Innovation and Investment: Technological Obsolescence in Australian Manufacturing[*]

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Abstract

This is an empirical study of investment in manufacturing and extent of technological innovation that is embodied in this capital investment. The empirics are from Australian manufacturing, but the model and the implications are applicable to any advanced capitalist economy. The research begins by identifying technological obsolescence from an approach devised by Wilfred Salter in his analysis of technical change. By defining obsolescence in terms of cost minimisation, Salter provides a method of identifying how and when firms find it profitable to invest in technological innovation embodied in the newest vintage capital equipment. Thus, technological innovation becomes endogenous to the investment process. Technical change in this paper is modelled as affecting the use of each input differently rather than reducing use of all inputs by a uniform proportion. Input-saving estimates calculated for different industries shows obsolescence to be identified with the introduction of new equipment that is labour saving. This result enables the inclusion of labour saving as a proxy for technological innovation into an investment ordering model based on the work of Michał Kalecki. With profits as the ability to invest factor, innovation as the inducement, the two factors combine for an explanation of the capitalist accumulation process.

Keywords: embodied technical change, Salter approach, Kaleckian economics, vintage capital

JEL: E22, L16, 031

"…technical progress cannot be regarded as automatic and independent of accumulation" Salter (1966, p. 72)

Background

Investment in capital equipment that embodies best practice technology is a specific form of innovation. When firms make a decision to invest in plant and equipment that embodies new technological knowledge, whether that knowledge is related to products or processes, technological innovation (TI) takes place. Salter (1966) provides a seminal analysis of how technical progress comes about through capital accumulation by focusing on the reverse side of innovation, that is, on technological obsolescence (TO). Salter (1966, p. 54) defines TO as "…plants which are sufficiently outmoded to be profitably replaced."[1] At any time, with the new and established knowledge, there is a spectrum of techniques used in production from 'up-to-date' to 'outmoded' and on to 'obsolete'. There are significant factors that determine investment decisions in addition to the Salter process. Thus, there is no inevitability that firms will automatically make investment decisions to immediately order the technologically superior capital stock. This is due to many factors including financial constraints, wage costs, industry competitiveness, and level of technological flexibility (or inertia).

Technological innovation (TI) has not been easily incorporated into the theory of investment analysis.[2] Most studies see technical progress as exogenous. Even new growth theory (which attempts to add new knowledge through improved skill) assumes as exogenous the acquisition of this new knowledge. By defining TO in terms of cost minimisation, Salter provides a method of identifying how and when firms find it profitable to invest in TI embodied in the newest vintage equipment. Thus, technological innovation becomes endogenous to the investment process.

Salter bases the calculation of TO on the comparison of the labour cost of operating existing capital equipment to the total cost (labour plus capital) of operating best-practice equipment. Bloch and Madden (1995) use this comparison to express the age of TO in terms of the rate of labour saving in a model with factor-augmenting technical change. Recent empirical work by Bloch (2007) provides estimates of the rate of labour saving in Australian manufacturing industries at the three-digit level of ANZSIC (Australia – New Zealand Standard Industrial Classification) scheme. This paper uses these estimates as proxies for TO within an empirical investment model to identify the impact of TI on investment expenditure in Australian manufacturing. The investment model is developed from Kalecki's (1968) theory of investment ordering, implying a role for profitability as well as TI as factors influencing both the level and variability of investment spending.

Investment with Innovation Model

In a review of investment models, Courvisanos (1996) argues that the Kaleckian approach to investment produces the best econometric results. Kalecki (1968)

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[1] Salter goes on to say: "Plants embodying techniques which are not up to current best-practice, but not yet obsolete, are termed 'outmoded'." From this definition it is clear that this study has nothing to do with planned obsolescence of products, which is related to marketing issues and not technical progress.

[2] For a detailed treatment of technological innovation and the difficulties of handling it as an economic concept, see Courvisanos (2005). See also Perelman (2006, p. 247) on the difficulties of modelling capital stock scrapping and its replacement by new technology.

introduces, in his third and final version of his business cycle theory, a complex interaction between the change in total profits and the marginal change (or increment) in profits arising from new investment orders. The former term, Kalecki identifies as the inducement to invest, while the latter term acts as a guide to future investment. All new investment tends to incorporate technical change to at least some extent, and this would be reflected through this latter increment term. With TI implied in the latter term as investment, successful major technical change would tend to deliver higher profit increments than would replacement investment (see Perelman, 2006). This investment orders function is appealing in a theoretical form, but obtaining data on increments of profit associated with new investment is unfeasible. There is a need for an alternative approach to specifying the investment function that is faithful to Kalecki's theory but that allows data to be applied.

A Kaleckian empirical study linking innovation and investment by Courvisanos (2007) relates Australian private new capital expenditure (investment) to profits and research and development (R&D) expenditure. In the total sample, both lagged profits and lagged R&D influence investment with nearly equal significance. Panel data analysis shows that in mature industries, profits are much more influential, while growth industries show marked diversity with some reflecting high R&D impact and others very low. One difficulty with this approach is that technical change in Australia generally entails the use of overseas technology and its application to Australian conditions. Much of this technology is embodied in imported capital equipment and need not be reflected in R&D expenditures of domestic firms.

Two issues arising from the Courvisanos (2007) study that provide a basis for investigation using the Salter approach are (i) the diverse nature of TI stemming out of more than just R&D, and (ii) labour costs and their influence on TI. The Salter approach allows the investigation directly of investment with innovation without needing to trace back to sources of TI associated with TO. This provides a more direct method of understanding the roles of profits (inducement to invest) and TI (incentive to invest) in the investment ordering process.

Laramie *et.al* (2007) derive a strong econometric result when using U.K. manufacturing and construction data to estimate an investment orders function that incorporates Kalecki's (1968) function with Keynes's susceptibility for long-term expectations to change. The susceptibility model of investment specified is $D_t = f(P_{t-1}, \Delta P, g_{t-1}, c_{t-1})$,
where D_t is aggregate investment orders in the current period t; P_{t-1}, is previous period (t-1) level of profits; ΔP is actual increment in profit levels from (t-2) to (t-1); g_{t-1} is previous period gearing ratio; and c_{t-1} is previous period capacity utilisation.[3] Consistent with Kalecki, this function identifies the investment order decisions with gestation lags to when these orders are expended and in full operation. National statistics quote investment expenditure data that identifies the realisation of the investment orders, including any modifications to the orders that may have occurred during the gestation period.

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[3] This conceptualisation of the susceptibility investment function is explained in detail in Courvisanos (1996, pp. 114-62).

Laramie *et.al* (2007, p. 197) find that previous profits, lagged by one and two quarters as a set, have the greatest impact on new investment orders. They state that "[b]oth of these profit coefficients are positive, indicating that it is unlikely that ΔP plays a part in influencing new orders". Capacity utilisation also plays a significantly large role, while gearing as a financial constraint has only a small impact on their results. Although capacity utilisation is important in the Laramie *et.al* results, its specification in that study is only as a proxy, where c_{t-1} is the difference between current output (Y) and output associated with target capacity utilisation (which is a fixed proportion of capital stock). In their results they identify that when Y falls below approximately two-thirteenths of the existing capital stock, then capacity utilisation has a negative influence on new orders.[4]

From a theoretical perspective, TI should be incorporated into investment theory as innovation alters the incentive to invest by changing the cost of production or altering product demand. Kalecki (1968) and Laramie *et.al* (2007) both imply technical progress in their investment function specifications but only indirectly, the former by theory and the latter by empirical estimation. Salter (1966) links the inducement to invest to TI by utilising a vintage capital model in which innovation is embodied in capital equipment. Specifically, Salter (1966, pp. 74-5) determines that the "margin of obsolescence" appears in a particular industry where the unit total cost of production using best-practice capital stock equals the unit operating cost of the oldest vintage plant. Labour hiring and materials are the operating costs in this calculation. On this margin, a particular capital stock in a particular industry will be such that TO and TI are mirror images. This can be linked to the above Kaleckian investment function through capacity utilisation on the basis that the "margin of obsolescence" can be alternatively identified as where the total cost of new capacity equals the operating costs of outmoded existing capacity. Thus, when the former becomes less than the latter, then existing marginal capacity becomes TO. If labour and other input costs rise, such that operating existing capital becomes costlier than introducing new capital stock, then the existing capital stock will be replaced with new labour saving best practice capital stock.

Salter goes on to identify mature industries where excess capacity is so high that there is no TO since the cost of replacement of existing plant is not profitable. In such industries, given existing new knowledge, TI will not happen until the labour costs increase enough to make new capital stock profitable. In new growth innovation-bound industries there is no existing capital stock, so there is no issue of existing operating costs and no excess capacity. Such a characterisation of investment with innovation brings the analysis directly back to the Kalecki (1968) investment orders formulation that began this section, with profits and profit increment as the investment variables. What Salter brings to the analysis is a clear decision-based convention or rule for when new TI should be introduced into the investment ordering process, subject to demand growth. In fact, it is new best-practice capital stock that can be used most effectively to meet any projected demand growth.

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[4] Indirectly, this study ascertains technological obsolescence when it estimates the average optimal life of U.K. capital stock (the inverse of capital-output ratio) as approximately 6.57 years.

Technological Innovation and Obsolescence in Australian Manufacturing

Bloch (2007) fits a system of equations including a cost function and derived input demand functions to time-series data for the period 1968 to 2000 for each of 38 Australian manufacturing industries. Technical change in the model is modelled as affecting the use of each input differently rather than reducing use of all inputs by a uniform proportion. The estimated coefficients provide separate estimates for the impact of technical change on use of labour, material and capital inputs in each industry. The coefficients and their standard errors are shown in Table 1, where RKS, RLS and RMS are rates of capital saving, labour saving and materials saving respectively.

A positive coefficient in Table 1 indicates that technical change in the industry is associated with saving that input in the production process, while a negative coefficient indicates that technical change is associated with more intensive use of the input. An outstanding feature of the table is that there is evidence of labour saving in each industry, as all coefficients are positive and statistically significant at the 5 per cent level or better. The estimated rates of labour saving range from .007 in Bakery Products, to .051 in Sheet Metal Products. Further, in every industry the rate of labour saving is greater than the rate of materials or capital saving, indicating a labour saving bias to technical change in Australian manufacturing. Rates of materials saving are mostly positive but small and often not statistically significant, while the coefficients suggest that technical change is mostly capital using (negative coefficients) but not necessarily statistically significant.

The relationship between technological innovation (TI) and investment can be twofold. TI can encourage investment by expanding product markets either through lowering production costs and prices (process innovation) or through improving product characteristics (product innovation). TI also encourages investment when new technology is embodied in capital equipment or can be applied without any further investment-type expenditure (disembodied technical change). Salter (1966), for example, applies a vintage capital model in which technical change is embodied in capital equipment. Specifically in this case, newer vintages of equipment require less labour per unit of output without requiring more capital or material input, so the deployment of new vintage equipment implies TI. This contrasts to the case where the TI is disembodied and can be deployed without any further investment in capital equipment.

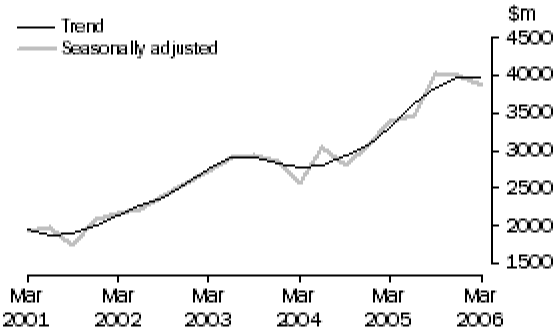
In Salter's vintage-capital model, new capital equipment is always acquired to supply any incremental output, as the total cost of an extra unit of production is always lower with the newest vintage than with any older vintage. Likewise, new vintage equipment is acquired if it is necessary to replace equipment that has physically worn out. In addition, firms may abandon older vintage equipment if the unit operating cost of this equipment (in terms of only labour and materials) exceeds the total unit cost of new equipment (including capital cost as well as labour and materials). This defines TO, as operation of older vintage equipment that is unprofitable, even though it is physically capable of continuing production. TO provides a further link between TI and investment in that TO is induced by TI, but for this to become a reality, investment is required to replace production from the obsolete equipment.

Table 1 – Rates of Input Saving Technical Change for Australian Manufacturing Industries

Industry	RKS	RLS	RMS	Industry	RKS	RLS	RMS
Fruit and Vegetable Processing (213)	**-0.034834** -(9.258)	**0.033606** (43.090)	**0.011700** (8.417)	**Petroleum and Coal Product mfg (252)**	**-0.067760** -(1.443)	**0.034241** (10.904)	**-0.040206** -(5.146)
Oil and Fat mfg (214)	**-0.196727** -(3.083)	**0.024863** (7.740)	**0.013885** (4.354)	**Basic Chemical mfg (253)**	**-0.004438** -(1.143)	**0.041990** (39.248)	**0.014013** (7.941)
Flour Mill and Cereal Food mfg (215)	**-0.080765** -(10.428)	**0.025489** (23.045)	**0.015846** (9.042)	**Other Chemical Product mfg (254)**	**-0.023211** -(7.782)	**0.044141** (53.868)	**0.005091** (3.609)
Bakery Product mfg (216)	**-0.155674** -(4.584)	**0.007257** (8.286)	**-0.001115** -(0.549)	**Rubber Product mfg (255)**	**-0.005447** -(1.304)	**0.031587** (22.726)	**0.006490** (3.053)
Other Food mfg (217)	**-0.023896** -(5.982)	**0.018184** (15.928)	**0.007805** (3.073)	**Plastic Product mfg (256)**	**-0.040165** -(8.168)	**0.019409** (9.664)	**0.003111** (1.963)
Beverage and Malt mfg (218)	**-0.046756** -(11.560)	**0.040804** (45.910)	**0.010823** (6.555)	**Glass and Glass Product mfg (261)**	**0.019025** (5.093)	**0.050656** (28.709)	**0.001042** (0.234)
Tobacco Product mfg (219)	**-0.051184** -(6.932)	**0.030440** (6.549)	**0.006237** (1.950)	**Ceramic mfg (262)**	**-0.013040** -(2.107)	**0.024512** (17.714)	**-0.014306** -(3.256)
Textile Fibre, Yarn and Woven Fabric mfg (221)	**-0.001797** -(0.335)	**0.049555** (67.830)	**0.029568** (13.546)	**Cement, Lime, Plaster and Concrete Product mfg (263)**	**-0.003384** -(0.643)	**0.021226** (24.831)	**-0.008399** -(2.643)
Textile Product mfg (222)	**-0.010536** -(1.188)	**0.019035** (8.754)	**0.007450** (3.689)	**Non-metallic Mineral Product mfg (264)**	**-0.076319** -(6.568)	**0.027043** (12.905)	**0.006070** (1.053)
Knitting Mills (223)	**0.034669** (4.170)	**0.038722** (11.123)	**-0.001186** -(0.146)	**Iron and Steel mfg (271)**	**-0.017527** -(3.136)	**0.045306** (20.873)	**0.011248** (4.207)
Clothing mfg (224)	**-0.018784** -(4.082)	**0.033184** (34.387)	**0.021779** (8.597)	**Basic Non-ferrous Metal mfg (272)**	**-0.092582** -(8.083)	**0.028687** (13.213)	**0.021785** (5.359)
Footwear mfg (225)	**0.001116** (0.178)	**0.022398** (21.809)	**0.005848** (2.033)	**Non-ferrous Basic Metal Product mfg (273)**	**-0.413201** -(1.454)	**0.031892** (17.422)	**0.015756** (4.925)
Leather and Leather Product mfg (226)	**0.000868** (0.048)	**0.036513** (10.553)	**-0.025721** -(8.019)	**Structural Metal Product (274)**	**-0.001393** -(0.181)	**0.014198** (12.052)	**0.004648** (2.321)
Log Sawmilling and Timber Dressing (231)	**-0.119612** -(5.144)	**0.014141** (11.313)	**0.017490** (3.039)	**Sheet Metal Product (275)**	**0.011025** (1.985)	**0.051632** (19.927)	**-0.014149** -(2.815)
Other Wood Product mfg (232)	**-0.056365** -(3.695)	**0.015008** (14.461)	**0.011938** (3.672)	**Fabricated Metal Product mfg (276)**	**-0.045021** -(7.063)	**0.009325** (13.080)	**0.012804** (4.620)
Paper and Paper Product mfg (233)	**-0.022863** -(7.666)	**0.041618** (49.407)	**0.007333** (4.791)	**Motor Vehicle and Part mfg (281)**	**-0.033991** -(4.866)	**0.022341** (18.096)	**0.002144** (1.181)
Printing and Services to Printing (241)	**-0.059040** -(7.231)	**0.029880** (30.584)	**0.018161** (5.365)	**Other Transport Equipment mfg (282)**	**0.006536** (0.339)	**0.032215** (13.693)	**-0.021155** -(6.601)
Publishing (242)	**-0.065041** -(7.067)	**0.016849** (11.736)	**0.020181** (4.941)	**Industrial Machinery and Equipment mfg (286)**	**-0.016997** -(3.421)	**0.019485** (16.971)	**-0.000914** -(0.579)
Petroleum Refining (251)	**0.018377** (1.559)	**0.039978** (5.950)	**-0.055069** -(9.145)	**Furniture mfg (292)**	**-0.001975** -(0.391)	**0.008410** (7.836)	**-0.007864** -(4.703)

The manufacturing sector data in Table 1 is for 3-digit ANZSIC categories identified as 38 separate industry groupings. There is no available investment data for two industries (*viz.* 218 Beverage and Malt, 219 Tobacco Product) , so that leaves 36 industries with which there is investment data to correspond to the estimates of labour, capital and material saving rates. The three input saving rate estimates are applied to the four-year average Australian investment manufacturing data for each industry group over the financial (July-June) years 2001-02 through 2004-05. These four years are a complete trough-to-peak expansion in the Australian manufacturing investment cycle (see Figure 1), following decline of manufacturing investment until mid-2001 as a rest of a minor recession in the Australian economy in 1999-2001.[5] This enables an examination of the investment ordering process at the time when there is relatively low susceptibility to over-investment and firms would be keen to introduce new efficient capital stock to meet rising aggregate demand in the economy.

Figure 1 - Manufacturing Investment March 2001 to March 2006



Source: Private New Capital Expenditure and Expected Expenditure, Australia, March 2006, Australian Bureau of Statistics (ABS), Catalogue No. 5625.0

The three input saving rate estimates are used to determine the impact of TI on the investment data. The investment data for each industry group are divided by the average industry value added (IVA) over the same four-year period to create an investment rate variable that is comparable across industries of radically different size. The other two rate variables included are (i) the average profits in each industry as a ratio of average IVA for same four-year period (lagging profits behind investment by one year), and (ii) the change in profits over the ratio of IVA for the four years. The average profit rate is a measure of the inducement to invest, while the change in profits is a measure of the incentive to invest in terms of the Kaleckian investment model described in the previous section. The same variables are also regressed against the investment rate variance measured across the 36 industry groups to examine whether the stability of investment is sensitive to the profit or TI measures.

Investment with Innovation Results for Australian Manufacturing

The results from regressions relating the various rates of input-saving and profit measures to investment rates in Australian manufacturing are shown in Table 2.

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[5] This expansion ended as at December 2005, as reported in the latest release of the capital expenditure for manufacturing in September 2006 in the following terms: "The trend estimate for Manufacturing has decreased 4.3% this [September] quarter, the third consecutive fall [since the peak in December 2005]. In seasonally adjusted terms, the estimate has decreased 2.5% which is the fourth consecutive fall."

Among the input-saving variables, only labour saving has a statistically significant coefficient. It is positive and indicates that each rise of .01 in the rate of labour saving is associated with a 0.0126 rise in the investment rate. The positive and significant coefficient of the labour saving variable combined with the absence of significance for any of the other input-saving variables is consistent with technical change being capital embodied and TI affecting investment through TO.

Among the profit measures included in the regressions reported in Table 2, only the average profit rate approaches statistical significance. The weak relationship for average profit and the absence of a relationship for change in profit contrasts to other studies of Kaleckian investment models (especially, Courvisanos, 2007). This is perhaps not surprising given the differences in the data used in estimation. Here, we are using cross-section data for different industries within Australian manufacturing over a limited sample period, 2001-02 to 2004-05. Each industry is affected by the same general business cycle conditions. In contrast, Courvisanos (2007) uses time-series data from 1984 to 1998, covering two expansions out of significant recessions. In that study, there was a larger role for business conditions as reflected in average profitability and change in profitability to affect investment rates over the length of the business cycle than with other factors, such as TI, which change only slowly.

Table 2 - Average Investment Rate in Australian Manufacturing 2001/02 to 2004/05 – Regression Results

	Estimated coefficient		
	RLS	**RKS**	**RMS**
Intercept	0.0289 (0.0317)	0.0683 (0.0252)	0.0679 (0.0254)
Avg Operating Profit/Avg IVA	0.16276* (0.0947)	0.1453 (0.1003)	0.1444 (0.0993)
Change in Operating Profit/Avg IVA	0.0679 (0.0471)	0.0768 (0.0507)	0.0791 (0.0558)
RLS	1.2590* (0.6729)		
RKS		0.00603 (0.1112)	
RMS			0.0350 (0.5582)
R-squared	0.2312	0.1472	0.1472
F-statistic	3.208**	1.841	1.842

Notes: Standard errors in parentheses
Observations = 36
** indicates significance at the 5% level
* indicates significance at the 10% level

Innovation can impact on the variability of investment as well as on its level. Our estimates give the rate of input-saving on average over a 32-year sample period, but it is unlikely that the course of TI is smooth. Instead, it is expected that there will be periods of rapid advance interspersed with lesser developments. To this extent, industries with more rapid average input saving might also exhibit more uneven induced TO and resulting investment. Further, in the context of Kaleckian investment theory, upswings in business conditions may increase susceptibility of investment so that investment might be unstable as profitability rises.

Table 3 presents results from regressions for two measures of the variability of the investment rate, the variance of the investment rate and the standard error given by the square root of the variance. The explanatory variables are the rate of labour saving, which is the only statistically significant measure of TI from Table 2, and the average profit rate and change in profit rate, as are used in the Table 2 regressions.

The explanatory power of the regressions in Table 3 greatly exceeds those of the regressions in Table 2. The rate of labour saving has a positive and mildly significant coefficient, while the change in profit variable has a positive and highly significant coefficient. Industries where TI and TO is indicated through a high rate of labour saving have more unstable investment over the sample period as do industries that experience a more positive change in profit rate.

Table 3 - Variation in Investment Rate in Australian Manufacturing 2001/02 to 2004/05 – Regression Results

Coefficient / Dependent Variable	**Variance of Investment Rate**	**Standard Error of Investment Rate**
Intercept	-0.0083 (0.0101)	-0.0092 (0.0167)
Avg Operating Profit/Avg IVA	0.0059 (0.0301)	0.0411 (0.0500)
Change in Operating Profit/Avg IVA	0.0752*** (0.0150)	0.0950*** (0.0248)
RLS	0.3776* (0.2138)	0.7185** (0.3548)
R-squared	0.4961	0.4120
F-statistic	10.5002***	7.473***
Notes: Standard errors in parentheses Observations = 36 *** indicates significance at the 1% level ** indicates significance at the 5% level *indicates significance at the 10% level		

Table 4 lists the 36 manufacturing industries with available investment data, ranked from highest to lowest in RLS. The four columns on the right provide total investment and average profit (as ratios of IVA) for each industry group for the period 2001/02 to 2004/05. Also identifying the variance of investment and operating profits (again as ratios of IVA). The table shows that for this period, the top five largest RLS-based industry groups have relatively low average profit rate, mid-range investment (except for 261 Glass and Glass Product, which is third highest in total investment over the four years). The variance rates of profits and investment for these same industries are also relatively low (except for 271 Iron and Steel, which is fourth in profit variance). Three industry groups with high profit rates and high variance in investment rates, that also exhibit high labour saving rates, are 253 Basic Chemicals, 233 Paper and Paper Products, and 251 Petroleum Refining (sixth, seventh, eighth respectively). These three are also significant capital goods spenders over this period, coming in at first, tenth and sixth (respectively) in total investment spending (as a ratio of IVA).

Table 4 – Australian Manufacturing Industries Ranked by Rates of Labour Saving and Related to Investment and Profits

RLS	Industry	Variance Investment Rate	Total Investment/ Avg IVA 4 yrs	Variance Op.Prof/IVA	Avg Op.Prof/ Avg IVA 4 yrs
0.05163227	**275 Sheet metal product mfg**	0.00018998	0.345670267	0.000917654	0.253231804
0.05065626	**261 Glass and glass product mfg**	0.00068998	0.834871142	0.000267037	0.212535794
0.04955518	**221 Textile fibre, yarn and woven fabric mfg**	0.00035862	0.380626781	0.000492124	0.077492877
0.04530621	**271 Iron and steel mfg**	0.00117259	0.420905569	0.008568691	0.252810059
0.04414072	**254 Other chemical product mfg**	0.0005112	0.41690286	0.00115794	0.250064416
0.04199034	**253 Basic chemical mfg**	0.01698189	0.9817467	0.001727629	0.277637368
0.04161829	**233 Paper and paper product mfg**	0.00256748	0.469406732	0.000859472	0.275897341
0.03997761	**251 Petroleum refining**	0.02261395	0.707317073	0.22456537	0.288802661
0.03872225	**223 Knitting mills**	0.00121968	0.255591054	0.010166417	0.083067093
0.03651328	**226 Leather and leather product mfg**	0.0002521	0.301234568	3.69822E-05	0.201234568
0.03424144	**252 Petroleum and coal product mfg n.e.c.**	0.0021169	0.444444444	0.000723026	0.363315697
0.03360561	**213 Fruit and vegetable processing**	0.0007033	0.454443195	0.001511216	0.235095613
0.03318356	**224 Clothing mfg**	0.00010741	0.226151495	0.002501002	0.267408863
0.03221492	**282 Other transport equipment mfg**	0.00090202	0.349451966	0.00078373	0.17311412
0.03189221	**273 Non-ferrous basic metal product mfg**	9.4155E-05	0.428321678	0.0001543	0.152972028
0.03158654	**255 Rubber product mfg**	0.00144256	0.356997972	0.000624844	0.140365112
0.02987982	**241 Printing and services to printing**	0.00032357	0.434232434	0.001264968	0.149250749
0.02868714	**272 Basic non-ferrous metal mfg**	0.00287493	0.960255603	0.014890056	0.498233044
0.02704294	**264 Non-metallic mineral product mfg n.e.c.**	0.00099003	0.342105263	0.001611184	0.196898496
0.02548913	**215 Flour mill and cereal food mfg**	0.00044939	0.391125719	0.00049744	0.289235826
0.02486342	**214 Oil and fat mfg**	0.0001737	0.36101083	0.008327392	0.39133574
0.02451222	**262 Ceramic mfg**	0.00041779	0.361885105	0.002035132	0.372893017
0.02239817	**225 Footwear mfg**	0.00020978	0.293785311	0.002098081	0.223163842
0.02234082	**281 Motor vehicle and part mfg**	0.00218093	0.725572869	0.000251868	0.189184235
0.02122631	**263 Cement, lime, plaster and concrete product mfg**	0.00138975	0.75994814	0.001589421	0.316146405
0.01948491	**286 Industrial machinery and equipment mfg**	3.9273E-05	0.269372694	0.000422292	0.223800738
0.01940928	**256 Plastic product mfg**	0.00164418	0.533756653	0.001103349	0.199831917
0.01903462	**222 Textile product mfg**	7.3088E-05	0.348459384	0.002740117	0.159103641
0.01818377	**217 Other food mfg**	0.00666665	0.674793444	0.000495895	0.241771638
0.01684944	**242 Publishing**	3.5431E-05	0.142240534	0.002175391	0.413086129
0.01500783	**232 Other wood product mfg**	0.00021293	0.285567803	0.000456659	0.228531146
0.01419791	**274 Structural metal product mfg**	2.278E-05	0.212743549	0.002798047	0.219062665
0.01414096	**231 Log sawmilling and timber dressing**	0.00012085	0.475083585	0.001664184	0.248527305
0.009325357	**276 Fabricated metal product mfg**	0.00012588	0.289938007	0.000835703	0.234620887
0.008410041	**292 Furniture mfg**	0.00012879	0.227267971	0.00041199	0.19200586
0.007257105	**216 Bakery product mfg**	7.2544E-05	0.388841927	0.005605984	0.17920541

The picture that emerges from Table 4 is of two mechanisms operating with TI in the high RLS industries. One is by the smaller, lower profit industries that are forced for survival to invest in new process technology in order to remain price and quality competitive in mature industries that are dominated by low wage cost manufacturers overseas. This is indicative of steel, sheet metal, glass and textiles. The other contemporaneous mechanism is the large investment from strong profits that induce new technologies to replace old vintage stock in order for these local industries to remain dominant. This is the case for basic chemicals, paper and petroleum. Also, evidence is that the same three large investment industries have relatively unstable investment compared to the top five RLS smaller industries that have much lower variance in investment rates.

Limitations

Three limitations have been identified whilst undertaking this study. First, is the assumption employed using the Salter approach in deriving estimates of the impact of technical change on the use of various inputs. For statistical tractability, it was assumed that technical change occurs at a constant rate over time. From detailed studies of technological obsolescence (see Frankel, 1955; Nair and Hopp, 1992; Whelan, 2006) it is clear that the speed of obsolescence is complex and depends on the rates of TI in different economies. These factors are subject to uncertainty in the sense that the expected outcome of the decision to introduce new enhanced capital stock is unknown *a priori*.

Second limitation is the short four-year period of investment data used in the regression analysis. This period is a significantly strong cyclical upswing which helps to identify positive investment decision-making and any links between TO and accumulation. It is difficult to go back over a longer investment period due to the lack of comparability of data between profits and investment within industry groups.

Third limitation is the lack of in-depth understanding of what is actually happening at the specific industry level in relation to TO and RLS. The decision-making in each industry would be peculiar to its own environment, but would emerge from in-depth case studies are patterns of behaviour that could lend support to the mechanisms described in the previous section.[6]

All three limitations are being addressed as part of the ongoing research in this project of linking Salter's technical change approach to the Kaleckian investment ordering model. The research is progressing both at the econometric level to address the first two limitations, and development of in-depth case studies to address the final limitation. The results presented in this paper provide results that encourage further investigations along this track.

Conclusion

This study is another step in the long and winding road towards incorporating TI into the accumulation process as expressed by Salter in the opening quote. By formalising the Salter approach into the Kaleckian investment ordering model, the rate of labour saving becomes a crucial element in identifying technological obsolescence, and in

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[6] For an explanation of the relevance of case studies to investigations in investment decision-making, see Courvisanos (1996, pp 190-216).

this way recognising when technical change is augmenting capital accumulation. New capital stock is produced that results in the older vintage stock being decommissioned as technologically obsolete.

Estimated rates of input-saving (labour, capital and materials) obtained for the Australian manufacturing sector by industry groups show that technical change has a significant labour saving bias. This bias is shown to be the dominant element in the technological obsolescence of old vintage capital equipment. Regression results indicate that the rate of labour saving played a significant role in the investment process out of the mild Australian cyclical trough at the start of the twenty-first Century. This result enables the inclusion of labour saving as a proxy for technological innovation into the Kaleckian investment ordering model. Together with profits as the ability to invest factor, the two variables combine for an explanation of the accumulation process in a prototype advanced capitalist economy. Instability in this accumulation process can also be identified by relating the strength of labour saving and the strong positive profit relationship to the variance of investment ordering. These results show Kaleckian investment instability as being based on profit changes and innovation.

One central insight of post-Keynesian economics, of which Kalecki played a prominent role, is that investment drives saving because it generates income and additional effective demand.[7] This macroeconomic feedback from investment to profits is the source of saving in the community. In his *Treatise on Money*, Keynes called it the Widow's Cruse, while Kalecki's Dictum states that "capitalists earn what they spend, and workers spend what they earn" (Sawyer, 1985, p.73).[8] What this study does is contribute to analysing the form of this investment. Keynes referred to "fruitful investment" in the context of productive expenditure on capital stock that is not speculative investment (Keynes, 1936, p.150). We take this one step further and identify the nature of fruitful investment in terms of the extent of technical change through innovation that is embodied in the capital accumulation process. Investment that incorporates technological innovation enables industries to become sustainable into the uncertain future, but with varying states of investment instability.

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[7] See Harcourt (2006, and in particular pp. 160-4).

[8] Professor Geoffrey Harcourt suggests that Kalecki's Dictum would be better phrased as "wage-earners spend what they earn while profit-receivers receive what they spend." (Dalziel and Lavoie, 2003, p. 340 fn.4).

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