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The definitive publisher version is available online at

<https://doi.org/10.1016/j.pacfin.2021.101508>

Future profitability and stock returns of innovative firms in Australia

1. Introduction

This study aims to (1) replicate the findings in Hirshleifer et al. (2018) on the association between innovative originality, future profitability and stock returns, and (2) extend these findings to the Australian setting.¹ Given the dominance of the U.S. in innovative production and efficiency across most industries, it stands to question whether the benefits of innovation reported by Hirshleifer et al. (2018) are realised in other research settings. We consider the Australian setting given its similarity to the U.S. in relation to the strength of legal systems, use of common law and underlying commonalities in registering and enforcing patents (LaPorta et al., 1997; Acharya and Subramanian, 2009; Hazel, 2020). However, the uniqueness of the Australian setting is that technological innovation, as reflected in firms' patenting activities, is significantly less active in comparison to the U.S.²

We first examine the relationship between innovation and future profitability. Innovation allows firms to generate superior profitability through the introduction of novel products and the ability to charge a price premium (Schumpeter, 1936; Hirshleifer et al., 2018). However, investments into innovative ideas may fail to yield a financially viable product due to lack of technologies and human capital, as well as product obsolescence (Ernst, 2001; Bloom et al., 2013). While Hirshleifer et al. (2018) documents that innovative firms in the U.S. are able to maintain higher profitability, it is unclear whether this result holds in the Australian setting. On one hand, we expect Australian firms with patented innovation to generate greater competitive advantages and to sustain higher profitability given the fewer number of innovators in the market. On the other hand, Australia is largely lacking in innovative efficiency (Dayton and Green, 2018), which may result in firms producing patents of lower quality, hence reducing their ability to generate or sustain higher profitability.

We also examine whether innovation is associated with future stock returns. The valuation of innovation involves complex considerations of how a firm will adapt and implement changes that will eventually generate profits for the firm. Prior evidence suggests that when investors have an abundance of information, much of which is complex and difficult to process, they tend to underweigh relevant value-creating innovations. Hirshleifer et al. (2018) terms this the *limited attention hypothesis* and documents that market

¹ A pitch version of paper was presented at the 2020 AFAANZ Shark Tank event followed by an invitation to submit to this journal.

² In 2019, IP Australia received a total of 29,758 standard patent applications while 621,453 utility patent applications were received in the U.S. by the U.S. Patent and Trademark Office (WIPO, 2020a). Utility patents in the U.S. are equivalent to Australian standard patents and last a minimum of 20 years from the date of application (IP Australia, 2020a).

participants fail to incorporate innovative originality into stock price valuation. In addition, investors often fail to differentiate companies that have genuine innovation from those that do not (Greenwald et al., 2004; Fitzgerald et al., 2020). In Australia, the tendency for market participants to place a limited weighting on value relevant innovations may not hold for two reasons. First, given the general lack of innovation (low patent production) in Australia, we argue that investors are less distracted and better able to process and price innovation information. Second, the two-tier patent system in Australia differentiates major innovations from incremental innovations. Under this two-tier system, *standard* patents are issued for major inventive innovations and *innovation* patents for incremental developments. Therefore, the *limited attention hypothesis* documented in the U.S. setting may not hold in the Australian setting.

Following the approach outlined in Hirshleifer et al. (2018), we confirm their findings that innovation by U.S. firms is associated with sustained profitability and future stock returns. When we extend these analyses to the Australian setting,³ we find that innovative firms are able to sustain greater profitability. However, we do not find a positive association between innovation and future stock returns. This result suggests that, unlike the U.S., there is no evidence of short-term mispricing of innovation in the Australian setting. There are two potential explanations for this result. First, Australian firms are generally less innovative, hence decreasing the *limited attention hypothesis*, as investors have less innovation information to process and price. Second, the two-tier patent system in Australia diminishes the *limited attention hypothesis* by allowing investors to differentiate major innovations from marginal innovations, which leads to improved valuation of innovation.

This study makes several contributions. While various public interest entities argue that innovation is an important part of transforming Australia's traditional industries for long term growth (Chong, 2015; Innovation and Science Australia, 2017; Green, 2018), there is a lack of empirical evidence to support their agenda. Our results lend support to the argument that innovation is value generating and an important part of ensuring the profitability of Australian companies. Furthermore, there are ongoing concerns about the sufficiency and appropriateness of government incentives that encourage innovation, with calls to increase funding and focus on direct investment instead of tax incentives (Scott-Kemmis, 2018; Innovation and Science Australia, 2017). Therefore, our empirical evidence is paramount in the evaluation of the current productivity of Australian innovation and its impact on firm performance. Empirical evidence from prior studies is limited to the U.S. setting, which cannot be used to inform Australian regulatory developments and economic policies on innovation. Evidence of investors being capable of valuing innovation in stock prices suggests that the two-tier patent system may be beneficial in distinguishing meaningful innovations

³ A detailed description regarding the construction of the Australian patent database is available in Bedford et al. (2020).

from incremental innovations (Bommer, 2001), which is relevant considering the Australian government's decision to phase out this system in 2021 (IP Australia, 2020b).

2. Sample and research design

2.1 Sample derivation

The U.S. sample derivation and data construction follow the same approach outlined in Hirshleifer et al. (2018). The sample period chosen for the Australian study is 1997 to 2018. Although an earlier sample period was employed in Hirshleifer et al. (2018) (1981 to 2006), the required patent data for Australian firms only became widely available from 1997 onwards. The choice to extend our study into a recent time period (until 2018) allows for empirical analysis that yields more meaningful policy implications.⁴ We obtain Australian patent data from the Intellectual Property Government Open Data 2019.⁵ Financial statement data are obtained from Aspect Huntley's *DataAnalysis* Database and share price data are obtained from Datastream and SIRCA's *CRD* Database. As we are the first large-scale study to examine innovation impact for Australian listed firms, our biggest challenge was to precisely match patent data with firm-level financial and market data. The matching approach used in this study is detailed in Bedford et al. (2020).

2.2 Research design

To test whether innovative firms maintain higher future profitability, we conduct Fama-Macbeth annual cross-sectional regressions of the following regressions:

$$\Delta ROE_{t+1} = \alpha + \beta_1 \text{InnOrig}_t + \beta_2 \Delta ROE_t + \beta_3 \text{InnOrig}_t \times ROE_t + \beta_4 \text{InnOrig}_t \times \text{PIE}_t + \beta_5 ROE_t + \beta_6 \text{ADV}_t + \beta_7 \text{R\&D}_t + \beta_8 \text{Capex}_t + \beta_9 \text{PIE}_t + \beta_{10} \text{MTB}_t + \beta_{11} \text{missingR\&Ddummy}_t + \text{missingR\&Ddummy}_t \times \text{control variables} + \text{Industry Fixed Effects} + e_{t+1} \quad (1)$$

$$\Delta ROA_{t+1} = \alpha + \beta_1 \text{InnOrig}_t + \beta_2 \Delta ROA_t + \beta_3 \text{InnOrig}_t \times ROA_t + \beta_4 \text{InnOrig}_t \times \text{PIE}_t + \beta_5 ROA_t + \beta_6 \text{ADV}_t + \beta_7 \text{R\&D}_t + \beta_8 \text{Capex}_t + \beta_9 \text{PIE}_t + \beta_{10} \text{MTB}_t + \beta_{11} \text{missingR\&Ddummy}_t + \text{missingR\&Ddummy}_t \times \text{control variables} + \text{Industry Fixed Effects} + e_{t+1} \quad (2)$$

Profitability is measured alternatively by using ROE (Equation (1)) and ROA (Equation (2)). Due to limitations of the patent citation data in Australia, we are unable to replicate the InnOrig_t measure outlined in Hirshleifer et al. (2018) which relies on the number of technology fields *cited* by the patent. In our

⁴ The analysis stops at 2018 to avoid patent data truncation problem given the time lag between patents being filed and granted. The Australian patent sample shows that on average it takes about 3 years for a filed patent to be granted. We also observe no evident drop in the number of granted patents near the end of the sample period.

⁵ <https://data.gov.au/dataset/ds-dga-a4210de2-9cbb-4d43-848d-46138fed271/details?q=patent%202019>

Australian replication, we use the average number of technological fields *assigned* to patents that are granted in the past five years (as opposed to *cited* by the patent). This measure is similar in spirit to the original paper as they both measure the technological breadth of patented inventions (Lerner 1994; Christodoulou et al., 2018). We validated this alternative measure in the U.S. setting before utilising it in the Australian replication.⁶ We find that the correlation between the alternative measure and the original measure in the full regression analysis sample is 82.6%, which gives us confidence that the two measures are capturing similar dimensions of innovation. Moreover, the main results in the U.S. setting are similar when we use this alternative measure.⁷ All variables are defined in Table 2.

To examine whether innovation can predict future stock returns, we conduct the following Fama Macbeth regression:

$$\text{RETURNS}_{t+1} = \alpha + \beta_1 \text{InnOrig}_t + \beta_2 \text{SIZE}_t + \beta_3 \text{BTM}_t + \beta_4 \text{MOM}_t + \beta_5 \text{ILLIQ}_{t,t} + \beta_7 \text{REV}_t + \beta_8 \text{missingR\&Ddummy}_t + \text{missingR\&Ddummy}_t \times \text{control variables} + \text{Industry Fixed Effects} + e_{t+1} \quad (3)$$

Stock returns are measured as future monthly stock returns (RETURNS_{t+1}) from July of year t to June of year $t+1$ for the U.S. sample. As most Australian firms have June year-ends, future monthly returns are measured from January to December of year $t+1$ in the Australian sample. A simplified return regression with only InnOrig_t as independent variable and an extended regression with additional control variables are also estimated. All variables are defined in Table 3.

3. Results

3.1 Summary statistics

Table 1 reports the summary statistics on the time-series mean of cross-sectional average characteristics of firms in the sample used for the U.S. and the Australian replications. The means are reported in four categories as defined by Hirshleifer et al. (2018). The mean values reported in Table 1 are similar to those reported in Hirshleifer et al. (2018). Compared to U.S. firms, we find that Australian firms are less innovative, make smaller investments in research and development, and have less patents (while they are similar in size).⁸ The results also suggest that compared to U.S. firms, Australian firms are less profitable but experience more asset growth and capital expenditure.

3.2 Innovation and firm profitability

⁶ We thank the editor for his guidance on how to address this problem.

⁷ The regression results on this alternative measure on the U.S. sample are available in Appendix B.

⁸ Size in \$m are reported in USD in the U.S. replication and in AUD in the Australian replication.

Table 2 reports the regression results of Equations (1) and (2) on the effect of innovation on the persistence of future profitability. Panel A of Table 2 reports the U.S. replication results using the same sample period as Hirshleifer et al. (2018). Panel B of Table 2 reports the Australian replication results. The experimental variable is the interaction between innovation and mean reversion of profitability ($\text{InnOrig}_t \times \Delta \text{ROE}_t$ and $\text{InnOrig}_t \times \Delta \text{ROA}_t$). Consistent with Hirshleifer et al. (2018), we find a positive and significant coefficient on $\text{InnOrig}_t \times \Delta \text{ROE}_t$ (coeff = 0.53). We find similar results in the Australian setting whereby the coefficient on $\text{InnOrig}_t \times \Delta \text{ROE}_t$ is positive and significant (coeff = 3.52). Consistent with Hirshleifer et al. (2018), the magnitude of the mean reversal of ROE is substantial. Our results suggest that a one standard deviation increase in InnOrig slows down the mean reversion of ROE by 16% relative to firms with zero InnOrig, in both the U.S. (0.53/3.27) and the Australian setting (3.52/22.04). However, we note that the mean reversion of ROE in Australia is substantially larger than in the U.S. Our results highlight that despite firms being less innovative in Australia, those that do innovate reap benefits from their innovation, are able to maintain their competitive advantage and manage to sustain a higher level of ROE. In contrast, when ROA is used as a measure of profitability, the results are weaker. Moreover, while we find evidence of a positive and significant coefficient on $\text{InnOrig}_t \times \Delta \text{ROA}_t$ in the U.S. setting, this coefficient is insignificant in the Australian setting.

3.3 Innovation and future stock returns

Finally, Table 3 reports the time-series average slopes (in percentage) from the monthly cross-sectional regressions from Equation (3). Columns (1) to (3) report the results of the U.S. replication. Consistent with Hirshleifer et al. (2018), we find a positive and significant coefficient on InnOrig suggesting that InnOrig has stock return predictive ability. This finding is interpreted as mispricing of InnOrig in current share prices and highlights the inability of investors to understand and process the information in innovation. The results of the Australian replication are reported in columns (4) to (6).⁹ Unlike U.S. findings, we find an insignificant association between InnOrig and future stock returns. We provide two potential explanations for the lack of mispricing in the Australian setting. First, as Australian firms have less innovation, the *limited attention hypothesis* (whereby investors underweigh innovation in current share prices) is minimised as they have less complex information to process. Second, the two-tier patent system, a unique feature of the Australian setting, allows investors to differentiate major innovations from incremental innovations, which is then priced accordingly by investors.

⁹ Replicating Model 3B poses some problems in the Australian setting due to the unavailability of certain control variables. In our attempt to control for a more extensive set of control variables, we include all the control variables used in Model 3B that are available in Australia and we continue to find an insignificant association between InnOrig and future stock returns.

4. Conclusion

Moving towards 2030, it is predicted that innovation will be critical to the expansion of the Australian economy (Innovation and Science Australia, 2017). However, there is a lack of empirical evidence on the performance of Australian innovations. This study is the first to empirically examine whether innovation is associated with the accounting profitability and stock returns of Australian publicly listed firms. We find that consistent with U.S. findings (Hirshleifer et al., 2018), innovative firms in Australia are able to maintain their competitive advantage and sustain persistence in profitability. However, unlike Hirshleifer et al. (2018), we do not find evidence of short-term mispricing of innovation in Australia. Given Australia's fewer patent registrations and its two-tier patent system which signals the distinguished qualities of technological inventions, our findings support the argument that market participants in Australia are better able to allocate attention and resources to assess and price innovation and evaluate its impact on future performance.

Our findings are relevant to inform Australian policy decisions on innovation and the debate on how to promote business innovation. For instance, criticisms have been levelled at the current tax incentive scheme being ineffective, with calls to increase direct funding for innovation through grant programs (Innovation and Science Australia, 2017). Our results lend support for more incentives being introduced to promote innovation, as innovative Australian firms are able to generate and sustain greater profitability. Going forward, there are significant opportunities to conduct research on innovation in Australia to further inform this debate, with Australian patent data unavailability no longer being a barrier to innovation research in Australia.

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Table 1: Summary statistics

	U.S. Replication (1982-2007)					Australian Replication (1997- 2018)				
	No	Low	Middle	High	All	No	Low	Middle	High	All
Innovative originality (InnOrig)	1850	1403	572	422	4247	599	618	48	31	1296
Firm Size (SIZE) (\$mn) ⁺		3.03	5.39	9.93	6.00		1.02	1.78	3.30	1.95
Book-to-market (BTM)	618	649	2701	1562	1021	1618	1548	5016	3595	1734
Momentum (MOM)	0.90	0.69	0.66	0.61	0.77	0.92	0.91	0.66	0.56	0.91
R&D/Market equity (R&D)	0.12	0.13	0.14	0.14	0.13	0.18	0.13	0.13	0.15	0.15
Patents/Assets (CTA)	0.00%	7.38%	6.25%	6.30%	3.94%	0.00%	0.55%	0.60%	1.05%	0.32%
Patents-based innovative efficiency (PIE)	0.00%	0.67%	2.47%	3.03%	0.85%	0.00%	0.03%	0.93%	1.23%	0.08%
Return on assets (ROA)	0.00	0.06	0.24	0.26	0.08	0.00	0.00	0.08	0.06	0.01
Return on equity (ROE)	9.67%	-6.42%	8.71%	2.26%	3%	-17.99%	-20.64%	-13.27%	-19.74%	-19.31%
Asset growth (AG)	-2.49%	-14.36%	-0.61%	-5.46%	-6.66%	-32.74%	-37.94%	-25.15%	-31.88%	-35.17%
Advertising/Assets (ADV)	0.16	0.14	0.12	0.14	0.15	0.29	0.34	0.15	0.15	0.30
Capex/Assets (CAPEX)	0.02	0.01	0.01	0.02	0.02	0.02	0.03	0.04	0.03	0.02
Net stock issuance (NS)	0.10	0.06	0.07	0.07	0.08	0.14	0.12	0.07	0.06	0.13
Short-term return reversal (REV)	0.05	0.06	0.03	0.04	0.05	0.12	0.18	0.06	0.08	0.14
Illiquidity (ILLIQ)	1.04%	0.93%	1.44%	1.28%	1.05%	-2.51%	-2.47%	-1.10%	-1.01%	-2.39%
	53.45	39.66	11.42	16.16	40.02	28.18	32.29	9.39	9.56	28.74

This table replicates Panel A of Table 2 in Hirshleifer et al. (2018). This table displays the time-series mean of cross-sectional average characteristics of firms in four categories. Firms with missing innovation measure and firms with neither R&D nor patents are in the “No” category. Firms with non-missing innovation measure are split into three groups, “Low”, “Middle” and “High” based on the 30th and 70th percentile of innovation. For the U.S. replication, the average sample is 4247 firms, of which 1850 are in the “No” category, 1403 are in the “Low” category, 572 are in the “Middle” category and 422 are in the “High” category. For the Australian replication, the average sample is 1296 firms, of which 599 are in the “No” category, 618 are in the “Low” category, 48 are in the “Middle” category and 31 are in the “High” category. In the U.S. replication, InnOrig is measured as the average number of unique technological fields cited in a recently granted patent over the last 5 years whereas in the Australian replication it is measured as the average number of unique technological fields assigned to a recently granted patent over the last 5 years. All the other variable definitions are consistent with Hirshleifer et al. (2018). SIZE is market capitalization (in millions) at the end of June (December) of year t in the U.S. (Australian) replication. Book-to-market (BTM) is the ratio of book equity to market capitalization at t. Momentum (MOM) is the previous eleven-month returns (with a one-month gap between the holding period and the current month). It is important to note the difference of accounting treatments of R&D spending in the U.S. and Australia. Under U.S. Generally Accepted Accounting Principles, most research and development spending is required to be expensed. In contrast, International Financial Reporting Standards, which are applied in Australia, allow the capitalisation of some development expenditures as assets if they pass the feasibility tests. R&D for the U.S sample is R&D expenses divided by market capitalization at the end of year t whereas R&D in the Australian sample is R&D assets divided by market capitalization at the end of year t. CTA is the number of patents issues to a firm in year t divided by the firm’s total assets. PIE in the U.S. is patents granted to a firm in year t scaled by R&D capital in year t-2, where R&D capital is the five-year cumulative R&D expenses with a 20% annual depreciation. PIE in Australia is patents granted to a firm in year t scaled by R&D assets in year t-2. ROA is income before extraordinary items plus interest expenses in year t divided by lagged total assets. ROE is income before extraordinary items plus interest expenses in year t scaled by lagged book equity. AG is the change in total assets in year t divided by lagged total assets. ADV is advertising expense in year t divided by lagged total assets. CAPEX is capital expenditure in year t divided by lagged total assets. NS is the change in the natural log of the split-adjusted shares outstanding in year t, where split-adjusted shares outstanding is shares outstanding times the adjustment factor. REV is monthly returns in the prior month. ILLIQ is the absolute stock return in June (December) of year t divided by dollar trading volume in June (December) of year t (the raw value is multiplied by 1,000,000) in the U.S. (Australian) setting.

+ SIZE is reported in USD in the U.S. replication and in AUD in the Australian replication.

Table 2: Innovation and future profitability

Panel A: U.S. replication

Dependent		InnOrig _t	ΔROE_t	$\text{InnOrig}_t \times \Delta ROE_t$	$\text{PIE}_t \times \Delta ROE_t$	ROE_t	ADV_t	$R\&D_t$	$CAPEX_t$	PIE_t	MTB_t	Intercept	R-square	Firms
ΔROE_{t+1}	Coeff	1.43	-3.27	0.53	0.04	-8.10	0.37	-2.79	-0.78	-0.24	1.51	-2.98	0.12	3031
	t-stats	(5.51)	(-9.09)	(3.51)	(0.38)	(-41.29)	(3.78)	(-14.37)	(-6.81)	(-1.83)	(5.20)	(-4.75)		
Dependent		InnOrig _t	ΔROA_t	$\text{InnOrig}_t \times \Delta ROA_t$	$\text{PIE}_t \times \Delta ROA_t$	ROA_t	ADV_t	$R\&D_t$	$CAPEX_t$	PIE_t	MTB_t	Intercept	R-square	Firms
ΔROA_{t+1}	Coeff	1.60	-1.95	0.48	-0.46	-9.24	0.33	-3.19	0.60	-0.11	0.54	-0.06	0.21	3049
	t-stats	(8.05)	(-5.68)	(1.70)	(-2.80)	(-10.10)	(2.15)	(-22.17)	(1.98)	(-1.49)	(1.24)	(-0.18)		

Panel B: Australian replication

Dependent		InnOrig _t	ΔROE_t	$\text{InnOrig}_t \times \Delta ROE_t$	$\text{PIE}_t \times \Delta ROE_t$	ROE_t	ADV_t	$R\&D_t$	$CAPEX_t$	PIE_t	MTB_t	Intercept	R-square	Firms
ΔROE_{t+1}	Coeff	2.27	-22.04	3.52	-125.28	-32.93	1.30	-0.29	2.51	54.81	1.95	-7.96	0.22	1006
	tstats	(9.02)	(-6.22)	(1.77)	(-1.32)	(12.69)	(2.24)	(-0.26)	(2.32)	(1.56)	(2.17)	(-1.60)		
Dependent		InnOrig _t	ΔROA_t	$\text{InnOrig}_t \times \Delta ROA_t$	$\text{PIE}_t \times \Delta ROA_t$	ROA_t	ADV_t	$R\&D_t$	$CAPEX_t$	PIE_t	MTB_t	Intercept	R-square	Firms
ΔROA_{t+1}	Coeff	0.59	-6.38	0.96	61.42	-15.95	0.93	0.21	0.97	5.23	0.11	-4.06	0.26	1006
	t-stats	(2.44)	(-2.63)	(1.26)	(1.12)	(-37.03)	(5.00)	(0.40)	(1.31)	(0.89)	(0.20)	(-2.61)		

This table replicates Panel A of Table 3 in Hirshleifer et al. (2018). This table reports the average slopes (in %) and their Newey-West (1987) autocorrelation-adjusted heteroscedasticity-robust t-statistics in parentheses from annual Fama and MacBeth (1973) cross-sectional regressions. In panel A, we replicate Hirshleifer et al. (2018) and regress the change in future profitability (alternatively using ΔROE_{t+1} and ΔROA_{t+1}) on InnOrig and other control variables in the U.S. setting. In Panel B, we conduct the same regression in the Australian setting. In the U.S. replication, InnOrig is measured as the average number of unique technological fields cited in a recently granted patent over the last 5 years whereas in the Australian replication it is measured as the average number of unique technological fields assigned to a recently granted patent over the last 5 years. Profitability is measured by return on equity (ROE) and by return on assets (ROA). ΔROE_t (ΔROA_t) is the change in ROE (ROA) between year t and year $t-1$. ADV_t is advertising expense divided by total assets. $R\&D_t$ is R&D expenditure divided by total assets. $CAPEX$ is capital expenditure divided by total assets. PIE in the U.S. is patents granted to a firm in year t scaled by R&D capital in year $t-2$, where R&D capital is the five-year cumulative R&D expenses with a 20% annual depreciation. PIE in Australia is patents granted to a firm in year t scaled by R&D assets in year $t-2$. MTB is market-to-book assets. We also control for industry dummies which are based on the Fama and French (1997) 48 industries for the U.S. replication and based on two-digit GICS industry code for the Australian replication. We set missing values for InnOrig, IE, advertising expenses, and R&D expenses to zero. In addition, we control for a dummy, which equals one for U.S. firms with no R&D expense over the past five years and 0 otherwise, and its interactions with all the other control variables in the regression. For the Australian replication, firms are considered to have missing R&D if they report no R&D assets, expenses or cash outflows on the financial statements, 0 otherwise. We omit the slopes on the industry dummies, the slopes on the missing dummy, and its interactions with other control variables for brevity. R-squared (Firms) is the time-series average of the R-squared (number of firms) from the annual cross-sectional regressions. To reduce the influence of outliers and facilitate the interpretation, we winsorise all continuous variables at the 1% and 99% levels and standardise independent variables (excluding dummy variables) to zero mean and one standard deviation. Our experimental variable is $\text{InnOrig}_t \times \Delta ROE_t$ and $\text{InnOrig}_t \times \Delta ROA_t$ which capture the impact of innovation on the persistence in current profitability.

Table 3: Innovation and future stock returns

	U.S. replication						Australian replication					
	Model 1		Model 2		Model 3B		Model 1		Model 2		Model 3B	
	(1)		(2)		(3)		(4)		(5)		(6)	
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
InnOrig _t	0.11	(2.05)	0.20	(6.80)	0.10	(3.10)	-0.07	(-1.05)	-0.03	(-0.79)	-0.06	(-1.25)
SIZE _t			-0.21	(-1.47)	-0.16	(-1.37)			-0.23	(-1.70)	-0.03	(-0.23)
BTM _t			0.44	(5.69)	0.18	(2.20)			0.79	(6.87)	0.90	(6.64)
MOM _t			0.10	(0.90)	-0.02	(-0.18)			6.73	(28.00)	6.54	(34.58)
ILLIQ _t			1.06	(4.93)	0.97	(3.72)			0.08	(0.58)	-0.08	(-0.61)
REV _t			-1.13	(-12.31)	-1.18	(-13.54)			0.04	(0.44)	0.01	(0.14)
AG _t					-0.25	(-5.17)					-0.11	(-1.27)
CAPEX _t					-0.01	(-0.13)					-0.04	(-0.45)
CTA _t					0.01	(0.39)					0.04	(0.84)
R&D _t					0.28	(4.50)					0.00	(0.08)
NS _t					-0.12	(-2.36)					-0.02	(-0.21)
ROA _t					0.12	(1.42)					-0.57	(-4.16)
PIE _t					0.01	(0.32)					-0.68	(-1.07)
R-square	0.00		0.05		0.06		0.00		0.10		0.10	
Firms	4130		3644		2943		1237		1052		935	

This table replicates Table 7 (Model 1 and Model 2) in Hirshleifer et al. (2018). This table reports the average slopes (in %) and their Newey-West (1987) autocorrelation-adjusted heteroscedasticity-robust t-statistics in parentheses from monthly Fama and MacBeth (1973) cross-sectional regressions. Columns (1) to (3) report the results for the U.S. replication and Columns (4) to (6) report the results for the Australian replication. Our variable measurement is consistent with Hirshleifer et al. (2018). For each month from July of year t to June of year $t+1$, we regress monthly returns of individual stocks on the natural log of one plus InnOrig of year t in the U.S. replication. As most Australian firms have June year ends, future monthly returns are measured from January to December of year $t+1$ in the Australian sample. In the U.S. replication, InnOrig is measured as the average number of unique technological fields cited in a recently granted patent over the last 5 years whereas in the Australian replication it is measured as the average number of unique technological fields assigned to a recently granted patent over the last 5 years. SIZE _{t} is the log of market capitalization at the end of June (December) of year t in the U.S. (Australian) replication. BTM _{t} is the natural log of book value of equity scaled by market capitalization measured in t . MOM _{t} is the previous eleven-month returns (with a one-month gap between the holding period and the current month). ILLIQ _{t} and REV _{t} are the previous month's stock illiquidity and stock return, respectively. AG _{t} is the change in total assets in year t divided by lagged total assets. CAPEX _{t} is capital expenditure in year t divided by lagged total assets. CTA _{t} is the number of patents issues to a firm in year t divided by the firm's total assets. It is important to note the difference of accounting treatments of R&D spending in the U.S. and Australia. Under U.S. Generally Accepted Accounting Principles, most research and development spending is required to be expensed. In contrast, International Financial Reporting Standards, which are applied in Australia, allow the capitalisation of some development expenditures as assets if they pass the feasibility tests. R&D for the U.S sample is R&D expenses in year t divided by market capitalization whereas R&D in the Australian sample is R&D assets in year t divided by market capitalization. NS _{t} is the change in the natural log of the split-adjusted shares outstanding in year t , where split-adjusted shares outstanding is shares outstanding times the adjustment factor. ROA _{t} is income before extraordinary items plus interest expenses in year t divided by lagged total assets. PIE _{t} in the U.S. replication is patents granted to a firm in year t scaled by R&D capital in year $t-2$, where R&D capital is the five-year cumulative R&D expenses with a 20% annual depreciation. PIE _{t} in the Australian replication is patents granted to a firm in year t scaled by R&D assets in year $t-2$. We set missing values for InnOrig _{t} , PIE _{t} , and R&D _{t} to zero, and control for a dummy variable (missing), which equals 1 for firms with no R&D investment and patent for the past five years and 0 otherwise, and its interactions with all the control variables in the multiple regressions. We omit the intercept, the slopes on the industry dummies, and the slopes on the missing dummy and its interactions with all other control variables for brevity. To reduce the influence of outliers and facilitate the interpretation, we winsorise all continuous variables at the 1% and 99% levels and standardise independent variables (excluding dummy variables) to zero mean and one standard deviation. We do not report the results of Model 3A from Hirshleifer et al. (2018) due to missing data on citation-based innovative efficiency (CIE) in the Australian setting. Results of Model 3A in the U.S. setting is available upon request.

Appendix A: Comparing patents in the U.S. and the Australian settings

U.S.	Australia
Innovation Quality - Global Innovation Index 2020	
Innovation score in 2020: 60.56 (ranked 3rd) (Cornell University et al., 2020)	Innovation score in 2020: 48.35 (ranked 23rd) (Cornell University et al., 2020)
Innovation Quantity - World Intellectual Property Organization (WIPO) Indicators 2020	
Patent applications in 2019: 621,453 (ranked 2 nd) (WIPO, 2020b)	Patent applications in 2019: 29,758 (ranked 19th) (WIPO, 2020b)
Litigation Costs	
A special theme report published by the WIPO on patent litigation systems finds that the U.S. has the highest litigation costs for patents compared to all other major jurisdictions (Australia not included) with an estimated average cost between USD\$1-6 million at first instance (WIPO, 2018).	Although reliable estimates are not available, litigation in Australia and New Zealand are estimated to be about one third (or less) then equivalent proceedings in the U.S. or Europe (James & Wells, 2019).
Government Funding	
The U.S. government R&D budget has decreased by 8% between 2008 and 2016. In 2015, government support through direct investment made up 72.4% of R&D incentives having increased 1.1% between 2006 and 2013 (OECD, 2017). R&D tax incentives also increased by 4.6% during the same period (OECD, 2017).	The Australian government R&D budget has increased by 6% between 2008 and 2016. Australia had the second highest percentage of government support through tax incentives for R&D (86.9%), having grown 13.6% between 2006 and 2015 (OECD, 2017). In contrast direct investment has declined 5.4% (OECD, 2017).
Diversity	
Between 2012 and 2015, 10% of U.S. patents were invented by women (OECD, 2017).	Between 2012 and 2015, 8.9% of Australian patents were invented by women (OECD, 2017).
Innovation Productivity	
Innovation-related performance is lower in Australia than the U.S.: overall intensity of investment in research (GERD/GDP or VA) in Australia is at just under 70% of the U.S. level (Scott-Kemmis, 2018). Australian universities and public sector research organisations generate patents at only 20% of the rate of U.S. universities per R&D dollar, and start-ups at 25-30% (Scott-Kemis, 2018).	

Appendix B: Alternative measure of InnOrig_t in the U.S setting

Panel A: U.S replication of Equations (1) and (2) using the alternative measure of InnOrig_t applied in the Australian replication

Dependent		InnOrig _t	ΔROE_t	$InnOrig_t \times \Delta ROE_t$	$PIE_t \times \Delta ROE_t$	ROE_t	ADV_t	$R\&D_t$	$CAPEX_t$	PIE_t	MTB_t	Intercept	R-square	Firms
ΔROE_{t+1}	Coeff	1.27	-3.36	0.59	0.02	-8.14	0.37	-2.82	-0.75	-0.24	1.54	-3.61	0.12	3031
	t-stats	(6.84)	(-10.49)	(5.37)	(0.19)	(-41.03)	(3.51)	(-15.05)	(-6.12)	(-2.18)	(5.01)	(-4.74)		
Dependent		InnOrig _t	ΔROA_t	$InnOrig_t \times \Delta ROA_t$	$PIE_t \times \Delta ROA_t$	ROA_t	ADV_t	$R\&D_t$	$CAPEX_t$	PIE_t	MTB_t	Intercept	R-square	Firms
ΔROA_{t+1}	Coeff	1.56	-2.03	0.50	-0.51	-9.23	0.32	-3.15	0.67	-0.13	0.51	-2.64	0.12	2932
	t-stats	(16.84)	(-7.46)	(1.22)	(-5.35)	(-10.37)	(2.30)	(-19.26)	(2.24)	(-1.63)	(1.15)	(-4.86)		

To validate the use of the alternative proxy for InnOrig_t, we re-estimate Equations (1) and (2) in the U.S. using the InnOrig_t definition applied in the Australian replication. InnOrig_t is measured as the average number of technological fields *assigned* to patents that are granted in the past five years. Consistent with Hirshleifer et al. (2018), we find a negative coefficient on ΔROE_t and ΔROA_t . Moreover, the coefficient on $InnOrig_t \times \Delta ROE_t$ is positive suggesting that innovative firms are able to sustain higher performance in the future. However, while the coefficient on $InnOrig_t \times \Delta ROA_t$ is not significant, it is important to note that this coefficient is only marginally significant at the 10% level in Hirshleifer et al. (2018) and in our reported results in Panel A of Table 2.

Panel B: U.S. replication of Equation (3) using the alternative measure of InnOrig applied in the Australian replication

	(1)		(2)		(3)		(4)	
	Model 1		Model 2		Model 3A		Model 3B	
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
InnOrig _t	0.10	2.02	0.20	6.24	0.11	3.57	0.11	3.61
SIZE _t			-0.21	-1.49	-0.16	-1.44	-0.16	-1.43
BTM _t			0.43	5.61	0.18	2.16	0.17	2.15
MOM _t			0.10	0.89	-0.02	-0.19	-0.02	-0.18
ILLIQ _t			1.06	4.93	0.96	3.70	0.97	3.71
REV _t			-1.13	-12.33	-1.18	-13.54	-1.18	-13.56
AG _t					-0.25	-5.15	-0.25	-5.15
CAPEX _t					-0.01	-0.13	0.00	-0.09
CTA _t					0.02	0.82	0.01	0.27
R&D _t					0.28	4.44	0.28	4.51
NS _t					-0.12	-2.32	-0.12	-2.34
ROA _t					0.13	1.45	0.12	1.42
CIE _t					0.00	0.21		
PIE _t							0.01	0.33
R-square	0.00		0.05		0.06		0.06	
Firms	4130		3644		2943		2943	

To validate the use of the alternative proxy for InnOrig_t, we re-estimate Equation (3) in the U.S. using the InnOrig_t definition applied in the Australian replication. InnOrig_t is the average number of technological fields *assigned* to patents that are granted in the past five years. Consistent with Hirshleifer et al. (2018), we find a positive and significant coefficient on InnOrig_t. It is notable that the coefficient on InnOrig_t (reported in Hirshleifer et al. (2018)) and on the alternative measure are very similar in size. Unlike Table 3, we report the results of Model 3A as citation-based innovative efficiency (CIE) is available from U.S. patent data. However, CIE is not available in Australia. Institutional ownership is not controlled for as we do not have access to this data.

Appendix C: Shark Tank Pitch Template

“Firm innovation, future profitability and stock returns: Australian evidence”

Pitcher Team Names		JEL code	G11, G12, G14, O32, O38	Date Completed	Last amended on
(A)	Working Title	Future profitability and stock returns of innovative firms in Australia.			
(B)	Basic Research Question	Does innovation predict future profitability and stock returns in Australian firms?			
(C)	Key paper(s)	<p>Target replication paper: David Hirshleifer, Po-Hsuan Hsu, Dongmei Li, Innovative Originality, Profitability, and Stock Returns, <i>The Review of Financial Studies</i>, Volume 31, Issue 7, July 2018, Pages 2553–2605, https://doi.org/10.1093/rfs/hhx101.</p> <p>Lauren Cohen, Karl Diether, Christopher Malloy, Misvaluing Innovation, <i>The Review of Financial Studies</i>, Volume 26, Issue 3, March 2013, Pages 635-666, https://doi.org/10.1093/rfs/hhs183.</p> <p>Joshua Lerner, The Importance of Patent Scope: An Empirical Analysis, <i>The RAND Journal of Economics</i>, Volume 25, Issue 2, 1994, Pages 319-333, https://www.jstor.org/stable/2555833.</p>			
(D)	Motivation/Puzzle	<p>The value of unique innovations in the US is argued to be difficult to ascertain by investors and its economic utility underweighted in firm valuation. It is unclear whether this is due to the complexity of innovation, or simply the abundance in the setting. Although innovation is expected to be an integral part to the expansion of the Australian economy (Innovation and Science Australia, 2017), there is no empirical evidence on the economic benefits of innovation, and whether this is recognized by shareholders. In the Australian setting where there is comparatively little innovation, we can ascertain whether investors continue to misprice innovation due to its complexity.¹⁰</p>			
(E)	Idea	<p>Given the dominance of the US in innovative efficiency, it stands to question whether the benefits of innovation reported by Hirshleifer <i>et al.</i> (2018) are realised in other settings. We consider the Australian setting given its similarity to the US setting in relation to strength of legal systems, and commonalities in registering and enforcing patents. On one hand, we expect innovative Australian firms to be able to generate higher economic returns given the fewer number of innovators. On the other hand, Australia is largely lacking in innovative efficiency, limiting a firm’s ability to generate and maintain higher profitability from its innovations.</p> <p>Hypothesis 1: There is no association between innovation and future firm profitability.</p> <p>Under the limited attention hypothesis, investors place limited weight on innovation as such information is complex, leading to mispricing of current share prices and higher stock returns in the future (Hirshleifer <i>et al.</i>, 2018). In Australia, the limited attention hypothesis may not hold due to its unique two-tier patent registration system which differentiates major innovations (standard patents) from incremental innovations (innovation patents). However, the general lack of innovation in Australia may suggest that most innovations are generally perceived as non-value creating.</p> <p>Hypothesis 2: There is no association between innovation and future firm stock returns.</p>			

¹⁰ In 2019, there were a total of 29,758 patent applications versus 621,453 patent applications in the U.S. (WIPO, 2020a).

(F)	Data	<p>(1) Data Setting: Australia (Publicly-listed companies). Unit of analysis: firm-year. Sample period: 1997 to 2018. Although an earlier sample period was employed in Hirshleifer <i>et al.</i> (2018) (1981 to 2006), the required data for Australian firms only became widely available from 1997. We extend our study into recent years to yield evidence that is meaningful to current policy decisions. Sampling interval: Annual (2) Sample size Approximately 31,000 firm-years. (3) Dataset structure Panel dataset with patent information aggregated at the firm-year level. (4) Data sources <u>Australian Patent Data:</u> Intellectual Property Government Open Data 2019, available from: https://data.gov.au/dataset/ds-dga-a4210de2-9cbb-4d43-848d-46138fed271/details?q=patent%202019 <u>Financial Statement Data:</u> Aspect Huntley's <i>DatAnalysis</i> Database <u>Share Price Data:</u> SIRCA's <i>CRD</i> Database (5) Data management We follow a similar data cleaning and matching process to that outlined in Hall <i>et al.</i> (2001). (6) Data reliability All data is sourced from government and commercial databases. (7) Other data obstacles (i) Due to limitations of the patent citation data in Australia, we are unable to replicate the “<i>innovative originality</i>” measure outlined in Hirshleifer <i>et al.</i> (2018) which relies on the number of technology fields cited by the patent. In our Australian replication, we use the number of technological fields assigned to the patent (as opposed to cited by the patent) (<i>Breadth</i>). <i>Breadth</i> is similar in spirit to the original paper (Christodoulou <i>et al.</i>, 2018). In addition to the original measure, we will validate the <i>Breadth</i> measure in the US setting before utilising it in the Australian replication. (ii) In the future stock returns regression, we omit “<i>Ownership</i>” (the percentage ownership by institutional investors) as our team does not have access to these data. The coefficient on “<i>Ownership</i>” is not significant in the models that we replicate. Accordingly we anticipate that our US replication findings will hold despite this slightly different specification.</p>
(G)	Tools	<p>To test our hypotheses, we replicate the main results of Hirshleifer <i>et al.</i> (2018), as reported in Panel A of Table 3 and Table 7 (Columns (1)-(2)). All variables below follow the same definitions as Hirshleifer <i>et al.</i> (2018). To test whether innovative firms sustain higher future profitability (Hypothesis 1), we conduct annual cross-sectional regressions of the following regression:</p> $\Delta Profitability_{t+1} = \alpha + \beta_1 Innovation_t + \beta_2 \Delta Profitability_t + \beta_3 Innovation_t \times Profitability_t + \beta_4 Profitability_t + \beta_5 Advertising_t + \beta_6 R\&D_t + \beta_7 Capex_t + \beta_8 Mtb_t + \beta_9 missingR\&Ddummy_t + missingR\&Ddummy_t \times control\ variables + Industry\ FE + e_{t+1} \quad (1)$ <p>To examine whether innovation predicts future stock returns (Hypothesis 2), we conduct the following Fama-Macbeth regression:</p> $Returns_{t+1} = \alpha + \beta_1 Innovation_t + \beta_2 Size_t + \beta_3 Btm_t + \beta_4 Mom_t + \beta_5 Illiquidity_t + \beta_6 Reversal_t + \beta_7 missingR\&Ddummy_t + missingR\&Ddummy_t \times control\ variables + Industry\ FE + e_{t+1} \quad (2)$
(H)	What's New?	<p>By exploiting a new data source of patents issued by the Australian Patent Office since 2019, this replication study explores the economic significance of (non-US) domestically registered patents of Australian firms.</p>

(I)	So What?	As there is a lack of empirical evidence to support current Australia policy decisions on innovation, it is paramount to provide empirical evidence on this issue to inform the debate on how to promote business innovation. For instance, criticism has been levelled at the current tax incentive scheme being ineffective, with calls to increase direct funding for innovation through grant programs (Innovation and Science Australia, 2017; Scott-Kemmis 2018).
(J)	Contribution?	To the best of our knowledge, this study is the first to empirically examine whether innovation, as captured by domestically registered patents, is associated with the accounting profitability and future stock returns of Australian publicly listed firms. This is also one of few studies using non-US patent data. This study also contributes to the academic literature by developing a new database of Australian patent data matched with listed firm-level data. Similar to the NBER Patent Data Project which has stimulated a vast body of research, the firm-patent database produced by this research will be made publicly available to promote innovation research in Australia.
(K)	Other Considerations	We have corresponded with the authors of the original study who denied our request for their data and statistical codes. Nevertheless, they have provided us with sufficient guidance to replicate the results of the original study.