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In America's thrall: the effects of the US market and US security characteristics on Australian stock returns

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Abstract

Can Australian equity returns be modelled by 'home-grown' factors? We examine the indigenous capital asset pricing model, the indigenous Fama–French three-factor model, and extensions to the latter, and find them all wanting. We find evidence of domestic market segmentation in Australia. For the smallest firms, all the models we study fail. For the largest Australian firms, we find that the US Fama–French three factors (downloaded from French's website: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/) provide a successful model of Australian returns. It is as if the largest firms in the Australian market are simply part of the larger US market.

Key words: Asset pricing; Domestic segmentation; International integration; Three-factor model

JEL classification: G12

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1. Introduction

There is persuasive empirical evidence from several studies demonstrating that the Australian equity market is strongly related to, indeed driven by, the US market.[1] We utilize such evidence in seeking to provide an acceptable model for equity

We have benefited from work conducted by Ang Hui on the three-factor model in Australia. We also appreciate helpful comments from Louis Ederington, Iain Watson, two anonymous referees, and seminar participants at the University of Western Australia, the 2004 Australasian Finance and Banking Conference and the 2005 Accounting and Finance Association of Australia and New Zealand Conference. The Supplementary Information Section may be downloaded from http://www.ecom.uwa.edu.au/staff/durand_robert. The authors accept full responsibility for any errors and omissions.

[1] See Ragunathan *et al*. (1999), Durand *et al*. (2001) and Durand and Scott (2003) for discussions of the effect of the US market on the Australian market.

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returns in Australia. We argue that Fama and French's three-factor model (1992, 1993) does not provide an adequate model of returns in Australia and seek to 'improve' it by incorporating variables that potentially capture America's influence over Australia. In doing so, our analysis probes the extent of the relationship between the Australian and US markets. We find that the largest firms in the Australian market are globally integrated; in particular, they are integrated with the US market. The smallest firms in the Australian market are not integrated with the US market. Therefore, the evidence in the present paper points to domestic segmentation in the Australian market.

Bekaert and Harvey (1995) argue that if markets are globally integrated, rather than segmented, equivalent risks should result in equivalent returns. Examining whether locally derived or globally derived factors provide a better explanation of returns is one way of addressing the question of global capital market integration. Finding that the globally derived factors are the best explanation of returns would be consistent with an internationally integrated global market place. Griffin (2002) provides an important and recent analysis that tested international market integration. His analysis found that local factors provide a better explanation of returns than global factors. This suggests that return/risk trade-offs are not necessarily equivalent in the countries he studied, and that the markets he studied are, to some extent, segmented rather than integrated.

In the present paper, we examine monthly returns of 25 size and beta sorted portfolios with a view to comparing competing asset pricing models. Our aim is to assess indigenous models and models allowing for degrees of integration between the Australian and US markets. Following Gibbons *et al.* (1989), we test the hypothesis that the intercept terms for each equation we estimate are jointly equal to zero. This allows us to address our second aim: that our model of returns should be complete. By completeness, we require that there should be no statistically significant movement that is not captured by the candidate factors. Where we estimate nested models, our use of a systems-based approach enables us to utilize likelihood-ratio tests, Akaike's Information Criterion (AIC) and Schwarz's Bayesian Criterion (SBC) as bases to select the best model.[2]

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[2] Such an approach has been used in several Australian studies. In particular, Halliwell *et al.* (1999) and Gaunt (2004) present a number of equations and point to average changes in the value of R^2 to compare models. Such analyses stretch the use of R^2 beyond reasonable bounds. We do not have, for example, any idea of the distribution of R^2 to determine if their change is statistically significant. We calculate values of adjusted R^2 for each equation in the systems we estimate to facilitate comparison with these previous studies. However, we stress that maximum likelihood has a wide range of applications including, in our case, the full-information maximum likelihood (FIML) methodology to estimate a system of equations. In the case of a single equation, maximum-likelihood estimation is ordinary least squares (OLS) estimation and the use of metrics such as the adjusted R^2 is justified. While we can calculate values for R^2 for the equations derived using FIML (as we do), in general they do not equate to the values calculated for a single equation derived using OLS. Such values of R^2 will only coincide if the subsystems are independent.

We find that the indigenous capital asset pricing model (CAPM) and the indigenous three-factor model fail to provide a complete model of returns. We then take up the baton from Ragunathan *et al.* (1999), Durand *et al.* (2001) and Durand and Scott (2003) augmenting the indigenous three-factor model with US-derived variables. These models are also unsuccessful: we find significant positive drift in many portfolios. We then model returns using US-based factors (Fama and French's Fama–French factors) using the market premium, size (SMB or Small minus Big) and book-to-market factors (HML or High minus Low) from French's website (i.e. the data US researchers use). In effect, we treat our 25 portfolios as if they were American portfolios. In other words, we make the radical assumption that an independent Australian market does not exist. We find that, for the largest firms in the Australian market, Fama and French's Fama–French factors satisfy our criteria for a successful model, as there is no significant alpha at the 1 per cent level. Our results point to a segmented market where the largest firms are fully integrated in the global market and where the smallest firms march to the beat of a different, and yet to be fully identified, drum.

Our paper is structured as follows. In Section 2 we briefly outline pertinent literature. We discuss our data and methodology in Section 3 and present our results in Section 4 of the paper. Section 5 concludes the paper.

2. Previous literature

Our analysis follows the long tradition of analyses of the cross-section of returns, both in the USA and in Australia. The CAPM (Sharpe, 1964; Lintner, 1965; Mossin, 1966) states that there is a positive and linear relationship between an asset's expected return and the product of its systematic risk and the expected market premium. Although the CAPM is based on a strong theoretical background, many empirical studies have found that it does not actually perform well in explaining cross-sectional variations in stock returns. The CAPM's inability to capture cross-sectional return variations has become especially apparent with the documentation of several return-related anomalies. Examples of these include the large number of empirical studies documenting the prominent small firm premium effect, where small firms consistently earn higher risk-adjusted returns than larger ones (Banz, 1981; Reinganum, 1981; Blume and Stambaugh, 1983; Reinganum, 1983; Fama and French, 1992) and the book-to-market effect (Fama and French, 1992), where firms with high book-to-market ratios generally earn higher returns than those with low book-to-market ratios.

Fama and French (1992, 1993) develop a three-factor model that includes the size and book-to-market factors in addition to the CAPM's market factor. They find that the model is able to capture a substantial proportion of the cross-sectional variations in stock returns. Fama and French (1995, 1996) subsequently document that the three-factor model is able to explain the size and book-to-market anomalies not explained by the CAPM, including the long-term return reversals documented by DeBondt and Thaler (1985). They find that past losers are likely to have positive size and book-to-market slopes, implying that they are smaller and relatively more distressed than past winners.[3] The performance of the three-factor model is also confirmed in a number of international settings in Fama and French's 1998 study.

In Australia, because of the historical lack of size and book-to-market factor data, there have only been a small number of studies that have examined the three-factor model. The study of Halliwell *et al.* (1999) was the first Australian-published three-factor model paper. Halliwell *et al.* follow the methodology of Fama and French (1993) by sorting stocks on both size and book-to-market ratios into 25 portfolios, then testing the ability of the three-factor model to explain the portfolio returns over the period 1981–1991. They find that the three-factor model provides greater explanatory power than the static CAPM. However, their results also indicate that while the size factor is, to some extent, significant, the majority of the book-to-market coefficients are not significant. Their results imply that the explanatory power of the two major factors appears to be considerably weaker when using Australian data.[4]

Faff (2001, 2004) provides further tests of the three-factor model in Australia. Faff (2001) examines the three-factor model over the period 1991–1999, and uses 'off the shelf' style index data to construct the size and book-to-market factors.[5] His results appear to give support to the three-factor model, as the intercept terms are insignificantly different from zero, whereas the size and book-to-market factors are statistically significant, with the size coefficient being negative. Faff (2001) conjectures that the reason the results are different from those of Halliwell *et al.* (1999) is likely due to the use of an almost entirely different sample period. He also observes that the negative size effect is consistent with overseas evidence.[6] Faff (2004) re-examines the three-factor model over the period 1 May 1996 to 30 April 1999 using daily data. Once again, Faff's results support the model, but, in keeping with his earlier study, he documents a negative size coefficient.

Gaunt (2004) examines the performance of the three-factor model in Australia over the years 1993–2001. His results are consistent with those of Halliwell *et al.* Gaunt argues that the three-factor model provides increased explanatory power in stock returns over the CAPM, with the beta and size

[3] However, the three-factor model cannot be used to explain the intermediate-term return momentum documented by Jegadeesh and Titman (1993, 2001).

[4] The results of Halliwell *et al.* might be affected by their sample, as many small firms were excluded because of missing book values and data on the number of shares outstanding, resulting in a relatively large average firm size in their sample.

[5] Faff uses four of the Australian equity 'style' indexes, including the ASX/Russell Value 100, ASX/Russell Growth 100, ASX/Russell Small 100, and ASX/Russell Small Growth 100 Index, provided by the Frank Russell Company using ASX data.

[6] See, for example, Gompers and Metrick (1998), Dimson and Marsh (1999) and Gustafson and Miller (1999).

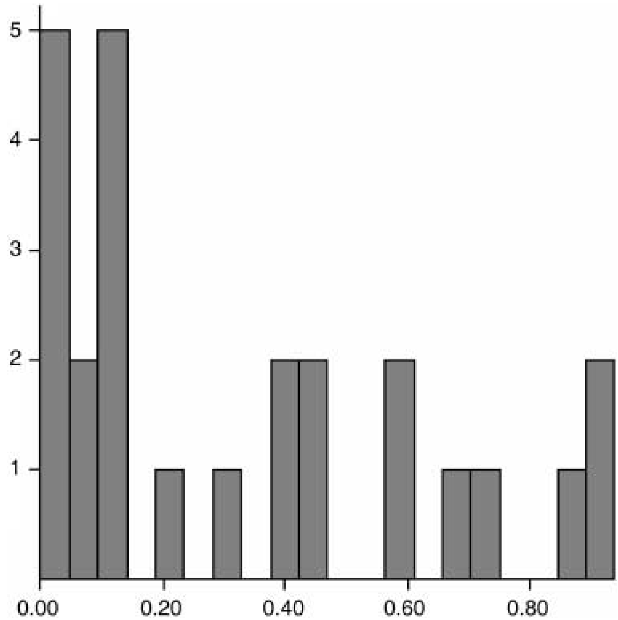

Figure 1 Distribution of *p*-values for the intercepts of the three-factor model reported in Gaunt (2004, p. 37).

coefficients being the most significant. The book-to-market coefficient was found to be significant in just 60 per cent of the portfolios examined. Unfortunately for advocates of the three-factor model, the evidence produced by Gaunt actually indicates that the three-factor model is not complete. Figure 1 presents a histogram of the intercept *p*-values reported in the first panel of table 4 in Gaunt (p. 37). A complete model of excess returns should not result in intercept terms that are statistically significantly different from zero. Some significant *p*-values will be generated by chance if a large number of equations are estimated; if 25 equations are estimated, we might expect to observe one or two *p*-values less than or equal to 0.05. Indeed, we should be able to plot the *p*-values and see that they conform to a uniform distribution. Figure 1 clearly indicates that there are more *p*-values below 0.05 than would be expected if these results had been generated randomly. Examining Gaunt's reported *p*-values more formally, a Kolmogorov–Smirnov test of the null hypothesis that the *p*-values conform to a uniform distribution results in a test statistic of 1.655 (which has a *p*-value of 0.008), confirming the impression conveyed by Figure 1: the null that the *p*-values conform to a uniform distribution can be rejected with confidence. A good model just would not have produced so many significant intercept terms.[7]

[7] Interestingly, testing the *p*-values for Gaunt's estimates of the static CAPM results in a Kolmogorov–Smirnov test statistic of 1.227, which has a *p*-value of 0.098. The model that Gaunt prefers least might, at a pinch, satisfy a criterion for selecting a good model.

Durack *et al*. (2004) find that the three-factor model outperforms the conditional CAPM of Jagannathan and Wang (1996), and that there is an important role for SMB in explaining the cross-section of Australian returns.[8] However, their analysis of the role of HML is inconclusive: it proves to be significant only in their generalized method of moments estimate of an augmented no-arbitrage equilibrium version of the conditional CAPM for excess returns. This finding led Durack *et al*. to suggest that further research into the role of HML is warranted.

Ragunathan *et al*. (1999) document that the US and Australian markets are interrelated, and that this effect is sensitive to the business cycle. Durand *et al*. (2001) investigate the impact of the US and Japanese markets on seven Asia-Pacific stock markets over the period 1985–1996. They find that the US market generally has considerable influence on the Pacific-Rim markets, with the strongest effect being on Australia. Durand and Scott (2003) conjecture that the correlation between the Australian and US markets might be caused by investors' overreactions. Durack *et al*. (2004) also consider an augmented model of the cross-section of returns with a view to examining the close linkage documented between the Australian and US markets. Durack *et al*. incorporate both the US market index and the exchange rate to explain changes in Australian stock returns.[9] By adding these two factors to the CAPM, they find that only the exchange rate factor is statistically significant, indicating that the effect of the US market factor is not as prominent as one might expect given the other literature outlined above. The effect of the exchange rate has also been considered by Di Iorio and Faff (2001) using a Fama–French framework; they provide evidence that the AUD/USD exchange rate is statistically significant in explaining returns. Di Iorio and Faff (2002) provide further evidence that the AUD/USD exchange rate is priced when the Australian economy and its dollar are relatively weak.

The approach of Durack *et al*. (2004) is subtly different from the seminal considerations of the cross-section of returns in an international setting. Their analysis considers whether augmenting a model with a foreign factor describes returns. Other studies have considered if locally and/or globally pervasive factors (where the latter are derived using securities from all countries in the sample) explain returns. Fama and French (1998) analyse whether their model applies outside the USA by examining if returns in a number of countries can be explained by a global market risk premium and global HML spanning portfolio.[10]

[8] Their results provide an interesting contrast to Jagannathan and Wang (1996) (the study Durack *et al*. replicate and extend with Australian data). Jagannathan and Wang argue that SMB (and HML) proxy for misspecified risk in the American context. Durack *et al*. argue the contrary: SMB plays an important role in Australia. Therefore, Jagannathan and Wang's inferences cannot be generalized outside America.

[9] Izan *et al*. (1991) document a significant relationship between exchange rates and the differences in return volatility and return correlations between countries.

[10] The data source provided information only for the very largest companies in the countries for which they had data. Therefore, they did not include a global SMB portfolio.

Griffin (2002) considers both country-specific and global versions of the Fama–French three-factor model in explaining international stock returns to address whether local or global factors provide a good explanation of returns. The results indicate that domestic factors exhibit lower pricing errors than the world factors when regressed upon portfolio and individual stock returns. Furthermore, Griffin finds that the inclusion of foreign factors, in addition to domestic factors, results in a less accurate pricing model. The extension of the three-factor model to a global context does not appear to be beneficial over a domestic three-factor model. At their core, examinations of whether local or global factors are priced would address Bekaert and Harvey's (1995) argument that return/risk trade-offs should be equal if countries' markets are integrated. However, studies such as Fama and French (1998) and Griffin (2002) do so within a specific model of the cross-section of returns rather than the more general approach of Bekaert and Harvey.

With the role of the US market as a pricing factor in Australia still being relatively unclear, the aim of this paper is to compare the performance of standard pricing models with models that incorporate the US market and US security-related factors in explaining Australian stock returns. Following the methodology of Fama and French (1993), we examine the ability of the CAPM, CAPM with the US and exchange rate (ER) factors, the Australian three-factor model, and the US three-factor model to explain portfolio returns.

3. Data and methodology

The data used in this paper begins in January 1990 and ends in December 2001,[11] and is obtained from the Share Price and Price Relative (SPPR) database compiled by the Centre for Research in Finance and the Australian Graduate School of Management at the University of New South Wales. The SPPR dataset contains historical monthly data of all listed companies with Fully Paid Ordinary shares on the Australian Stock Exchange (ASX).

The Australian market excess return ($R_m - R_f$) is the equal-weighted market return (R_m) less the 13 week Treasury bill (R_f). Both of these are obtained from the Core Research Database (CRD) provided by the Securities Industry Research Centre of Asia-Pacific (SIRCA). The size (SMB) and book-to-market (HML) factors are those used in Durack *et al*. (2004). The SMB factor is defined as the return to a value-weighted portfolio of the smallest 30 per cent of stocks, minus the return to a value-weighted portfolio of the largest 30 per cent of stocks, both of which are rebalanced on the last trading day at the end of each month. The HML factor is defined as the return to a value-weighted portfolio of the 30 per cent of stocks with the highest book-to-market equity ratios, minus the return to a value-weighted portfolio of the 30 per cent of stocks with lowest book-to-market equity ratios, again rebalanced on the last trading day of the month.

[11] However, in a later robustness test we use data from 1980 (see footnote 23 below).

We report the number of stocks for which we had size and book-to-market data in Table A1 of the Appendix to this paper. The US market excess return, size and book-to-market factors are obtained directly from the data library in Ken French's webpage.[12] Datastream provides the series of direct exchange rates.[13]

Asset pricing tests have utilized portfolios, rather than individual stocks, as the dependent variables in regression analysis since the seminal works of Black *et al.* (1972) and Fama and MacBeth (1973). The present paper uses the portfolio formation methodology of Durack *et al.* (2004) who, in turn, follow Fama and French (1992), where all non-financial firms are used in the formation of 100 portfolios sorted into size then into beta deciles.[14] As the number of securities traded on the ASX is substantially lower than in the US markets, we instead group stocks based on size and beta quintiles to form 25 distinct portfolios for our cross-sectional return tests. At the beginning of each year t, stocks are sorted into size quintiles based on their total market capitalizations at year $t-1$; subsequently, they are sorted into beta quintiles based on their pre-estimated beta values over the period $t-2$ to $t-5$. Table A1 of the Appendix indicates the number of stocks available for portfolio formation and Table A2 indicates the number assigned to each portfolio.[15]

Rather than estimating each regression individually, we recognize that we are estimating a system of equations. Accordingly, we utilize a technique that estimates the equations simultaneously. Specifically, the estimation method that we use in this paper is the full information maximum likelihood (FIML) technique. FIML maximizes the likelihood function of the system of equations (rather than for each individual equation), making use of the assumption that the disturbances are multivariate normally distributed (Kennedy, 1992).[16] We initially attempted to estimate all 25 equations in one system but found that we were unable to do so because of collinearity in the dataset. To resolve this problem while still using a systems-based approach, we divided the 25 portfolios into five systems, with each individual system representing each

[12] The address of the website is http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/. The US factors are expressed in US currency.

[13] Where observations are not available from Datastream, data is obtained from the US Federal Reserve web page: http://www.federalreserve.gov.

[14] Barber and Lyon (1997) note that the effects of size and book-to-market factors are very similar for financial and non-financial firms.

[15] Stocks that do not have a continuous history of returns during the ranking period are excluded from the portfolio formation.

[16] The assumption of multivariate normality begs the question about the sensitivity of our analysis to any violations of that assumption. Further analysis of our data did not suggest that our inferences were affected by problems such as autocorrelated or heteroscedastic disturbances.

beta quintile. System 1 contains the 5 portfolios in the lowest beta quintile, while System 5 contains the 5 portfolios in the highest beta quintile. Table A3 of the Appendix illustrates how portfolios were allocated to groups.

To measure the ability of a specified regression system in explaining portfolio returns, the AIC and the SBC are used. Systems that have lower AIC and SBC scores are preferable. The Gibbon, Ross and Shanken (GRS) test is used to examine whether the regression independent variables suffice as an explanation for returns:[17] if the specified independent variables are sufficient in capturing cross-sectional portfolio returns, then the intercept terms should not be significantly different from zero for all regressions (Merton, 1973).[18] We also use likelihood-ratio tests to examine the difference between the CAPM, CAPM with the US factor, and the CAPM with the US and the ER factors, as well as the difference between the three-factor model and the three-factor model with the US and the ER factors; in doing so, we address the question of whether the additional variables result in a significantly improved explanation of returns.

4. Results

We do not report the results of the CAPM and CAPM with US and exchange rate (ER) factors in this paper. They may be downloaded from the Supplementary Information Section in the corresponding author's web page (http://www.ecom.uwa.edu.au/staff/durand_robert). In general, the results indicate that these models are unable to describe the portfolio returns, as the majority of the intercept terms are still significant at the 1 per cent level. The results of the GRS tests further confirm that the intercept terms are significantly different from zero in all five systems in all models, implying that none of the models satisfies our criterion for a suitable model.

The results of the tests for the Australian three-factor model over the period 1990–2001 are presented in Table 1. In general, they are consistent with the earlier studies in that the market and size factors are statistically significant, while the book-to-market is not (Halliwell *et al*., 1999; Gaunt *et al*., 2000; Durack *et al*., 2004).[19] Although the three-factor model appears to outperform the CAPM, it is still unable to fully account for the variations in stock returns because the GRS tests indicate that the intercept terms are significant in all five systems.

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[17] The GRS test utilizes a finite sample adjustment. Campbell *et al*. (1997, pp. 204–207) consider the power of the GRS test and their analysis indicates that using it for a system of five equations is appropriate.

[18] Under Merton's zero intercept criterion, the non-linear parameter restriction is applied. An alternative multivariate test approach of Gibbons (1982), which considers the non-zero intercept and non-linear regression model, might also have been used in the analysis.

[19] The findings of these studies are at odds with Faff (2001, 2004); however, Durack *et al*. suggest that this might be because of differences in the derivation of the factors.

Table 1
Australian three-factor model regressions

$$R_{p,i} - R_f = a_i + b_i(R_m - R_f) + s_i SMB + h_i HML + j_i JAN + k_i JULY + e_i$$

Panel A: Coefficient estimates and p-*values*

Size/Beta	Low	2	3	4	High	Low	2	3	4	High
	a					p(a)				
Small	0.3048	−1.0383	−0.9413	−1.1663	−1.0821	0.4601	0.0002**	0.0004**	0.0000**	0.0000**
2	0.0182	−0.0379	−0.3247	−0.6436	−0.6043	0.8808	0.8293	0.0266*	0.0001**	0.0013**
3	0.4354	0.2037	−0.0411	−0.2392	−0.5311	0.0001**	0.0206*	0.6978	0.2035	0.0008**
4	0.6267	0.4906	0.4913	0.0873	−0.3172	0.0000**	0.0000**	0.0000**	0.3798	0.0516
Big	0.8106	0.6294	0.5231	0.3722	−0.1253	0.0000**	0.0000**	0.0000**	0.0000**	0.2690
	b					p(b)				
Small	0.8300	1.3790	1.4330	1.8502	1.6654	0.1004	0.0000**	0.0000**	0.0000**	0.0000**
2	0.8378	0.9131	1.1427	1.4254	1.4883	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**
3	0.5965	0.7513	1.0124	1.3171	1.5349	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**
4	0.3942	0.5500	0.7125	1.0510	1.4104	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**
Big	0.5060	0.6304	0.7297	0.9148	1.2398	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**
	s					p(s)				
Small	0.2061	0.3150	0.4982	0.4744	0.5631	0.4954	0.0860	0.0118*	0.0010**	0.0000**
2	0.0423	0.1389	0.1849	0.2962	0.3142	0.6380	0.1599	0.0674	0.0013**	0.0117*
3	−0.1409	−0.0441	−0.0797	0.0653	0.0711	0.0279*	0.5632	0.2565	0.6239	0.4708
4	−0.0791	−0.0900	−0.2243	−0.1713	−0.1345	0.1295	0.0682	0.0004**	0.0289*	0.1998
Big	−0.2639	−0.3109	−0.3524	−0.4120	−0.3410	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**
	h					p(h)				
Small	−0.3188	0.3594	0.0252	−0.1459	−0.1474	0.3711	0.0696	0.9117	0.5246	0.3946
2	0.1053	−0.0230	−0.0069	−0.0947	−0.2200	0.3949	0.8585	0.9541	0.4565	0.1656
3	0.1138	0.0876	0.1017	−0.1609	−0.1058	0.2669	0.2694	0.2897	0.2656	0.3901
4	0.0587	0.0511	0.0253	0.0213	0.0214	0.2426	0.3374	0.8023	0.8159	0.8699
Big	−0.0446	0.0593	0.1042	0.1304	0.2152	0.3220	0.1833	0.0813	0.1298	0.0354*

Table 1 (continued)

Size/Beta	Low	2	3	4	High	Low	2	3	4	High
	j					p(j)				
Small	−0.0081	0.0064	0.0122	0.0427	0.0637	0.8787	0.9039	0.7552	0.2337	0.0633
2	−0.0261	0.0225	−0.0274	0.0113	0.0280	0.2100	0.3914	0.2151	0.4756	0.3574
3	−0.0174	−0.0279	−0.0037	−0.0038	0.0263	0.2763	0.0830	0.8023	0.8961	0.1724
4	−0.0052	−0.0133	−0.0020	0.0013	0.0188	0.7147	0.2307	0.8588	0.9320	0.3276
Big	−0.0026	0.0004	0.0027	−0.0076	−0.0004	0.7861	0.9787	0.9026	0.5251	0.9746
	k					p(k)				
Small	0.0013	0.0394	−0.0225	0.0082	0.0076	0.9903	0.3026	0.6334	0.8244	0.8426
2	−0.0190	0.0252	0.0029	0.0044	0.0059	0.4088	0.2584	0.9093	0.8172	0.8500
3	0.0035	−0.0086	−0.0117	−0.0170	0.0065	0.8549	0.5922	0.5574	0.5527	0.8225
4	−0.0007	0.0018	0.0125	−0.0034	−0.0266	0.9597	0.8885	0.2987	0.8492	0.2006
Big	0.0050	0.0020	−0.0004	−0.0108	−0.0224	0.6479	0.8532	0.9632	0.4786	0.2395

	Panel B: GRS	*Panel C: AIC and SBC*		*Panel D: Adjusted* R^2				
		AIC	SBC					
System 1	46.7586**	−19.0921	−19.0888	0.2836	0.5762	0.6239	0.7414	0.7714
System 2	33.5622**	−18.6305	−18.6272	0.5538	0.6342	0.7080	0.8271	0.7745
System 3	16.6677**	−18.0545	−18.0512	0.4404	0.6128	0.7085	0.7025	0.8001
System 4	14.6414**	−17.0279	−17.0246	0.4036	0.5704	0.5774	0.7104	0.6959
System 5	9.4691**	−15.5974	−15.5941	0.4953	0.5725	0.6154	0.6421	0.6861

At the end of December each year from 1990 to 2001, all of the stocks publicly listed on the Australian Stock Exchange, with the exception of those in banks and finance, insurance, investment and financial services, and property trusts, are used to form 25 portfolios based on their size and beta values. Individual firms' betas are estimated using past monthly returns over the period 24–60 months (i.e. $t-2$ to $t-5$ years) before formation. Stocks are first sorted into size quintiles based on their market values (at $t-1$) and subsequently into beta quintiles based on their pre-estimated beta values to form the 25 portfolios. These portfolios are then divided into five systems, with each individual system representing each beta quintile. Therefore, System 1 contains the 5 portfolios in the lowest beta quintile, while System 5 contains the 5 portfolios in the highest beta quintile. Full-information maximum likelihood is then used to estimate the regression coefficients in each system. This table reports the Australian three-factor regression's coefficient estimates and their *p*-values in Panel A, the Gibbon, Ross and Shanken (GRS) test statistics in Panel B, and the Akaike's Information Criterion (AIC) and Schwartz's Bayesian Criterion (SBC) test statistics in Panel C. * indicates significance at 5 per cent level and ** indicates significance at 1 per cent level. Panel D reports the value of adjusted R^2 for each equation in the system.

Table 2
Australian three-factor model with US and ER factors regressions

$$R_{p,i} - R_f = a_i + b_i(R_m - R_f) + s_i SMB + h_i HML + u_i US + r_i ER + j_i JAN + k_i JULY + e_i$$

Panel A: Coefficient estimates and p-*values*

Size/Beta	Low	2	3	4	High	Low	2	3	4	High
	a					p(a)				
Small	−0.1590	−1.5159	−0.5606	−1.7249	−0.8556	0.8837	0.0568	0.4703	0.0037**	0.1064
2	−0.2581	−0.2979	−0.2937	−0.7205	−0.2716	0.4831	0.4802	0.4961	0.0165*	0.5516
3	0.2944	0.1333	−0.0132	−0.1381	−0.0933	0.2947	0.5892	0.9553	0.7096	0.7898
4	0.4464	0.4498	0.4651	0.1383	−0.3527	0.0073**	0.0014**	0.0629	0.5606	0.4155
Big	0.6051	0.7380	0.4799	0.5181	0.0985	0.0000**	0.0000**	0.0294*	0.0156*	0.7094
	b					p(b)				
Small	0.9530	1.4055	1.4256	2.0669	1.7767	0.1002	0.0000**	0.0000**	0.0000**	0.0000**
2	0.9697	0.9779	1.2246	1.4595	1.4557	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**
3	0.6576	0.7668	1.0592	1.3337	1.4634	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**
4	0.3972	0.5254	0.7221	1.0468	1.4367	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**
Big	0.5078	0.5389	0.7202	0.8944	1.1954	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**
	s					p(s)				
Small	0.1464	0.3042	0.4979	0.3592	0.5011	0.6854	0.1698	0.0207*	0.0387*	0.0008**
2	−0.0289	0.1054	0.1410	0.2781	0.3292	0.7919	0.3510	0.2013	0.0054**	0.0263*
3	−0.1735	−0.0512	−0.1054	0.0558	0.1068	0.0199*	0.5505	0.1708	0.6861	0.3427
4	−0.0791	−0.0750	−0.2294	−0.1693	−0.1486	0.1838	0.1910	0.0018**	0.0604	0.2455
Big	−0.2630	−0.2605	−0.3462	−0.4018	−0.3174	0.0000**	0.0000**	0.0000**	0.0000**	0.0003**
	h					p(h)				
Small	−0.2637	0.4023	−0.0129	−0.0787	−0.1611	0.4905	0.0703	0.9629	0.7673	0.3910
2	0.1432	0.0132	−0.0054	−0.0850	−0.2524	0.2693	0.9299	0.9672	0.5416	0.1437
3	0.1305	0.0904	0.1039	−0.1694	−0.1508	0.2587	0.3020	0.2994	0.2670	0.2364
4	0.0747	0.0513	0.0284	0.0169	0.0267	0.1601	0.4119	0.8098	0.8770	0.8482
Big	−0.0259	0.0399	0.1085	0.1157	0.1907	0.5982	0.4351	0.1950	0.2684	0.1226

Table 2 (continued)

Size/Beta	Low	2	3	4	High	Low	2	3	4	High
	u					p(u)				
Small	−0.0616	0.2014	−0.1832	−0.2489	−0.3860	0.8856	0.5087	0.4651	0.3763	0.0781
2	−0.1847	−0.0226	−0.2171	−0.0450	−0.0908	0.1784	0.8884	0.1205	0.7406	0.6760
3	−0.0770	−0.0076	−0.1277	−0.0931	−0.0480	0.4773	0.9418	0.3248	0.6187	0.7302
4	0.0841	0.0737	−0.0056	−0.0157	−0.0457	0.3029	0.3058	0.9486	0.8724	0.7735
Big	0.1004	0.1661	0.0490	−0.0243	−0.0024	0.0859	0.0132*	0.4788	0.7702	0.9874
	r					p(r)				
Small	0.4070	0.2138	−0.1480	0.6414	0.1303	0.6490	0.7289	0.7915	0.2404	0.7748
2	0.3646	0.2148	0.1501	0.0969	−0.1898	0.2088	0.4908	0.6570	0.7006	0.6305
3	0.1737	0.0668	0.0784	−0.0049	−0.3075	0.4333	0.7351	0.7126	0.9876	0.2617
4	0.0756	−0.0247	0.0242	−0.0282	0.0642	0.6373	0.8168	0.8892	0.8878	0.8480
Big	0.0819	−0.2165	−0.0077	−0.0959	−0.1756	0.4555	0.0810	0.9582	0.5151	0.4347
	j					p(j)				
Small	−0.0091	0.0055	0.0129	0.0417	0.0641	0.8793	0.9206	0.7639	0.2882	0.0538
2	−0.0266	0.0220	−0.0274	0.0111	0.0287	0.1972	0.4416	0.2448	0.4905	0.4194
3	−0.0177	−0.0280	−0.0037	−0.0037	0.0272	0.2981	0.1123	0.8316	0.9022	0.1484
4	−0.0056	−0.0134	−0.0020	0.0014	0.0188	0.7142	0.3030	0.8745	0.9310	0.3511
Big	−0.0031	0.0006	0.0026	−0.0074	0.0000	0.7082	0.9700	0.9103	0.5705	0.9988
	k					p(k)				
Small	0.0001	0.0403	−0.0234	0.0061	0.0050	0.9989	0.3837	0.6083	0.8846	0.9055
2	−0.0204	0.0247	0.0012	0.0040	0.0056	0.3818	0.3288	0.9679	0.8420	0.8669
3	0.0029	−0.0087	−0.0126	−0.0176	0.0065	0.8690	0.6195	0.5469	0.5812	0.8196
4	−0.0002	0.0022	0.0124	−0.0035	−0.0269	0.9862	0.8925	0.3274	0.8516	0.2109
Big	0.0056	0.0032	−0.0002	−0.0109	−0.0223	0.6781	0.8150	0.9858	0.5415	0.2632

Table 2 (continued)

Panel B: GRS		*Panel C: AIC and SBC*		*Panel D: Adjusted* R^2				
		AIC	SBC					
System 1	3.5005**	−19.2116	−19.2061	0.2790	0.5769	0.6228	0.7453	0.7779
System 2	4.1083**	−18.7433	−18.7378	0.5627	0.6322	0.7119	0.8250	0.7745
System 3	0.9301	−18.0905	−18.0850	0.4398	0.6079	0.7101	0.6999	0.8031
System 4	2.7973*	−17.0462	−17.0407	0.4190	0.5706	0.5713	0.7065	0.6919
System 5	0.5939	−15.6633	−15.6578	0.5216	0.6055	0.6124	0.6404	0.6854

At the end of December each year from 1990 to 2001, all of the stocks publicly listed on the Australian Stock Exchange, with the exception of those in banks and finance, insurance, investment and financial services, and property trusts, are used to form 25 portfolios based on their size and beta values. Individual firms' betas are estimated using past monthly returns over the period 24–60 months (i.e. $t-2$ to $t-5$ years) before formation. Stocks are first sorted into size quintiles based on their market values (at $t-1$) and subsequently into beta quintiles based on their pre-estimated beta values to form the 25 portfolios. These portfolios are then divided into five systems, with each individual system representing each beta quintile. Therefore, System 1 contains the 5 portfolios in the lowest beta quintile, while System 5 contains the 5 portfolios in the highest beta quintile. Full-information maximum likelihood is then used to estimate the regression coefficients in each system. This table reports the Australian three-factor with the US and exchange rate (ER) factors regression's coefficient estimates and their *p*-values in Panel A, the Gibbon, Ross and Shanken (GRS) test statistics in Panel B, and the Akaike's Information Criterion (AIC) and Schwartz's Bayesian Criterion (SBC) test statistics in Panel C. * indicates significance at 5 per cent level and ** indicates significance at 1 per cent level. Panel D reports the value of adjusted R^2 for each equation in the system.

Given the findings of Ragunathan *et al*. (1999), Durand *et al*. (2001) and Durand and Scott (2003), we augment the Australian three-factor model with the US and ER factors, whose results are presented in Table 2. Although the model exhibits fewer significant alphas, the GRS test statistics indicate that the three systems have alphas that are jointly and significantly different from zero, implying that augmenting the three-factor model with US and ER is not satisfactory. The likelihood-ratio tests reported in Table E (in the Supplementary Information Section)[20] show that augmenting the Australian three-factor model with US and ER factors seems to add some value to the model of returns.

We find the results presented in Table 2 unsatisfying in light of work documenting a strong link between the two markets. That this link does not show up in models of the entire cross-section of Australian returns is, to our minds, curious.[21] Therefore, we pursue the issue further by taking the perhaps radical step of assuming that there is no independent Australian market, and that the US market excess, size-premium and value-growth premium (i.e. (R_m – R_f), SMB and HML) affect our 25 portfolios as if they were 25 assets trading on the US market. Should the factors prove to be significant, it would imply that the markets were integrated; the factors capturing the pay-offs for exposure to systematic risk in the USA would also capture the rewards for exposure to systematic risk in Australia. We regress the 25 portfolio returns on the US market excess return, US SMB, and US HML factors (i.e. the US Fama–French factors), along with January and July dummy variables to control for end-of-financial-year seasonality that may affect the portfolio returns. For comparability, the regression of the US three-factor model is carried out over the same period (1990–2001) as the Australian three-factor model.

Our approach is similar to that of Faff and Mittoo (2003). Faff and Mittoo examine the market integration between Australia, Canada and the USA by analysing whether the risk premiums they estimate are equal for all the markets (and they find that the pricing of Australian stocks is different from the other two markets). Rather than estimating risk premiums, our analysis imposes the restriction that the US risk premiums captured by the three American factors must equal those that apply in Australia. Any finding that the three factors have a statistically significant relationship to the returns of the portfolios is evidence of market integration.

The results in Table 3 indicate that the three US factors are strongly related to Australian portfolio returns. Strikingly, the US market coefficient is significant for 16 out of 25 portfolios, with the most pronounced effect on the portfolios that consist of large stocks. The SMB coefficient is significant for various portfolios, with the effect concentrating on portfolios with large stocks. While the January dummy

[20] This may be downloaded from http://www.ecom.uwa.edu.au/staff/durand_robert.

[21] Durack *et al*. (2004) also find that the US market beta is insignificant in their analysis of the cross-section of returns. Given that the Australian market beta fails, and that the correlation between the US and Australian market betas is found to be 0.93, they are not surprised by their results (Durack *et al*., 2004, p. 156).

Table 3
US three-factor model regressions

$$R_{p,i} - R_f = a_{us,i} + b_{us,i}(USR_m - USR_f) + s_{us,i}USSMB + h_{us,i}USHML + j_iJAN + k_iJULY + e_i$$

Panel A: Coefficient estimates and p-*values*

Size/Beta	Low	2	3	4	High	Low	2	3	4	High
	a					p(a)				
Small	0.5544	−0.5558	−1.0311	−1.8546	−0.6497	0.6773	0.7173	0.5875	0.2959	0.7010
2	−0.0199	−1.2803	−0.7891	−2.1731	−0.6978	0.9725	0.0614	0.4297	0.1815	0.6371
3	−0.2268	0.0383	−0.6114	−1.2724	1.1720	0.6664	0.9655	0.2104	0.2133	0.1100
4	0.0462	−0.3479	−0.6996	−1.9060	−1.1859	0.8840	0.2542	0.1221	0.0013**	0.2267
Big	−0.1706	−0.4990	−0.8224	−1.0580	−0.6757	0.5928	0.1819	0.0324*	0.0291*	0.3012
	b					p(b)				
Small	0.1692	0.7149	0.5959	0.9799	0.5991	0.6916	0.1031	0.2592	0.0584	0.2473
2	0.2072	0.5263	0.6262	1.0873	0.8553	0.2538	0.0200*	0.0092**	0.0141*	0.0321*
3	0.2435	0.4229	0.3746	0.6866	−0.2237	0.2045	0.1244	0.0287*	0.0455*	0.3420
4	0.3750	0.4068	0.5920	0.8565	0.7179	0.0004**	0.0000**	0.0000**	0.0000**	0.0111*
Big	0.4651	0.5438	0.7181	0.7673	0.6625	0.0000**	0.0000**	0.0000**	0.0000**	0.0003**
	s					p(s)				
Small	0.3335	0.1578	0.7351	0.8351	0.4643	0.7026	0.8441	0.4200	0.4026	0.5446
2	0.5562	0.6968	0.4000	0.6759	0.4578	0.0661	0.0745	0.4583	0.3866	0.4771
3	0.4780	0.3442	0.6573	0.6983	0.1270	0.0452*	0.4240	0.0167*	0.1675	0.7269
4	0.2594	0.5296	0.5494	0.9696	0.7561	0.1839	0.0016**	0.0220*	0.0024**	0.0959
Big	0.4618	0.6263	0.5906	0.8397	0.5592	0.0121*	0.0038**	0.0146*	0.0025**	0.0988
	h					p(h)				
Small	−0.0316	0.7143	0.7316	1.0601	0.6038	0.9632	0.4249	0.3838	0.2388	0.4953
2	0.2673	1.0538	0.7673	1.4030	0.3817	0.4068	0.0011**	0.1663	0.0536	0.6141
3	0.5111	0.1994	0.5745	0.8780	−0.0720	0.0525	0.6348	0.0347*	0.1164	0.8568
4	0.3221	0.4141	0.5508	1.0652	0.6939	0.0496*	0.0158*	0.0626	0.0032**	0.1788
Big	0.2460	0.3290	0.5081	0.4405	0.4414	0.2175	0.1231	0.0394*	0.1789	0.3090

Table 3 (continued)

Size/Beta	Low	2	3	4	High	Low	2	3	4	High
	j					p(j)				
Small	−0.0404	0.0220	0.0620	0.0588	0.0666	0.5565	0.7884	0.3319	0.2713	0.3695
2	−0.0341	0.0023	0.0095	−0.0014	−0.0100	0.2713	0.9602	0.8283	0.9825	0.8962
3	−0.0187	−0.0263	−0.0263	−0.0283	−0.0040	0.4966	0.5395	0.2633	0.5608	0.9406
4	−0.0258	−0.0056	−0.0179	−0.0239	−0.0128	0.0658	0.8540	0.5184	0.5043	0.7549
Big	0.0036	−0.0080	−0.0088	−0.0094	−0.0108	0.8146	0.7178	0.6425	0.6745	0.8076
	k					p(k)				
Small	0.0373	0.1437	0.1280	0.1761	0.2368	0.6687	0.0143*	0.1757	0.0295*	0.0233*
2	0.0269	0.0453	0.0644	0.1387	0.1616	0.6074	0.0506	0.3557	0.0227*	0.0326*
3	0.0172	0.0245	0.0409	0.0854	−0.0439	0.6849	0.4750	0.0323*	0.0550	0.5123
4	−0.0018	0.0242	0.0429	0.0750	0.1355	0.9471	0.1615	0.1491	0.0722	0.0371*
Big	0.0204	0.0339	0.0378	0.0560	0.0737	0.3510	0.0912	0.1972	0.0961	0.2399

Panel B GRS		*Panel C AIC and SBC*		*Panel D: Adjusted* R^2				
		AIC	SBC					
System 1	0.1835	−16.6225	−16.6192	0.0000	0.1084	0.0716	0.1428	0.1598
System 2	1.1305	−15.4551	−15.4518	0.0621	0.1663	0.0839	0.1629	0.1667
System 3	1.0870	−14.6646	−14.6613	0.1051	0.0844	0.1261	0.1265	0.0170
System 4	2.3983*	−13.1950	−13.1917	0.1670	0.2373	0.2380	0.2918	0.2179
System 5	0.7929	−12.6282	−12.6249	0.2423	0.2908	0.2901	0.2864	0.1690

At the end of December each year from 1990 to 2001, all of the stocks publicly listed on the Australian Stock Exchange, with the exception of those in banks and finance, insurance, investment and financial services, and property trusts, are used to form 25 portfolios based on their size and beta values. Individual firms' betas are estimated using past monthly returns over the period 24–60 months (i.e. t – 2 to t – 5 years) before formation. Stocks are first sorted into size quintiles based on their market values (at t – 1) and subsequently into beta quintiles based on their pre-estimated beta values to form the 25 portfolios. These portfolios are then divided into five systems, with each individual system representing each beta quintile. Therefore, System 1 contains the 5 portfolios in the lowest beta quintile, while System 5 contains the 5 portfolios in the highest beta quintile. The full-information maximum likelihood is then used to estimate the regression coefficients in each system. This table reports the US three-factor regression's coefficient estimates and their p-values in Panel A, the Gibbon, Ross and Shanken (GRS) test statistics in Panel B, and the Akaike's Information Criterion (AIC) and Schwartz's Bayesian Criterion (SBC) test statistics in Panel C. * indicates significance at 5 per cent level and ** indicates significance at 1 per cent level. Panel D reports the value of adjusted R^2 for each equation in the system.

does not appear to be significant, the July dummy coefficient is significant for a number of portfolios that are not in the lowest beta quintile.

When comparing the models, the US three-factor model appears to perform best in explaining the variations in Australian portfolio returns. While a large number of regression alphas under the other models are statistically significant, only one portfolio, namely portfolio 19, under the US three-factor model still exhibits significant alphas at the 1 per cent level. Further analysis indicates that the return of portfolio 19 is driven by three outliers.[22] Subsequently, we removed these stocks from the portfolio, and re-ran the regression test for System 4. The results of our analysis are reported in Table 4. We find that the alpha term of portfolio 19 is no longer significant. The GRS tests in Panel B of Table 4 further confirm this result, indicating that the alphas are not jointly and significantly different from zero for System 4. In addition, the AIC and SBC scores are the lowest for the US three-factor model among all of the models examined, indicating that it is the preferred model. These results imply that the US three-factor model outperforms the domestic Australian model.[23]

While our analysis has leant heavily on Merton's no-significant-alpha criterion, and while we have relied on the GRS test as our guide, there should, perhaps, be more to a successful asset pricing model. A closer examination of the individual portfolio regressions, as opposed to the systems, is instructive. Panel A of Table 4 shows that no variable is statistically significant for portfolio 1 (the portfolio of the smallest stocks with the lowest beta); in all the models we studied, only in Table 1, reporting the standard CAPM, do we find that excess market returns are significant, and the alpha value is insignificant. For the other portfolios in the smallest size quintile, portfolios 1, 2, 3, 4 and 5, we find no statistically significant variables[24] in Table 4 (and, in the preceding analyses for competing portfolios, we find that models where variables are significant also tend mostly to have significant alphas). Similarly, Table 4 does not report any significant variables for portfolios 6, 12, 14 and 15. Yet, in the cases of portfolios 12, 14 and 15, the analyses reported in Tables A, B, C (in the Supplementary Information Section), 1 and 2 show that, individually, each fails the significant-alpha test. Therefore, the success of the US three-factor model appears linked to market capitalization. For the largest firms in the Australian market, the three-factor model is a satisfactory model for returns. For the smallest firms in the market, the models we have examined appear wanting. Our results suggest that the

[22] We scanned through the average returns of all stocks in the portfolio and identified that the average returns of the top three outliers are approximately 16.86 per cent above the average of all other stocks.

[23] To further explore this issue, we re-ran the regressions for the US three-factor model over a longer sample period 1980–2001 (where we had the US HML but not the Australian HML), and found similar results.

[24] Except for the July dummy variable for portfolio 2, 4 and 5.

Table 4
US three-factor model regressions (without outliers in portfolio 19)

$$R_{p,i} - R_f = a_{us,i} + b_{us,i}(USR_m - USR_f) + s_{us,i}USSMB + h_{us,i}USHML + j_iJAN + k_iJULY + e_i$$

Panel A: Coefficient estimates and p-*values*

Size/Beta	Low	2	3	4	High	Low	2	3	4	High
	a					p(a)				
Small	0.5544	−0.5558	−1.0311	−1.5994	−0.6497	0.6773	0.7173	0.5875	0.3640	0.7010
2	−0.0199	−1.2803	−0.7891	−1.9355	−0.6978	0.9725	0.0614	0.4297	0.2404	0.6371
3	−0.2268	0.0383	−0.6114	−1.1053	1.1720	0.6664	0.9655	0.2104	0.2929	0.1100
4	0.0462	−0.3479	−0.6996	−1.3230	−1.1859	0.8840	0.2542	0.1221	0.0526	0.2267
Big	−0.1706	−0.4990	−0.8224	−0.9483	−0.6757	0.5928	0.1819	0.0324*	0.0557	0.3012
	b					p(b)				
Small	0.1692	0.7149	0.5959	0.9401	0.5991	0.6916	0.1031	0.2592	0.0672	0.2473
2	0.2072	0.5263	0.6262	1.0447	0.8553	0.2538	0.0200*	0.0092**	0.0189*	0.0321*
3	0.2435	0.4229	0.3746	0.6525	−0.2237	0.2045	0.1244	0.0287*	0.0589	0.3420
4	0.3750	0.4068	0.5920	0.7350	0.7179	0.0004**	0.0000**	0.0000**	0.0001**	0.0111*
Big	0.4651	0.5438	0.7181	0.7468	0.6625	0.0000**	0.0000**	0.0000**	0.0000**	0.0003**
	s					p(s)				
Small	0.3335	0.1578	0.7351	0.7422	0.4643	0.7026	0.8441	0.4200	0.4555	0.5446
2	0.5562	0.6968	0.4000	0.5954	0.4578	0.0661	0.0745	0.4583	0.4515	0.4771
3	0.4780	0.3442	0.6573	0.6463	0.1270	0.0452*	0.4240	0.0167*	0.2086	0.7269
4	0.2594	0.5296	0.5494	0.8037	0.7561	0.1839	0.0016**	0.0220*	0.0270*	0.0959
Big	0.4618	0.6263	0.5906	0.8028	0.5592	0.0121*	0.0038**	0.0146*	0.0041**	0.0988
	h					p(h)				
Small	−0.0316	0.7143	0.7316	0.9383	0.6038	0.9632	0.4249	0.3838	0.3059	0.4953
2	0.2673	1.0538	0.7673	1.2891	0.3817	0.4068	0.0011**	0.1663	0.0817	0.6141
3	0.5111	0.1994	0.5745	0.7975	−0.0720	0.0525	0.6348	0.0347*	0.1711	0.8568
4	0.3221	0.4141	0.5508	0.7712	0.6939	0.0496*	0.0158*	0.0626	0.0517	0.1788
Big	0.2460	0.3290	0.5081	0.3884	0.4414	0.2175	0.1231	0.0394*	0.2485	0.3090

Table 4 (continued)

Size/Beta	Low	2	3	4	High	Low	2	3	4	High
	j					p(j)				
Small	−0.0404	0.0220	0.0620	0.0617	0.0666	0.5565	0.7884	0.3319	0.2680	0.3695
2	−0.0341	0.0023	0.0095	0.0014	−0.0100	0.2713	0.9602	0.8283	0.9819	0.8962
3	−0.0187	−0.0263	−0.0263	−0.0263	−0.0040	0.4966	0.5395	0.2633	0.6064	0.9406
4	−0.0258	−0.0056	−0.0179	−0.0254	−0.0128	0.0658	0.8540	0.5184	0.5129	0.7549
Big	0.0036	−0.0080	−0.0088	−0.0081	−0.0108	0.8146	0.7178	0.6425	0.7281	0.8076
	k					p(k)				
Small	0.0373	0.1437	0.1280	0.1754	0.2368	0.6687	0.0143*	0.1757	0.0252*	0.0233*
2	0.0269	0.0453	0.0644	0.1381	0.1616	0.6074	0.0506	0.3557	0.0254*	0.0326*
3	0.0172	0.0245	0.0409	0.0850	−0.0439	0.6849	0.4750	0.0323*	0.0576	0.5123
4	−0.0018	0.0242	0.0429	0.0732	0.1355	0.9471	0.1615	0.1491	0.0575	0.0371*
Big	0.0204	0.0339	0.0378	0.0558	0.0737	0.3510	0.0912	0.1972	0.0847	0.2399

	Panel B: GRS	*Panel C: AIC and SBC*		*Panel D: Adjusted* R^2				
		AIC	SBC					
System 1	0.1835	−16.6225	−16.6192	0.0000	0.1084	0.0716	0.1423	0.1598
System 2	1.1305	−15.4551	−15.4518	0.0621	0.1663	0.0839	0.1623	0.1667
System 3	1.0870	−14.6646	−14.6613	0.1051	0.0844	0.1261	0.1260	0.0170
System 4	0.9521	−13.1255	−13.1222	0.1670	0.2373	0.2380	0.2352	0.2179
System 5	0.7929	−12.6282	−12.6249	0.2423	0.2908	0.2901	0.2859	0.1690

At the end of December each year from 1990 to 2001, all of the stocks publicly listed on the Australian Stock Exchange, with the exception of those in banks and finance, insurance, investment and financial services, and property trusts, are used to form 25 portfolios based on their size and beta values. Individual firms' betas are estimated using past monthly returns over the period 24–60 months (i.e. $t-2$ to $t-5$ years) before formation. Stocks are first sorted into size quintiles based on their market values (at $t-1$) and subsequently into beta quintiles based on their pre-estimated beta values to form the 25 portfolios. These portfolios are then divided into five systems, with each individual system representing each beta quintile. Therefore, System 1 contains the 5 portfolios in the lowest beta quintile, while System 5 contains the 5 portfolios in the highest beta quintile. Full-information maximum likelihood is then used to estimate the regression coefficients in each system. This table reports the US three-factor regression's coefficient estimates and their *p*-values (without outliers in portfolio 19) in Panel A, the Gibbon, Ross and Shanken (GRS) test statistics in Panel B, and the Akaike's Information Criterion (AIC) and Schwartz's Bayesian Criterion (SBC) test statistics in Panel C. * indicates significance at 5 per cent level and ** indicates significance at 1 per cent level. Panel D reports the value of adjusted R^2 for each equation in the system.

Australian market is segmented between firms that are integrated in the global market and those that are not.

If the returns of the largest firms in the market can be explained by the US factors (indicating that they are globally integrated) and the smallest firms seem to be driven by domestic factors, perhaps a combination of the US three-factor model and the Australian three-factor model (and January and July seasonal dummies) might capture the cross-section of returns? Our analysis concludes with a consideration of this possibility and the results of our analysis of this mega-model are presented in Table 5.[25] The AIC and SBC statistics reported in Panel C of Table 5 and the likelihood-ratio tests reported in Table F (in the Supplementary Information Section) indicate that the combination of the Australian and US three-factor models, with seasonal dummies, adds value to the model of returns. Panel A of Table 5 shows that, in all but one instance, Australian excess returns are statistically significant and the Australian SMB factor is statistically significant in 11 of the 25 instances.

Despite the findings in Panel C of Table 5,[26] there are two problems that lead us to be very reluctant to conclude that the mega-model is a satisfactory solution to modelling the cross-section of Australian returns. First, the effects of the previously significant US factors have now disappeared. Our analysis is clouded by multicollinearity between explanatory variables. The mega-model examined in Table 5 simply ‘throws the baby out with the bathwater’. Second, focusing on Panel B of Table 5, we find one statistically significant GRS test statistic, indicating that the mega-model still falls short of our criterion that there should be no significant alphas. The result is driven by portfolio 21 (with an estimated alpha of 0.7115 with a *p*-value of 0.0000). In our examination of the Australian three-factor model reported in Table 1, the estimated alpha of portfolio 21 was 0.8106 (with a *p*-value of 0.0000). In Table 5 it would appear that the additional variables have a confounding effect on the analysis of portfolio 21. This confounding effect returns us to the unsatisfactory position we found ourselves in after the analysis reported in Table 1 where, given the strong evidence against the model, there was no incentive to consider the effect of outliers.

5. Conclusion

This paper has analysed asset pricing models in Australia. Extending published works that have found strong links between the Australian and US markets, our analysis has examined the integration of the markets within a standard asset-pricing test framework. The bottom line of our study is that the Australian market is domestically segmented. The largest firms in the Australian market are closely integrated with the US market. The returns of the smallest firms in the market are not adequately captured by the models we test.

[25] The data include the outliers removed in the analysis reported in Table 4.

[26] And also in contrast to Table F (in the Supplementary Information Section).

Table 5
Combined Australian and US three-factor model regressions

$$R_{p,i} - R_f = a_i + b_i(R_m - R_f) + s_i SMB + h_i HML + b_{us,i}(USR_m - USR_f) + s_{us,i} USSMB + h_{us,i} USHML + j_i JAN + k_i JULY + e_i$$

Panel A: Coefficient estimates and p-*values*

Size/Beta	Low	2	3	4	High	Low	2	3	4	High
	a					p(a)				
Small	0.5153	−0.9396	0.0058	−0.3577	−0.5786	0.6184	0.3475	0.9952	0.6151	0.2607
2	−0.0405	−0.3873	0.0629	−0.4108	−0.1664	0.9040	0.3151	0.8688	0.3617	0.8059
3	0.2872	0.0848	0.0715	−0.3416	−0.1366	0.4571	0.8018	0.7991	0.5466	0.7248
4	0.2505	0.2695	0.3572	−0.0629	−0.3715	0.2140	0.1446	0.1299	0.8329	0.4361
Big	0.7115	0.1726	0.3207	0.2178	−0.2698	0.0000**	0.2823	0.0300*	0.3646	0.4637
	b					p(b)				
Small	0.8340	1.3544	1.6284	2.0356	1.9366	0.1709	0.0002**	0.0000**	0.0000**	0.0000**
2	0.9210	0.8928	1.2598	1.4593	1.4882	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**
3	0.6539	0.7464	1.0656	1.3786	1.5844	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**
4	0.3463	0.5083	0.7189	1.0338	1.3783	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**
Big	0.4871	0.5390	0.7145	0.9314	1.2246	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**
	s					p(s)				
Small	0.1976	0.3335	0.4117	0.3846	0.4364	0.6063	0.1304	0.0743	0.0370*	0.0044**
2	−0.0028	0.1434	0.1259	0.2803	0.3078	0.9809	0.1943	0.2773	0.0148*	0.0494*
3	−0.1669	−0.0401	−0.1076	0.0350	0.0492	0.0219*	0.6463	0.2046	0.8309	0.6705
4	−0.0562	−0.0680	−0.2274	−0.1648	−0.1261	0.3524	0.2407	0.0023**	0.0858	0.3621
Big	−0.2512	−0.2636	−0.3429	−0.4194	−0.3345	0.0000**	0.0000**	0.0000**	0.0000**	0.0001**
	h					p(h)				
Small	−0.3108	0.3689	0.0995	−0.0827	−0.1064	0.5685	0.0837	0.6956	0.7676	0.6031
2	0.0994	−0.0418	0.0227	−0.0765	−0.1904	0.4716	0.7690	0.8632	0.5993	0.2721
3	0.1058	0.0721	0.1120	−0.1677	−0.0763	0.3703	0.4302	0.3068	0.3315	0.5722
4	0.0309	0.0297	0.0168	0.0088	0.0137	0.6359	0.6481	0.8813	0.9327	0.9335
Big	−0.0501	0.0210	0.0926	0.1198	0.2034	0.2976	0.6720	0.2109	0.2460	0.0917

Table 5 (continued)

Size/Beta	Low	2	3	4	High	Low	2	3	4	High
	usb					p(usb)				
Small	−0.1543	0.1532	−0.3071	−0.3993	−0.4055	0.7529	0.7194	0.3515	0.2422	0.1301
2	−0.1682	0.0220	−0.2801	−0.0773	−0.1577	0.3256	0.8997	0.0820	0.6184	0.5043
3	−0.0244	0.0330	−0.1284	−0.0828	−0.0877	0.8655	0.7989	0.3485	0.7385	0.5871
4	0.1235	0.1000	0.0124	0.0208	−0.0407	0.2272	0.2541	0.8999	0.8543	0.8525
Big	0.0925	0.2345	0.0801	0.0093	0.0394	0.2308	0.0010**	0.3223	0.9214	0.8127
	uss					p(uss)				
Small	0.1253	−0.2068	−0.4710	−0.2327	−0.2585	0.8581	0.6333	0.2712	0.4228	0.3936
2	0.0972	0.1992	−0.0414	−0.0799	0.0181	0.5984	0.4640	0.8301	0.7354	0.9572
3	−0.0186	0.0162	0.0193	0.0386	−0.1855	0.9144	0.9176	0.9045	0.8793	0.3331
4	0.1157	0.0482	0.0398	0.0858	0.1686	0.2315	0.6222	0.7220	0.5721	0.4756
Big	−0.0468	0.0820	0.0178	0.0274	0.0496	0.5350	0.2433	0.8703	0.8032	0.7994
	ush					p(ush)				
Small	−0.1841	−0.0497	−0.3493	−0.3318	−0.0201	0.7493	0.9243	0.4616	0.2752	0.9432
2	0.0994	0.1627	−0.1513	−0.1112	−0.3208	0.4767	0.2874	0.3889	0.5622	0.2247
3	0.1687	0.0861	−0.0380	0.1237	−0.1778	0.3673	0.6210	0.7874	0.6953	0.2584
4	0.1890	0.1133	0.0872	0.0668	−0.0422	0.0543	0.2484	0.3571	0.6153	0.8421
Big	0.0645	0.2207	0.1214	0.1195	0.0759	0.3542	0.0019**	0.1077	0.2055	0.6400
	j					p(j)				
Small	−0.0065	0.0099	0.0229	0.0504	0.0660	0.9342	0.8762	0.6966	0.2823	0.0482*
2	−0.0292	0.0174	−0.0249	0.0140	0.0333	0.2015	0.6019	0.2975	0.4510	0.3106
3	−0.0203	−0.0295	−0.0035	−0.0067	0.0315	0.2812	0.0759	0.8581	0.8764	0.2295
4	−0.0097	−0.0156	−0.0039	−0.0007	0.0177	0.5187	0.1874	0.7846	0.9682	0.3595
Big	−0.0031	−0.0040	0.0004	−0.0101	−0.0022	0.7541	0.7388	0.9879	0.4113	0.8915

Table 5 (continued)

Size/Beta	Low	2	3	4	High	Low	2	3	4	High
	k					p(k)				
Small	0.0046	0.0372	−0.0318	0.0028	−0.0028	0.9695	0.4363	0.4824	0.9436	0.9464
2	−0.0202	0.0275	0.0005	0.0032	0.0088	0.4367	0.3158	0.9874	0.8783	0.8323
3	0.0006	−0.0090	−0.0123	−0.0188	0.0039	0.9763	0.6392	0.5801	0.5360	0.9180
4	0.0008	0.0026	0.0122	−0.0022	−0.0228	0.9596	0.8705	0.3639	0.9077	0.3278
Big	0.0042	0.0037	−0.0008	−0.0118	−0.0218	0.7389	0.7789	0.9359	0.4338	0.3349

Panel B: GRS		*Panel C: AIC and SBC*		*Panel D: Adjusted* R^2				
		AIC	SBC					
System 1	3.0796*	−19.2409	−19.2343	0.2756	0.5707	0.6294	0.7449	0.7787
System 2	0.6293	−18.8298	−18.8232	0.5599	0.6336	0.7127	0.8246	0.7796
System 3	0.7960	−18.1357	−18.1291	0.4588	0.6077	0.7071	0.7007	0.7989
System 4	0.6673	−17.0661	−17.0595	0.4405	0.5767	0.5731	0.7061	0.6943
System 5	0.3048	−15.7047	−15.6981	0.5033	0.6417	0.6202	0.6432	0.6810

At the end of December each year from 1990 to 2001, all of the stocks publicly listed on the Australian Stock Exchange, with the exception of those in banks and finance, insurance, investment and financial services, and property trusts, are used to form 25 portfolios based on their size and beta values. Individual firms' betas are estimated using past monthly returns over the period 24–60 months (i.e. $t - 2$ to $t - 5$ years) prior to formation. Stocks are first sorted into size quintiles based on their market values (at $t - 1$) and subsequently into beta quintiles based on their pre-estimated beta values to form the 25 portfolios. These portfolios are then divided into five systems, with each individual system representing each beta quintile. Therefore, System 1 contains the 5 portfolios in the lowest beta quintile, while System 5 contains the 5 portfolios in the highest beta quintile. Full-information maximum likelihood is then used to estimate the regression coefficients in each system. This table reports the combined Australian and US three-factor regression's coefficient estimates and their p-values in Panel A, the Gibbon, Ross and Shanken (GRS) test statistics in Panel B, and the Akaike's Information Criterion (AIC) and Schwartz's Bayesian Criterion (SBC) test statistics in Panel C. * indicates significance at 5 per cent level and ** indicates significance at 1 per cent level. Panel D reports the value of adjusted R^2 for each equation in the system.

For the largest Australian companies, asset returns are captured by US rather than indigenous factors. Given that these firms represent the most liquid and important companies in the Australian market, the results are striking. The indigenous CAPM and the indigenous three-factor model failed, as did a multifactor model containing the indigenous three-factors augmented with US variables: our analysis found statistically significant positive intercept terms; therefore, the model fails Merton's (1973) criterion. Analysing returns using US-based factors (Fama and French's Fama–French factors) we found a model that satisfied our criterion for a successful model.

Our analysis did not find an adequate model for the returns of smaller Australian stocks. Our findings highlight the importance of further research in asset pricing in Australia. A model of the cross-section of Australian returns that worked for both large and small firms would, to our minds, be a satisfying achievement. Yet the clear indication of market segmentation found in our study suggests that this Holy Grail may not be attained for the Australian market in the future.

In addition to providing strong evidence of market integration for the largest firms and a segmented Australian market, our analysis challenges the often uncritical expositions relating to the calculation of the cost of capital presented in many finance programmes. Stulz (1995) argues that, in internationally integrated markets, a global, rather than a local, market benchmark should be used to calculated beta in a CAPM setting. Ragunathan *et al*. (2000) demonstrate that, in Australia, using local, rather than global, betas results in biased cost of capital estimates.[27] Our analysis reiterates the importance of using global benchmarks. Perhaps, more importantly, our results remind us that use of the static CAPM does not capture investors' expected returns and, as such, provides a poor benchmark for determining required rates of return.

Our study has significant ramifications for investment practice in Australia. First, if Australian fund managers are assessed using the alpha from a model of returns, and if they are investing in the assets that we find are integrated with the US market, using an indigenous CAPM or an indigenous three-factor model will result in incorrect conclusions being drawn about their performance. Indeed, given the significant positive alphas we find, it seems that using the wrong models will tend to flatter fund managers. Second, investors might need to reconsider strategies for the international diversification of their portfolios. Neither Australian nor American investors would appear to achieve improved portfolio diversification by investing in the other country. Furthermore, we do not know if indigenous factors fail in other countries as they do in Australia: if they do, international investment to achieve a better return/risk trade-off might be more challenging than is commonly thought.

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[27] Australian industry betas fall by 30 per cent (on average) when shifting from a national to world betas and are substantially less than 1.

The Australian market is highly concentrated in its largest firms and, to this extent, Australia is in America's thrall. For large Australian firms, it is as if the Australian market and Australian spanning portfolios are not factors of hedging concern to Australian investors. Clearly, the relationship of Australian and US returns is one that will be a fruitful course of research in coming years. We are moving to a post-three-factor world. Recent analysis has argued that momentum and liquidity are candidates for inclusion in models of the cross-section of Australian returns (Chan and Faff, 2003; Demir *et al*., 2004). Based on our analysis, consideration of the American influence on such factors might be warranted.

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Appendix

Table A1
Sample size at each portfolio formation date

Portfolio formation (31 December)	Number of stocks available for portfolio formation	Number of stocks available for SMB factor formation	Number of stocks available for HML factor formation
1990	658	187	53
1991	642	200	53
1992	619	217	57
1993	651	240	63
1994	651	290	100
1995	718	350	123
1996	783	397	160
1997	762	440	407
1998	764	493	460
1999	795	530	500
2000	792	623	537
2001	811	750	650

Table A2
Portfolio number

Size/Beta	Low	2	3	4	High
Small	1	2	3	4	5
2	6	7	8	9	10
3	11	12	13	14	15
4	16	17	18	19	20
Big	21	22	23	24	25

Table A3
Portfolio system

Size/Beta	Low	2	3	4	High
Small 2 3 4 Big	System 1	System 2	System 3	System 4	System 5