similar conclusions using a measure of the radicalness of an innovation based on the number or citations a patent receives. The basic idea in this measure, introduced by Trajtenberg (1990), is that patents that receive more citations than others have a more important impact on subsequent technical development and therefore can be seen as more radical. One finding of Akkermanns et al (2009) is that LMEs other than the US and Ireland do not systematically show stronger specialisation in radical innovation. Another finding is that in four of eight industries examined n more detail, CMEs tend to be more specialised in radical innovation.[3]

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[2] The index is the one used by Hall and Soskice in their comparison of German and US patenting, a country's fraction of its total patents in a particular field is subtracted from the world's fraction of total global patents in the same field

[3] The industries include plastics, drugs, nonferrous metals, metalworking machinery, miscellaneous machinery, ships and aircraft.

A possible inference to draw from the empirical evidence going against the VoC hypothesis is that the assumption that institutions matter for innovative performance is wrong. This would appear to the conclusion drawn by Taylor (2004, p. 68), who suggests that the key factors may be foreign direct investment and international flows of scientific and technical labour between lead innovators and other nations[4]. Further, as I noted above, Herrmann (2008) and Lange (2009) question the importance of institutions for enterprise performance, arguing that in an increasingly global economy corporations can put in place strategies that circumvent the constraints of domestic institutions.

The evidence showing that differences in innovative style and performance across nations do not conform to the predictions of the VoC hypothesis regarding comparative institutional advantages does not necessarily mean that institutions do not matter. This evidence may reflect that the VoC conception of institutional complementarities that underlie the classification of nations into the LME or CME categories is wrong, or outdated. For example relatively fluid labour markets in a nation may well increase the likelihood that firms there develop more radical innovations, but contrary to the VoC conception of institutional complementarities fluid labour markets may not be bundled together with education and training institutions favouring investments in general over industry-specific skills.

Proposing alternative taxonomies of nations in the hope of finding one that conforms to one's predictions concerning institutional comparative advantage is not a very good way to investigate the importance of institutions for innovative performance. A more direct and conceptually sound approach is to test directly for the impact of particular national institutions on innovation style and performance. This is the strategy adopted here. In section 3 below, drawing on innovation data for the EU-27, I use multi-level regression analysis in order to test for statistically significant impacts of national labour market structures and education and training systems on enterprise-level innovation outcomes. The analysis shows that higher levels of labour market mobility in a nation increase the likelihood of enterprises there engaging in relatively radical forms of innovation

[4] Also see Tayor (2007) for a more general critique of the idea that national institutions can account for differences in innovation rates.

requiring a high level of in-house capability for knowledge exploration. The analysis demonstrates a stronger positive relation between the development of national systems of life-long learning and the likelihood of these forms of innovation activity. Further, it provides evidence consistent with the view that there are institutional complementarities between labour market institutions and systems of life-long-learning.

3. A multilevel analysis of innovation modes

In this section I use multi-level logistic modeling to determine the way the characteristics of enterprises and features of the national institutional context impact on the likelihood of an enterprise engaging in a particular mode of innovation. In multi-level analysis data is hierarchically structured. This means that units at one level are clustered within units at the next higher level. Multi-level modeling allows one to model processes at multiple levels of the population hierarchy. One reason to do this is that the failure to take into account the hierarchically structured nature of the data may lead to technical problems, with standard errors of the regression coefficients being underestimated. More generally, multi- level modeling responds to the criticism often made of single-level models that too much emphasis is placed on individual-level characteristics to the neglect of the social or institutional context. By simultaneously modeling at multiple levels it is possible to determine where and how effects are occurring including possible interaction effects between individual attributes and the institutional context. (Rasbash, et al. 2005, pp. 6-12; Goldstein, 2003).

The econometric analysis of innovation mode operates at two levels, with enterprises at level-1 being clustered within nations at level-2. The variables characterising enterprises at level-1 are derived from the individual responses to the Innobarometer Survey carried out in the EU-27 and in Norway and Switzerland in October 2007 on behalf of the DG Enterprise and Industry of the European Commission.[5] The analysis here concerns only the EU-27. The Innobarometer survey provides estimates of the percentage of enterprises that have introduced new or significantly improved products, processes or organisational methods over the period 2005-2007. The target population

[5] Access to the micro data from the 2007 Innobarometer Survey was kindly provided by Keith Sequeira of Unit 1 - Innovation Policy Development, DG Enterprise and Industry, European Commission,

for the survey was enterprises employing 20 or more persons in selected manufacturing and service sectors.[6] The selection of companies by sector was random with oversampling according to size category and region in order to be representative of the total universe examined.[7] The targeted number of main interviews was 200 in each country surveyed, except Malta, Cyprus and Luxembourg where the target number of the interviews was 70. This resulted in a sample size for the EU-27 of 5036 observations.

The level-1 or enterprise-level variables include a measure of the enterprise's sector of activity (SCTR), a measure of firm size (SIZE) and a measure of annual income growth (GRWTH).[8] The variables characterising the national context at level-2 are derived from selected national-level aggregates available for the EU-27 on the website of Eurostat. These variables, which measure characteristics of national labour markets and systems of education and training, are described in section 3.2 below.

3.1 Developing measures of innovation mode

Radical innovations can be defined as innovations that transform existing markets or industries and upon which many incremental innovations are developed. Developing empirical indicators to identify radical and incremental modes of innovation is problematic, however. Survey manuals, such as the Oslo Manual that is the basis for the definition of innovation used in the Innobarometer Survey, do not propose guidelines for how to measure radical innovations. This makes it difficult to bring survey-based evidence to bear on the various propositions analysed here.

The strategy I adopt is to classify enterprises into mutually exclusive innovation modes that distinguish between differences in the in-house creative effort an enterprise expends on innovation activity. The classification is similar, but not identical, to the

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[6] The target sectors were: Information technology, Medical devices, Production technology, Communications equipment, Biopharmaceuticals, Automotive, Analytical Industry, Construction Equipment, Metal Manufacturing, Lighting and electrical Equipment, Aerospace Vehicles, Defence, Plastics, Construction Materials, Entertainment, Transportation and Logistics, Furniture, Processed Food, Business services, Aerospace Engines, Chemical Products, Heavy machinery, Power Generation and transmission, Building Fixtures, Equipment, Services, Hospitality and tourism, Publishing and Printing, Textiles, Financial services, Oil and gas products and services, Apparel, Distribution services, Fishing and fishing products, Heavy construction services, Footwear, Jewellery and precious metals, Sporting and children Goods, Leather.

[7] The person interviewed in each company was a top-level executive responsible for strategic decision-making (typically General manager, Financial Director, or significant owner).

[8] See Table A1 in the Annex for a description of the enterprise-level variables.

classification developed by Arundel and Hollanders (2005) in collaboration with Paul Crowley of Eurostat to classify CIS-3 respondent firms into mutually exclusive innovation modes.[9].

The classification here distinguishes between lead innovators, intermittent innovators, adopters and non-innovators. The key criteria upon which firms are classified into different innovation modes are: 1) whether they have developed on their own or in collaboration with other organisations new or significantly improved products as opposed to adopting or modifying new products developed by other organisations; and 2) whether they undertake in-house R&D for their innovation activity as opposed to contracting out R&D to other organisations or innovating without R&D activity. This distinction is not the same as that between radical and incremental innovation. However, much as Arundel et al. (2007, p.) have observed with respect to the CIS-3 based taxonomy of innovation modes, there are large differences along the continuum between lead innovators and adopters in each firm's capacity to explore new knowledge, which is conceptually similar (although on a different scale) to the difference between radical and incremental innovations.

Lead innovators are enterprises that have developed entirely new or significantly improved products in-house or in collaboration with other companies or organisations and which carry out in-house R&D on a continuous basis. These are firms that are likely to develop innovations that are later adopted or modified by other companies. They constitute 23.5 percent of all enterprises.

Intermittent innovators, like lead innovators, have developed entirely new or significantly improved products in-house or in collaboration with other companies or organisations. Unlike lead innovators intermittent innovators either innovate on the basis of R&D contracted out to other companies or without any in-house R&D. These are firms that will innovate periodically, as required by the introduction of a new product line. They account for 20.5 percent of all enterprises.

[9] The main distinction is that the Arundel and Hollanders classification is based in part on the distinction between new-to-market and new-to firm innovations. This distinction cannot be captured on the basis of the 2007 Innobarometer survey.

Table 1
Innovation modes: EU-27
(weighted percent of enterprises by innovation mode

	Lead innovators	Intermittent innovators	Adopters	Non-innovators
Belgium	16.1	16.03	17.21	50.69
Czech Republic	8.4	13.60	16.97	61.00
Denmark	31.4	18.41	23.82	26.34
Germany	28.9	17.57	20.50	33.08
Estonia	19.77	20.02	8.11	52.10
Greece	23.57	12.79	26.52	37.13
Spain	11.81	14.33	14.91	58.96
France	35.39	14.32	7.78	42.51
Ireland	24.89	19.96	32.38	22.76
Italy	33.26	25.00	10.10	31.64
Cyprus	23.12	5.34	34.09	37.44
Latvia	31.95	18.75	22.46	26.83
Lithuania	31.27	7.17	25.48	36.07
Luxembourg	14.79	10.25	11.67	63.29
Hungary	7.90	8.78	20.98	62.33
Malta	24.19	14.77	35.62	25.41
Netherlands	26.42	15.95	11.55	46.07
Austria	19.15	19.76	22.48	38.61
Poland	11.44	41.40	15.06	32.10
Portugal	25.09	17.96	25.27	31.68
Slovenia	32.01	19.27	18.45	30.27
Slovakia	11.60	18.80	37.97	31.63
Finland	44.26	9.69	16.76	29.29
Sweden	27.89	26.48	15.40	30.22
UK	23.91	13.33	21.90	40.86
Bulgaria	7.48	29.29	23.00	40.23
Romania	15.70	28.66	28.27	27.37
EU-27	23.46	20.55	16.96	39.03

Source: based on data from the 2007 Innobarometer Survey.

Adopters are enterprises that sell new or significantly improved products developed by other companies or organisations, possibly after customising or modifying the products. This is a measure of the importance of technological diffusion. These firms constitute 17 percent of all enterprises.

Non-innovators are enterprises that have not introduced any new of significantly improved products over the reference period. They account for 39 percent of all enterprises.

The distribution of the three types of innovators and non-innovators across the EU-27 is presented in Table 1 above.

3.2 Country-level variables

At the country-level national aggregate measures of labour markets and education and training systems are developed using data available for the EU-27 on Eurostat's electronic data base. In order to capture the degree of fluidity of the labour market for European nations, we use a measure of labour market mobility (MOB) based on data from the Labour Force Survey on the share of persons by country whose job started within the last three months. MOB is defined as the average of this share over three quarters: the 2nd quarter of 2005 and the 1st and 2nd quarters of 2006.[10]

We use two different measures of the importance and characteristics of initial vocational training in a nation. The first, IVTFIRM, is derived from 2005 Continuing Vocational Training Survey and is defined as the percentage of persons employed in all enterprises receiving formal workplace initial vocational training. This measure may well underestimate the importance of initial vocational training in a nation as implied by a recent article by Busemeyer (2009). Busemeyer points to an important distinction between nations such as Germany, Austria and Switzerland which have strong workplace-based apprenticeship systems, referred to as 'differentiated' skill regimes, and nations such as Sweden, Belgium and the Netherlands which have extended school-based initial vocational training systems, referred to as 'integrationist' skill regimes.

Since the IVTFIRM measure is likely to underestimate the importance of initial vocational training in nations with extended school-based systems if initial vocational training, I use a second measure of the importance of initial vocational training, (IVTSCND) defined as the percentage of students enrolled at the secondary-level in

[10] The figure are taken from, Statistics in Focus, 'Population and Social Conditions', 6/2006, Eurostat. A weakness with this measure is that does not take into account difference in the importance of school leavers across nations.

vocational educational programmes as a percentage of all students enrolled at secondary level in both vocational and general educational programmes. This provides a measure of the balance in a nation between programmes focussed on the acquisition of general skills and designed to gain entry to third level education, and programmes focussed on the acquisition of technical and vocational skills that can provide direct entry to the labour market.

The VoC literature focuses on the role that well developed systems of initial vocational training play in generating a workforce with a mix of industry and firm specific skills appropriate for incremental innovation. Recent work on national systems of competence building (Holm, et al. 2010; Lorenz and Lundvall, 2010) has focused on the importance of both formal and informal forms of life-long learning for the developing of the high level of in-house capacity for knowledge exploration characteristics of lead innovators. In an environmental characterised by rapid changes in products and technology, well developed and diversified systems of life-long-learning may contribute in various ways to a nation's capacity for more radical forms of innovation. Firstly, formal forms of life-long learning contribute to up dating the industry-specific technical skills required to keep abreast of rapid changes in technology and products. Secondly, informal forms of life-long learning, often with little apparent relation to firm or industry-specific skills, may promote greater knowledge diversity that, in possibly unanticipated ways, contributes to new knowledge creation.

In order to develop a measure of the importance of systems of life-long learning (LLL) which captures these different dimensions of learning, we use the results of the 2003 Labour Force Survey module on life-long learning. The module distinguishes between formal, non-formal and informal or self-learning. Formal life-long learning is defined as that provided by the degree conferring institutions of the formal educational system and contributes to upgrading of formal scientific and technical knowledge. Non-formal education and training refers to all forms of taught learning, including that provided by employers, that occurs outside the formal degree-conferring educational system. This provides a measure of the acquisition of applied industry and firm specific skills . Informal learning refers to self-taught learning including the use of printed materials and on-line computer based learning. Knowledge resulting from informal life-long-learning, regardless of how general or industry-specific is, can contribute to increasing diversity of the enterprise's knowledge base. [11]

Table 2
Country-level variables

	MOB	LLL	IVTFIRM	IVTSCND
Belgium	3.0	49.3	0.9	19.3
Czech Republic	2.8	43.2	0.7	18.0
Denmark	6.9	82.5	3.2	8.9
Germany	3.8	46.5	5.4	10.3
Estonia	4.8	37.8	0.1	5.8
Greece	5.8	20.5	0.4	5.7
Spain	2.2	27.0	2.9	5.3
France	8.8	59.9	2.2	7.8
Ireland	5.0	50.6	3.0	4.5
Italy	3.3	55.0	3.5	15.0
Cyprus	4.4	43.2	0.2	2.6
Latvia	5.3	51.9	1.8	6.9
Lithuania	3.7	33.0	1.8	3.4
Luxembourg	2.5	84.7	1.5	13.4
Hungary	3.1	14.6	1.0	5.6
Malta	2.6	59.1	2.4	5.7
Netherlands	1.3	46.6	2.1	12.3
Austria	4.9	86.7	6.6	17.9
Poland	4.3	39.1	0.9	9.3
Portugal	2.9	47.1	0.7	5.1
Slovenia	4.2	84.7	0.4	17.0
Slovakia	3.4	67.1	0.5	18.2
Finland	7.6	81.6	1.2	16.1
Sweden	8.2	72.2	0.9	12.5
UK	4.0	44.1	18.4	10.9
Bulgaria	6.4	22.0	1.8	14.3
Romania	3.4	11.4	0.3	15.2

Source: Eurostat's electronic database.

[11] The figures are available on Eurostat's electronic data base. For the Eurostat quality report on the lifelong learning module of the LFS, see: http://circa.europa.eu/irc/dsis/employment/info/data/eu_lfs/LFS_MAIN/Adhoc_modules/2003/ExplanatoryNotes/Final_Report_Ahm2003_EN.pdf

Well-developed systems of life-long-learning may have greater positive impacts on the activities of lead innovators when they are combined with high levels of labour market mobility. The two institutions working in tandem may well increase the chances that a firm will have the skills and competences required for more radical types of innovation. In order to test for the presence of these positive interaction effects we include a variable constructed by multiplying the measure of labour market mobility by the measure of life-long learning (MOB * LLL).

Table 2 above presents the values of the country-level variables for the EU-27.

3.3 The multi-level logit model

The single-level logit model takes the following form. Let y_i indicate the binary reponse (0, 1) for the ith unit and let π_i be the probability that $y_i = 1$

The logit link function has the form

$$\text{logit}\,(\pi_i) = \log\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1 x \qquad (1)$$

where the quantity $\pi_i / (1-\pi_i)$ is the odds that $y_i = 1$

In the two-level random intercept model the subscripts *j* vary across the level 2 units and the subscripts *i* vary from individual to individual within the level 2 units. Unlike the single-level logit model, in the two-level model the intercept term consists of two terms: a fixed component β_0 and a random effect u_{0j} due to the fact that the level 2 units are treated as a random sample from a population of units.

$$\text{logit}\,(\pi_{ij}) = = \beta_{0j} + \beta_1 x_{ij} \qquad (2)$$

$$\beta_{0j} = \beta_0 + u_{0j}$$

The random effect u_{0j} measures the departure of the jth unit's intercept from the average or summary intercept across all level 2 units predicted by the fixed parameter,

β_0. It is assumed that u_{0j} follows a normal distribution with mean zero and variance = σ^2_{u0}

Level-2 context variables x_{2j} can be included in order to estimate the direct effect of differences in context conditions on the dependent variable. Such direct effects modify the intercept and reduce the variabilty in the intercept across level-2 units (u_{0j}).

$$\text{logit}(\pi_i) = \beta_{0j} + \beta_{1j}x_{1ij} + \beta_2 x_{2j} \quad (4)$$
$$\beta_{0j} = \beta_0 + u_{0j}$$

with u_{0j} assumed to be normally distributed with means 0 and variances σ^2_{u0}.

Our objective is to predict the likelihood of an enterprise being grouped in one of the innovation mode clusters in terms of factors operating at two levels, the enterprise level and the national level. The dependent variables (lead, intermittent, adopter or non-innovator) will have binomial distributions. For example:

LEAD ~ Binomial (n_i, π_i)

The structure of the random intercept logit models estimated in the following section is given in equation (5). The subscripts *j* vary across the sample of 27 EU nations and the subscrits *i* vary from employee to employee within nations.

$$\text{logit}(\pi_i) = \beta_{0j} + \beta_1\text{SCTR1}_{ij} + \beta_2\text{SCTR2}_{ij} + \beta_3\text{SCTR4}_{ij} + \beta_4\text{SCTR5}_{ij} + \beta_5\text{SIZE2}_{ij} + \beta_6\text{SIZE3}_{ij} + \beta_7\text{SIZE4}_{ij} + \beta_8\text{GRWTH1}_{ij} + \beta_9\text{GRWTH2}_{ij} \quad (5)$$

with

$$\beta_{0j} = \beta_0 + u_{0j}$$

The country-level random intercept, u_{0j}, is assumed to be normally distributed with mean 0 and a variance to be estimated.

National context effects are estimated by adding to the basic equation the aggregate variables capturing features of national labour markets and education and training systems. These variables have been standardized with mean 0 and standard deviation 1 which allows for a comparison of the size of the context effects.

$$\beta_{10}\text{MOB}_j + \beta_{11}\text{LLL}_j + \beta_{12}\text{IVTFIRMLL}_j + \beta_{13}\text{IVTSCND}_j + \beta_{14}\text{MOB*LLL}_j \quad (6)$$

Since the enterprise-level variables are all binary 0,1 variables and the national-level context variables all have means equal to 0, the log-odds of any of the innovation modes (e.g. LEAD) for the reference enterprise in the 'average' nation will be the fixed parameter β_0 plus the associated random effect u_{0j} . In nations where the values for the context variables are above (below) average, the fixed component of the predicted log-odds of the particular innovation mode for the reference enterprise will be higher (lower) than β_0 depending on whether the coefficients on the national context variables are positive or negative. For example, if the estimated coefficient on MOB is positive then, other context conditions being equal, in nations with higher levels of labour market mobility the predicted log-odds of innovation for the reference enterprise will be greater than β_0. Including the effects of the context variables on the dependent variable should reduce the estimated variance in the intercept term across nations (σ_{u0}^2).

Table 3 presents the results for the random intercept model for the each of the innovation modes and for non-innovators. Looking at the enterprise-level fixed effects first, the Model 1 result show that relative to the retail and other services sector enterprise in manufacturing, in construction and utilities and in business and financial services are more likely to be lead innovators. The positive effect is the strongest for enterprises in the manufacturing sector. Relative to small firms with 20-49 employees, larger firms are more likely to be lead innovators, and compared to firms whose annual income has remained unchanged firms with positive a growth in annual in income are more likely to be lead innovators. For intermittent innovators the only statistically significant effect concerns firms in business and financial services. Compared to firms in retail and other services, these firms are more likely to be intermittent innovators.

Table 3
Multi-level Logistic regressions: predictors of innovation modes

	Model 1	Model 2	Model 3	Model 4

	Independent variable			
	Lead	Intermittent	Adopters	Non-innovators
Enterprise-level fixed effects				
Intercept	-2.13***	-1.66***	-1.13***	-0.04
Manufacturing	0.92***	0.10	-0.92***	-0.20***
Construction, utilities	0.76***	-0.04	-0.62***	-0.10
Retail and other services	Reference			
Business and financial services	0.52***	0.23**	-0.24**	-0.38***
Other	-0.16	-0.24	0.26	0.06
20 – 49 employees	Reference			
50 – 249 employees	0.41***	-0.04	-0.06	-0.23***
250 – 499 employees	0.87***	-0.07	-0.11	-0.66***
>499 employees	1.13***	-0.14	-0.14	-0.91***
Increase in annual income	.0.28***	0.07	0.11	-0.35***
Decrease in annual income	0.08	-0.03	0.04	-0.08
Approximately the same	Reference			
Random effects				
Intercept	0.35 (0.10)	0.17 (0.06)	0.13 (.05)	0.21 (0.06)
LR test vs logistic regression	Chibar2(01) = 211.39	Chibar2(01) = 78.16	Chibar2(01) = 52.67	Chibar2(01) = 162.8

*** significant at .01 level; ** .05 level; * .10 level

Model 3 shows that compared to retail and other services firms in manufacturing, in construction ad utilities and in business and financial services are less likely to be adopters. The negative coefficient is strongest for firms in manufacturing. Model 4 shows that relative to firms in retail and other services firms in manufacturing and in business and financial service are less likely to be non-innovators. Relative to firms with 20-49 employers larger firms are less likely to be non-innovators and compared to firms with an unchanged annual income, firms with positive growth in annual income are less likely to be non-innovators.

The random effects estimate for the model for lead innovators shows that there is considerable variance across nations in the intercept term. This supports the view that the more radical innovative activity of lead innovators varies significantly across nations. The random effects estimates are lower for the other innovation modes and in particular the random effect for adopters varies much less across nation than that for lead innovators.

In Figures 1 through 4, on the basis of these random intercept regression results, I present bar charts showing the mean estimates of the random intercepts with 95 percent confidence intervals for each mode of innovation for the 27 EU member nations. These are estimates of how much the intercept in each nation departs from the overall average for the population of 27 nations and thus provide a measure of the importance of ‘national effects’ on the level of each type of innovation activity or on the importance of non-innovators. It is clear from the large confidence intervals in the figures that the rankings are not precise and it would perhaps be best to refer to a coarse distinction between low, average and high nations

Examining the case of lead innovators, the results in Figure 1 show that amongst the EU-15 lead innovation activity is especially high in the Scandinavian nations and in Germany, Portugal, France and Italy. Lead innovation activity is below average in Belgium and in a number of the new member nations including Bulgaria, Hungary, the Czech Republic, Slovakia, Poland and Romania. It is not statistically different from the overall average in Luxembourg, Estonia, Spain, Greece, the Netherlands, Ireland, Austria, The UK and Cyprus.

In the case of intermittent innovators for the majority of nations there is no significant departure in the intercept term from the overall average. The exceptions are Sweden, Bulgaria, Romania and Poland for which the level of intermittent innovative activity is above the average, and Lithuania, Finland, France and Hungary for which it is below the average.

Figure 3 below shows random intercept predictions for adopters. As in the case of intermittent innovators for the majority of the EU-27 there is no statistically significant departure from the intercept for the overall population average. The diffusion activity of adopters is above average in Ireland, Malta and Slovakia, and it is below average in France, Estonia, Italy and the Netherlands.

Figure 1

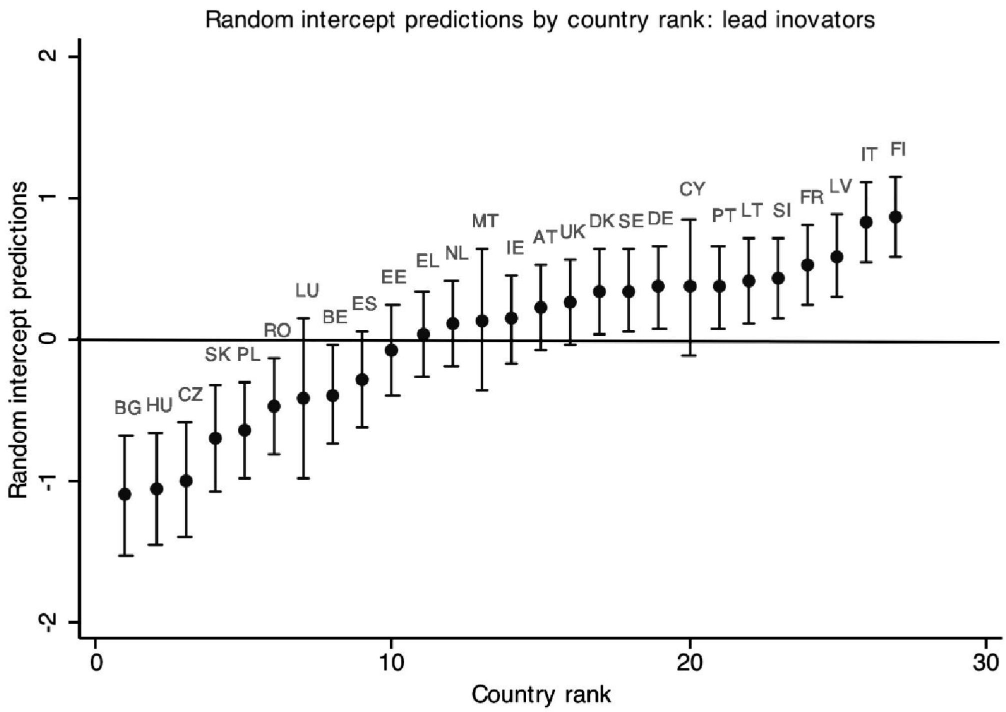


Figure 2

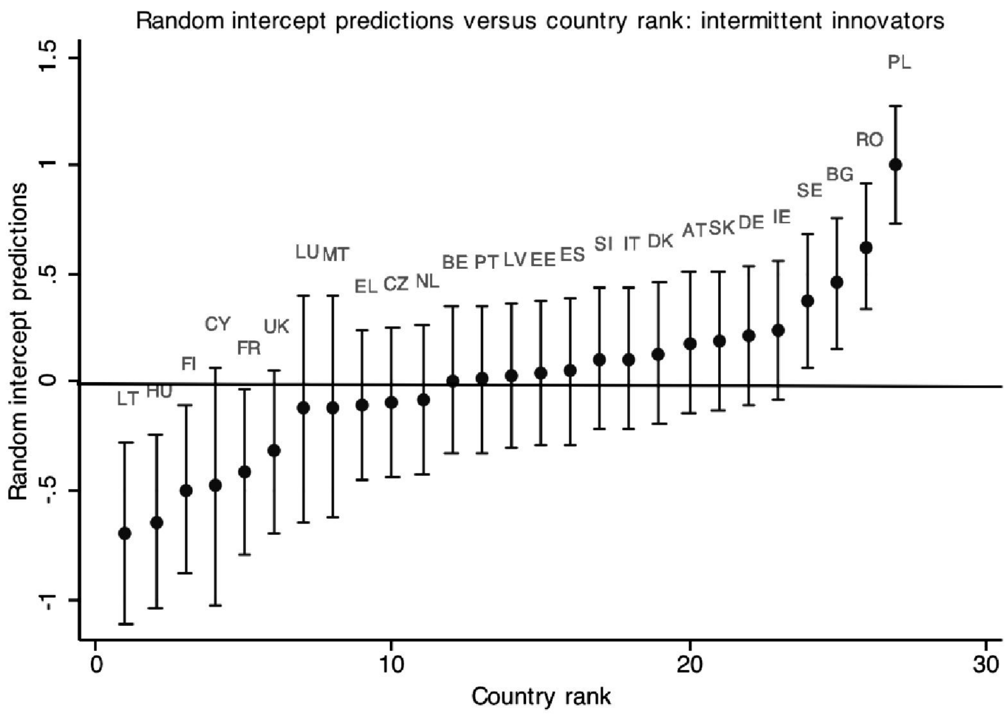


Figure 3

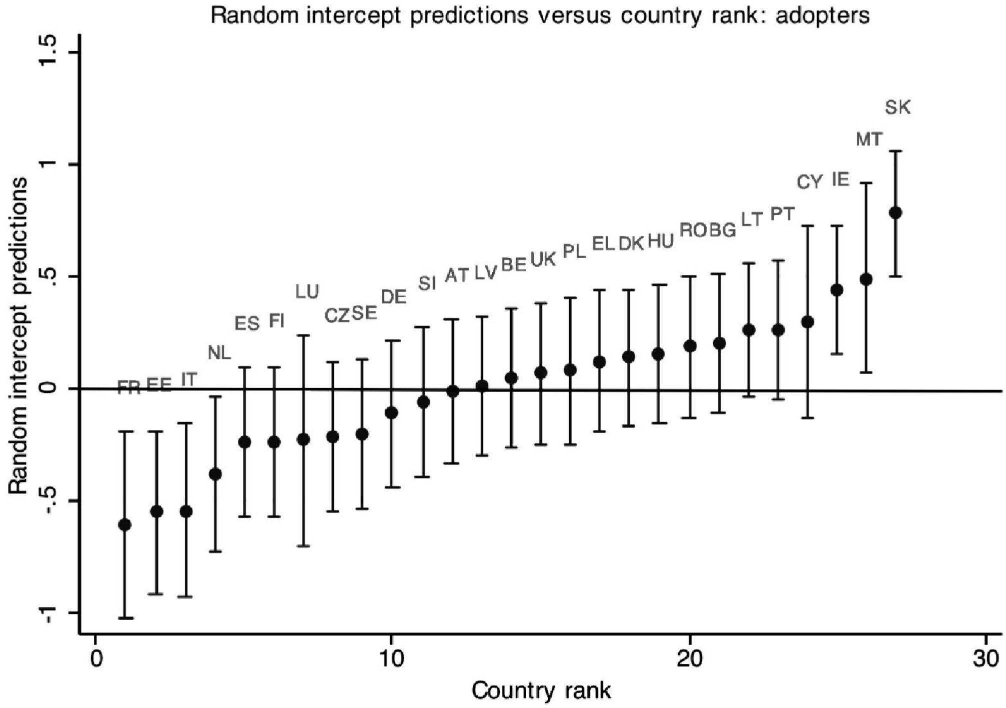
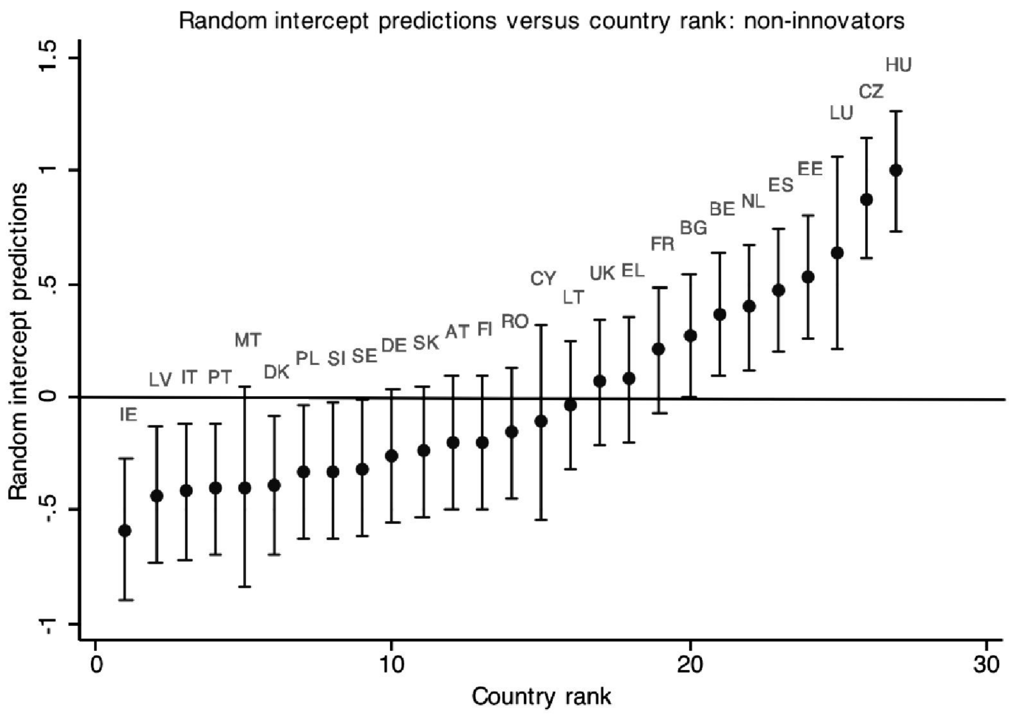


Figure 4



There is considerably more variation in the mean estimates of the random intercepts of non-innovators shown in Figure 4. Amongst the EU-15, the likelihood of non-innovator is above the overall average in Belgium, Netherlands, Spain and Luxembourg and amongst the new member it is higher in Bulgaria, the Czech Republic, Estonia and especially Hungary nations. It is below the average in Ireland, Latvia, Italy, Portugal, Denmark, Slovenia and Sweden.

Tables 4 through 7 present the random intercept models with country-level contextual effects. Since the measure of life-long learning (LLL) is positively correlated with the measure of labour market mobility (MOB) and with the measures of extended school based initial vocational training (IVTSCND) I present separate models grouping together variables that are not correlated.[12] As there were no statically significant changes in the coefficients for the level-1 enterprise variables, these are not reported in the results

Table 4
Multi-level Logistic regressions with contextual effects: predictors of lead innovators

	Model 5	Model 6	Model 7
Enterprise-level fixed effects			
Intercept	-2.13***	-2.13***	-2.12***
Country-level fixed effects			
MOB	0.20*		
IVTSCND	-1.12		
LLL		0.30***	
IVTFIRM		0.10	
*MOB * LLL*			0.33***
Random effects			
Intercept	0.28 (.09)	0.22 (.07)	0.23 (0.7)
LR test vs logistic regression	Chibar2(01) = 173.42	Chibar2(01) = 122.13	Chibar2(01) = 52.67

*** significant at .01 level; ** .05 level; * .10 level

[12] See Table A2 in the annex for the correlations between the country-level variables.

Table 5
Multi-level Logistic regressions with contextual effects: predictors of intermittent innovators

	Model 8	Model 9	Model 10
Enterprise-level fixed effects			
Intercept		-1.67	-1.67
Country-level fixed effects			
MOB	0.02		
IVTSCND	0.15*		
LLL		-0.06	
IVTFIRM		0.00	
*MOB * LLL*			-.01
Random effects			
Intercept	.16 (.05)	.17 (.05)	0.17 (.06)
LR test vs logistic regression	Chibar2(01) = 71.77	Chibar2(01) = 74.61	Chibar2(01) = 77.59

*** significant at .01 level; ** .05 level; * .10 level

Focussing first on the results for the regression estimates of the likelihood of lead innovation activity (Table 4) there is a positive coefficient on the measure of labour market mobility (MOB), though it is of borderline statistical significance. There is a larger and highly statistical significant positive coefficient for the measure of life-long-learning (LLL). Further there is a slightly larger and highly significant positive coefficient on the measure for interaction effects between labour market mobility and systems of life-long-learning. The variance estimate for the random effects are reduced and this is especially true for Model 6 with the life-long-learning variable and for Model 7 with the measure of interaction effects. Including these level-2 context variables in the regression estimates account for approximately one third of the total variance in the intercept terms across nations.

These results provide strong support for the view that institutions do matter for innovation style and performance. They first show first of all as the VoC literature that labour market mobility contributes positively to firm's capacity for more radical innovation. However, there is no support for the VoC view that nation's with weak initial vocational training systems and an emphasis on the development of general over industry specific skills provide firms with advantages in undertaking more radical innovations. A quite striking result is positive impact of well developed systems of life-long-learning on the likelihood of lead innovation activity. This supports the view of Hom et al (2010) and Lorenz and Lundvall (2010) on the positive contribution of systems of life-long-learning to the in-house creative capacity of enterprises. Further, the positive and statistically significant coefficient on the measure of interaction effects between life-long-learning and labour mobility is consistent with the presence of complementarities between the two institutional dimensions.

Table 6
Multi-level Logistic regressions with contextual effects: predictors of adopters

	Model 11	Model 12	Model 13
Enterprise-level fixed effects			
Intercept	-1.14	-1.13	-1.13
Country-level fixed effects			
MOB	-0.08		
IVTSCND	-0.06		
LLL		-0.05	
IVTFIRM		-0.01	
*MOB * LLL*			-0.92
Random effects			
Intercept	0.13 (.05)	0.13 (.05)	0.13 (.05)
LR test vs logistic regression	Chibar2(01) = 50.82	Chibar2(01) = 52.19	Chibar2(01) = 50.21

*** significant at .01 level; ** .05 level; * .10 level

In the case of the models estimating the likelihood of intermittent innovators (Table 5) there is a positive coefficient on the variable for extended school based systems of initial vocational training (IVTSCND). It is of borderline statistical significance. This can be seen as providing support for the VoC view that well-developed systems of initial vocational training are supportive of strategies of more incremental innovation.

However, this should be qualified by noting that the variable measuring the importance workplace-based systems of vocational training (IVTFIRM), which might be expected to generate a skill mix that is relatively firm-specific, and hence especially suited for incremental innovation, is unrelated to the likelihood of intermittent innovation activity.

Table 7
Multi-level Logistic regressions with contextual effects: predictors of non-innovators

	Model 14	Model 15	Model 16
Enterprise-level fixed effects			
Intercept	-.05	-0.04	-.05
Country-level fixed effects			
MOB	0.87		
IVTSCND	1.02		
LLL		-0.19**	
IVTFIRM		-0.02	
*MOB * LLL*			-.20**
Random effects			
Intercept	0.18 (.06)	0.16 (.05)	0.17 (.05)
LR test vs logistic regression	Chibar2(01) = 143.8	Chibar2(01) = 109.56	Chibar2(01) = 121.1

*** significant at .01 level; ** .05 level; * .10 level

There are no statistically significant results in the regressions accounting for adopters (Table 6). In the models for non-innovators (Table 7) the results tend to go in the opposite direction to those in the regressions for lead innovators. There is a statistically significant negative coefficient on LLL and a statistically significant negative coefficient on the variables for interaction effect between MOB and LLL.

To summarize the results of the econometric exercise, they provide support for the view that labour market and education and training institutions do matter for innovation style and performance. However, these institutions are distributed across the EU-27 in a manner that is inconsistent with the VoC hypotheses concerning institutional complementarities and the distinction between LMEs and CME. Further, the results provide some evidence in support of the view that high level of labour market mobility, which the VoC literature argues is characteristic of LMEs, is complementary to well developed system of life-long-learning, which are a type of institutionally coordinated activity that arguably would be more developed in CME type nations.

4. Radical innovation and managerial style

In the VoC literature the links between fluid labour markets and vocational training systems favouring investments in general over industry-specific skills in LMEs are seen as highly complementary to hierarchical company structures where power is concentrated at the top. This is seen as making it easy for senior management to release labour and implement new business strategies as required for the development of new product lines. (Hall and Soskice, 2001, pp.33 and 40-41).

This vision of the radically innovative firm as a unitary structure with decision-making power concentrated at the top finds little support in the work in strategic management focusing on the internal organisation of creative and innovative firms. For example, the classic taxonomy of Mintzberg (1979) identifies ‘adhocracies’ as the most suitable organisational design for high performance in new emerging technology sectors characterised by rapid changes in technology and products. Such firms depend on relatively decentralised structures that support the autonomous ability of their skilled technical and managerial staff to coordinate their activities through an informal process that Mintzberg refers to as ‘mutual adjustment’. The ability of employees to coordinate in this manner depends on relation-specific knowledge built up through processes of team and enterprise learning that are largely tacit and hence by definition difficult to reproduce in new corporate settings. Some of these relational requirements for success in sectors characterised by radical changes in technology do not sound all that different from the organisational features that Hall and Soskice (1991, p. 39) describe as characteristic of incremental innovators in CMEs.[13]

[13] For research supporting this view of the internal organisation of highly creative enterprises, see: Albrecht and Hall (1991); Amabile, (1988); Amabile, et al. (1996); Kimberly and Evanisko, (1981); Roffe, (1999).

In work carried out with Bengt-Aake Lundvall and other colleagues, we develop survey-based evidence to support the idea that adhocracies perform better that more hierarchically organised firms in developing more radical innovations. In Arundel et al (2007), on the basis of data aggregated at the national level, we show that in nations where work is organised to support high levels of employee discretion in solving complex problems, firms tend to be more active in terms of innovations developed through their creative in house efforts. In countries where learning and problem-solving on the job are more constrained, and little discretion is left to the employee, firms tend to engage in a supplier-dominated innovation strategy. Their technological renewal depends more on the absorption of innovations developed elsewhere. [14]

The VoC view regarding the advantages of hierarchical organisational is closely linked to the idea that radical innovations are strongly competence destroying. Competence destroying in this context refers not only to competences that are specific to a particular firm but also to competences that are specific to a particular technology or class of products and consequently all firms specialised in those products or technologies will be effected. The implied position in the VoC account is that competence destroying nature of radical innovations means that management will rely on generally skilled workers with short-term tenures who are laid-off as required by the implementation of new products lines. Correspondingly, management in radically innovative firms will have little interest in adopting organisational practices designed to foster employee commitment or to build-up employees relation-specific skills.

There are a number of weaknesses with this argument. First, if we work with a general definition of radical innovations as technological discontinuities in the form of new products or processes that are order of magnitude improvements in price/performance (Tushman and Anderson, 1986; Anderson and Tushman, 1990) then there will be variations in the extent to which radical innovations are competence destroying with respect to industry and firm-specific technical skills. For example, in the case of the computers, the first integrated circuit minicomputer developed by Digital Equipment Corporation in 1965 was competence destroying in relation to computers developed on the basis of vacuum tubes. However, subsequent innovations having major impacts on

[14] Also see Holm et al. (2010) and Lorenz and Lundvall (2010).

price/performance, such as the development of semi-conductor memory that was faster than core memory, were competence enhancing (Tushman and Anderson, 1986, p. 454). More generally, if we look a range of innovations that were radical in terms of their impact on price/performance it is easy to identify ones that were competence enhancing. Examples cited by Tushman and Anderson (1986), include the electric for the mechanical typewriter, IBMs 360 series that was based on a synthesis of known technologies, and the introduction of fan jets and the screw propeller which dramatically improved the speed of jets and ocean-going steamships.

Second, even in cases where radical innovations are highly competence-destroying the idea widely developed in the VoC literature that firms operating in the newly emerging industries that these innovations have given rise to will be unconcerned by the loss of existing skilled personnel finds little support in the case-study literature. The history of the production of integrated circuits in Silicon Valley provides a case in point. Transistors which substituted for and were competence destroying in relation to vacuum tubes were invented in 1948 by Bell Lab scientists, including William Shockley who later founded the first semi-conductor firms in Silicon Valley. Transistors substituted for many applications of vacuum tubes and although they were competence-destroying most of the early producers of transistors were electronic firms that produced vacuum tubes, including GE, RCA, Raytheon, Sylvania, Motorola and Texas Instruments. (Klepper, 2007).

Robert Noyce, one of the traitorous eight that founded Fairchild, invented integrated circuits containing many transistors on a substrate of semi-conductor material in 1958. Most early production of integrated circuits used a substrate of germanium. Noyce and scientists at Fairchild developed the planar process using an entire silicon substrate which eventually became the industry standard (Klepper, 2007, p. 5). Subsequent improvements in integrated circuits involved vastly increasing the number of transistors on a single chip, from as few as 10 in 1950s, to hundreds in the 1960s (medium-scale integration) and tens of thousands in the 1970s (large-scale integration).

Following Fairchild's invention of the integrated circuit the number of Silicon chip producers in Silicon Valley rapidly increased. According to the genealogy presented in Klepper (2007) many of these were spin-offs from existing firms and of the 23 spin-offs generated by 1969 eight came out of Fairchild. Further entries, many of them spin-offs of existing enterprises, occurred during the early 1970s, and by 1975 the dominance of Silicon Valley in the production of integrated circuit was established with Silicon valley firms accounting for 38 percent of the market.

The lineage of Silicon Valley producers, with the majority entering the market as spin-offs from established firms in the region, points to the importance of industry specific knowledge for success in what is generally accepted to be a radically innovative sector. The role that the clustering of firms into localised networks played in helping Silicon Valley firms to cope with the problems that labour turnover posed for preserving essential skills also speaks to importance of both industry and firm specific knowledge.

As Lundvall and Lam (2006) have observed, labour market mobility is a two-edged sword for the creative firm. Highly creative firms draw their capability from the diverse know-how and practical problem solving skills embodied in individual experts. Formal professional knowledge may play only a limited role and the expert's problem solving capabilities have more to do with experience and tacit knowledge generated through interaction, trial-and-error and experimentation. Because these tacit skills cannot be easily codified the creative firm faces a problem of reproducing what has been learnt into an organizational memory and is highly vulnerable when it comes to individuals leaving the organisation.

These problems of accumulating and transferring experience-based tacit knowledge take a different form when firms are organised into localised networks and industry clusters as in Silicon Valley. Mobility across organisational borders within industrial clusters contribute to professional and social relationships which provide the 'social capital' and 'information signals' needed to ensure the efficient accumulation and transfer of tacit knowledge in an inter-firm career framework (Saxenian 1996).

Once it is appreciated that highly innovative firms rely on a mix formal professional knowledge and tacit experience-based knowlege, the importance of putting in place appropriate forms of work organisation and personnel practices are easy to understand. This is recognised by Gordon Moore, co-founder of Intel, in a discussion paper analysing the conditions for Silicon Valley's success, clearly points to importance of industry and firm-specific knowledge:

> "Aligning the goals and incentives of the firm with those of the talented individuals whose efforts build a successful firm takes on greater importance in highly technical, skill-intensive firms. The goals of the firm must be clear, and the payoffs for employees certain. The scarcity of these trained scientists and engineers makes them difficult to replace. Moreover, especially in high technology firms, employees quickly develop project- and firm-specific knowledge. When the opportunity to apply that knowledge (outside the current firm) is great – i.e. in most high technology businesses – the costs of mismanaging personnel become greater." (Moore and Davis, 2001, p. 7)

Further, this understanding of the importance of work organisation and personnel management in highly creative firms is directly connected to a key result of the multi-level analysis in Section 3, showing that well developed systems of life-long learning contribute to the forms of innovation characteristic of lead innovators. Both formal and informal forms of life-long learning will prove highly complementary in to the tacit experience-based form on knowledge acquisition underlying expert's problem-solving capacities.

Conclusions

While the VoC approach has the merit of proposing a parsimonious theory of the relation between national institutions and innovation style, it finds little empirical support in comparisons of innovation performance across large populations of nations. Some authors have attempted to account for anomalous cases by arguing that firms are able to distance themselves from the constraints of domestic institutions and that they in fact enjoy much more freedom in the choice of corporate strategy than the VoC approach would allow. Other critics see the empirical evidence going against the VoC thesis as support for the view that institutions do not matter much for innovation style and performance.

In this paper, focusing on the role of labour market institutions and educational and training systems, I support the VoC view that domestic institutions matter for innovation style but I take exception with the VoC account of the relational requirements for radical innovation and the institutional complementarities that best support these requirements. The idea developed in the VoC literature that powerful senior management in radically innovative firms regularly imposes massive layoffs of personnel with general purpose skills in order to develop new products or technologies is a notion that finds little support in the innovation management literature. I have argued to the contrary that radically innovative firms rely critically on managerial practices and decentralised forms of work organisation favouring the acquisition of experience-based and tacit knowledge of the part of experts with industry-specific skills.

These relational requirement in turn help account for the result of the multi-level regression analysis of innovation modes for EU-27 nations showing that nations combining high levels of labour market with institutionally rich systems of life-long learning favouring the renewal of industry and firm-specific skills perform better in developing innovations requiring a high level of in-house capacity for knowledge exploration. While the relevance of this for EU-policy can only be alluded to here, these results provide strong support for key elements of the EU 2020 strategy. In particular, they point to important synergies between the objective of improving the innovative performance of European enterprises and central aspects of the European Employment strategy, including expanding and improving investment in human capital through efficient lifelong learning strategies open to all, and promoting greater flexibility though the use of innovative and adaptable forms of work organisation. These points will be further developed in a subsequent paper focusing more directly on policy analysis.

References

Akkermanns, D., C. Castaldi, and B. Los, (2009), 'Do 'liberal market economies' really innovate more radically than 'coordinated market economies'? Hall and Soskice reconsidered', 2009, *Research Policy,* 38, pp; 181-91.

Albretcht, T. and B. Hall, 1991. 'Facilitation talk about new ideas: The role of personal relationships in organizational innovation'. *Communication Monographs*, 58, 273-288.

Amabile, T. 1988, A model of creativity and innovation in organizations, in Staw, B.M, Cummings, L.L. (eds), *Research in Organisational Behaviour*, JAI Press, Greenwich, CT, Vol. 10 pp.123-67.

Amabile, T., R. Conti, H. Coon, J. Lazenby, and M. Herron, 1996. Assessing the Work Environment for Creativity', *Academy of Management Journal*, Vol. 39, No. 5: 1154-1184.

Aoki, M. (1990) ‘An economic model of the Japanese firm’, *Journal of Economic Literature*, Vol. 28, No. 1, pp. 1-27.

Arundel, A., Lorenz, E, Lundvall, B.-Å. and Valeyre, A. 2007, ‘How Europe’s economies learn: a comparison of work organization and innovation mode for the EU-15’, *Industrial and Corporate Change*, vol. 16, no. 6, pp. 1175-1210.

Busemeyer, M. 2009, ‘Asset specificity, institutional complementarities and the variety of skill regimes in coordinated market economies’, Socio-Economic review, 7,(3) pp. 375-430.

Goldstein, H. 2003. *Multilevel statistical models* (3rd edition). London, Arnold.

Hall, P. and D. Soskice, 2001, *Varieties of Capitalism*, Oxford, Oxford University Press.

Herrmann, A. M., 2008, ‘Rethinking the link between labour market flexibility and corporate competitiveness: a critique of the institutionalist literature’, *Socio-Economic Revie*w, 6, pp. 637-669.

Holm, J. E. Lorenz, B-A. Lundvall and A. Valeyre), 2010“Organisational Learning and Systems of Labour Market Regulation in Europe” (forthcoming), *Industrial and Corporate Change*.

Jensen, M., B. Johnson, E. Lorenz and B-A. Lundvall (2007) “Forms of knowledge and modes of innovation”, *Research Policy*, 36, pp. 680-693.

Johnson, B., E. Lorenz and B-A. Lundvall (2002) “Why all this Fuss about Codified and Tacit Knowledge?”, *Industrial and Corporate Change*, April, pp. 245-262.

Klepper, S. (2007) ‘Silicon Valley – A chip off the old Detroit Bloc’, forthcoming in D. Audretsch and R. Strom (eds.) *Entrepreneurship and Public Policy*, Cambridge, Cambridge University Press.

Lam, A. and B.A. Lundvall, 2006, ‘The Learning Organisation and National Systems of Competence Building and Innovation’ in E. Lorenz and B.A. Lundvall (eds.) *How Europe’s Economies Learn: Coordinating competing models*, Oxford: Oxford University Press.

Lange, K., 2009, Institutional enbeddedness and the strategic leeway of actors: the case of the German therapeutical biotech industry’, Socie-Econbomic Review, 7 (2) pp. 181-208.

Lorenz, E. and Lundvall, B-A. (eds.) 2006. *How Europe’s Economies Learn: Coordinating competing models*, Oxford, Oxford University Press.

Lorenz, E. and Lundvall, B.A. , “Accounting for Creativity in the European Union: A multi-level analysis of individual competence, labour market structure, and systems of education and training”, *Cambridge Journal of Economics*, 2010

Lundvall, B.A. 1992, *National systems of innovation: towards a theory of innovation and interactive learning*, Printer.

Kimberly and Evanisko, 1981. 'Organizational innovation: the influence of individual, organizational, and contextual factors on hospital adoption of technological and administrative innovations', Academy of Management Journal, 24 : 689 – 713

Mintzberg, H. (1979), *The Structuring of Organizations*, Englewood cliffs.

Nelson, R. 1993, *National Innovation Systems*: a comparative analysis', Oxford University Press.

Rasbash, J., F. Steele, W. Browne, and B. Prosser, 2005, *A User's Guide to MLwiN*, Centre for Multilevel Modelling, University of Bristol.

Roffe, I. 1999. 'Innovation and creativity in organisations: a review of the implications for training and development', Journal of European Industrial Training, Vol. 23: 224-241

Saxenian, A. 1996. *Beyond Boundaries: Open Labor Markets and Learning in Silicon Valley*, Oxford, Oxford University Press.

Streeck, Wolfgang. 1991. "On the Institutional Conditions of Diversified Quality Production." In E. Matzner and W. Streeck, (eds.), *Beyond Keynesianism*. Aldershot: Edward Elgar.

Taylor, M. 2004, 'Empirical evidence against Varieties of Capitalism's theory of technological innovation'; *International Organization*, 58, pp. 601-31.

Trajtenberg, M., 1990 A penny for your quotes: patent citations and the value of innovations, *The Rand Journal of Economics*, 21 (1).

Tushman, M. and P. Anderson, 1886, 'Technological discontinuities and organizational environments', *Administrative Science Quarterly*, 13 (3), pp. 439-65.

Annex

Table A1

	MOB	LLL	IVTFIRM	IVTSCND
MOB	1.00			
LLL	.29	1.00		
IVTFIRM	-.03	.08	1.00	
IVTSCND	-.04	.37	.04	1.00

Table A2
Definition of enterprise-level variables

SCTR1	Binary variable equal 1 if sector is manufacturing, equal to 0 otherwise.
SCTR2	Binary variable equal 1 if sector is construction or utilities, equal to 0 otherwise.
SCTR3	Binary variable equal 1 if sector is retail and other services, equal to 0 otherwise.
SCTR4	Binary variable equal 1 if sector is business and financial services, equal to 0 otherwise.
SCTR5	Binary variable equal 1 if sector is other, equal to 0 otherwise.
SIZE1	Binary variable equal 1 if the firm employs 20-49 persons , equal to 0 otherwise.
SIZE2	Binary variable equal 1 if the firm employs 50 to 249 persons, equal to 0 otherwise.
SIZE3	Binary variable equal 1 if the firm employs 250 to 499 persons, equal to 0 otherwise.
SIZE4	Binary variable equal 1 if the firm employs over 249 persons, equal to 0 otherwise.
GRWTH1	Binary variable equal 1 if the firm's annual income growth I positive, equal to 0 otherwise.
GRWTH2	Binary variable equal 1 if the forms annual income growth is negative, equal to 0 otherwise.
GWTH3	Binary variable equal 1 if the firms annual income remains approximately unchanged, equal to 0 otherwise.