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The Influence of Human Resource Management Systems on Innovation: Evidence from Irish Manufacturing and Service Firms

By

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Abstract

The ability of firms to maximise their innovative potential is fundamental to economic growth. The successful implementation of human resource management (HRM) practices is important for firm performance, and there is a growing understanding of the benefits to firms when HRM practices are applied together. We investigate if HRM practices are significantly more effective when implemented as 'bundles' or 'systems' of complementarities than when they are implemented individually in Irish manufacturing and service firms. The National Workplace Survey (2009), a dataset rich with information on HRM practices at the firm level, is employed. HRM bundles relating to performance management and appraisal, knowledge sharing and involvement and empowerment in decision making all are positively associated with innovation in manufacturing and service firms, and bundles of flexible employment contracts practices positively influence innovation in service firms. In summary, HRM practices when applied together, rather than in isolation, are important for firm innovation.

1. Introduction

Academics and policy-makers agree that the ability of countries and firms to maximise their innovative potential is fundamental to long term economic growth (Romer, 1990). However, the innovation process itself has been characterized as 'complex, uncertain and somewhat disorderly' (Kline and Rosenberg 1986), akin to a 'black box' (Fagerberg 2003). Over the last number of decades a substantial body of research has emerged in the area of innovation using the firm as the 'unit of analysis'.

Firm characteristics, such as R&D spend, age, size, sector and ownership, and economic geography have been identified as influential drivers of innovation output, particularly in relation to manufacturing companies (Audretsch and Feldman 1996; Boschma 2005; Gordon and McCann 2005; Jordan and O'Leary 2008; McCann and Simonen 2005; Tether 1998; Romer 1990; Roper, Du, and Love 2008). In general, less attention has been paid to service firms in the innovation literature (Mina, Bascavusoglu-Moreau, and Hughes 2014).[1] However, a growing literature has aided our understanding of the drivers of innovation in service firms. R&D plays a less important role in services than in manufacturing firms (Evangelista 2000; Tether 2003).[2] A number of studies report that service firms rely on information and communications technology and non-R&D innovation expenditure, as well as external knowledge sources (Cainelli, Evangelista, and Savona 2006; Tether and Tajar 2008; Hipp 2010). Tether (2005) reports that service firms collaborate more frequently with their customers and suppliers than their manufacturing counterparts; with evidence that this practice is beneficial for innovation (Leiponen 2005; Mansury and Love 2008; Love, Roper, and Bryson 2011). Many authors highlight the variation between and within individual service sectors; as the service sector encompasses a broad range of activities with different characteristics (Miles 2005; Tether 2002).[3] Some authors claim that the degree of similarity between services and manufacturing firms increases with the level of knowledge intensity, and that knowledge intensive services will innovate in much the same way as high-technology manufacturing firms (Leiponen 2005; Love, Roper, and Bryson 2011). However,

[1] However, the introduction of the Community Innovation Survey (CIS) in the early 1990s provided researchers with service sector indicators (Mina, Bascavusoglu-Moreau, and Hughes 2014).
[2] Although, a study conducted by Leiponen (2012) finds that R&D activities play a similar role in both services and manufacturing innovation.
[3] In general, firms are typically classified as being either manufacturing firms or services firms, but increasingly service provision is becoming a growing component of manufacturing firms' offerings (Chesbrough 2011).

due to data constraints many studies have focused on either manufacturing or services firms making comparisons difficult.

More recently, managerial capabilities have been highlighted as an important factor in firm level innovation. Successful innovation requires that firms and managers provide clear and consistent signals to employees about the goals and objectives of the firm (Barnes et al. 2006). In fact, some studies report that intangibles, such as organisational and human capital factors, are of more importance for service innovation than more tangible assets (Gallouj and Savona 2009; Sirilli and Evangelista 1998; Hipp and Grupp 2005). While there is considerable evidence suggesting that the adoption and implementation of HRM practices influences firm performance; less attention has been paid to examining the influence of such practices on firm innovation outcomes (Baron and Kreps 1999; World Bank 2007). The organisational economics literature highlights that HRM practices are usually implemented as part of a system of HRM practices and the complementary nature of such practices in turn benefits firm performance. However, studies examining the influence of HRM practices on firm innovation tend to focus on one particular HRM practice, such as performance appraisal or team-working. A notable exception is the Laursen and Foss (2003) study which explicitly examines if HRM complementarities benefit firm innovation and reports that HRM practices positively influence product innovation when applied together. Our understanding of the innovation process is by no means complete and there is a need for a greater understanding of how organisational and work place practices influence a firm's ability to innovate. Our paper focuses on the influence of HRM practices on both product and service innovation in manufacturing and service firms. We specifically address the question: do complementary HRM practices positively influence firm-level product and service innovation?

Previous studies, in general, have been constrained to examining the innovation process in manufacturing firms, and often lack data pertaining to management practices. The National Workplace Survey includes data on manufacturing and service firms, and is rich on management practices data, allowing us to examine the HRM practice-innovation outcome link. The dataset collects information on the incidence of product and service innovation at firm level. The dataset is particularly rich on HRM practices information at firm level. We specify two empirical models for our analysis. The first model examines the effect of HRM

practices (in isolation) on the likelihood of a firm introducing an innovation. The second model examines the effect of 'systems' of HRM practices on the likelihood of a firm introducing an innovation.

While the complementary nature of HRM practices is addressed at length in the organisational economics literature (Baron and Kreps, 1999), prior studies of firm innovation appear to lack an appreciation of HRM complementarites. However, a study of Danish manufacturing firms reports that HRM practices positively influence product innovation when applied together (Laursen and Foss, 2003). The authors highlight the need for future work to focus on identifying if there are sectoral regularities in the relationship between HRM practice complementarities and innovation performance. This study adds to this emerging literature and reveals strong support for the importance of HRM complementarities for firm innovation performance in both manufacturing and service firms.

The remainder of the paper is structured as follows. Section 2 discusses the background to the study and presented the study's hypotheses. In Section 3, the data and methods are presented. Section 4 presents the econometric results, and Section 5 provides the conclusion to this paper.

2. Background to Study

Human Resource Management Practices

Numerous scholars have examined the way in which firms manage, empower and reward their employees and the influence of such HRM practices on worker and firm performance. A key premise of this research is that improved performance is a function of interactions between employee ability, informal learning, discretionary opportunities and multitasking (Bratton and Gold 2012). There is considerable disparity in the literature concerning the definition and measurement of Human Resource Management (HRM) practices. Indeed, there is a myriad of new acronyms which attempt to define these integrated, synergistic 'bundles' of HRM practices that are said to augment workplace performance (Bratton and Gold 2012). Suffice to say that, in general, these work practices depart from the traditional work systems

and labour-management relationships which are characterized by tightly defined jobs. Traditional work systems with tightly defined jobs are associated with rates of pay, clear lines of demarcation separating the duties and rights of workers and supervisors, decision-making powers retained by management, and communications and conflicts channelled through formal chains of command and grievance procedures (Ichniowski et al. 2000).

Many firms include an element of performance management in their HRM approach. Performance management refers to a set of interconnected practices designed to ensure that a person's overall capabilities and potential are appraised, so that relevant goals can be set for work and development, and so, through assessment, data on work behaviour and performance can be collected and reviewed. Performance management has a 'control' purpose to aid decisions about pay, promotion and work responsibility, and a development purpose in improving performance, identifying training opportunities and planning action (Bratton and Gold 2012). Performance management can take many forms within a firm and may include training and development, performance review, implementation of an equality/diversity policy and on-going consultation with staff. However, if firms want to elicit desired behaviours from employees, they must provide feedback and incentives within their performance management function that reinforce the desired behaviours (Collins and Clark 2003). Incentive structures, in and of themselves, form an important part of HRM strategies. Employee rewards, or motivation-enhancing work practices, help direct employees' efforts towards the accomplishment of work objectives and provide them with the incentives necessary to engage in high levels of performance. It is generally accepted that it is important to implement an incentive structure that aligns employees' utility functions with the organisation's overall objective (Mendelson and Pillai, 1999). Employee rewards can consist of both pecuniary and non-pecuniary practices (Hayton, 2005).

It is generally accepted that creativity is enhanced if employees are exposed to a broad range of perspectives and information (Nonaka and Takeuchi 1995). Many HRM practices encourage communication, information exchange and mutual learning; all important to the generation of new ideas. Teamwork and networking are two HRM mechanisms for achieving knowledge sharing and frequently are an important tool within a firms battery of HRM practices. In addition, flexible employment contracts can be an important element of a firm's HRM strategy, although many HRM strategy models emphasize the need to build and sustain

committed and capable staff (Grant 1991; Barney 1995; Spender 1996; Newton 1998). Studies of flexible short-term employment contracts have shown that such workers tend not to be as involved in work-related training (Arulampalam and Booth 1998) as their full-time peers; while Davis-Blake, Broschak, and George (2003) report that a 'blended' workforce of standard and non-standard (temporary and part-time) employees negatively affecting the employer-employee relationship.

Many HRM practices centre around employee empowerment allowing employees to address problems and opportunities that arise contemporaneously (Lepak and Snell 1999; Kang, Morris, and Snell 2007), fostering exploratory learning, creativity and innovation (Drucker 1999). Griffin, Neal, and Parker (2007) explain how empowering employees to make relative autonomous decisions regarding the tasks performed and the planning of these tasks increases individual task adaptivity and proactivity. In practice, empowerment practices delegate decision-making authority and responsibility down the hierarchy and facilitate employee participation through upward feedback mechanisms (Subramony 2009). In addition, it is generally accepted that heterogeneity in decision making and problem solving styles produces better decisions through the operation of a wider range of perspectives and a more thorough analysis of issues (Richard 2000). Empirical evidence demonstrates how employee involvement in decision-making enables faster and more effective decision-making by relieving information-processing bottlenecks (Mendelson and Pillai 1999). Employees who benefit from such HRM practices are more willing to engage in extra-role behaviours that serve the interests of the organisation (Maurer, Pierce, and Shore 2002).

HRM practices and Innovation

Our understanding of HRM practices and their influence on firm performance is supported by considerable theoretical and empirical work in the area (Baron and Kreps, 1999). In addition, there is a growing, albeit small, body of scholarly work on the impact of such practices on firm innovativeness. A review of these studies is presented next.

A small number of studies report a positive relationship between performance appraisal and innovation. In a study of 146 Taiwanese firms, Chen and Huang (2009) report the positive

influence of performance appraisal on administrative and technical innovation.[4] Previous studies have also highlighted that positive pressure from performance management and appraisal serves as a critical motivator for staff, and can enhance employees' motivation to engage in innovative activities, with firms achieving favourable innovation outcomes (Jaw and Liu 2003; Jiménez-Jiménez and Sanz-Valle 2005). Multi-functional or cross functional teams, (an important component in the package of new HRM practices) are increasingly considered an important influence on firm innovation performance (Nakata and Im 2010; Gupta and Wilemon 1996; Tidd and Bodley 2002) (Hipp and Grupp 2005). Laursen and Foss (2003) report that such practices allow for better use of local knowledge, which is often held in separate departments or sections, leading to improvements in processes, and to minor product improvements. In addition, knowledge sharing, via networks, provides employees with the opportunity to acquire knowledge from outside the firm. A previous study reports that networks play an important part in determining the probability that Irish plants will be innovative and, to a lesser extent, the success of that innovation (Roper 2001). Employee empowerment affords employees the independence to address problems and opportunities as they arise. Such cooperative behaviours form the basis for, what is termed, entrepreneurial action in organisations (Burgelman 1983). In a study of product innovation by Dutch firms, Beugelsdijk (2008) reported that job autonomy significantly and positively influenced both incremental and radical innovation.

While flexible employment contracts are increasingly common, their role in the innovation process remains unclear. Pavitt (1991) asserts that innovation is dependent on attracting, building and nurturing key capabilities. The resulting argument from such an assertion is that employees will be prepared to contribute discretionary effort and to carry the risks involved in innovation only if they have a sense of security in their employment (Storey et al. 2002). In addition, this feeds into the idea of innovation being 'path dependent' and as such emerges from prior experimentation and learning (Storey et al. 2002). According to such models, the erosion of these conditions through the use of short-term, temporary and part-time employment contracts would undermine the capability of an organization to innovate. So the short-term cost advantages from contingent contracts may be off-set by hindering capabilities for new ideas and innovation. On the other hand, some authors have argued that looser

[4] However, it should be noted that Chen and Huang (2009) reported that performance appraisal did not positively influence knowledge acquisition, sharing or application.

employment relationships may have positive implications for firm innovation (Adams and Brock 1986). This hypothesis stems from three very different logics. One is that diverse contracting practices enable and support continual accessing of new ideas, new attitudes and new perspectives. While the other logic is that flexible employment policies exert a discipline upon labour which counteracts complacency and rigidity. In addition, a third argument is that through the use of contingent contracts, firms have the opportunity to gain access to an array of diverse skills and experience, which perhaps could not be afforded on a full-time permanent basis (Storey et al. 2002). Using a large-scale survey and detailed case studies, Storey et al. (2002) found that employers in manufacturing and service firms rarely use flexible employment practices as a strategic lever to achieve innovation. Storey et al. (2002) report that short-term contracts were used to meet fluctuations in production, to reduce fixed labour costs or to access services which were difficult to secure through a permanent employment contract. However, a Dutch study reports that the fraction of employees with flexible working hours positively influences radical innovation, although the relationship is insignificantly with respect to incremental innovation (Beugelsdijk 2008). In addition, a negative association is reported for standby contracts and radical innovation (Beugelsdijk 2008).

In brief, there is a growing body of evidence highlighting favourable innovation outcomes for firms with HRM practices. For instance, performance appraisal has been shown to positively influence firm innovation (Chen and Huang, 2009; Jaw and Liu 2003; Jiménez-Jiménez and Sanz-Valle 2005), multi-functional teams have also been shown to benefit firm innovation (Gupta and Wilemon 1996; Hipp and Grupp 2005; Nakata and Im 2010; Tidd and Bodley 2002), as have networks (Roper, 2001). In addition, job autonomy has been identified as a a positive input for innovation, both radical and incremental (Beugelsdijk, 2008). However, the case is less clear with respect to flexible employment contracts (Beugelsdijk, 2008; Storey et al, 2002).

Complementary HRM practices and Innovation

The studies discussed above, while by no means definite, highlight the importance of HRM practices for innovation. However, most studies have focused on one or a small number of

HRM practices rather than appreciating the complementary nature of many of these HRM practices which are rarely, in practice, adopted in isolation. For example, if a firm involves employees in decision-making with respect to investment decisions or product innovation, but does not empower employees with freedom and power to choose tasks and pace of work, such consultative decision-making is not likely to be effective in influencing performance (Baron and Kreps, 1999). Likewise, team wok practices could prove disastrous if employees do not have the incentives to optimise the organisational objective function (Mendelson and Pillai, 1999). HRM practices can build an environment that is supportive of cooperation, promotes the development of human and social capital, and therefore encourages organisational learning (Hayton, 2005). While the complementary nature of HRM practices is addressed at length in the organisational economics literature (Baron and Kreps, 1999), few studies explicitly examine if HRM complementarities benefit firm innovation. Laursen and Foss (2003), in a study of Danish manufacturing businesses, report that HRM practices positively influence product innovation when applied together. In addition, the National Centre for Partnership and Performance (NCPP) in Ireland also examined the impact of workplace practices on innovation performance, reporting a positive association when firms employ a number of workplace practices (NCPP, 2009).[5] A study of firm innovation in transition economies reported that complementary HRM practices positively influence innovation output relative to no HRM practices. (Bourke and Crowley, 2015).

Strategically, firms do not always adopt an individual HRM in isolation. Indeed, a crucial element in firms' strategic decision-making is the identification and effective harnessing of complementarities between different managerial activities, optimising resource use (Milgrom and Roberts, 1990, 1995). It is generally accepted that there is no one or two 'magic' HRM practices that will stimulate worker and business performance and rather it is complementary bundles of HRM practices that give rise to superior output and quality performance (Bratton and Gold 2012). A priori, and in line with Laursen and Foss (2003), we expect HRM practices to be more conducive to innovation outcomes when adopted, not in

[5] It should be noted that the NCPP study focused on private and public organisations, and did not control for differences across manufacturing and service firms.

isolation, but as a system of mutually reinforcing practices. This expectation is empirically tested in the following sections.

3. Methodology

As hypothesised above, it is expected that HRM practices when applied together, will be more conducive to innovation outcomes than when implemented individually. Hence, it is expected that firms employ 'systems' of complementary HRM practices within the firm. Consequently, the objective of the paper is to see if bundles of management practices employed together have a significant association with firm innovation, than when they are implemented individually. Based on the discussion in the theoretical section, the probability of introducing an innovation is specified as follows:

$$\mathrm{Y}_{Ii} = \begin{cases} 1 \; if \; \mathrm{Y}_{0i}^{*} = \alpha_1 + \mathrm{HRM}_{\iota}\alpha_2 + \mathrm{X}_{0i}\alpha_0 + \epsilon_{0i} > 0 \\ 0 \; if \; \mathrm{Y}_{0i}^{*} = \alpha_1 + \mathrm{HRM}_{i}\alpha_2 + \mathrm{X}_{0i}\alpha_o + \epsilon_{0i} \leq 0 \end{cases} \quad (1)$$

Where Y_{0i}^{*} is a latent decision variable measuring the decision of a firm to introduce an innovation and γ_{Ii} is the corresponding observed binary variable being 1 for firms that introduce an innovation and 0 for firms that do not introduce an innovation. HRM is related to the application of different management practices individually and X is a set of other variables explaining differences in innovation intensity across firms. The variables included in the vector X are standard variables in the literature aiming to explain innovation performance such as firm size (Pavitt *et al.* 1987, Tether, 1998, Crepon *et al.* 1998), and technology intensity as a proxy for R&D investment (Jaffe, 1986; Hatzichronoglou, 1997 Crepon *et al*., 1998; Freel, 2003; Griffith *et al*., 2008; Roper *et al*., 2008). ε_{0i} is the error term for equation (1).

$$\mathrm{Y}_{Ii} = \begin{cases} 1 \; if \; \mathrm{Y}_{0i}^{*} = \alpha_1 + \mathrm{HRMB}_{\iota}\alpha_2 + \mathrm{X}_{0i}\alpha_0 + u_{0i} > 0 \\ 0 \; if \; \mathrm{Y}_{0i}^{*} = \alpha_1 + \mathrm{HRMB}_{i}\alpha_2 + \mathrm{X}_{0i}\alpha_o + u_{0i} \leq 0 \end{cases} \quad (2)$$

Next, we run this model again, but rather than including individual HRM practices as a vector, we include proxies of HRM bundles as denoted as HRMB in equation (2). u_{0i} is the

error term for equation (2). We employ standard probit models for equations (1) and (2) and report their marginal effects.

We use a form of factor analysis – namely principal component analysis (PCA), to reduce the broad set of practices to 'bundles'. The PCA method estimates linear combinations of the underlying variables (Table 3), which in this case are indices of various HRM practices (Table 4) that explain the highest possible fraction of the remaining variance in the dataset (Laursen and Foss, 2003). The first principal component is estimated to explain the highest possible fraction of the total variance. The second principal component is estimated to explain the highest possible fraction of the total variance that is not explained by the first, and so forth, until the explained residual variance in each round is maximised.[6] The HRM indicators (outlined later in the data section) are discrete in this study. There is no consensus on using PCA on binary data, specifically because standard methods of performing factor analysis (i.e., those based on a matrix of Pearson's correlations) assume that the variables are continuous and follow a multivariate normal distribution. To overcome this issue, we do not use the 'raw' binary data for the PCA analysis, but transform the variables and make them smooth (see Laursen and Foss, 2003). To do this, we employ a polychoric correlation matrix[7] on the underlying data for the discrete management practices (see UCLA, 2015 for more details on this approach) making the variables suitable for PCA analysis. Following Laursen and Foss (2003), an economic interpretation of the sets of factor loadings from the PCA analysis is that the typical pattern is one in which some of the HRM practices play a major role in the configuration of the factor. We interpret each of the factors as a HRM practice system that is more strongly representative of some HRM practices over other HRM practices.

4. Data

The data employed in this paper stems from the employers data of the National Workplace Surveys of 2009. The National Workplace Employer's Survey captures the perspectives and experiences of employers during the most severe downturn experienced since the beginning of the Irish State. The data provides information on the characteristics of firms and most importantly for this study, the incidence of product and service innovation and detailed

[6] In the case of this study the number of factors is limited to four.
[7] We use the user-written command polychoric in STATA 14.

information on HRM practices for 1,981 Irish firms. This sample comprises 519 manufacturing and 1,462 service firms. The surveys were collected by three collaborating institutions: Economic and Social Research Institute (ESRI); Amárach Research; and the National Centre for Partnership and Performance (NCPP). The surveys from employers were collected by means of a national postal and web survey in the first half of 2009 (NCPP, 2009). The sampling frame for the private sector survey was developed by the ESRI from a number of sources, but predominantly used information collected from the Data Ireland database of firms and organisations in Ireland (NCPP, 2009). The sample was stratified according to size and sector. In this study the unit of analysis is the organisation and the sampling frame was employed to reweight the data for analysis so that it was fully representative of the full population of all employers.[8]

[Table 1 and 2 about here]

The innovation variables used in this paper are indicators of product and service innovation in manufacturing and service firms. Firms are defined as innovators if they have introduced a new or significantly improved product and/or services. This is similar to how Schumpeter (1934) originally conceived product/service innovation where he stated, the entrepreneur is the catalyst of innovation in our society and innovation is the result of entrepreneurial discovery in the market place, which results in new products.[9] The definition of the variables employed in this study and their corresponding descriptive statistics are presented in Tables 1 and 2. Almost 76 per cent of manufacturing firms introduced a product or service innovation and 65 per cent of service firms introduced a new or upgraded service or product. 7 per cent of manufacturing firms are categorised as high tech and 74 per cent of service firms are categorised as highly knowledge intensive.[10] 59 per cent of manufacturing firms and 64 per cent of service firms indicated the downturn as being a crucial factor influencing change within the firm. The majority of firms within the sample are small to medium sized firms.

[Table 3 about here]

[8] Some observations needed to be dropped from the analysis as there were missing values associated with some responses to the employment of management practices. The re-weighting takes these missing observations into account.

[9] It would have been helpful to take into account other kinds of innovations, particularly technological process innovations. The survey does not ask a question on technological process innovations (i.e new machinery to improve production). Hence, it is not possible to account the potential bias of unoberserved innovation activity that arises when product service innovators are also process innovators.

[10] As defined by NACE REV.2 Technology Intensity Definition in Table A1 of the Appendix.

Our focus now turns to the incidence of HRM practices in Irish manufacturing and service firms. Table 3 lists the types of HRM practices that are employed within firms in the manufacturing and service industries. Information to and consultation with staff on the change within the company, staff training and development and incentive schemes were the most commonly employed practices in manufacturing and service firms. The use of agency workers and formal partnership agreements are the least employed practices in manufacturing and service firms, respectively. The incidence of firms employing a HRM practice is high with only 2 per cent of the sample recording a zero implementation of any of the listed management practices. Hence, the use of management practices is high, although evidently (from Table 3) this varies considerably by practice type.

[Table 4 about here]

The sets of factor loadings for each factor are presented in Table 4, which represent the factor loadings for manufacturing and service firms respectively. When the two aforementioned tables are compared they broadly exhibit similar factor loadings. For instance, the first factor (HRMB1) for both manufacturing and service firms broadly exhibit bundles of performance management and appraisal indicators, where the factor is dominated predominately: by staff training and development for managers/employees; formal staff performance review; formally agreed in-house dispute resolution procedures; and incentive schemes. The second factor (HRMB2) for both manufacturing and service firms broadly exhibit bundles of knowledge sharing indicators, where the factor is dominated predominantly by: new work practices such as team working/multi-tasking/quality circles; arrangements for employees to work across divisions or sectors within the organisation; arrangements for staff to work on projects with employees of other firms or organisations (networking); arrangements for employees to experiment with new ways of carrying out their work; making the organisation less hierarchical; and increasing the managerial/supervisory role. The third factor (HRMB3) broadly exhibits bundles of involvement and empowerment in decision-making indicators, where this factor is predominantly dominated by: arrangements for direct involvement of employees in decision making and problem solving; employee discretion in the way their work is organised or carried out; arrangements for work-life balance for employees; information to and consultation with staff on change in the company; and information to and

consultation with staff on the business context. The fourth factor (HRMB4) broadly exhibits bundles of flexible employment contract indicators, where this factor is predominantly dominated by: use of part time staff; use of agency workers and use of other temporary labour/contract staff.

Following this PCA analysis, we use this information to predict four indicators (newly constructed variables i.e factors) that represent systems of HRM practices that broadly constitute (1) performance management and appraisal, (2) knowledge sharing, (3) involvement and empowerment in decision-making and (4) flexible employment contracts. The mean coefficient scores are presented in Table 4.[11] These systems of HRM indicators are identified as being complementary following the discussion in the theoretical section. We now address the principle objective of this paper.

5. Results

The empirical estimations of our models are presented in Table 5. All four estimations are significant. Model's A and C in Table 5 represent the empirical estimation that examines the effect that individual HRM practices have on the likelihood of firms innovating for manufacturing and service firms respectively. Model's B and D in Table 5 represent the empirical estimations that examine the effect HRM bundles have on the likelihood of firms innovating for manufacturing and service firms. All models contain the same control variables.

The principle objective of this paper is to examine whether HRM practices are significantly more effective when implemented as 'bundles' or 'systems' of complementarities than when they are implemented individually. The individual effect of 25 HRM practices were examined, and only seven of the HRM practices were found to be significant for manufacturing firms and only five were found to be significant for services (see models A

[11] The min and max of the mean coefficient scores are also presented in Table 2 of the Appendix. A high coefficient score within the min and max represents a high level of bundling. The coefficients do not produce any real meaningful interpretation. However, their sign is important in identifying if combining practices has a positive or negative effect on the likelihood of a firm innovating. The factors for the manufacturing industry explain 71 per cent of the total variance observed and the factors for the service industry explain 87 per cent of the total variance observed

and C).[12] However, when these HRM practices are combined into HRM bundles (systems), these synergistic proxies are significant at the five per cent level for both manufacturing and service firms. The only exception is the flexible employment contract bundle for manufacturing firms. Hence, the pattern being presented suggests that HRM practices are better implemented as part of a system than individually. As highlighted in the methodology section, the underlying work practices for each factor (HRM bundle) appear intuitively to be natural complementarities.

HRMB1 which is a proxy in this study for the umbrella of performance management, incentive and appraisal indicators has a significantly positive association with the firm's likelihood of innovating. This supports the contention that HRM practices implemented to appraise performance and incentivise performance will lead to improved firm performance ((Brattin and Gold, 2012; Mendelson and Pillai, 1999; Hayton, 2005). Sharing information, sharing learning experiences and communicating with others in the workforce are important for generating ideas (Nonaka and Takeuchi, 1995) and employee involvement in decision making leads to faster and more effective decisions (Mendelson and Pillai, 1999). Our empirical results also support the viewpoint with the knowledge sharing bundle of indicators exhibiting a positive association with firm innovation. HRMB3 which represents a bundle of involvement and empowerment in decision making indicators also has a positive effect on the likelihood of firms innovating. Again, this is not surprising as the literature indicates that firms that enable increased empowerment and involvement of workers in the decision-making process results in greater levels of exploration, creativity and innovation in the firm (Drucker, 1999).

However, not all the systems of HRM practices have a positive association with firm innovation. The bundle representing flexible employment contracts has a positive association with firm innovation for service firms but no association with innovation for manufacturing firms. This lack of significance for manufacturing firms perhaps is not that surprising as previous studies argue the importance of building a workforce that is committed and capable (Grant, 1991; Barney, 199; Splender; 1996 and Newton, 1998). Having a blended workforce

[12] Three of the HRM practices were only significant at the 10 per cent level.

can negatively affect a firm's performance (Davis-Blke, Broschak and George, 2003). In addition, if we accept the contention that innovation is 'path dependent' and emerges from prior experimentation and learning (Storey et al. 2002); then a HRM strategy of flexible contracts is likely to inhibit innovation. Interestingly, HRMB4 (flexible employment contracts) was found to be important for innovation in service firms. Given the lack of consensus in the literature on the impact of flexible contracts on innovation this results is not altogether surprising. Adams and Brock (1986) contend that looser employment relationships may have positive implications for firm innovation. Our results highlight the contrasting impact of flexible contracts on innovation in manufacturing and service firms.

Another key difference is that more individual HRM practices were associated with innovation for manufacturing firms than for service firms (as identified in models A and C). This seems to indicate that when HRM practices are implemented independently in manufacturing firms that they have more of an effect than when they are implemented independently in service firms. Perhaps, implementing HRM practices as a 'system' is even more important for service firms if they are to have any effect at all on innovation.

Our attention now turns to the control variables. Larger firms are more likely to innovate. This is not surprising as the innovation indicator is discrete and it is not possible to know the number of innovations introduced per firm. It is expected that larger firms would be introducing more innovations and therefore more likely to introduce an innovation (as a function of the measurement of innovation used in this study). The technology intensity of firms does not seem to exhibit any clear associations with innovation. There are also no differences identified for domestic/foreign or multi/single plant operators. Manufacturing firms that stated the downturn as a key catalyst for change were more likely to innovate and service firms that stated customers as key catalyst for change were more likely to innovate.

6. Conclusion

In this paper we examine the association between HRM practices and innovation in a sample of Irish manufacturing and service firms. Our research question was to examine if

complementary HRM practices positively influence firm-level product and service innovation. We employed an extremely rich dataset on HRM practices for our analysis. The data was from the Irish National Workplace Survey (2009) which also collected data on firm characteristics, firm performance indicators and firm responses to changes in the business environment. The main emphasis of this paper is empirical and builds on previous work such as that completed by Laursen and Foss (2003).

We applied PCA analysis to identify bundles of HRM patterns that were emerging at firm level. Surprisingly, the bundles identified were very similar across manufacturing and service firms. Furthermore, the underlying HRM practices configuring each bundle were intuitively closely related and strongly complementary. We identified four HRM bundles: performance management and appraisal; knowledge sharing; involvement and empowerment in decision making; and flexible employment contracts. All four of these bundles were positively associated with innovation in service firms and three were positively associated with innovation in manufacturing firms. We conclude that HRM practices when applied together are important for firm innovation. In addition, since the HRM bundles were nearly all significant when applied together and most of the HRM practices when examined independently were insignificant – we found strong support for the importance of HRM complementarities for firm performance.

Laursen and Foss (2003) highlighted the need for future work to focus on identifying if there are sectoral regularities (or not) in the relationship between HRM practice complementarities and innovation performance. We clearly identify that the patterns are extremely uniform between HRM complementarities and the effect they have on innovation in manufacturing and service firms. Furthermore, the technological intensity indicators (low/high tech etc) do not indicate any clear differences. Hence, it appears from these results that HRM practices when applied together will have a positive effect on firm innovation across both manufacturing and service firms regardless of their technological intensity. Notwithstanding the contribution of this paper, more research on the relationship between complementary HRM practices and innovation is required, particularly in identifying the optimal ‘system’ or ‘bundle’ of HRM practices for enhancing innovation outcomes. Such research would have

considerable managerial implications in terms of organising the HR function to stimulate innovation.

This study is not without its limitations. While the results indicate that employing ‘bundles’ of HRM practices is conducive to innovation, we are constrained by the cross-sectional nature of the data. This limits the complexity of our analytical approach, particularly as we have no historical information on the changing HRM characteristics of the firms themselves. Clearly, panel data would be preferable to allow for the possibility of the lagged impact of HRM practices on innovation. A further limitation of the paper is that it is unknown how widespread a HRM practice is in each firm, in other words, we have no measure of intensity of implementation. Our data is limited to whether the HRM practice is implemented in the firm or not. Of course, it could be argued that the degree to which they are implemented will have a bearing on the likelihood of firms innovating and the quality of that innovation. The impact of this may differ across different types of HRM practices. Future research in this area would benefit from panel data, as well as a measure of intensity of HRM practice implementation.

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Table 1: Variable Descriptions

Dependent variable
Product or service =1 if firm introduced new or significantly improved products or services in the last two years, 0 otherwise.
Independent variables
Firm Characteristics
Log of Employment (2008)=log of the number of full-time employees in the business in the surveyed year.
Domestic =1 if respondent states the firm is best described as being irish owned, 0 otherwise.
Multi-plant firm=1 if the firm has more than one outlets or branches in Ireland, 0 otherwise. *Innovations in other subsidiaries are not taken into account.
Low-tech=1 if the firm is categorised as being in the low technology industry (manufacturing) category outlined in Table 2, 0 otherwise.
Low-medium tech=1 if the firm is categorised as being in the low-medium technology industry (manufacturing) category outlined in Table 2, 0 otherwise.
Medium-high tech=1 if the firm is categorised as being in the medium-high technology industry (manufacturing) category outlined in Table 2, 0 otherwise.
High-tech=1 if the firm is categorised as being as being in the high technology industry (manufacturing) category outlined in Table 2, 0 otherwise.
Low knowledge intensive
Services= 1 if the firm is categorised as being in the low knowledge intensive services category outlined in Table 2, 0 otherwise.
Knowledge intensive
Services= 1 if the firm is categorised as being in the high knowledge intensive services category outlined in Table 2, 0 otherwise.
Downturn effect=1 if the firm highlighted the downturn as an intense pressure for change in the company, 0 otherwise
Competition effect =1 if the firm highlighted competition from other firms as an intense pressure for change in the company, 0 otherwise.
Customer effect =1 if the firm highlighted demands from customers as an intense pressure for change in the company, 0 otherwise.
Employee effect =1 if the firm highlighted increasing demands for changes in the workplace from employees as an intense pressure for change in the company, 0 otherwise.

Source: NCCP 2009a National Workplace Survey Data.

Table 2: Descriptive Statistics of Firm Characteristics for Manufacturing and Service Firms

	Manufacturing	Services
Variable	Mean	Mean
Innovation	75.91	65.38
Domestic	70.5	88.5
Multiplant	20.61	30.32
Log of Employees	3.62	3.05
High Knowledge Services	N/A	74
Low Tech Manufacturing	33.14	N/A
Low-Medium Tech Manufacturing	30.82	N/A
Medium-High Tech Manufacturing	28.9	N/A
High Tech Manufacturing	7.12	N/A
Pressure for Change: Downturn	58.95	63.74
Pressure for Change: Competition	32.94	24.07
Pressure for Change: Customers	15.22	14.84
Pressure for Change: Employee	21.96	18.28

Source: NCCP 2009a National Workplace Survey Data.

Table 3: Descriptive statistics of Human Resource Management Practices for Manufacturing and Service Firms

Human Resource Management Practices	Manufacturing Mean	Services Mean
Arrangements for direct involvement of employees in decision making and problem solving	62.62	63.06
Employee discretion in the way their work is organised or carried out	66.09	68.74%
Formal partnership agreement involving unions and employees	19.85	10.12%
Informal partnership style arrangements between management and employee representatives	39.31	29.41%
Use of part time staff	56.65	70.65%
Use of agency workers	15.41	8.75%
Use of other temporary labour/contract staff	38.15	29.68%
Explicit policy on equality/diversity in the workplace	65.90	61.62%
Arrangements for work-life balance for employees	51.25	54.71%
Information to and consultation with staff on change in the company	79.96	77.42%
Information to and consultation with staff on the business context	69.75	68.19%
Formally agreed in-house dispute resolution procedures	68.98	63.26%
Temporary lay-offs or involuntary reduction in working	53.37	41.72%
Flexible working times	61.66	65.59%
Staff training and development for managers	75.92	72.02%
Staff training and development for employees	76.11	78.59%
Formal staff performance review	59.54	58.48%
New work practices such as team working/multi-tasking/quality circles	46.82	43.84%
Arrangements for employees to work across divisions or sectors within the organisation	59.73	55.19%
Arrangements for staff to work on projects with employees of other firms or organisations (networking)	27.55	21.61%
Arrangements for employees to experiment with new ways of carrying out their work	52.41	46.51%
Making the organisation less hierarchical	51.83	47.40%
Increasing managerial/supervisory role	42.39	41.17%
Incentive schemes (Either regular increment, profit sharing, company bonus schemes, individual bonus, non-monetary incentives, employee share options, gain sharing, team bonuses, merit/performance related pay)	68.79	67.57%

Source: NCCP 2009a National Workplace Survey Data.

Table 4: Factor Loadings of Human Resource Management Practices for Manufacturing and Service Firms

	Manufacturing				Services			
Management Practice	**HRMB 1**	**HRMB 2**	**HRMB 3**	**HRMB 4**	**HRMB 1**	**HRMB 2**	**HRMB 3**	**HRMB 4**
Arrangements for direct involvement of employees in decision making and problem solving	0.1186	0.2727	0.6698	0.0559	0.1515	0.3600	0.5961	-0.0062
Employee discretion in the way their work is organised or carried out	-0.2903	0.3089	0.5991	0.1558	0.0110	0.4363	0.4152	-0.1354
Formal partnership agreement involving unions and employees	0.6869	-0.1306	-0.0483	0.0307	0.3899	-0.2073	0.0871	0.4858
Informal partnership style arrangements between management and employee representatives	0.3218	0.0732	0.1386	0.0182	0.2869	0.0998	0.3427	0.2720
Use of part time staff	-0.1038	0.0628	0.1555	0.682	0.1426	0.1636	0.1382	0.4784
Use of agency workers	0.2909	0.0252	0.0406	0.8238	0.1869	-0.0577	0.0465	0.7798
Use of other temporary labour/contract staff	0.2202	-0.0107	0.0334	0.7793	0.0724	0.1589	0.0774	0.8054
Explicit policy on equality/diversity in the workplace	0.6251	0.1281	0.2676	0.2858	0.4402	0.1885	0.3482	0.3848
Arrangements for work-life balance for employees	0.2127	0.2258	0.5855	0.2399	0.2008	0.4414	0.4986	0.2029
Information to and consultation with staff on change in the company	0.4657	0.2223	0.6801	-0.0122	0.2513	0.1805	0.8318	0.1179
Information to and consultation with staff on the business context	0.4486	0.2063	0.646	0.0496	0.2865	0.0928	0.7872	0.0522
Formally agreed in-house dispute resolution procedures	0.6525	0.1778	0.1149	0.1354	0.5202	0.1631	0.2563	0.3359
Temporary lay-offs or involuntary reduction in working	0.06	0.3264	-0.2696	0.1129	0.1552	0.1564	-0.0174	0.2641
Flexible working times	-0.1342	0.4451	0.2994	0.2102	0.0327	0.4762	0.2548	0.1741
Staff training and development for managers	0.7097	0.3433	0.1432	0.2799	0.8307	0.1653	0.2175	0.1759
Staff training and development for employees	0.609	0.3237	0.3176	0.2219	0.8053	0.2467	0.2452	0.0845
Formal staff performance review	0.59	0.2701	0.2923	0.1274	0.6361	0.1506	0.2532	0.1603

Table 4: Factor Loadings of Human Resource Management Practices for Manufacturing and Service Firms (continued)

	Manufacturing				Services			
Management Practice	**HRMB 1**	**HRMB 2**	**HRMB 3**	**HRMB 4**	**HRMB 1**	**HRMB 2**	**HRMB 3**	**HRMB 4**
New work practices such as team working/multi-tasking/quality circles	0.4015	0.5752	0.2259	0.0929	0.5122	0.5401	0.1993	0.0951
Arrangements for employees to work across divisions or sectors within the organisation	0.2071	0.627	0.1816	0.0743	0.4188	0.5498	0.1781	0.1611
Arrangements for staff to work on projects with employees of other firms or organisations (networking)	0.1608	0.6781	0.1715	-0.0981	0.2882	0.5478	0.1816	0.1739
Arrangements for employees to experiment with new ways of carrying out their work	0.1082	0.8021	0.276	-0.0035	0.2879	0.6997	0.2043	-0.0350
Making the organisation less hierarchical	0.1955	0.6374	0.2044	0.1015	0.4117	0.5566	0.3052	0.0279
Increasing managerial/supervisory role	0.1887	0.3694	0.0001	0.0961	0.5133	0.2903	0.0575	-0.0077
Incentive schemes (Either regular increment, profit sharing, company bonus schemes, individual bonus, non-monetary incentives, employee share options, gain sharing, team bonuses, merit/performance related pay)	0.5616	0.0838	0.0559	0.2393	0.3894	0.0085	0.3443	0.2219
Cumulative per cent	0.229	0.423	0.582	0.7118	0.2783	0.4816	0.6961	0.8671
Coefficient score (means)	0.379	0.519	0.590	0.223	0.468	0.308	0.686	0.170

Notes

1. HRMB represents human resource management practice bundles.
2. After running the factor analysis, the factors were rotated to get a clearer pattern of the underlying variables in each factor. The rotation is varimax which produces orthogonal factors. This setting is helpful to create indexes or new variables without inter-correlated components.
3. The factors for the manufacturing industry explain 71 per cent of the total variance observed. The factors for the service industry explain 87 per cent of the total variance observed.
4. New variables were created that produce the regression coefficients to estimate the individual scores.

Table 5: Probit regressions explaining product/service innovations

	Manufacturing (519 firms)		Services (1613 firms)	
	Model A	Model B	Model C	ModelD
Firm Size (log of employees)	0.060***	0.054***	0.036***	0.038***
Multiplant	0.012	0.002	-0.047	-0.038
Domestic	0.033	0.035	0.010	-0.011
High knowledge intensive services			-0.007	0.014
High Technology Intensity	0.023	0.053		
Medium-high technology Intensity	-0.129***	-0.106**		
Medium-Low technology Intensity	-0.049	0.054		
Downturn effect	0.071*	0.088**	0.042	0.035
Competition effect	-0.005	-0.002	-0.000	-0.0033
Customers effect	-0.004	0.018	0.101***	0.086***
Employees effect	-0.069	-0.095*	0.023	0.0224
Arrangements for direct involvement of employees in decision making and problem solving	0.122***		0.054*	
Employee discretion in the way their work is organised or carried out	0.097**		-0.031	
Formal partnership agreement involving unions and employees	-0.065		0.029	
Informal partnership style arrangements between management and employee representatives	-0.003		-0.000	
Use of part time staff	0.037		0.002	
Use of agency workers	0.016		0.053	
Use of other temporary labour/contract staff	-0.152***		0.036	
Explicit policy on equality/diversity in the workplace	-0.021		0.042	
Arrangements for work-life balance for employees	-0.092**		0.000	
Information to and consultation with staff on change in the company	0.0		0.055	
Information to and consultation with staff on the business context	-0.011		-0.005	
Formally agreed in-house dispute resolution procedures	-0.027		-0.021	
Temporary lay-offs or involuntary reduction in working	0.065		-0.011	
Flexible working times	0.023		-0.031	
Staff training and development for managers	0.085		-0.031	
Staff training and development for employees	0.066		0.056	
Formal staff performance review	-0.005		0.013	
New work practices such as team working/multi-tasking/quality circles	0.029		0.005	

Table 5: Probit regressions explaining product/service innovations (continued)

Arrangements for employees to work across divisions or sectors within the organisation	0.027		0.055*	
Arrangements for staff to work on projects with employees of other firms or organisations (networking)	-0.056		0.045	
Arrangements for employees to experiment with new ways of carrying out their work	0.090**		0.120***	
Making the organisation less hierarchical	0.084**		0.055*	
Increasing managerial/supervisory role	-0.029		0.012	
Incentive schemes	0.103**		0.098***	
HRMB1 (Performance management and appraisal)		0.086**		0.169***
HRMB2 (Knowledge sharing)		0.271***		0.166***
HRMB3 (Involvement and empowerment in Decision-making)		0.162***		0.238***
HRMB4 (Flexible employment contracts)		0.019		0.101**
No of observations	519	519	1462	1462
LR chi^2	99.21	62.53	196.3	163.94
Prob>chi^2	0.000	0.000	0.000	0.000
Log Pseudo-likelihood	-226.284	-246.327	-843.542	-860.547

Notes

1. Variables with *** are significant at 1% level, ** are significant at 5% level and * are significant at 10 % level.
2. Standard errors are not reported but are available from authors on request.
3. Low tech manufacturing firms and low knowledge intensive firms are the reference categories.
4. HRMB represents human resource management practice bundles.
5. The results presented are marginal effects

Appendix

Table A1: NACE REV.2 Technology Intensity Definition

MANUFACTURING

Low technology Industries

Manufacture of furniture; wood and of products of wood, paper and paper products; printing and reproduction of recorded media (excluding 18.2); Food products, beverages and tobacco, textiles, wearing apparel, leather and related products.

Medium-Low technology industries

Building and repairing of ships and boats; repair and installation of machinery and equipment; manufacture of rubber and plastics products, other non-metallic mineral products and basic metals; fabricated metal products (except machinery and equipment and weapons and ammunition); coke, refined petroleum products; reproduction of recorded media (18.2).

Medium-High technology industries

Manufacture of chemicals and chemical products (excluding pharmaceuticals); weapons and ammunition;
machinery and equipment, n.e.c.; motor vehicles; trailers and semi trailers; other transport equipment (excluding ships, boats, air and spacecraft and related machinery); medical and dental instruments and supplies.

High technology industries

Manufacture of Aircraft and spacecraft and related machinery; basic pharmaceuticals products and pharmaceutical preparation; computer, electronic and optical products.

SERVICES

Knowledge Intensive Services

Water transport, air transport; publishing activities, motion picture, video and television programme production, sound recording and music publishing activities, programming and broadcasting activities, telecommunications, computer programming, consultancy and related activities, information service activities; financial and insurance activities; legal and accounting activities, activities of head offices; management consultancy activities, architectural and engineering activities; technical testing and analysis, scientific research and development, advertising and market research, other professional, scientific and technical activities, veterinary activities; employment activities; security and investigation activities; Public administration and defence, compulsory social security, education, human health and social network activities, arts, entertainment and recreation.

Less Knowledge Intensive Services

Wholesale and retail trade; repair of motor vehicles and motorcycles; land transport and transport via pipelines; warehousing and support activities for transportation, postal and courier activities; accommodation and food service activities; real estate activities and leasing activities; travel agency, tour operator reservation service and related activities; services to buildings and landscape activities; office administrative, office support and other business support activities; activities of membership organisations, repair of computers and personal and household goods, other personal service activities; activities of households as employers of domestic personnel; undifferentiated goods – and services – producing activities of private households for own use, activities of extraterritorial organisations and bodies.

Source: Eurostat Indicators of High Tech Industry and Knowledge Intensive Services, January, 2014

Table A2: Descriptive Statistics of HRMB coefficient scores

Type	Obs	Mean	SD	Min	Max
Manufacturing					
HRMB1	519	0.379	0.546	-1.498	2.151
HRMB2	519	0.519	0.413	-0.394	1.473
HRMB3	519	0.590	0.536	-1374	2.341
HRMB4	519	0.223	0.542	-1.396	2.092
Services					
HRMB1	1,462	0.468	0.377	-0.619	1.356
HRMB2	1,462	0.308	0.399	-0.667	1.336
HRMB3	1,462	0.686	0.384	-0.462	1.459
HRMB4	1,462	0.170	0.317	-0.453	1.153