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Abstract

How do personnel practices affect firm performance? To examine this issue we use a panel of over 1,500 New Zealand firms, drawn from a diverse range of industries. The panel comprises respondents to official surveys of management practices in 2001 and 2005. These surveys ask a wide range of comparable qualitative questions covering organisational practices including human resource management (HRM). To this panel, we link longitudinal firm performance data from Statistics New Zealand's Longitudinal Business Database. We find that suites of complementary HRM-related practices impact positively on firm productivity and wages; effects on employee turnover depend on the practices considered.

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Disclaimer

This research uses data that was accessed while Richard Fabling was on secondment to Statistics New Zealand in accordance with security and confidentiality provisions of the Statistics Act 1975. Only people authorised by the Act are allowed to see data about a particular business or organisation. The results of this work have been confidentialised to protect individual businesses from identification. The analysis and interpretation of these results were undertaken while the authors were at the Reserve Bank of New Zealand and Motu, respectively. The opinions, findings, recommendations and conclusions expressed in this report are those of the authors. Statistics New Zealand, the Reserve Bank of New Zealand, Motu and the University of Waikato take no responsibility for any omissions or errors in the information contained here.

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1 Introduction

We examine the relationship between human resource management (HRM) practices and firm performance. Our main concern is to identify whether changes in work place organisation contribute to productivity growth in the New Zealand economy. We also consider how any prospective productivity gains are shared between workers and owners of capital. Our analysis extends the international literature and establishes a robust causal link between HRM practices, and firm and worker outcomes. In particular, the breadth of industry coverage contrasts with many prior studies that concentrate solely on manufacturing firms. We find that – at least in the case of New Zealand – manufacturing, service and other sectors all benefit from adopting high-performance work practices.

Our findings leverage off the strengths of the available data. Firstly, we have a relatively large panel dataset with a four year gap between observations of consistently-measured HRM and other business practices. This gap is useful because management practices exhibit strong persistence over time (eg, Black and Lynch 2004; Ichniowski and Shaw 1995) and our identification of causal effects relies on observing changes in firm-level behaviour. Our data comes from official mandatory Statistics New Zealand (SNZ) surveys ensuring response rates of over 80 percent. Further, our panel attrition rate is relatively low (Fabling 2007a).

Second, our performance metrics are estimated separately from the management practice survey and are constructed using the universe of firms in the population, so that we can consider detailed industry production functions and control for inter-industry differences – an important issue given our diverse industry coverage. Our main population restriction relates to firm size, but even in this regard our cut-off of six employees is much lower than most studies.

Third, our sample surveys have detailed questions on a wide array of practices outside the area of HRM. It is plausible that arguments about the importance of bundles of HRM practices could also extend to these broader areas of practice. For example, Osterman (1994) finds that adoption of high-performance work practices is closely associated with strategic choices regarding quality and customer service. Our data allows us to control for such factors directly – determining the impact of personnel practices in the presence of the adoption of general "good" business practices. These factors also help control for aspects of business operations – such as having capable managers – traditionally left to firm-fixed effects.

Finally, we consider the effect of HRM and other business practices on multiple performance metrics, including firm productivity and worker outcomes. To investigate this latter issue, we make use of the Linked Employer-Employee Dataset (LEED) – derived from firm and employee tax data – and consider the impact of organisational change on average wages and the rate of "excess" employee turnover.

Section 2 provides a short literature review that motivates our model (presented in Section 3). Section 4 briefly outlines the contents of the prototype Longitudinal Business Database (LBD) including the management and performance variables. Section 5 presents panel fixed effects regression results demonstrating that adoption of a suite of high-performance work practices is positive for firm productivity and worker compensation, and reduces staff turnover. Section 6 concludes by reiterating the strengths of the dataset and our key findings.

2 Motivation

High-performance work practices are generally thought to include compensation practices (including performance pay), training, worker autonomy, hiring policies, teamwork, and job rotation (Wood 1999; Godard 2004; Lazear and Shaw 2007; Boxall and Purcell 2008). The personnel economics literature has burgeoned on the back of detailed case studies of individual firms undertaking organisational change (eg, Lazear 2000; Shearer 2004); small-scale comprehensive industry studies (eg, MacDuffie 1995; Ichniowski et al 1997), and broader surveys of HRM practices and firm performance (eg, Black and Lynch 1996, 2001, 2004; Cappelli and Neumark 2001). This body of work has consistently found connections between moves towards these high-performance practices, better firm performance and/or higher wages for workers (Lazear and Shaw 2007, and Pfeffer 2007 provide recent reviews of the field).

Evidence suggests that adoption of new capital equipment and increases in human capital were important components of US productivity growth over the mid-1990s (Nickell and Nicolitsas 2000; Abowd et al 2007). Within that context adoption of personnel practices has been cited as an important factor in aggregate productivity growth (eg, Black and Lynch 2004) and as providing a complementary role in the ICT "revolution" (eg, Bresnahan et al 2002; Bartel et al 2007). Furthermore, in the US at least, changes in the relative demand for skills has widened the earnings distribution "... but also is likely to reflect changes in human resources practices" (Lazear and Shaw 2007).

Some studies indicate the importance of differentiating the impact of various workplace practices on increasing total firm rents through increased productivity, and the distribution of those rents between owners and employees (Freeman and Lazear 1995; Lazear 2000). For example, Freeman and Kleiner (2005) follow a US shoe manufacturer that shifted from piece rates to time rates (that is, away from high-performance work practices) and experienced decreasing productivity but increasing profitability. Other recent studies have focussed on worker outcomes, particularly changes in average wages, the within-firm distribution of wages, staff turnover and welfare as potentially being affected by choices of personnel practices (eg, Osterman 2000; White et al 2003; Bauer and Bender 2004; Black et al 2004; Harley et al 2007).

The importance of utilising a suite of employee practices has been emphasised in a number of studies (Kochan and Osterman 1994; Milgrom and Roberts 1995; MacDuffie 1995; Ichniowski et al 1997; Kandel and Lazear 1992; Kruse et al 2003). Ichniowski and Shaw (2003) discuss complementarities between implementation of incentive schemes and more general HRM innovations. These include the importance of avoiding free-rider behaviour on the part of some employees (in group incentive schemes) and encouraging individuals to expand their horizons to problem-solving across the firm. In the latter case, employees are expected to multi-task, so employee management and incentive systems need to be more complex relative to systems in traditionally managed firms (Holmstrom and Milgrom 1994).

On the basis of hypotheses from the HRM and personnel economics literature, we test whether the adoption by firms of a suite of "high-performance" employee practices has beneficial effects on their performance relative to that of firms that do not adopt such a suite of practices.

3 The model

To formalise expectations of how suites of HRM practices affect firm performance and worker outcomes, consider a generalised production function incorporating quality differences across firms in each of output[1] and labour

[1] Output quality may be tangible (eg, products with more features) or intangible (eg, brand names).

(for simplicity, capital is assumed to be homogeneous[2]). Output prices depend on the perceived quality of outputs relative to those of competitors; thus we are dealing with a monopolistically competitive market as in Syverson (2004). We denote quantities of firm i's output, labour input and capital input as Y_i, L_i and K_i respectively; the quality (productivity) of labour as λ_i and the quality of output as ν_i. The efficiency parameter, A_i, is assumed to be a function of a vector of firm characteristics, $A(\mathbf{C}_i)$, where $\mathbf{C}_i$ may include such factors as age and sector, as well as underlying management capability within the firm. We normalise variables so that $E(A_i) = E(\lambda_i) = E(\nu_i) = 1$ with A_i, λ_i, $\nu_i > 1$ (< 1) indicating superior (inferior) quality relative to the average across all firms. The generalised production function for each firm is of the form

$$\nu_i Y_i = f[A_i, \lambda_i L_i, K_i] \tag{1}$$

where the first partial derivative of f with respect to each argument is positive.

The output price (q_i) received by firm i is a function of output quality (ν_i)

$$q_i = q(\nu_i), \qquad \frac{dq}{d\nu_i} > 0. \tag{2}$$

The quality of labour input is determined by the innate quality of workers employed by the firm, denoted S_i; and a vector of J human resource management practices, $\mathbf{P}_i = (P_{1i}, \ldots, P_{ji}, \ldots, P_{Ji})$, with higher values corresponding to adoption of "higher performance" work practices. Thus labour productivity is given by

$$\lambda_i = \lambda(\mathbf{P}_i, S_i), \qquad \frac{\partial \lambda}{\partial S_i} \geq 0, \frac{\partial \lambda}{\partial P_{ji}} \geq 0 \quad \forall j. \tag{3}$$

Further, we assume that S_i is a function of the wage offered by the firm, w_i, relative to the market average wage (which is suppressed for clarity)

$$S_i = S(w_i), \qquad \frac{dS}{dw_i} \geq 0 \tag{4}$$

Combining (3) and (4)

$$\lambda_i = \lambda'(\mathbf{P}_i, w_i), \qquad \frac{\partial \lambda'}{\partial w_i} \geq 0, \frac{\partial \lambda'}{\partial P_{ji}} \geq 0, \frac{\partial^2 \lambda'}{\partial w_i \partial P_{ji}} \geq 0 \quad \forall j \tag{5}$$

[2] Fabling and Grimes (2007) assume that the quality of capital also varies across firms; however for the purposes of this paper, the variation in product quality and labour quality is sufficient to establish our results. The results nevertheless hold for the more complex specification with variable capital quality.

The first two partial derivatives in (5) follow naturally from (3) and (4). The assumption regarding the third set of partial derivatives is based on findings that high-performance work practices are most effective where workers utilise problem-solving skills to increase productivity (eg, Bresnahan et al 2002). Thus, firms with higher quality workers (ie, with higher S_i and w_i) will obtain greater benefit from employing certain HRM practices within $\mathbf{P}_i$. For cross-country evidence that this may be the case see Bloom and van Reenan (2007).

In addition to being important for physical productivity, worker quality and HRM practices may also be important for product quality, ν_i, and hence product price, q_i. Thus, in an analogous fashion to (5), we have

$$q_i = q'(\mathbf{P}_i, w_i), \qquad \frac{\partial q'}{\partial w_i} \geq 0, \frac{\partial q'}{\partial P_{ji}} \geq 0, \frac{\partial^2 q'}{\partial w_i \partial P_{ji}} \geq 0 \quad \forall j. \tag{6}$$

The firm maximises profit, Π_i, through its choices of HRM practices, wage rates and quantities of labour and capital. Profits equal revenue less factor costs paid to employees and owners of capital, and less other costs borne by the firm including costs of implementing HRM practices, h_i, given by

$$h_i = h(\mathbf{P}_i), \qquad \frac{\partial h}{\partial P_{ji}} \geq 0 \quad \forall j. \tag{7}$$

Profits will also be reduced by "employee turnover" costs – that is, the costs of hiring (and severing) workers, denoted m_i. The firm's rate of employee turnover is hypothesised to be reduced through adoption of high-performance work practices and also by offering higher wages. Thus

$$m_i = m(\mathbf{P}_i, w_i), \qquad \frac{\partial m}{\partial w_i} \leq 0, \frac{\partial m}{\partial P_{ji}} \leq 0 \quad \forall j. \tag{8}$$

Combining all influences on profitability, firm profits

$$\Pi_i = q'(\mathbf{P}_i, w_i) f[A(\mathbf{C}_i), \lambda'(\mathbf{P}_i, w_i) L_i, K_i] - w_i L_i - r K_i - h(\mathbf{P}_i, w_i) - m(\mathbf{P}_i, w_i) \tag{9}$$

are maximised with respect to L_i, K_i, w_i, $\mathbf{P}_i$, taking firm characteristics $\mathbf{C}_i$, the cost of capital r, and the functional forms of q', f, A, λ', h and m as given.[3]

Given the relationships embedded in the functions, as indicated by the partial derivatives above, we hypothesise that the following reduced form features

[3] We assume that these functions yield interior solutions.

Table 1
Observations by industry and year

Industry (ANZSIC division)		2001	2005	panel
A	Agriculture, forestry and fishing	285	870	123
B	Mining	45	60	30
C	Manufacturing	936	1,626	492
D	Electricity, gas and water	0	15	0
E	Construction	96	429	51
F	Wholesale trade	267	636	168
G	Retail trade	126	468	81
H	Accommodation, cafes and restaurants	132	270	57
I	Transport and storage	114	393	72
J	Communication services	54	111	30
K	Finance and insurance	159	399	102
L	Property and business services	300	1,497	171
N	Education	63	189	48
O	Health and community services	120	426	69
P	Cultural and recreational services	60	246	36
	TOTAL	**2,757**	**7,635**	**1,530**

Throughout the paper counts of firms are random-rounded to base three to comply with Statistics New Zealand confidentiality requirements. Panel industry based on 2005 ANZSIC (very few panel firms change ANZSIC division).

will hold with respect to the influence of HRM practices on firm outcomes. First, we expect that an increase in (at least some elements of) $\mathbf{P}_i$ will result in higher (multi-factor and labour) productivity, and/or higher product quality (with associated higher output price). Owing to the complementarity between innate worker quality and high-performance work practices, we also hypothesise that an increase in $\mathbf{P}_i$ will be associated with higher average wages and higher quality workers in the firm. Both the increase in $\mathbf{P}_i$ and the associated increase in w_i will decrease employee turnover. Each of these hypotheses is testable with our longitudinal firm-level data.

One complication in testing the impact of particular HRM practices on firm performance is that there is a considerable literature indicating that "bundles" of high-performance work practices are more effective in lifting performance than is the introduction of isolated practices (Lazear and Shaw 2007 provide a good summary). Accordingly, and in the absence of an explicit theory as to how the components of $\mathbf{P}_i$ interact, we test for the impact of bundles of high-performance practices.

Another complication in testing hypotheses in this field is that the adoption of high-performance HRM practices will likely be positively correlated with adoption of other business practices. For instance, firms with good planning processes may be those most likely also to adopt high-performance HRM practices. A rigorous analysis must therefore be able to control for the adoption of other general management practices (and firm characteristics) that are separate from, but potentially correlated with, the HRM practices that are being tested. Our data are rich enough to control for a broad set of general management practices. A third complication is that optimal HRM practices may vary across sectors. For instance, practices that may be most effective in services may differ from those in manufacturing (eg, because objective assessment of individual output may be harder to assess for certain types of tasks). The breadth of our data enables us to test separately for manufacturing and for services firms in addition to tests for the entire economy.

4 Data

Our analysis uses responses to official Statistics New Zealand surveys of management practices in 2001 and 2005.[4] These surveys ask a wide range of comparable qualitative questions covering practices in the areas of: leadership, planning, customer and supplier relations, human resource management, quality and process monitoring, benchmarking, and innovation. Both surveys are stratified on industry and employment, with broad industry coverage and a minimum firm size of six employees. Excluded industries are Electricity, Gas and Water; Government Administration and Defence; Libraries, Museums and the Arts; Sport and Recreation; and Personal and Other Services.[5] Because both surveys are mandatory, response rates are over 80 percent. The unit of observation is the enterprise (hereafter "the firm").[6] We use these data in a pooled cross-section with a total of 10,392 responses,[7] and as a panel of 1,530 observations. Table 1 sets out the size of the sample by one-digit industry in each year.[8] Of particular note, we have

[4] The Business Practices Survey and Business Operations Survey respectively.

[5] Electricity, Gas & Water; and Sport & Recreation were surveyed in 2005, but not 2001.

[6] In most cases firms have a single plant – only 28 percent of responses relate to firms with multiple employing plants, of which roughly a third have at least 80 percent of their employment in a single plant.

[7] The number of observations goes up markedly in 2005 due to a combination of an increased requirement for statistical accuracy in aggregate outputs and some strata being over-sampled relative to this accuracy requirement.

[8] Using the Australia New Zealand Standard Industry Classification (ANZSIC) system.

a manufacturing panel of almost 500 firms and an even larger panel of firms from service industries, allowing us to separately test our findings for those sectors.

4.1 Human resource management variables

The HRM variables cover a wide range of topics, incorporating variables relating to management engagement with staff (CONSULT and VALUES); the level of autonomy granted to non-management employees (SUPPLY_AUTON and QUAL_AUTON); TRAINING; performance measurement and reward (PERF_REVIEWS and PERF_PAY); and the attention management gives to the firm's HRM performance (FIRM_HR_PERF). The precise definition of these variables is listed in table 2 together with weighted mean responses by year for the population. Each variable is a binary constructed by aggregating qualitative responses so that the estimated proportion of the population with positive responses are as close to 0.5 as possible. By construction most practices have quite stable incidence rates (at the aggregate level) over the period.

Table 3 shows the rate of adoption or cessation of practices for firms in the panel. There are many transitions in and out of each practice with 62-80 percent of firms maintaining consistent individual practices over the four year period. These figures closely mirror Black and Lynch (2004), who find persistence rates of 66-80 percent over a three year period for a panel of US manufacturers. Overall, the net change in practices is mildly negative in many cases, which is reasonably consistent with the stability of the measured economy-wide uptake rates presented in table 2. If anything, our model would suggest a tendency to find net positive adoption rates in the panel (relative to the aggregate economy) since having good HRM practices is expected to improve firm performance and, thus, reduce attrition. The fact that we do not observe such a bias gives us more confidence that we can interpret our panel results as being applicable to a wider group of firms.

Compared to the population, firms in the panel have materially higher participation in performance reviews and performance pay.[9] A high rate of initial participation, coupled with relatively high rates of retention makes it

[9] Specifically, the participation rates in 2001 (2005) can be derived by adding values in the second and third (first and third) columns of table 3. For PERF_REVIEWS, 77.2 (79.6) percent of firms had the practice in 2001 (2005), compared to around 63 percent in the whole economy (table 2). For PERF_PAY the equivalent numbers are 59.8 (61.8) percent in the panel for 2001 (2005), compared with 43.1 (40.9) percent over all firms.

Table 2
Human resource management questions and mean responses

Variable	Question (BOS)	Responses	$\mu(01)$	$\mu(05)$
CONSULT	*In developing goals, how often does this business incorporate the requirements of employees? (4-point scale + "don't know")*	*"Never", "Sometimes", "Frequently"=0; "Always"=1*	0.372	0.308
VALUES	*To what extent does this business promote a set of company values to its employees? (4-point scale + "don't know")*	*"Not at all", "A little amount", "A moderate amount"=0; "A great deal"=1*	0.456	0.453
SUPPLY_AUTON	*When supply problems arise, do this business's non-managerial staff have the authority to contact external suppliers? (3-point scale + "don't know")*	*"Never", "Sometimes"=0; "Always"=1*	0.301	0.248
FIRM_HR_PERF	*During the last two financial years, to what extent did this business focus on human resources (eg job satisfaction, skill development) when assessing [business] performance? (4-point scale + "don't know")*	*"Not at all", "A little amount"=0; "A moderate amount", "A great deal"=1*	0.666	0.658
PERF_REVIEWS	*Over the last financial year, what percentage of employees in this business had formal performance reviews (consistent methods that are recognised and regularly used)? (6-point scale + "don't know")*	*"Zero"=0; Otherwise=1*	0.632	0.627
PERF_PAY	*What percentage of employees in this business are on "pay for performance" schemes (eg productivity based incentives, profit sharing, bonuses, etc)? (6-point scale + "don't know")*	*"Zero"=0; Otherwise=1*	0.431	0.409
TRAINING	*Over the last financial year, please estimate the percentage of employees in this business who participated in training (5-point scale + "don't know")*	$\leq 50\%$ *of staff trained=0;* $> 50\%$ *of staff trained=1*	0.472	0.395
QUAL_AUTON	*Are non-managerial staff actively encouraged to identify problems in goods, services or processes? Are non-managerial staff actively encouraged to suggest improvements to goods, services or processes? (4-point scales + "don't know")*	*"Not at all", "A little amount", "A moderate amount"=0; "A great deal"=1*	0.598	0.711

Means (μ) calculated using population weights excluding "don't know" and missing responses.

Table 3
Human resource management practice transitions

	Adopted	Dropped	Unchanged	
HRM variable	$[0 \rightarrow 1]$	$[1 \rightarrow 0]$	$[1 \rightarrow 1]$	$[0 \rightarrow 0]$
CONSULT	0.138	0.247	0.152	0.464
VALUES	0.195	0.164	0.303	0.338
SUPPLY_AUTON	0.145	0.181	0.132	0.542
FIRM_HR_PERF	0.192	0.162	0.493	0.153
PERF_REVIEWS	0.113	0.089	0.683	0.115
PERF_PAY	0.131	0.111	0.487	0.271
TRAINING	0.156	0.197	0.272	0.375
QUAL_AUTON	0.247	0.135	0.467	0.151

Unweighted analysis excluding "don't know" and missing responses.

potentially harder to identify causal effects from adopting performance management practices for at least two reasons. Firstly, the methodology we adopt (a panel fixed effects regression) identifies causal effects off firms changing practices – having fewer observations of firms changing behaviour makes it harder to pin down the coefficient of interest. Second, early adopters of good HRM practices are likely to be those more motivated to change – that is, those with higher returns to adopting.

To test whether the adoption of a suite of HRM practices affects firm performance, we need to construct a measure that captures how these practices occur together. Faced with a similar challenge, Bloom and van Reenan (2007) construct a raw management score (a simple average for each of their 18 practices) for each firm and, alternatively, use a factor analytic approach (using the first two factors). Their results are similar across the two approaches. We adopt a variant of the latter approach, since we wish our measures to reflect the revealed preference of firms in the way that they combine complementary work practices. Our approach entails performing a principal components analysis on the individual HRM variables (using the population-weighted pooled cross-sections), retaining factors with eigenvalues greater than one. Table 4 presents the weights on each of the three principal components that this process generates.[10] We label these variables HRM_GENERAL, HRM_PERF and HRM_AUTON respectively, reflecting the underlying component weights. Individual HRM practices with weights of at least 0.3 are presented in bold in table 4. HRM_PERF has high weights accorded to individual performance reviews and performance pay;

[10] These three factors capture 64 percent of the variation in the underlying variables.

Table 4
HRM principal component weights

Variable	HRM_GENERAL	HRM_PERF	HRM_AUTON
CONSULT	**0.347**	-0.264	-0.157
VALUES	**0.435**	-0.213	-0.090
SUPPLY_AUTON	0.175	0.180	**0.847**
FIRM_HR_PERF	**0.452**	-0.183	-0.195
PERF_REVIEWS	**0.369**	**0.446**	-0.279
PERF_PAY	0.181	**0.759**	-0.068
TRAINING	**0.349**	0.048	0.006
QUAL_AUTON	**0.406**	-0.205	**0.360**

Principal components calculated on the pooled cross-sections using population weights and tetrachoric correlation matrices ("don't know" and missing responses excluded on a pairwise basis).

HRM_AUTON has high weights on autonomy to contact suppliers, and to identify problems and suggest improvements to product quality. By contrast, HRM_GENERAL displays less variation in weights. The weighting patterns within these three principal components accord with our maintained hypothesis that firms adopt certain groupings of HRM practices that reflect complementarities between specific human resource practices.

To control for general business practices, we similarly construct a set of twenty-two principal components (labelled "General Factors") from a set of non-HRM business practices spanning a wide range of topics.[11]

We can now provide some tentative evidence as to why many firms drop individual practices (table 3). Table 5 reports marginal effects from probit regressions estimated over firms that initially had each individual practice, where the dependent dummy variable equals one if the practice was dropped. We regress this dummy on 2001 values of performance variables,[12] all other individual HRM practices, General Factors and industry dummies.

[11] The general business factors capture 91 percent of the variation in the underlying variables. Appendix A lists the questions that form the General Factors. We do not seek to separately interpret results for these controls, rather only reporting whether they are jointly significant.

[12] We exclude labour productivity from these regressions because of its high correlation with multi-factor productivity and the log average wage.

Table 5
Correlates of the decision to drop individual practices

	CONSULT	VALUES	SUPPLY_AUTON	FIRM_HR_PERF	PERF_REVIEWS	PERF_PAY	TRAINING	QUAL_AUTON
Multi-factor productivity	-0.001	0.007	-0.019	0.044	0.062***	0.116***	0.119	-0.041
	[0.098]	[0.068]	[0.094]	[0.048]	[0.020]	[0.037]	[0.076]	[0.048]
Log average wage	0.125	-0.092	-0.444***	-0.095	-0.052**	-0.261***	-0.173	-0.045
	[0.120]	[0.105]	[0.159]	[0.071]	[0.023]	[0.060]	[0.116]	[0.069]
"Excess" employee turnover	0.069	-0.050	0.052	-0.119	-0.022	-0.066	0.005	-0.116
	[0.228]	[0.179]	[0.294]	[0.121]	[0.042]	[0.087]	[0.190]	[0.114]
CONSULT		-0.265***	-0.104	-0.156***	-0.016	-0.067*	-0.103	-0.101**
		[0.065]	[0.101]	[0.046]	[0.016]	[0.038]	[0.069]	[0.043]
VALUES	-0.218***		-0.054	-0.055	-0.019	-0.006	-0.125*	-0.036
	[0.081]		[0.100]	[0.049]	[0.018]	[0.041]	[0.072]	[0.046]
SUPPLY_AUTON	0.064	-0.060		0.071	0.015	-0.035	0.079	0.040
	[0.075]	[0.063]		[0.050]	[0.019]	[0.038]	[0.074]	[0.049]
FIRM_HR_PERF	-0.201**	0.050	-0.004		-0.065**	-0.039	0.015	-0.078
	[0.096]	[0.083]	[0.104]		[0.030]	[0.046]	[0.088]	[0.059]
PERF_REVIEWS	-0.048	0.070	-0.137	0.011		0.050	0.111	0.025
	[0.137]	[0.083]	[0.117]	[0.062]		[0.043]	[0.104]	[0.064]
PERF_PAY	-0.085	0.139**	0.127	0.086*	-0.058**		0.094	0.057
	[0.098]	[0.066]	[0.109]	[0.047]	[0.028]		[0.076]	[0.042]
TRAINING	0.011	-0.066	-0.079	0.038	-0.050***	-0.040		0.014
	[0.077]	[0.064]	[0.097]	[0.044]	[0.018]	[0.041]		[0.046]
QUAL_AUTON	0.158	0.039	0.026	-0.109**	0.020	0.042	-0.131	
	[0.098]	[0.069]	[0.104]	[0.054]	[0.013]	[0.041]	[0.080]	
N	249	303	201	417	417	369	303	396
Pseudo-R^2	0.253	0.206	0.272	0.176	0.397	0.233	0.219	0.170
Industry joint test	0.011	0.000	0.000	0.106	0.001	0.270	0.023	0.000
GF joint test	0.238	0.443	0.011	0.022	0.002	0.090	0.040	0.034

Marginal effects probit regressions estimated on the panel sub-population having each practice in 2001. Dependent variable is a dummy equal to one if the practice is dropped in 2005. All right-hand side variables are 2001 values. All regressions include (unreported) industry dummies and General Factors (p-values for joint tests of significance reported). Robust standard errors in brackets. ***; **; * denotes significance at the 1%; 5%; 10% level.

Focusing firstly on the initial performance variables, firms that pay higher average wages are less likely to drop practices. This is consistent with our model, where successful implementation of HRM practices attracts better (higher paid) workers. At the same time, however, higher productivity firms appear more likely to drop PERF_REVIEWS and PERF_PAY. At least in the case of PERF_PAY, the coefficient on multi-factor productivity becomes insignificant if the wage variable is dropped from the regression.

The coefficients on individual HRM practices are generally consistent with interpreting the principal components as suites of complementary work practices.[13] For example, CONSULT, VALUES and FIRM_HR_PERF have high positive weights in HRM_GENERAL and negative weights in the other two principal components (table 4). We interpret the weights as implying that these practices play a complementary role to each other, and that the payoff to firms is highest when all three practices are performed together (since firms tend to practice them together). Table 5 shows that firms are more likely to drop the CONSULT practice if they do not have VALUES and similarly for FIRM_HR_PERF. Not having CONSULT raises the probability of dropping VALUES and FIRM_HR_PERF. Similarly, PERF_REVIEWS are less likely to be dropped if PERF_PAY is in place. In other words, firms tend to drop practices if they do not also have the practices that tend to be observed together in other firms (ie, the complementary practices in the suite).[14]

Why do firms adopt sub-optimal bundles of practices in the first place? Perhaps it is simply that managers experiment with different HRM settings in search of the optimal suite of practices. This interpretation is consistent with (unreported) results examining the characteristics of firms adopting practices, where we find little systematic relationship between having HRM practices and adopting complementary practices.[15] Thus managers may have some *ex post* ability to deduce what has or hasn't worked for their firm, but be less able *a priori* to determine the best way to combine individual HRM practices.

[13] Since the principal components are derived from the full (population-weighted) cross-section of firms they are unlikely to be driven by the HRM practices of the panel.

[14] There is some ambiguity in this interpretation deriving from the fact that the inferred complementarity of some practices varies depending on which principal component weights are focussed on – eg, comparison of FIRM_HR_PERF and PERF_REVIEWS weights in HRM_GENERAL and HRM_PERF. For this reason, we focus the discussion on practices that are consistently related across all three principal components.

[15] An alternative interpretation of this non-result might be that firms simultaneously adopt all the components of the appropriate suite so that prior HRM practices shouldn't be expected to predict the uptake of new practices.

4.2 Quantitative firm performance variables

Quantitative firm performance data come from SNZ's prototype Longitudinal Business Database (LBD). The LBD consists primarily of administrative data collected by government departments. We make use of firms' goods and services tax (GST) returns and financial accounts (IR10) provided by the Inland Revenue Department (IRD); and information on employers and employees aggregated to the firm level (from IRD via LEED). These data are linked together using the Longitudinal Business Frame (LBF), which tracks firm characteristics over time. We also use SNZ's Annual Enterprise Survey (AES) in the construction of productivity measures. These components of the database are briefly discussed below.[16]

As its name suggests, the LBF is a product of SNZ's sampling frame and contains longitudinal information (eg, industry, ownership type, and sector) on a comprehensive population of firms.[17] The frame tracks legal units over time so that, from an economic perspective, there is a certain level of false entry and exit in the firm data.[18] This is the first research paper using New Zealand data that makes use of longitudinal plant identifiers to correct false entry and exit *at the firm-level* – an approach that yields an additional 84 firms for the panel analysis.[19]

AES is SNZ's primary data source for the production of National Accounts, and as such is the benchmark dataset for estimation of value-added. The survey is full coverage for large firms with a stratified sample survey for smaller firms. It has industry-specific questions in order to accurately measure gross domestic product.

[16] Fabling (2009) provides a more detailed account of the contents of the LBD.

[17] Because GST data is used to help maintain the frame for small firms, there exists a natural floor (the mandatory GST filing threshold at NZ$40,000 GST sales) below which coverage of the database is limited.

[18] For example a partnership that incorporates may be treated as an entrant and assigned a new enterprise identifier despite the lack of any change to activity, location or ownership. For cross-sectional sampling of firms this presents no issues, however our results rely on our ability to construct a panel. Fortunately, in the LBF, SNZ goes to great effort to repair plant-level links using, among other things, individual worker employment patterns to identify continuing plants (Kelly 2003). The identified plant-level links in turn suggest many candidate firm-level repairs (Fabling 2007b).

[19] This is a significant proportion of the total panel size, and so it is important to have confidence in the quality of the repaired links. A list of potential repairs was constructed using a rule based on at least one plant moving from a BPS firm to a BOS firm. Because of the small pool of candidates, it was possible to then manually use business name, location, industry, and contact person details, together with analysis of other plant and employment movement to eliminate false positives from the simple match.

GST data include information on sales and purchases of goods and services. In this paper, we use the Business Activity Indicator (BAI), which is derived from the raw GST data, primarily through the apportionment of group filings to individual firms.[20]

Together with the BAI data, IR10s are used to construct productivity measures for firms not in AES. An IR10 return is a set of company accounts comprising a profit and loss statement and a balance sheet. Consequently IR10s include information on sales (and other income) and purchases, as well as a detailed breakdown of expenditure including depreciation and rental and leasing costs. Balance sheet items include fixed assets broken into vehicles; plant and machinery; furniture and fittings; land and buildings; and other.

LEED is constructed by SNZ using IRD tax data, notably Pay-As-You-Earn (PAYE) returns for employees. LEED variables in the LBD have been aggregated to the firm-level. Variables available in this manner include counts of employers (on an annual basis) and employees (on a monthly basis) with matching data on income gained from employment within the firm. Summary characteristics of individuals also include gender and age breakdowns, tenure distributions of employees,[21] and summary measures of the dispersion of wages within the firm.[22]

This paper focuses on a small number of performance variables derivable from the above sources, namely multi-factor productivity (based on a Cobb-Douglas production function with potentially non-constant returns to scale); labour productivity; log of the average wage; "excess" employee turnover; and an average worker fixed effect, proxying for worker quality. All performance metrics, aside from employee turnover, are estimated by aggregating over two consecutive years to reduce potential measurement error.[23] Linking of the firm performance data causes us to lose some observations because we

[20] GST data is collected at different frequencies, depending on the size of the firm filing, so that BAI processing also temporally apportions down to a monthly frequency. However, since we re-aggregate this data to the financial year, we are most likely unwinding this apportionment (IRD recommends that firms choose a GST filing cycle synchronised with their financial year).

[21] We use accessions and separations in this paper, because tenure data is heavily left-censored in early years. Accessions and separations are summarised at the firm level using data underlying official statistics that exclude transitory employment.

[22] We examined whether HRM practices had an effect on the distribution of within-firm wages, however, there was no apparent effect and the results do not appear in the paper. This non-result may be a consequence of the fact that the income distribution in New Zealand has not changed much over the estimation period (Hyslop and Yahanpath 2006).

[23] We are restricted to using two years by the absence of employment data prior to 2000.

Table 6
Summary statistics

	Population				Panel			
	2001		2005		2001		2005	
	μ	σ	μ	σ	μ	σ	μ	σ
Multi-factor productivity	0.112	0.576	0.068	0.649	0.008	0.594	-0.015	0.566
Labour productivity	0.357	0.654	0.292	0.752	0.401	0.719	0.286	0.714
Log average wage	0.088	0.397	0.008	0.434	0.142	0.417	0.144	0.399
"Excess" employee turnover	-0.064	0.285	-0.006	0.299	-0.072	0.258	-0.033	0.238
HRM_GENERAL	1.437	0.697	1.457	0.669	1.519	0.681	1.578	0.643
HRM_PERF	0.256	0.502	0.253	0.531	0.461	0.503	0.484	0.489
HRM_AUTON	0.041	0.479	0.049	0.449	-0.007	0.463	0.017	0.444

Means (μ) and standard deviations (σ) reported on a weighted basis for the population and an unweighted basis for the balanced panel.

require firms to be active in each of the pair of years,[24] and because we do not impute missing data. All performance metrics used in this paper make use of the universe of firms in the economy that meet the population criteria for the survey and have data available. For the productivity variables we make use of all employing firms to estimate industry-specific production functions (over 315,000 observations). For worker-related metrics, we restrict the population to firms with at least six employees as these measures are likely to be noisy for very low employment levels (resulting in roughly 57,000 observations).[25] A detailed explanation of the construction of each of these variables is left to Appendix B.

Table 6 presents summary statistics of key variables for the population and balanced panel. The panel looks quite similar to the population, except in regard to the already-noted higher occurrence of performance management systems (HRM_PERF).

[24] "Economically active" firms have observed output, purchases of inputs or factors of production, specifically: positive employee count or PAYE salaries and wages; positive BAI sales or purchases; and/or positive IR10 total income, total expenditure or total fixed assets.

[25] We also drop the top and bottom one percent of observations of each performance metric.

5 Results

5.1 Estimation approach

To recap Section 3, our model predicts that adoption of high-performance work practices should lead to an increase in productivity, higher average firm wages and higher quality workers. Both the improved practices and the associated increase in wages are expected to decrease employee turnover. We estimate balanced panel fixed-effect regressions consistent with that framework using HRM principal components (HRM_GENERAL, HRM_PERF, HRM_AUTON) to represent suites of practices (in keeping with the existing literature). The fixed-effect panel approach enables us to identify the impact of human resource practices on firm outcomes through changes in the three HRM variables.

We include the twenty-two General Factors in each equation to control for a broad array of non-HRM management practices, some of which are likely to be correlated with the high-performance work practices in our HRM principal components. Thus our test of the importance of HRM practices for firm performance is likely, if anything, to understate the significance of the HRM variables. To foreshadow our estimates, our results are consistent with these predictions. Firms that adopt high-performance work practices experience higher growth in (multi-factor and labour) productivity and average wages.

Because of the broad industry coverage in the data, we produce sectoral estimates for manufacturing, services and – for completeness – "other" firms (comprising agriculture, forestry, fishing, mining and construction). Within service industries, we further split the sample by the industry average share of professional and semi-professional workers (similar to Grimes et al 2009), since prior evidence suggest that the effect of changes in HRM_GENERAL should be more positive for "high" over "low"-professional industries (Fabling and Grimes 2010).[26] Aside from the "low"-professional services group, we consistently find positive causal effects of HRM suite adoption on firm performance and worker outcomes.[27]

[26] Based on industry-level aggregates produced using BOS data from 2005-2007, the high-professional share service industries are property and business services; health services; finance and insurance; education; motion picture, radio and television services; air and space transport; and machinery and motor vehicle wholesaling.

[27] Unreported results suggest no significant difference across the following whole economy splits: firms that only adopt practices, those that only drop practices and those that both adopt and drop practices; firms with and without working proprietors; and firms above and below 100 total employment.

Table 7
Multi-factor productivity panel results

	(1) Whole Economy	(2) Manu	(3) Services	(4) Other	(5) High prof services
HRM_GENERAL	0.115***	0.173***	0.112**	0.213*	0.201**
	[0.037]	[0.056]	[0.055]	[0.122]	[0.079]
HRM_PERF	0.027	0.057	0.090	-0.173	0.132
	[0.045]	[0.067]	[0.070]	[0.167]	[0.123]
HRM_AUTON	0.009	0.035	-0.030	-0.049	0.001
	[0.034]	[0.054]	[0.052]	[0.162]	[0.076]
N	495	174	264	57	150
within R^2	0.076	0.206	0.135	0.412	0.231
GF joint test	0.122	0.053	0.090	0.188	0.003

Balanced panel fixed effects regression with robust standard errors in brackets. All specifications include unreported General Factors (p-value for joint test of significance reported). ***; **; * denotes significance at 1%; 5%; 10% level.

Tables 7-10 set out our main results – estimates from panel fixed effects regressions of HRM principal component coefficients broken down by performance metric and sector. The tables are identically structured. Column (1) reports coefficients for the whole economy, while columns (2)-(4) report results for the manufacturing, service and other sectors respectively. Finally, column (5) provides estimates for the high-professional worker industries – the "low" category is omitted from the tables for brevity.[28] Coefficients for General Factors are not presented, however the p-value of a test of their joint significance is reported at the bottom of each column.[29]

5.2 Firm productivity

Focussing first on the whole economy estimates (column 1) of tables 7 and 8, the principal component measuring general HRM practices is consistently significantly positive for both productivity measures. Coefficients are interpreted as the percentage change in firm productivity relative to industry average, so that a coefficient of 0.115 suggests that improving HRM_GENERAL by one will raise relative MFP by 11.5 percent. Using the principal com-

[28] Except in the case of HRM_PERF in the labour productivity estimates, coefficients of HRM suites are never significantly different from zero (at the 10 percent level) for the "low" professional employment share group.

[29] The General Factors are often jointly significant (at the 10 percent level) in these estimates, supporting their inclusion as controls.

Table 8
Labour productivity panel results

	(1) Whole Economy	(2) Manu	(3) Services	(4) Other	(5) High prof services
HRM_GENERAL	0.108***	0.131**	0.106*	0.224*	0.153*
	[0.041]	[0.060]	[0.059]	[0.122]	[0.086]
HRM_PERF	0.032	0.042	0.116	-0.135	0.102
	[0.051]	[0.079]	[0.072]	[0.130]	[0.124]
HRM_AUTON	0.020	0.003	-0.005	0.115	-0.008
	[0.040]	[0.061]	[0.059]	[0.150]	[0.080]
N	498	177	264	57	150
within R^2	0.111	0.243	0.180	0.519	0.244
GF joint test	0.002	0.004	0.009	0.091	0.004

See table 7 for notes.

ponent factor weights in table 4, a change in the index of this scale would require the adoption of at least three of our HRM practices.

As well as being statistically significant, this effect is also economically significant. If we segment firms in the panel into four quartiles based on their change in HRM_GENERAL between 2001 and 2005, then the quartile of firms with the highest positive change in this index started with relatively low productivity in 2001 (on average). This is what we expect – relatively poor performing firms making large changes to HRM practices in an attempt to close the performance gap, and better performing firms seeing no need to change.[30] Firms in the high-change quartile raise their index score by at least 0.48, and on average by 0.97, implying an MFP increase of 5.5 percent or 11.2 percent respectively.

Sectoral estimates all point to general HRM practices influencing productivity. Focussing on point estimates, the effect for manufacturing appears stronger than for services, though this difference is driven by the "low"-professional industries (compare columns 2, 3 and 5). Examination of standard errors imply that these differences are not significant. Overall, these results constitute strong evidence of benefits of HRM suite adoption outside of the manufacturing sector.

[30] A performance crisis, raising the likelihood of plant closure, may be a useful management tool for securing employee agreement to radical re-engineering of HRM systems (Ichniowski and Shaw 1995).

Table 9
Log average wage panel results

	(1) Whole Economy	(2) Manu	(3) Services	(4) Other	(5) High prof services
HRM_GENERAL	0.010	-0.008	0.025**	-0.013	0.041**
	[0.009]	[0.014]	[0.013]	[0.040]	[0.018]
HRM_PERF	0.025**	0.037**	0.002	0.065**	-0.008
	[0.011]	[0.015]	[0.019]	[0.032]	[0.031]
HRM_AUTON	-0.001	-0.007	-0.011	0.028	-0.013
	[0.010]	[0.015]	[0.015]	[0.038]	[0.022]
N	789	297	405	87	225
within R^2	0.039	0.101	0.092	0.338	0.111
GF joint test	0.255	0.210	0.040	0.003	0.334

See table 7 for notes.

5.3 Worker outcomes

Turning to the effects on workers, there is consistent evidence that firms outside of the service sector that introduce performance pay systems have higher growth in average wages (table 9, coefficient on HRM_PERF). Services firms – and particularly "high"-professional services firms – experience higher growth in average wages when the general suite of HRM practices is adopted. The contrast between the manufacturing and "high"-professional service sectors is consistent with the hypothesis that more complex tasks are less amenable to simple performance-reward systems; instead, more holistic high-performance work systems are required.[31]

Increased productivity and wages may arise from either sorting of better workers into firms that reward better performance, and/or it may come from existing workers being rewarded for greater effort (Lazear 2000). Unfortunately, we do not have a longitudinal measure of worker quality in our dataset. However, we can observe the effect of changes in practices on worker turnover (a prerequisite for a substantial sorting effect). We find that better work practices (HRM_GENERAL) reduces employee turnover as does adoption of performance pay systems, at least for manufacturing firms (table 10). This result would be a natural consequence of adopting high-performance work

[31] Our finding of a relationship between adoption of HRM practices and wage *growth* extends the finding by Bloom and van Reenan (2007) of a relationship between "human capital management" and the average wage *level*.

Table 10
"Excess" employee turnover panel results

	(1) Whole Economy	(2) Manu	(3) Services	(4) Other	(5) High prof services
HRM_GENERAL	-0.031**	-0.052***	-0.031*	-0.044	-0.038
	[0.012]	[0.017]	[0.018]	[0.040]	[0.031]
HRM_PERF	-0.028*	-0.040**	-0.028	0.023	-0.016
	[0.016]	[0.020]	[0.028]	[0.059]	[0.041]
HRM_AUTON	0.021	0.060***	0.003	0.022	-0.001
	[0.014]	[0.020]	[0.021]	[0.058]	[0.029]
N	789	297	405	87	225
within R^2	0.069	0.161	0.101	0.373	0.103
GF joint test	0.000	0.026	0.001	0.015	0.027

See table 7 for notes.

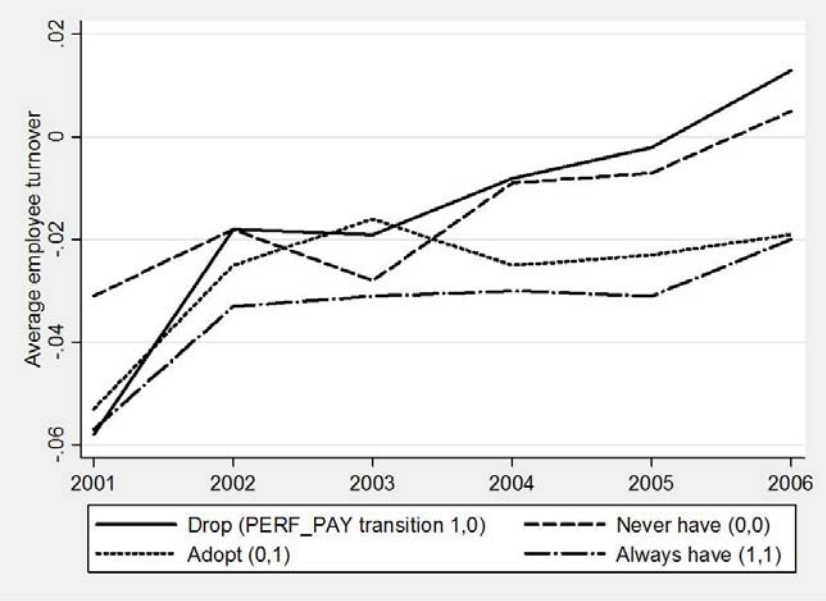
practices after an initial sorting period has occurred.[32]

Turnover increased between 2001 and 2006 for all types of firms in the panel (where "type" is defined according to performance pay practices). The overall effect of changing performance pay practices is identified from the fact that firms that drop performance-related compensation suffer a substantial increase in employee turnover relative to adopters (figure 1). Overall our estimates and the data suggest that the long-run effect of adopting high-performance work systems, and especially performance pay, is to reduce employee turnover (as postulated in our model), but there may be a transition effect whereby recent adoption of such systems temporarily increases employee turnover, consistent with a sorting effect.

Attracting higher ability workers into the firm is unlikely to be the whole story – in-house development of skills is also probably important. Reflecting this possibility, high-intensity training has a high weight in HRM_GENERAL. To get an overall impression of the role of human capital (either "make" or "buy") we make use of worker fixed effects estimates from Maré and Hyslop (2008). This variable can only be used in cross-section since the worker fixed effects are estimated across all years, making any interpretation of panel results impossible. Together with the worker fixed effects results we also provide cross-sectional estimates for the log average wage. Table 11 show consistently positive relationships between suites of HRM practices, higher

[32] HRM_AUTON has a significant positive impact on employee turnover in the manufacturing sector. Perhaps, by giving employees greater autonomy, the firm exposes itself to greater poaching of its better workers since the quality of those employees is more observable to other firms.

Figure 1
Average "excess" employee turnover (relative to industry) by PERF_PAY transitions



paid and higher quality workers. It appears that firms with good HRM practices pay higher wages at least partly because well-organised firms have better workers, either because they have practices that reward success (and therefore attract better individuals) or because the management practices improve the (potentially workplace-specific) skills of employees.[33]

Before concluding, we consider an alternative interpretation of our results. Because labour is a headcount measure, the productivity effect we observe may partly come from high-performance work practices encouraging employees to work longer hours. As with worker quality, we have no longitudinal measure of hours worked in the data, however we do have an estimate of total

[33] However, because these are cross-sectional regressions, we cannot attribute causality. In this regard we note the significant positive *association* between average wages and HRM_PERF in the cross-sectional regressions for services firms which contrasts with the finding of no relationship between these variables in the panel estimates. This contrast points to the need to exercise caution in interpreting cross-sectional results in studies where panel data are unavailable.

Table 11
Log average wage and worker fixed effect cross-section results

	LOG AVERAGE WAGE				
	(1a) Whole economy	(2a) Manu	(3a) Services	(4a) Other	(5a) High prof services
HRM_GENERAL	0.019	0.003	0.024	0.043	0.048**
	[0.013]	[0.015]	[0.019]	[0.027]	[0.023]
HRM_PERF	0.136***	0.094***	0.147***	0.115***	0.183***
	[0.018]	[0.016]	[0.027]	[0.026]	[0.026]
HRM_AUTON	0.034*	0.041**	0.033	0.045	0.084***
	[0.020]	[0.017]	[0.028]	[0.039]	[0.027]
N	6,408	1,812	3,687	909	2,082
R^2	0.115	0.148	0.116	0.167	0.146
GF joint test	0.000	0.000	0.000	0.073	0.000
	AVERAGE WORKER FIXED EFFECT				
	(1b) Whole economy	(2b) Manu	(3b) Services	(4b) Other	(5b) High prof services
HRM_GENERAL	0.017	0.002	0.015	0.051**	0.050**
	[0.012]	[0.014]	[0.017]	[0.023]	[0.025]
HRM_PERF	0.092***	0.036**	0.114***	0.064***	0.155***
	[0.012]	[0.014]	[0.017]	[0.023]	[0.025]
HRM_AUTON	0.045***	0.042**	0.039*	0.087***	0.043
	[0.015]	[0.016]	[0.020]	[0.028]	[0.028]
N	6,408	1,806	3,690	912	2,070
R^2	0.085	0.057	0.102	0.170	0.155
GF joint test	0.002	0.024	0.000	0.053	0.000

Cross-section regressions are survey-weighted OLS with robust standard errors (in brackets) adjusted for survey design. All estimates include unreported two-digit industry dummies, and General Factors (p-value for joint test of significance for the latter reported). ***; **; * denotes significance at 1%; 5%; 10% level.

Table 12
Log average hourly wage cross-section results (2005 only)

	(1) Whole economy	(2) Manu	(3) Services	(4) Other	(5) High prof services
HRM_GENERAL	-0.003	0.007	-0.010	-0.011	-0.013
	[0.018]	[0.029]	[0.024]	[0.039]	[0.028]
HRM_PERF	0.050**	0.004	0.055**	0.109**	0.079**
	[0.019]	[0.028]	[0.026]	[0.047]	[0.036]
HRM_AUTON	0.061***	0.058*	0.050*	0.152***	0.052
	[0.021]	[0.033]	[0.028]	[0.048]	[0.034]
N	3,393	831	2,109	453	1,191
R^2	0.226	0.102	0.279	0.144	0.138
GF joint test	0.057	0.167	0.089	0.293	0.007

See table 11 for notes.

hours worked in 2005 (from BOS).[34] Table 12 presents cross-sectional regressions with the log average hourly wage as the dependent variable. Bearing in mind that the hourly wage variable is measured with error, firms with performance pay systems do appear to pay higher hourly wages to employees (except perhaps in the manufacturing sector). These results are consistent with our earlier interpretation that high-performance work practices have a positive effect on staff retention at least partly because workers benefit from consequential productivity gains.

5.4 Potential coefficient bias

We have interpreted our findings as implying causal relationships and we turn now to whether that interpretation is appropriate. Our method not only controls for unchanging (fixed effect) characteristics of the firm, but also for contemporaneous changes to non-HRM business practices. This makes it highly unlikely that our approach attributes the effects on performance of changes in non-personnel practices to contemporaneously adopted HRM practices, so strengthening the claim that the results imply causality. However, our estimation approach will potentially produce results that are biased if HRM practice decisions are endogenous to changes in firm performance (which are

[34] Some respondents to the survey had trouble answering this question and in particular probably supplied average rather than total hours worked. As a consequence, we restrict this analysis to firms reporting total hours worked that is consistent with a minimum implied by their reported full-time staff, and further drop the top and bottom five percent of derived hourly wage rates as potentially being unreliable.

not, in turn, being driven by changes in our other controls).

Several studies have explicitly focussed on the issue of what triggers radical rethinking on personnel policies (eg, Ichniowski and Shaw 1995; Nickell et al 2001). Among other factors, a performance crisis can stimulate reengineering of HRM practices, possibly because the potential loss of jobs from closure provides the necessary stimulus for managers and workers to overcome existing low-trust relationships that have made change difficult in the past (Ichniowski and Shaw 1995). Our summary of the average initial MFP of firms is consistent with this picture – firms that make large changes in practices (either up or down) tend to be relatively poor performers initially. If negative shocks to the prospective future performance of the firm cause HRM practice changes, then we might expect our estimated fixed effects coefficients to be biased downwards. Using German linked employer-employee data, Bauer (2003) tests this hypothesis and finds that "...the effects of implementing flexible workplace systems on labour productivity are biased downwards due to ...the potential endogeneity of ...workplace practices".

Another potential source of coefficient bias comes from the inability to identify exactly when HRM practice changes occurred. The time interval between high-performance work practice adoption and subsequent performance measurement could be anywhere from one day to over three years. If, as is likely, there are lags between making changes and reaping the full impact of those changes then our results will again be biased downwards by including very recent practice changers. Along a similar vein, firms in the panel have very high participation in (relative to the population) and retention of (relative to other practices) performance management systems, suggesting that the coefficient of HRM_PERF may be negatively affected by estimating the causal impact from changers rather than from the average firm. These possibilities, together with Bauer's results, suggests our findings may well underestimate the true causal effects.

6 Conclusions

This paper has looked at the role personnel practices play in determining performance differences across firms. The availability of a uniquely rich panel dataset has allowed us to examine this issue in a way that extends the ex-

isting literature.[35] The strengths of the data include extensive controls for non-HRM practices within the firm, a relatively long time period between observations of business practices, a large panel (over 1,500 firms), broad industry coverage with a low employment cut-off, and access to the universe of administrative performance data covering multiple firm and worker outcomes.

We test the importance of suites of practices using principal components to combine discrete practices into indices. Our three resulting principal components have intuitive interpretations as representing "good" broad HRM practices, performance measurement and reward, and the degree of employee autonomy. After controlling for firm-invariant characteristics and changes in general (non-HRM) business practice, we find that changing the broad suite of HRM practices has a strong effect on firm performance in terms of raising productivity, better staff retention and higher average human capital in workers. These effects are economically large, with MFP increases of at least five and a half percent for firms in the upper quartile of change in the suite of practices. Workers also share in the productivity gains, receiving higher average wages. This may reflect increased on-the-job training and greater job security encouraging higher investment in firm-specific skills. Although we estimate a drop in employee turnover from adopting high-performance work practices, it is possible that sorting of higher-quality workers into firms with good HRM practices is a mechanism through which firms secure higher quality (better paid) workers.

Uniquely, we find that the performance advantages conveyed by good HRM systems extend beyond the manufacturing sector. Firms in the services and "other" sectors also appear to experience higher productivity when they shift to a better general HRM suite. Within the services sector, the effect is concentrated in industries with a higher proportion of professional staff. Furthermore, consistent with prior hypotheses, adoption of general high-performance HRM practices is more important for ("high"-professional) services firms than is adoption of performance pay systems in isolation. Thus one size does not fit all when it comes to designing optimal personnel systems. Nevertheless, the importance of adopting high-performance work systems — designed to cater for firm type – is strongly supported by our results.

[35] In particular, the New Zealand literature has been based on cross-sectional analysis (eg, Guthrie 2001; Guthrie et al 2002; Fabling and Grimes 2007; Fabling and Grimes 2010).

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Appendix A – General management practices

The general factors are principal components (using tetrachoric correlations) constructed from binary response categories to a wide range of survey questions outside of HRM. Only factors with eigenvalues greater than one are retained, yielding twenty-two variables to act as controls for general business practices. The following questions were used in the construction of the factors (BOS 2005 wording):[36]

Strategy and goals

- How important are the following to the strategies of this business: [five questions, each on a 4-point scale + "don't know"]
  - pricing of products
  - quality of products
  - flexibility/ability to make changes
  - delivery of products
  - innovation
- During the last two financial years, to what extent did this business focus on existing domestic markets? [4-point scale + "don't know"]
- Does this business have a clear vision or mission for the future? [yes/no]

Customers

- Does this business have set procedures (consistent methods that staff know and adhere to) for dealing with customer complaints? [yes/no]
- To what extent do staff, other than sales and marketing staff, have contact with major customers? [4-point scale + "don't know"]
- How closely does this business work with customers to develop or improve products? [4-point scale + "don't know"]

[36] In a small number of cases response categories were grouped to enable comparability across surveys. A couple of consistently-measured business practice variables have also been dropped where the question non-response rate (including "don't know" responses) would have seriously reduced the number of observations of general business factors.

Information and benchmarking

- Does this business have a formal system in place to manage the storing and retrieving of information? [yes/no]
- Is it part of the regular work of one or more people (either staff or outside contractors) to assess whether this business is achieving its goals? [yes/no/not applicable]
- During the last two financial years, to what extent did this business focus on the following when assessing performance: [three questions, each on a 4-point scale + "don't know"]
  - financial measures
  - cost measures
  - quality measures
- During the last two financial years, has the performance or processes of this business been compared in a systematic way to businesses: [four questions, each with a 4-point scale + "don't know"]
  - in the same industry
  - in different industries
  - within New Zealand
  - overseas
- How closely does this business monitor competitors' products? [4-point scale + "don't know"]

Employee practices

- Does this business have processes in place to manage health and safety? [yes/no]

Quality and process

- Does this business have quality management systems certification? [yes/no]
- Does this business have measures in place to reduce the environmental impact of this business? [yes/no]

Appendix B – Performance metrics

Productivity variables

Multi-factor productivity (MFP) is calculated by way of ordinary least-squares regression assuming a Cobb-Douglas production function in labour and capital with industry-year-specific coefficients (almost exclusively at the two-digit industry level), and the potential for non-constant returns to scale. Specifically,

$$\ln(Y_{ijt}) = \alpha_{jt} \ln(L_{ijt}) + \beta_{jt} \ln(K_{ijt}) + A_{jt} + \epsilon_{ijt}, \qquad t \in (2000/01, 2005/06) \tag{10}$$

where i,j and t index the firm, industry and two-year period respectively, and MFP relative to the industry average is the residual of this estimation (ie, ϵ_{ijt}). To estimate this production function we must construct measures of value-added (Y), labour (L) and capital services (K). Each of these data is discussed in turn.

Value-added is defined as gross output less intermediate consumption. Our first choice is to source value-added from the Annual Enterprise Survey. These data rely on industry-specific survey questions to construct value-added of a sufficient quality to be acceptable for National Accounts. AES postal responses account for 5 percent of observations, but 49 percent of total employment reflecting a sampling strategy consistent with estimating GDP accurately. In the absence of AES observations, we make use of administrative tax data to construct

$$Y_{ijt} = sales_{ijt} - (purchases_{ijt} - \Delta stock_{ijt}) \tag{11}$$

where *sales* and *purchases* come from BAI and $\Delta stock$ from IR10s.

The labour input measure is from LEED and is the sum of two components: employees and working proprietors. The first of these is the annual average number of employees drawing a PAYE wage as at the 15th of each month (ie, a rolling mean employment or RME). Working proprietor counts come from various tax sources, which are generally collected annually in line with the firm's financial year. The lack of a more refined estimate of working proprietor labour input is problematic to the estimation of labour input for firms that are starting up or ceasing. We assume that working proprietors work half of the year in such cases, however, to be cautious, we exclude observations

of entering and exiting firms from our estimation of MFP coefficients.[37,38]

In common with many other datasets, construction of a useable capital services measure is the most taxing research task. Capital services data come from the same source as value-added – that is, either AES or IR10 – and is calculated as the sum of rental and leasing costs, together with depreciation and a cost-of-capital charge for owned assets. The first of these is observed directly in IR10s, but not collected separately in AES. To cope with this, rental costs as a proportion of other expenses are estimated from IR10s as an industry-year-specific function of depreciation costs and fixed asset holdings. Estimated rental cost shares are then applied to AES other expenses, except in cases where a firm has both an AES form and an IR10, in which case the firm's actual rental cost share from their IR10 is applied to the AES data.[39]

Depreciation costs are collected directly in both AES and IR10s, which just leaves the estimation of the cost-of-capital component. We use a constant year-specific interest rate for all firms, being a "risk-adjusted" four percentage points over the annual average 90-day borrowing rate.[40] This interest rate is applied to the productive capital held over the period, calculated by averaging opening and closing book values of total fixed assets. Because IR10s only collect closing book values, lagged IR10 data are used as the source of opening book values. For AES, both opening and lagged closing book values may be available from the same survey form. To be consistent across data sources, preference is given to using lagged AES closing values where they exist. For both AES and IR10-based estimates, entering firms are assumed to have zero opening assets.

Labour productivity is calculated by the difference between log value-added and log total employment controlling for value-added data source. For both MFP and labour productivity a dummy is included to control for differences between data sources. This dummy is positive and significant for almost all

[37] Robustness checks suggest that including these firms doesn't affect estimated coefficients.

[38] Almost by construction, very few firms in our panel are likely to be affected by this issue because: (a) the working proprietor component of the total labour is likely to be small; and (b) very few panel firms either enter in 2000 or exit in 2006.

[39] Because both AES and IR10-based value-added estimates treat these rental costs as purchases, the estimated rental cost is then added back into value-added.

[40] For New Zealand, this cost-of-capital varies between 9.34 and 11.28 percent (including the risk adjustment factor). Tests with higher and lower risk adjustment factors indicated that the regression coefficients were robust to plausible variations in this assumption.

industries, indicating that AES tends to be associated with higher value-added firms. Comparison for firms that have both data sources suggests that some of this levels difference is measurement related.[41]

Worker variables

All worker variables – average wage, employee turnover and average worker fixed effect – are derived from LEED. While the log average wage is self-explanatory, the other two variables need some definition. "Excess" annual employee turnover is derived from summed quarterly estimates of worker accessions (L_{it}^{A}) and separations (L_{it}^{S}) using

$$\frac{(L_{it}^{A} + L_{it}^{S}) - (L_{it} - L_{it-1})}{L_{it} + L_{it-1}}, t \in (2001, 2006) \tag{12}$$

That is, the measure captures the number of employees that change over and above the number required to account for the net change in employment over the year, divided by average employment across the two years. Because the source data has exceptional coverage, we treat missing employment observations as zero, provided the firm is observed to be economically active.

The average worker fixed effect comes from Maré and Hyslop (2008) who use a variant of the Abowd et al (2002) methodology to estimate the unobservable component of worker earnings after controlling for age and gender. We average these worker fixed effects across all workers in the firm and interpret the results as a proxy measure for human capital differences between firms. Because the worker fixed effects are estimated over the full time period, it is not possible for us to use or interpret this variable in our panel estimation.

[41] Initial productivity panel estimates also included a dummy controlling for industry change. However, reported results exclude that dummy since very few firms change two-digit industry and inclusion of that dummy had no effect on the estimates of the HRM principal component coefficients.