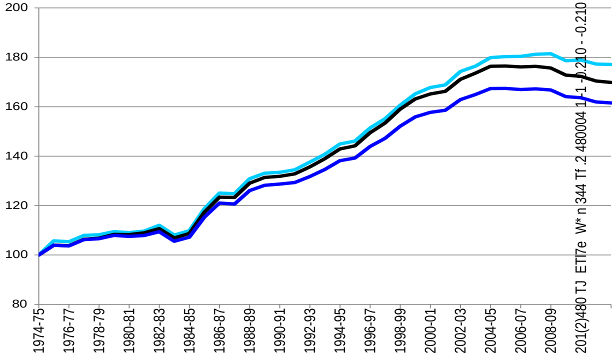
International Comparison: Australia Lags Behind Many OECDs

Impact of Capitalising Intangibles

Figure: Multifactor productivity, market sector, 1974-75 to 2012-13 Index 1974-75= 100, (Elnasri & Fox 2014)



Production Function Approach

- Start with an aggregate output, Y, function speci ed as a function of technology, A, capital stock, K, and labour input:

$$Y = A(t)f(K; L)$$

- In line with Lehr & Lichtenberg (1999) and Connolly & Fox (2006), capital stock is decomposed into knowledge capital K_N and other (tangible/traditional) capital K_T
- The output elasticity of capital, , is speci ed with respect to the `e ective' capital stock $[K_T + (1 + \ )K_N]$,

  where

Production Function Approach Cont'd

- Labour is decomposed into skilled L_N and unskilled L_T. The output elasticity of labour, , is speci ed with respect to the productivity enhancing e ect of human capital measured by , $[L_T + (1 + \quad)L_N]$
- Thus, a Cobb-Douglas representation of the production function is given by:

$$
\begin{aligned}
Y &= A[K_T + (1 + \quad)K_N] \; [L_T + (1 + \quad)L_N] \\
&= A[K + \quad K_N] \; [L + \quad L_N] \\
&= AK \; \left[1 + \quad \frac{K_N}{K}\right]
\end{aligned}
$$

Take the natural logarithm:

$$\ln Y = \ln A + \quad \ln K + \quad \ln L + \quad \ln \left[1 + \frac{K_N}{K} \right] + \quad \ln \left[1 + \frac{L_N}{L} \right]$$

Augment the production function with a vector of other explanatory variables, Z:

$$\ln Y = \ln A + \quad \ln K + \quad \ln L + \quad \frac{K_N}{K} + \quad \frac{L_N}{L} + \sum_{j=1}^{n} \; {}_j \ln Z_j$$

By using the approximation $\ln \; (1 + \frac{K_N}{K}) = \; \frac{K_N}{K}$ and $\ln (1 + \frac{K_N}{L}) = \; {}^{L_N}$

Consistent with Solow's (1956) growth accounting approach, an expression of multifactor productivity (MFP) can be written as:

$$\ln MFP = \ln Y - S_K \ln K - S_L \ln L = \ln A + S_K \frac{K_N}{K} + S_L \frac{L_N}{L} + \sum_{j=1}^{n} {}_j \ln Z_j ;$$

where S_K and S_L are capital and labour income shares respectively

An alternative representation of the function, which can be used as a robustness check on the validity of the results; specify K_N and L_N as separate inputs:

$$\ln Y = \ln A + S_{K_T} \ln K_T + S_{K_N} \ln K_N + S_{L_T} \ln L_T + S_{L_N} \ln L_N + \sum_{j=1}^{n} {}_j \ln Z_j$$

Rewrite the above two models as two regression equations:

$$\text{Eq1} : \ln \text{MFP}_{1t} = a_o + a_1 \frac{K_{Nt}}{K_t} + a_2 \frac{L_{Nt}}{L_t} + \sum_{j=1}^{n} {}_j \ln Z_j + {''}_{1t}$$

The coe cient on $\frac{K_{Nt}}{K_t}$ can be used to derive an estimate of weighted by the output elasticity of K ( )

Thus, ^ can be calculated from the formula $a_1 = S_K$ by using capital's share of income as a proxy for

The Regression Equations Cont'd

$$Eq2 : \ln MFP_{2t} = b_o + b_1 \ln K_{Nt} + b_2 \ln K_{Tt} + b_3 \ln L_{Nt} + b_4 \ln L_{Tt} + \sum_{j=1}^{9}$$

Is Knowledge Capital Productive?

$$\textbf{Eq1}: \ln MFP_{1t} = a_0 + a_1 \frac{K_{Nt}}{K_t} + a_2 \frac{L_{Nt}}{L_t} + \sum_{j=1}^{Q} {}_j \ln Z_j + \varepsilon_{1t}$$

$$\textbf{Eq2}: \ln MFP_{2t} = b_0 + b_1 \ln K_{Nt} + b_2 \ln K_{Tt} + b_3 \ln L_{Nt} + b_4 \ln L_{Tt} + \sum_{j=1}^{Q} {}_j \ln Z_j + \varepsilon_{2t}$$

Dependant variable : $\ln MFP$

Eq1		Eq2	
Knowledge Capital Share (K_N/K)	0.369***	Knowledge Capital	0.399***
	(0.060)		(0.089)
Human Capital	0.268**	Skilled	0.177**
	(0.116)		(0.086)
		Unskilled	0.144*
			(0.073)
Openness	0.227***	Openness	0.143
	(0.058)		(0.086)
Unemployment rate	-0.009**	Unemployment rate	-0.010**
	(0.004)		(0.003)
Terms of Trade	-0.127***	Terms of Trade	-0.083***
	(0.042)		(0.025)
		Other capital	-0.441***
			(0.063)
Adj R^2	0.98		0.98
Durbin-Watson	1.03		1.15

Numbers in parentheses are heteroscedasticity and autocorrelation robust Newey-West standard errors.
Terms *,**,*** denote significance at the 10%, 5% and 1% levels respectively.

Computerised Information

Eq1: $\ln MFP_{1t} = a_o + a_1 \frac{K_{nt}}{K_t} + a_2 \frac{L_{Nt}}{L_t} + \sum_{j=1}^{n} {}_j \ln Z_j + \varepsilon_{1t}$

Eq2: $\ln MFP_{2t} = b_o + b_1 \ln K_{Nt} + b_2 \ln K_{Tt} + b_3 \ln L_{Nt} + b_4 \ln L_{Tt} + \sum_{j=1}^{n} {}_j \ln Z_j + \varepsilon_{2t}$

$H_o : \hat{} = {}^{c}$
$H_1 : \hat{} \neq {}^{c}$

Dependant variable: ln MFP	Eq1				Eq2
$K_N = K$	$\hat{}$	c	P-value	Decision	ln K_N
0.0004*	0.050	59E Td [0.0W2 0 1 0 -248 w0 0 m 0 01 91075 l8 9			

$$\text{Eq1:} \ln MFP_{1t} = a_o + a_1 \frac{K_{nt}}{K_t} + a_2 \frac{L_{Nt}}{L_t} + \sum_{j=1}^{n} {}_j \ln Z_j + "_{1t}$$

$$\text{Eq2:} \ln MFP_{2t} = b_o + b_1 \ln K_{Nt} + b_2 \ln K_{Tt} + b_3 \ln L_{Nt} + b_4 \ln L_{Tt} + \sum_{j=1}^{n} {}_j \ln Z_j + "_{2t}$$

H_o : ^ = c
H_1 : ^ 6= c

Dependant variable: ln MFP	Eq1				Eq2
$K_N = K$	^	c	P-value	Decision	$\ln K_N$
0.122* (0.058)	12.69	3:87	(0.159)	Do not Reject H_o ! optimal investment	0.188*** (0.057)

Other Product Development Design and Research

Eq1:ln M F P 1 t 2.798J/F36 KG 020.9576(1t43ln)]TJ/.9813

Brand Equity

Eq1: $\ln MFP_{1t} = a_o + a_1 \frac{K_{nt}}{K_t} + a_2 \frac{L_{Nt}}{L_t} + \sum_{j=1}^{n} {}_j \ln Z_j + "_{1t}$

Eq2: $\ln MFP_{2t} = b_o + b_1 \ln K_{Nt} + b_2 \ln K_{Tt} + b_3 \ln L_{Nt} + b_4 \ln L_{Tt} + \sum_{j=1}^{n} {}_j \ln Z_j + "_{2t}$

$H_o : \hat{} = {}^c$
$H_1 : \hat{} \neq {}^c$

Dependant variable: ln MFP	Eq1				Eq2
$K_N = K$	$\hat{}$	c	P-value	Decision	$\ln K_N$
0.299***	17.028	14.31	(0.415)		

$$Eq1: \ln MFP_{1t} = a_o + a_1 \frac{K_{nt}}{K_t} + a_2 \frac{L_{Nt}}{L_t} + \sum_{j=1}^{n} {}_j \ln Z_j + "_{1t}$$

$$Eq2: \ln MFP_{2t} = b_o + b_1 \ln K_{Nt} + b_2 \ln K_{Tt} + b_3 \ln L_{Nt} + b_4 \ln L_{Tt} + \sum_{j=1}^{n} {}_j \ln Z_j + "_{2t}$$

$H_o : \hat{} = {}^c$
$H_1 : \hat{} \neq {}^c$

Dependant variable: ln MFP	Eq1				Eq2
$K_N = K$	^	c	P-value	Decision	Td [(4)]TJ/F6 4.98

Organisational Capital

Eq1: $\ln MFP_{1t} = a_0 + a_1 \frac{K_{nt}}{K_t} + a_2 \frac{L_{Nt}}{L_t} + \sum_{j=1}^{Q} {}_{j} \ln Z_j + "_{1t}$

Eq2: $\ln MFP_{2t} = b_0 + b_1 \ln K_{Nt} + b_2 \ln K_{Tt} + b_3 \ln L_{Nt} + b_4 \ln L_{Tt} + \sum_{j=1}^{Q} {}_{j} \ln Z_j + "_{2t}$

$H_0 : \hat{} = {}^{c}$
$H_1 : \hat{} \neq {}^{c}$

Dependant variable: ln MFP	Eq1				Eq2
$K_N = K$	$\hat{}$	c	P-value	Decision	ln K_N
0.054*** (0.009)	3.74	9.12	(0.000)	Reject H_0 ! de cient returns (i.e., over-investment)	0.092*** (0.032)

Mineral Exploration

Eq1:ln $MFP_{1t} = a_o + a_1 \, ^{K}nt$

Conclusion

- Estimation results suggest that all types of knowledge capital (except mineral exploration and artistic originals) have

Directions for Further Research

- Extend the analysis to the sectoral level. The study is based on data of knowledge capital which is estimated at the level of the market sector. There are two weaknesses inherent in this method
  - It ignores sectoral di erences. The composition and intensity of intangibles investment vary across sectors (e.g., Business R&D is heavily concentrated in manufacturing while services invest more in Organisational Capital)
  - The Australian market sector excludes industries like education, health and government where the use of knowledge capital has the potential to in uence productivity
- With additional observation, a more exible functional form could be adopted to address the complex relationship between knowledge capital, output and inputs
- Relax strong assumptions (perfect competition; constant $\frac{R_N}{R_T}$, imposed by treating as a constant