BUSINESS EXPENDITURE ON RESEARCH AND DEVELOPMENT IN NEW ZEALAND – FUTURE POTENTIAL AND FUTURE INDUSTRIES

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ABSTRACT

Studies of business expenditure on R&D (BERD) are important because BERD supports firms' technological progress that is the only sustainable way to a nation's long-term productivity growth, which is essential for its long-term international competitiveness.

The gap between our BERD intensity – at 0.49% GDP and that of 1.53% for OECD nations taken as a whole – is large and this suggests New Zealand experiences substantial competitive disadvantages.

To investigate these competitive disadvantages, in this study: (i) we update our previous estimates for the country-specific and firm-specific components of the BERD intensity gap; (ii) we re-estimate the gap and its components using estimates of industry-level purchasing power parities as a proxy for purchasing power parities for R&D input costs; and (iii) we report and discuss the industry-level sub-structure of the gap components.

In conclusion we recommend the use of the gap, its components, and their industry-level structure, as useful indicators to monitor changes in BERD intensity over time relative to other nations. We provide examples of such application in the context of recent policy initiatives in New Zealand. Our results demonstrate how the BERD intensity gap for New Zealand and other nations is dependent on estimates of industry-level prices for R&D inputs in nations. Interestingly, this suggests that a nation's international competitiveness due to BERD is itself influenced by the competitiveness of the business of performing R&D.

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Abstract

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The gap between our BERD intensity – at 0.49% GDP and that of 1.53% for OECD nations taken as a whole – is large and this suggests New Zealand experiences substantial competitive disadvantages.

To investigate these competitive disadvantages, in this study: (i) we update our previous estimates for the country-specific and firm-specific components of the BERD intensity gap; (ii) we re-estimate the gap and its components using estimates of industry-level purchasing power parities as a proxy for purchasing power parities for R&D input costs; and (iii) we report and discuss the industry-level sub-structure of the gap components.

In conclusion we recommend the use of the gap, its components, and their industry-level structure, as useful indicators to monitor changes in BERD intensity over time relative to other nations. We provide examples of such application in the context of recent policy initiatives in New Zealand. Our results demonstrate how the BERD intensity gap for New Zealand and other nations is dependent on estimates of industry-level prices for R&D inputs in nations. Interestingly, this suggests that a nation's international competitiveness due to BERD is itself influenced by the competitiveness of the business of performing R&D.

1. Introduction

1.1 About BERD

This paper reports a study[1] of Business Expenditure on R&D (BERD) for New Zealand and selected other countries for comparison.

BERD studies[2] are important because BERD supports firms' technological progress that is the only sustainable pathway to a nation's long-term productivity growth, which is essential for its long-term competitiveness.

BERD studies are particularly important for New Zealand because at 0.49% of total GDP, our BERD intensity is low compared with an average intensity for OECD nations of 1.53%[3].

BERD metrics can be calculated in different ways. In this study we are concerned with the BERD Intensity Gap, being the difference in respective BERD- to-GDP percentages for New Zealand and an average for OECD nations.

We can split out the BERD intensity gaps into "structure" and "intensity" components and this will tell us about the respective influence on BERD of a nation's industrial composition and the propensity of firms to invest in R&D.

We can also sub-divide each of these components into industry-level contributions and so we can inspect measures of BERD intensity gaps at the industry level.

The total BERD intensity gap, the structure and intensity components and the industry manifold form a useful indicator set that we can use to monitor changes over time in BERD for New Zealand and other nations. Such an indicator set will provide improved information for R&D policy and R&D strategies.

1.2 About this Study

In this study we:

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[1] The authors gratefully acknowledge the helpful comments on our previous study by Colin Clark, Australian Productivity Commission and by participants at the NZAE Conference 2007. We thank Hamish Hill and his team at Statistics New Zealand for helpful comments. We thank Alistair Ramsden of the Ministry of Research, Science and Technology for investigations in progress to secure R&D price level proxies.

[2] Previous work in this area includes that by: (i) the Australian Productivity Commission (2007) (below); (ii) Davis, G. and G. Tunny (2005), "International Comparisons of Research and Development, Australian Government The Treasury; (iii) an unpublished mimeo by (i) Di Maio, M and N. Blakely, New Zealand Treasury (2004); and (iv) an unpublished mimeo by Liu, J. and P. Mazoyer, Ministry of Research, Science and Technology (1999).

[3] OECD (2008) Main Science and Technology Indicators.

(i) update and refine our previous estimates of the BERD intensity gap and its "structure" and "intensity" components[4] for New Zealand and selected nations, where all data are translated with a single total-GDP USD PPP;

(ii) re-estimate the metrics in (i) using an industry-level GDP USD PPPs[5], as proxies for relative prices for R&D and output at the industry-level of nations;

(iii) report, for the two cases (i) and (ii), the industry-level sub-components of each of the structure and industry components;

We conclude with a discussion of the use of the metrics obtained as indicators to measure change in the BERD intensity gap over time in the context of contemporary policy initiatives.

2.0 Methodology for our BERD Estimates

2.1 Measures to describe BERD

BERD estimates are reported in various ways including as:

Nominal BERD

(i) all-economy BERD - an aggregate of current expenditure of a nation's firms (eg dollars per annum) in current currency units;

(ii) industry-BERD - an aggregate of current expenditure of all firms in a particular industry in current currency units;

Nominal BERD Intensity

(iii) the all economy BERD expressed as a percentage of national GDP, both in current currency units;

(iv) the industry BERD expressed as a percentage of industry GDP, both in current currency units.

Inter-country Difference in Nominal BERD Intensity

(v) the difference between nominal BERD intensity of one nation compared with another – both in current currency units;

(vi) the difference between nominal BERD intensity of one industry in one nation compared with the corresponding estimate for another nation both in current currency units.

Gap in BERD Intensity deflated by Purchasing Power Parities

(vii) the difference between one nation's BERD Intensity and a multi-country average – such as the OECD average – where all nominal BERD and GDP data are deflated with appropriate PPPs. Due to

[4] Debski I. and J. Williams (2007) "Business Research and Development in New Zealand, the relevance of industry composition and R&D intensity", a paper prepared for the New Zealand Association of Economists' Conference, Christchurch, New Zealand, 27-29 June 2007.

[5] Refer section 3.5

lack of data this is often the one GDP USD PPP for the economy as a whole. However, some studies do seek to use proxies for PPPs relevant to R&D prices at the industry level.

2.2 Calculating the BERD Intensity Gap and its Components

As with our previous study, the methodology used to calculate aggregate BERD intensities and the associated structure and intensity components in this study follows the "shift-share" methodology described by the Australian Productivity Commission, 2007 in Appendix C[6] of their report entitled: "Public Support for Science and Innovation".

This methodology also produces a "mixed effect" that is not directly attributable to any one of the two main components. As in our previous study we apportioned this mixed effect between the two components using the approach taken by the APC.

We are concerned with BERD intensity gaps in this study. Because these are differences, the gaps may reasonably be compared with corresponding gaps from other studies. By comparison, in this study, the BERD intensities themselves are not comparable to those in official publications – particularly because we have omitted industries with ISIC codes less than 15 from the analysis.

As noted by the APC, this kind of analysis is sensitive to the level of aggregation employed. The APC Commission observes larger structural effects when a more disaggregated level is used for industry data.

2.3 Interpreting the BERD Intensity Gap and its Components

The BERD Intensity Gap in this study is the difference between the BERD Intensity for a nation and the BERD Intensity for an average of OECD nations.

The "structure" component of this gap is country-specific and describes how much of this gap is caused by a nation's over- or under-emphasis[7] on particular industries – some of which are more R&D-intensive than others – for producing a nation's output.

The "intensity" component of this gap describes how much of this gap is caused by a nation's over- or under-expenditure[8] on R&D in each industry. The intensity component is firm-specific because it is largely influenced by the propensity (unique to each nation) of firms in a nation to invest in R&D in a particular industry.

[6] http://www.pc.gov.au/study/science/finalreport/science2.pdf

[7] By "emphasis", we mean share of total GDP.

[8] Over or under compared to an OECD average.

2.4 Previous Study

In our previous study, using a shift-share analysis with a 28-level industry structure similar to other reported studies[9,10] we:

(i) calculated BERD Intensity gaps to an OECD average for New Zealand and selected nations by using an all-economy 2003[11] GDP USD PPP for the OECD average data - but not for the New Zealand data;

(ii) calculated firm-specific and country-specific components of these estimates;

(iii) reported the distribution of all-economy nominal BERD over industry-levels for selected countries; and

(iv) reported the nominal BERD-intensity across industry-levels for selected nations.

2.5 This Study

In this study we seek to update the previous study and to investigate the industry-level manifold of structure and intensity components. Hence we re-estimate BERD Intensity gaps for two models:

(1) All Economy Model

(i) a new 26-level industry structure (in order to aggregate some industry levels to better match the industry level data for Japan and Korea);

(ii) updated NZ BERD data with 2006 levels; and

(iii) a translation of all BERD and GDP data with a 2006 total-GDP USD PPP.

(2) Industry-Level Model

(i) as for the All Economy Model but with a translation at the industry-level of all BERD and GDP data with 2006 industry-level GDP PPP USD

We also report the firm-specific and country-specific components of these BERD Intensity gaps in these models.

We then show the industry-level sub-structure of these components graphically and discuss differences between the models.

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[9] Reference Australian Productivity Commission (above)
[10] Reference Dougherty (below)
[11] Refer section 3.5

2.6 Accounting for the International and Industrial Price Relativities of R&D

In this study, consistent with other contemporary studies, the All-Economy model corrects all national data for exchange rates and a single price level relative to the USA. The currency-price level deflator is the PPP in USA dollar terms for each nation for total GDP as an output. However R&D is an input, not an output. Further, as with all inputs the relativity between nations in the price levels of R&D differs by industry and is not well-represented by the relative prices associated with the total GDP of nations.

Hence the All Economy model is likely to misrepresent the amount of R&D performed in real terms in a nation.

Dougherty et al[12] provide estimates of R&D prices for selected large nations and note that the main deficiencies of using a GDP PPP are that:

- the prices of the inputs to aggregate GDP do not reflect the prices of R&D in their production;
- aggregate GDP reflects the price of final output often including taxes and contributions from non-production sectors; and
- aggregate GDP does not reflect the industrial composition of each nation.

In the view of these authors, the ideal measure for international comparisons is a real R&D intensity measure where R&D effort under different price levels of different nations is converted into a volume-based measure for each nation. This is done using input-specific purchasing power parities (PPPs) so that an R&D PPP for each nation is calculated as a weighted average of various input PPPs.

Dougherty et al develop R&D-specific prices and weights and aggregate them into R&D PPPs at the level of individualised industries for 1997 and 1987. They used interviews with R&D performing firms to guide the application of their methodology.

As noted by Messinis[13], Dougherty et al are able to show that the Griliches-Jaffe R&D deflators of combining the price of labour with output prices (Jaffe, 1973; Griliches, 1984) perform as well as the fully developed R&D PPPs. The authors' result suggests that detailed data on non-labour input prices are not essential.

Dougherty et al report that there is little empirical work on R&D price indices and that Zvi Griliches also observed this lack of good information on R&D prices in the 1980s. Often, the issue is ignored because detailed price data is

[12] Dougherty, Sean M., Inklaar, Robert, McGukin, Robert H. and Bart Van Ark (2007) "International Comparisons of R&D Expenditure: Does an R&D PPP make a difference?" NBER Working Paper 12829.

[13] Messinis, G (2004) "R&D Price Inflation, Real BERD and Innovation: Pharmaceuticals, OECD 1980-2000", Centre for Strategic Economic Studies, Victoria University of Technology, Melbourne, Australia.

not available or a GDP PPP is used in cost comparisons. The authors provide a helpful account of earlier studies in this area.

In this study our Industry-Level model provides BERD estimates based on USD PPPs[14] for industry-level output to deflate industry-level BERD and industry-level output. In so doing we seek to account in some way for the industry-specific price of R&D. However, we recognise that the deflated BERD estimates so obtained are still not truly representative of real R&D expenditure at each industry level.

Dougherty et al note that while such use of using industry-level output prices in ratios of industry-level R&D and industry-level output can partially address the composition issue – because industry-level output price levels differ markedly from overall GDP price levels – the remaining distortions in prices can be a serious problem.

3.0 Data

Data from three sources were used in this analysis.

3.1 New Zealand R&D expenditure data

This analysis used the results from the 2005/2006 R&D Survey. Data by organisation, coded to the Australian and New Zealand Standard Industry Classification (ANZSIC) by Statistics New Zealand, was used to calculate BERD by ANZSIC to the three digit level (and four digit level for C2543). Firms classified to ANZSIC L78100 (or OECD International Standard Industry Classification – ISIC - category 73), those providing scientific research services, were reclassified to the benefiting industry where possible. When the research services are provided to a wide range of sectors no reclassification was made. The reclassification is standard practice by Statistics New Zealand, and was used in the development of the R&D Survey research report. Therefore the results are slightly different from those previously reported. Data was in current New Zealand dollars.

3.2 New Zealand GDP data

This analysis used the contribution to GDP by industry data published by Statistics New Zealand for the year ended March 2003. The industry classification used is based on the ANZSIC. For industries groups matched to the OECD ISIC categories of 73 and 75 to 99 a considerable amount of activity occurs in the government sector. We estimated the contribution of private sector activity to these groups using data on employees by industry (available by ANZSIC), published by Statistics New Zealand. This formed one part of a weighting factor to be applied to the GDP contribution of that industry sector (see concordance notes for explanation of the other part). Data was in current New Zealand dollars. Note: no correction was made for the difference

[14] Refer s3.5

in time period between the R&D data and GDP data in calculation of R&D intensities.

3.3 OECD data on R&D intensity by industry, for comparison countries

International industry share of GDP data corresponding to the level of industry disaggregation for the New Zealand data framework are constructed using data from the Groningen Growth and Development Centre, 60-Industry Database[15].

BERD data by industry for 2003 are taken from 2006 ANBERD[16] tables of the OECD. Corresponding BERD and GDP estimates for an OECD average were derived using the 26-level industry framework for New Zealand.

3.4 Concordance between data sources

New Zealand R&D expenditure data was categorised by ANZSIC. New Zealand GDP data was categorised by a broader classification based on ANZSIC. ANBERD data was categorised by ISIC. The concordance used between these is unique to this study. The level of resolution was reduced to maximise the direct concordance between classifications. However, in some cases New Zealand GDP data categories still covered two or more OECD ISIC categories. In order to maintain reasonable resolution these New Zealand GDP categories were sub-divided, using data on the number of employees by industry (which was available by ANZSIC). The proportion of employees in each OECD ISIC category was calculated using the concordance of ANZSIC to ISIC. This comprised the other component of the weighing (see para (ii) above on New Zealand GDP data notes for the other component) applied to the GDP contribution of those sectors.

Note that, as is common for available international BERD data the figures do not include the allocation of BERD to primary industries. BERD for primary industries is proportionately higher for commodity exporting nations – such as New Zealand and Australia - than for other nations. The net impact of this effect on BERD intensity - a quotient of BERD to GDP - is mixed because the proportion of primary sector GDP to total GDP can be higher or lower than the corresponding contribution for BERD.

3.5 PPP Deflators

For the Industry Level model the industry-level USD PPP deflators were assigned the same or similar categories of USD PPPs for 2005 from the OECD.Stat Extracts database, according to the table below.

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[15] http://www.ggdc.net/October 2005

[16] OECD (2006), "Research and Development Expenditure in Industry 1987 - 2004", OECD, Paris.

Industry for USD PPP	ISIC 3 Codes Assigned this PPP
food and non-alcoholic beverages	20, 21, 22, 23, 24, 25, 26, 27, 28
clothing and footwear	17, 19
machinery and equipment	29, 30, 31, 32, 33
transport	34, 35
household furnishings, equipment and maintenance	36, 37
housing, water, electricity, gas and other fuels	40, 41
construction	45
restaurants and hotels	50-52, 55
communication	60-64, 65-67
education	70-71, 72, 73, 74
health	75-99

For the All Economy model, one GDP USD PPP was obtained as provided by the OECD ANBERD (2006) publication[17].

4.0 Results

We present our results in Tables 1, 2, 3 and 5 and Figures 1a to 1g. We provide results from the APC's study in Table 4 for comparison.

Table 1 shows the 26 industry groupings for all data for all countries. This is the structure for the industry manifold of structure and intensity components in this study.

In discussing our results we acknowledge that we have no estimate of the margin of error.

[17] Reference 15.

4.1 All-Economy Model

Table 2 shows the results for selected nations from the All-Economy Model[18].

For example, we would interpret the result for New Zealand as saying:

- the BERD intensity for New Zealand is lower than the OECD average by 1.2%;
- half of this difference is due to New Zealand production placing less emphasis (compared with the OECD average) on R&D-intensive output; and
- half of this difference is due to New Zealand firm's under-spending (compared with the OECD average) in corresponding industries on R&D.

We emphasise that while interesting and while similar to OECD estimates, the BERD intensity (BI) estimates in this study are not comparable with OECD estimates, due to the different industry structure used in this study, together with the omission of certain industries in this study.

Our results for New Zealand are similar to those from our previous study[19]. Our results for most other nations show very close agreement with the results reported by the APC – and better overall agreement than for our previous study.

While we have not calculated error margins in this study, this level of agreement with the results of the APC study over diverse nations gives us confidence in the robustness of our methodology for both the All Economy and the Industry-Level Models.

4.2 Industry-Level Model

Table 3 shows the results from the Industry-Level Model for selected nations.

We can see that compared with the All-Economy model, the use of industry-level output price level deflators produces:

- an increase in the firm-specific (INT) component for New Zealand of 0.17 percent;
- an increase in the firm-specific (INT) component for Australia of 0.13 percent;
- increases for the USA in both components of 0.05 for INT and 0.18 for STR;
- an increase in INT of 0.07 for the UK together with a reduction in STR of 0,04;

[18] It is important to note that the BERD intensities (BI) calculated are unique to the data construction of this study and will likely differ from results for other studies.
[19] In our previous study we reported -0.6 for STR and -0.7 for INT.

- large rises in the firm-specific (INT) component together with about twice as large falls in the country-specific (STR) component for Japan Korea and Germany.

The effect of price level changes is complex and has an impact on changing the STR and INT components of all industries in different ways. We do not seek to analyse this further at this stage in this paper. The complexity of these changes is evident on comparing the industry-level manifolds of the all economy model with that for the industry-level model.

We prepared figures for the manifolds of the industry-level model – but for brevity, we do not present them in this paper.

The results for INT for New Zealand and Australia are consistent with our expectations. They suggest that more R&D is being performed by firms in real terms, relative to the OECD average, than indicated by the All Economy model. The result is intuitively appealing because we presume the cost of R&D in New Zealand is lower than the corresponding cost in more industrialised nations; and it is reasonable to assume that this R&D price differential is greater that the price differential for corresponding total output. The big assumption we have to make is that R&D price relativities between nations are reasonably represented by industry-output relativities.

We propose, in a future study, to derive BERD estimates using other proxies for the industry-level R&D price.

4.3 Mixed Effects

Table 5 shows how the INT and STR components consist of MAIN effects and MIXED effects – due to the methodology used. For New Zealand and Australia, the mixed effects amount to about 50% of the main effect, but for other countries the mixed effects are small. This result tells us that the MAIN effects are good approximations of the TOTAL effects and that for New Zealand this mixed effect is important in the models in this study. Further investigation of the mixed effect is beyond the scope of the present study.

4.4 Industry-Level Effects

Figures 1a to 1g show the industry-level manifolds of each of the STR and INT components for selected nations. Each component is comprised of the sum of the respective industry-level manifold. The values are absolute and should be multiplied by 100 to provide a percentage value.

For all figures, the industry-level data consists of MAIN effects as discussed above. Because of the methodology used, it is not possible to include the mixed effects in the industry-level data.

By an artefact of data construction in this study a positive (negative) value of STR or INT lowers (raises) the BERD intensity relative to the OECD average.

The most striking results from these graphs are that:

- for Japan, Korea, Germany and to some extent the USA, the BERD Intensity gap is driven by the influences of only a few industries - both positively and negatively in ways that are often different for STR and INT components;
- for the UK the BERD intensity gap is influenced by a wider range of industries; and
- for Australia and more so for New Zealand the BERD intensity gap is influenced by a wide range of industries, mostly negatively, with few important exceptions as discussed below.

By looking at the STR components, we can see that the BERD Intensity of nations is raised (relative to the OECD average) because R&D is required to support the following industries and the respective industrial composition emphasises them:

New Zealand – food, beverages and tobacco (15+16)

Australia - food, beverages and tobacco (15+16); basic metals (27); transport and storage, post and telecommunications (60-64); financial intermediation (65-67)

USA – medical precision instruments (33); computer and related activities (72); research and development (73)

Japan – computing machinery, radio, TV and communications (30+32)

Korea – computing machinery, radio, TV and communications (30+32); motor vehicles and other transport equipment (34-35)

Germany – chemicals and chemical products (24); machinery and equipment (29+31); motor vehicles, other transport equipment (34-35)

United Kingdom – transport and storage, post and telecommunications (60-64); computer and related activities (72); research and development (74)

Similarly, by looking at the INT components, we can see that the BERD Intensity of nations is raised (relative to the OECD average) because of the propensity of private sector firms to over-invest (relative to the OECD average) in R&D in the following industries:

New Zealand – textiles, leather and footwear (17-19); medical precision instruments (33); real estate business activities (70-71)

Australia – transport and storage, post and telecommunications (60-64); financial intermediation (60-67); research and development (73); other business activities (74)

USA – pulp, paper, printing, publishing (21-22); medical precision instruments (33); motor vehicles and other transport equipment (34-35); wholesale and retail trade (50-52); computer and related activities (72)

Japan – food, beverages and tobacco (15+16); chemicals and chemical products (24); rubber and plastics products (25); machinery and equipment and electrical machinery (29+31); medical precision instruments (33); motor vehicles, other transport equipment (34-35) research and development (73); computing machinery, radio, TV and communications (30+32)

Korea – machinery and equipment (nec) electrical machinery (nec); construction (45); transport and storage, post and telecommunications (60-64); computer and related activities (72); other business activities (74)

Germany – chemicals and chemical products (24); motor vehicles, other transport equipment (34-35)

United Kingdom – chemicals and chemical products (24); machinery and equipment and electrical machinery (29+31); motor vehicles, other transport equipment (34-35); post and telecommunications (60-64)

5.0 Policy Context

5.1 A Conceptual Framework for R&D and Technological Progress

The BERD intensity gaps, components and industry manifolds provide us with a useful toolkit to analyse and monitor BERD investment in our innovation system, in order to develop policies to support it.

To help us think about the implications of these estimates for assessing the contribution of R&D to technological progress, we can use part of a simple conceptual framework provided by Tassey[20].

R&D investment is a complex activity. Policy initiatives for raising BERD must account for this complexity[21]:

"Technology and the public and private institutions that support its development and use are interdependent components of a national innovation system. This system is not easily replicated due to the complexity of the actors and institutions, including multiple infrastructures, which ultimately yield the market applications that produce the desired economic benefits. Thus, policies that are effective at stimulating such systems are to be highly valued."

[20] Tassey, G (2007), "The Technology Imperative", Edward Elgar Publishing Limited, Cheltenham, UK, p107.
[21] Tassey G. (2007) above p266

In some cases R&D is vital to support certain fundamental types of technologies that in some cases are not provided by the private sector. Tassey says[22] that industrial productivity relies on R&D activity to create:

(i) technology platforms for an industry (called generic technologies by Tassey) that replace existing technologies by producing radically new ("disruptive") products and processes;

(ii) market applications derived from these platforms (called proprietary technologies); and

(iii) infrastructure for an industry to support technological activity (called infratechnologies).

Importantly, support for each of these requires a different type of investment and a different R&D strategy.

This complexity partly arises because interactions between technology pathways are important for technological progress. Innovation does not proceed linearly from one generic technology to a final product. There are often complex interactions between complementary technologies that combine their respective pathways. In this respect, feedback loops are regular occurrences in which marketplace experiences become inputs for the redirection of R&D.

If we are concerned with the role for BERD in enhancing international competitiveness, we need to recognise that the business of R&D is itself internationally competitive. That is, globally, firms compete to be the best providers of particular types of R&D in part to assume leadership in developing the associated technologies and ultimately, the high-value products from them.

Firms recognise the challenges and opportunities for firms from accessing R&D on a global setting[23]. Tassey[24] provides many examples where firms in emerging nations appear to be "hollowing-out" many competitive advantages of the United States by becoming dominant players in the R&D associated with them. This is also a threat for New Zealand as with all countries. Despite this challenge, globalisation presents important opportunities for those nations that are able to manage their innovation systems in a superior way and cultivate competitive knowledge-intensive industries, as noted above.

5.2 Potential Policy Directions

The OECD Review of New Zealand's innovation policy provides a number of recommendations and observations that can help shape policy to support technological progress in New Zealand and thereby sustain the competitiveness of existing industries and help create new industries.

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[22] Tassey G. (2007) above p116.
[23] OECD (2007), "OECD Reviews of Innovation Policy New Zealand", OECD Paris.
[24] Tassey G. (2007) above

On the topic of public investment to support firm innovation, the OECD Review recommended[25] that the goal for allocation of government support:

"…should include better exploitation of potential strengths in niche markets, commercial exploitation of hotspots of scientific research in which New Zealand has world-class capability and innovations in areas in which New Zealand businesses have a substantial customer base".

The OECD Review sees opportunities in incremental change in industry in order to create and foster high-value-added knowledge-based businesses through[26]:

- using New Zealand's expertise in areas of science and technology relevant to agriculture, fishing and other primary sectors to develop high-value products in those sectors, and to develop novel equipment, services, software and other inputs provided by the domestic supply chain;
- fostering the creation, growth and development of businesses based on the strengths of the New Zealand research base and on existing technological, design and organisational strengths of New Zealand businesses; and
- exploiting New Zealand's other advantages, such as its scenery and geography, to create value-added products and services and take advantage of one-off opportunities for establishing competitive advantage, such as the winning of the Americas Cup."

Underpinning this incremental change is the New Zealand research base that has an important role to provide appropriate "generic" technologies[27]:

"the New Zealand research base is strong, world-class in some areas, and able to generate the new science and early-stage technology that can form the basis of new high-technology/high-value-added business potentially capable of competing in world markets. Both CRIs and universities…have succeeded in transferring the results of their research to the commercial sector, often by encouraging the establishment of new businesses."

The Review identifies[28] the natural-resource-based sectors as providing opportunities for the development of "proprietary" technologies, since they:

"….offer considerable scope for the application of advanced science and technology, such as the development of new types of plants and trees…marine farming and the production of therapeutic compounds using genetically altered animals and plants. Investment in science, technology and innovation is vital if New Zealand is to maintain its competitiveness in these

[25] OECD Review "Overall Assessment and Recommendations"
[26] OECD Review s4.10
[27] OECD Review s4.8
[28] OECD Review s 4.2

sectors, increase their productivity and create opportunities for innovation further up the supply chain."

On the topic of feedback loops to support interactions between complementary technologies, the OECD Review[29] sees opportunities for, industries supplying high-technology proprietary technologies to large natural-resource-based firms – even if the large firms themselves are not R&D-intensive:

"Many of New Zealand's larger firms are in natural-resource-based sectors and their demand (together with that of related government agencies) for specialised goods, services and software creates opportunities for high-technology/high-value-added businesses. Demand for leading edge inputs enables firms (and CRIs) to develop and test in the market products which can then be sold to similar operations around the world."

6.0 Conclusions

Our new estimates of BERD intensity gaps and their components, together with the associated industry manifolds have revealed important new insights into BERD for New Zealand and other nations.

These simple yet revealing indicators can help shape an understanding of why BERD is changing in our economy and where it is changing. They can enable us to assess more critically the various BERD measures used for inter-country comparisons.

Our simplistic corrections with industry-level prices show that price effects are strongly influential on BERD intensity gaps. This study re-states the imperative – identified in other studies - to account for the relativities in the international input prices of R&D in estimates of BERD intensity gaps. We propose to investigate this area further.

Policy initiatives and firms' R&D strategies concerned with BERD will benefit from periodic updates of the BERD metrics in Tables 2 and 3 and in the industry-level manifolds in order to monitor changes in BERD over time.

A few examples will show the application of such indicators for recent policy initiatives in New Zealand.

The INT indicator can show where firms are driving R&D investment into new industries that may not be presently important for a nation. Similarly the STR indicator can show where demand by current industries for R&D is driving R&D intensity.

For monitoring the impact of the recently introduced tax credit, over time, we can reasonably expect the INT industry-level manifold to show the response

[29] OECD Review s4.2

in firms' propensity to invest in R&D. At the same time, we would expect low short-term response from the STR industry-level manifold.

By comparison, over a longer period of time, as new R&D intensive industries develop, we can reasonably expect the STR industry-level manifold to respond to increased investment in R&D resulting from the tax credit. We would also expect STR to respond favourably to policy changes designed to support the creation of new industries. This may also be accompanied by simultaneous responses in the INT manifold as firms become more confident about the potential of emerging industries.
Potentially, the implementation of the government's support for the six Transformational Research, Science and Technology[30] (TRST) technologies as focus areas for new government investment offers the prospect of providing a raft of new generic technologies to support the subsequent generation of new proprietary technologies.

Inspection of the INT and STR components for the more industrialised nations shows that many tend to focus their R&D efforts in a few industries. This focus is in part a firm-specific feature and at other times it is a country-specific feature – arising from industrial composition. With the INT and STR components we have the capacity to monitor progress in R&D intensity in the focus industries of many nations and discuss this terms of the drivers of structure and intensity behaviour.

We conclude that the lesson for New Zealand from this tendency of the more industrialised nations to specialising R&D activity in a few industries is contained in the recommendations and advice of the OECD Review. It is that we should continue to support the R&D demanded to support the international competitiveness of our existing industrial composition and at the same time provide R&D for new emerging technologies and for the competitiveness of their associated new industries . We should also recognise the complexity of this support. At a minimum, we should not ignore the fundamental and different roles of generic, proprietary and infra technologies.

The Fast-Forward[31] initiative to fund research and development to raise the quality and lower the cost of primary industry production in a partnership between industry and government follows the principle of providing R&D to support strengths in existing industrial composition to generate new technologies and new market applications of technologies.

This initiative has the potential to influence a small area (perhaps ISIC coded 15 – 25) of the industry-level manifolds for both INT and STR. The partnership element in the initiative has the potential to build feedback loops to encourage interaction of complementary technologies. If so we may reasonably expect the impact of this initiative to be more diffuse across a wider set of industries. Potentially we can monitor such impacts in terms of the STR and INT components.

[30] http://www.morst.govt.nz/current-work/transformational-rst/
[31] http://www.maf.govt.nz/mafnet/new-zealand-fast-forward/index.htm

The dependence of real BERD intensity on R&D price relativities underscores the vulnerability of nations which focus their R&D in a few industry areas. They are open to challenge from global competitors incrementally hollowing out crucial and complementing R&D activities. At the same time, firms in those nations will actively seek out excellent R&D activities in order to complement their existing focus and to maintain R&D competitiveness.

In this respect the international competitiveness of the business of providing R&D is an important consideration in developing R&D strategies to raise the international competitiveness of a nation's production.

Table 1: Industry categories (ISIC Revision 3 concordance)
Source: OECD ANBERD Database 2006

Categories	ISIC Revision 3 Descriptions
15+16	food, beverages, tobacco
17...19	textiles, leather, footwear
20	wood and products of wood
21..22	pulp, paper, printing, publishing
23	coke, refined petroleum products
24	chemicals an chemical products
25	rubber and plastics products
26	non-metallic mineral products
27	basic metals
28	fabricated metal products
29+31	machinery and equipment nec, electrical machinery nec
30+32	office and computing machinery, radio, TV and communications
33	medical precision instruments
34-35	motor vehicles, other transport equipment
36-37	furniture, manufacturing nec, recycling
40+41	electricity, gas, water
45	construction
50...52	wholesale and retail trade, repair
55	hotels and restaurants
60..64	transport and storage, post and telecommunications
65...67	financial intermediation
70…71	real estate, business activities
72	computer and related activities
73	research and development
74	other business activities
75...99	community and personal services

Table 2: BERD Estimates from All Economy Model
(using GDP USD PPPs)

Country	BERD Intensity (BI)	BERD Intensity Gap (BI Gap)	Intensity Component of BI Gap	Structure Component of BI Gap
	BERD as % GDP	BI - BI(OECD) as % GDP	INT as % GDP	STR as % GDP
New Zealand	0.51	-1.2	-0.6	-0.6
Australia	0.92	-0.8	-0.2	-0.6
USA	1.79	0.1	0.1	0.0
Japan	2.4	0.7	0.9	-0.2
Korea	2.76	1.1	-0.6	1.7
Germany	1.97	0.3	-0.2	0.5
UK	1.36	-0.4	-0.2	-0.2
OECD	1.71	0.0		

Table 3: BERD Estimates from Industry-Level Model
(using estimates of industry-level GDP USD PPPs)

Country	BERD Intensity (BI)	BERD Intensity Gap (BI Gap)	Intensity Component of BI Gap	Structure Component of BI Gap
	BERD as % GDP	BI - BI(OECD) as % GDP	INT as % GDP	STR as % GDP
New Zealand	0.45	-1.0	-0.5	-0.6
Australia	0.85	-0.6	-0.1	-0.6
USA	1.79	0.3	0.1	0.2
Japan	1.61	0.1	1.3	-1.1
Korea	1.89	0.4	0.1	0.3
Germany	1.5	0.0	0.0	0.0
UK	1.16	-0.3	-0.1	-0.2
OECD	1.48	0.0		

Table 4: BERD Estimates reported from APC Study as comparison (using GDP USD PPPs)

Source Figs C.6 and C.8 APC Report

Country	BERD Intensity (BI)	BERD Intensity Gap (BI Gap)	Intensity Component of BI Gap	Structure Component of BI Gap
	BERD[1] as % GDP	BI - BI(OECD)	INT	STR
New Zealand	n/a	n/a	n/a	n/a
Australia	1.20	-1.1	-0.2	-0.9
USA	2.60	0.3	0.2	0.1
Japan	2.90	0.6	0.9	-0.3
Korea	3.00	0.7	-0.5	1.2
Germany	2.50	0.2	-0.3	0.6
UK	1.70	-0.6	-0.3	-0.2
OECD	2.3	0.0		

1. Calculated from BI Gap and OECD(BI)

Table 5: Main and Mixed Effects of INT and STR from All Economy Model

(TOTAL-INT = MAIN-INT + MIXED-INT)
(TOTAL-STR = MAIN-STR + MIXED-STR)

Country	TOTAL-INT (Table 2)	TOTAL-STR (Table 2)	MAIN-INT	MAIN-STR	MIXED-INT	MIXED-STR
New Zealand	-0.6	-0.6	-0.4	-0.4	-0.2	-0.2
Australia	-0.2	-0.6	-0.1	-0.4	-0.1	-0.2
USA	0.1	0.0	0.1	0.0	0	0
Japan	0.9	-0.2	0.7	-0.2	0.2	0
Korea	-0.6	1.7	-0.5	1.3	-0.1	0.4
Germany	-0.2	0.5	-0.2	0.5	0	0
UK	-0.2	-0.2	-0.2	-0.2	0	0

Fig 1a: NZ - STR and INT Components of BERD Gap
USD PPP All Economy

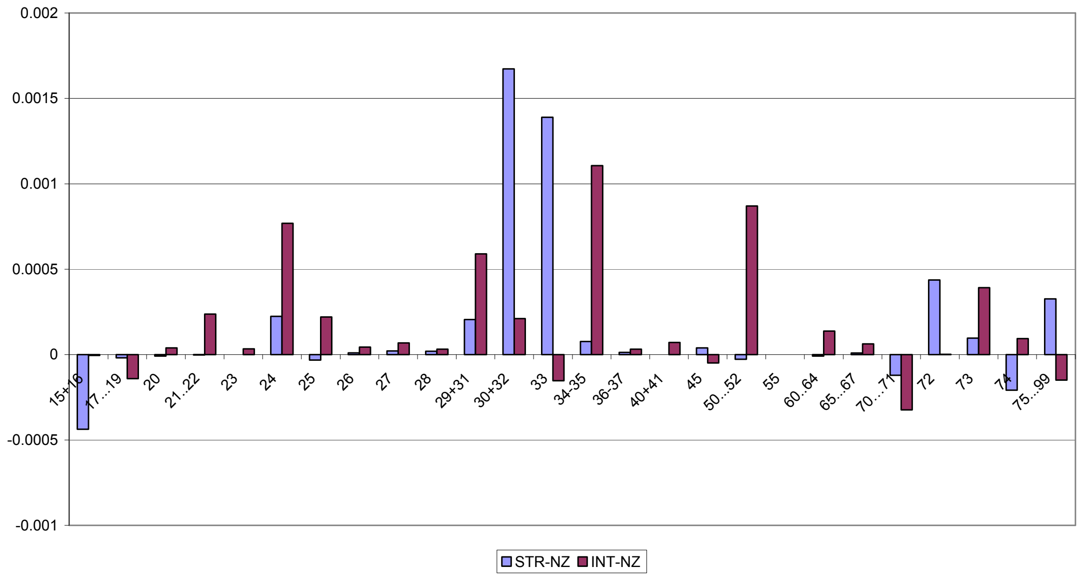


Fig 1b: AUST - STR and INT Components of BERD Gap
USD PPP All Economy

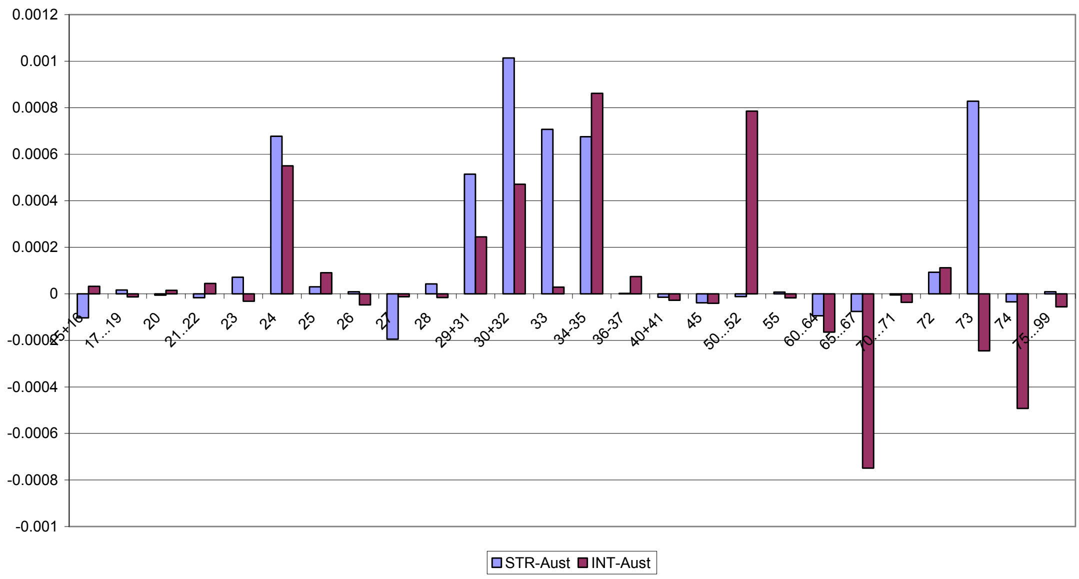


Fig 1c: USA - STR and INT Components of BERD Gap
USD PPP All Economy

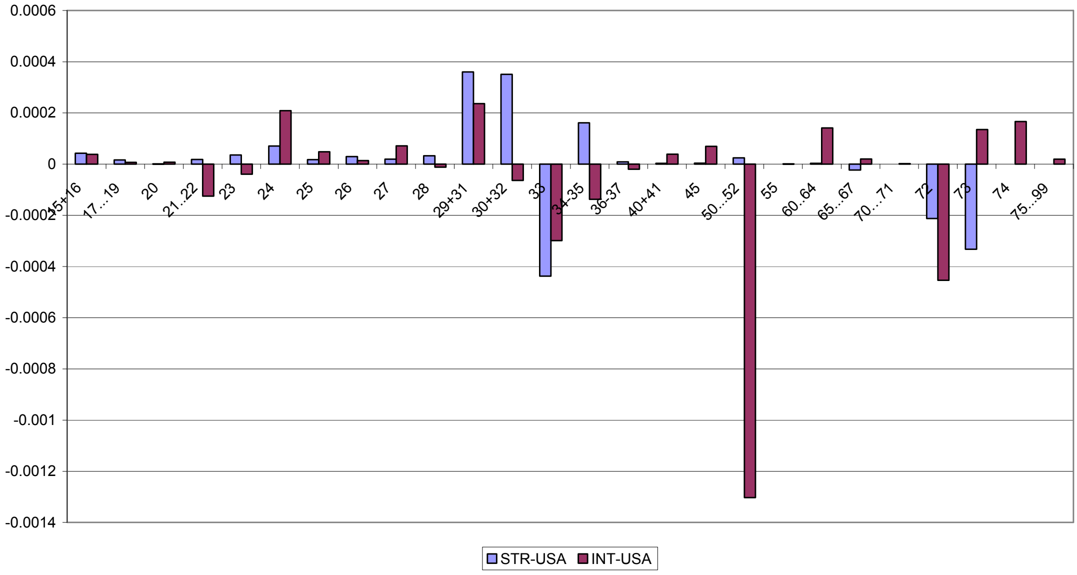


Fig 1d: JPN - STR and INT Components of BERD Gap
USD PPP All Economy

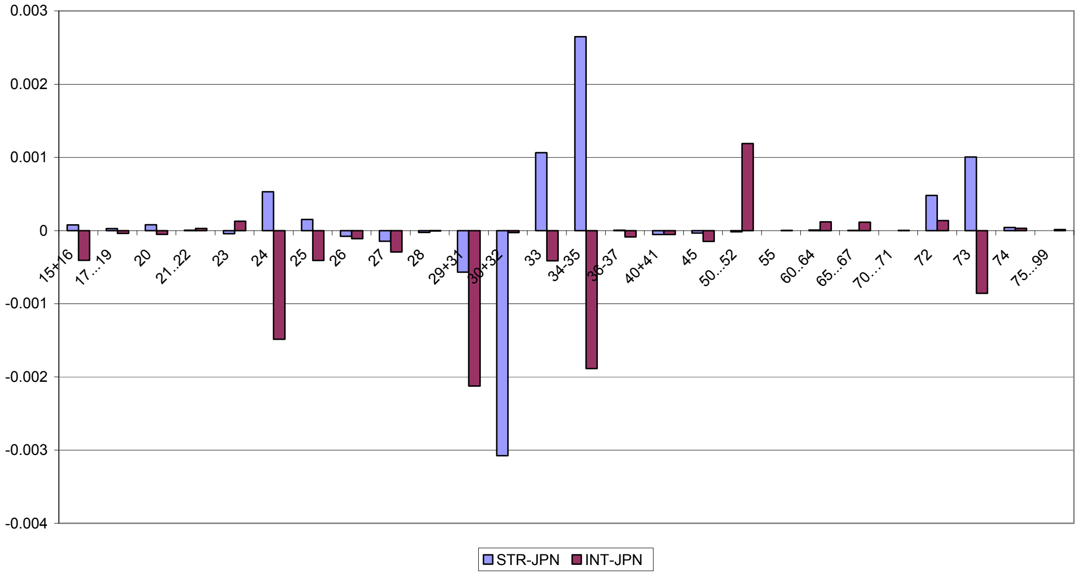


Fig 1e: KOR - STR and INT Components of BERD Gap
USD PPP All Economy

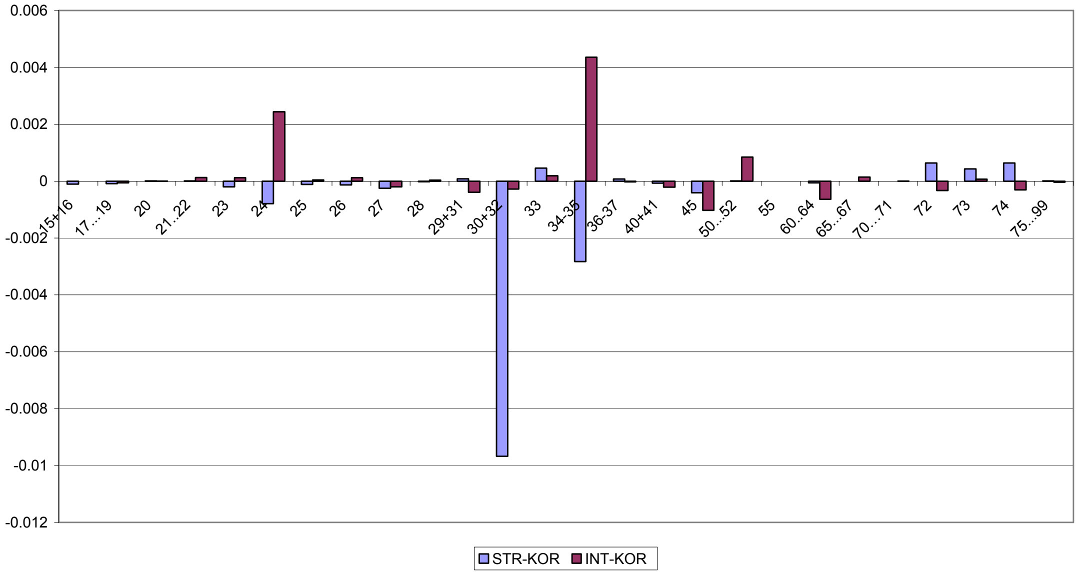
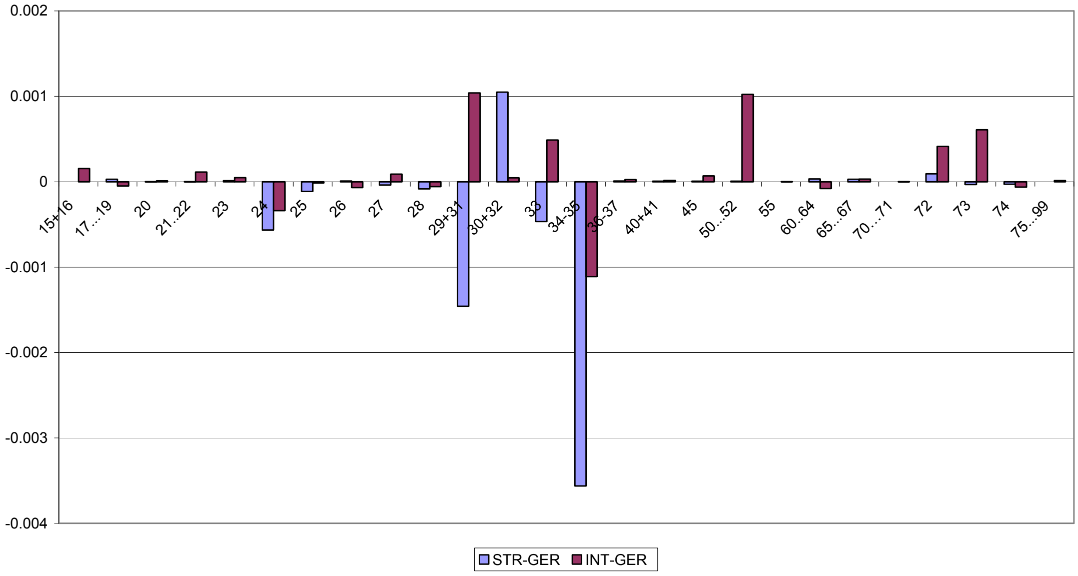


Fig 1f: GER - STR and INT Components of BERD Gap
USD PPP All Economy



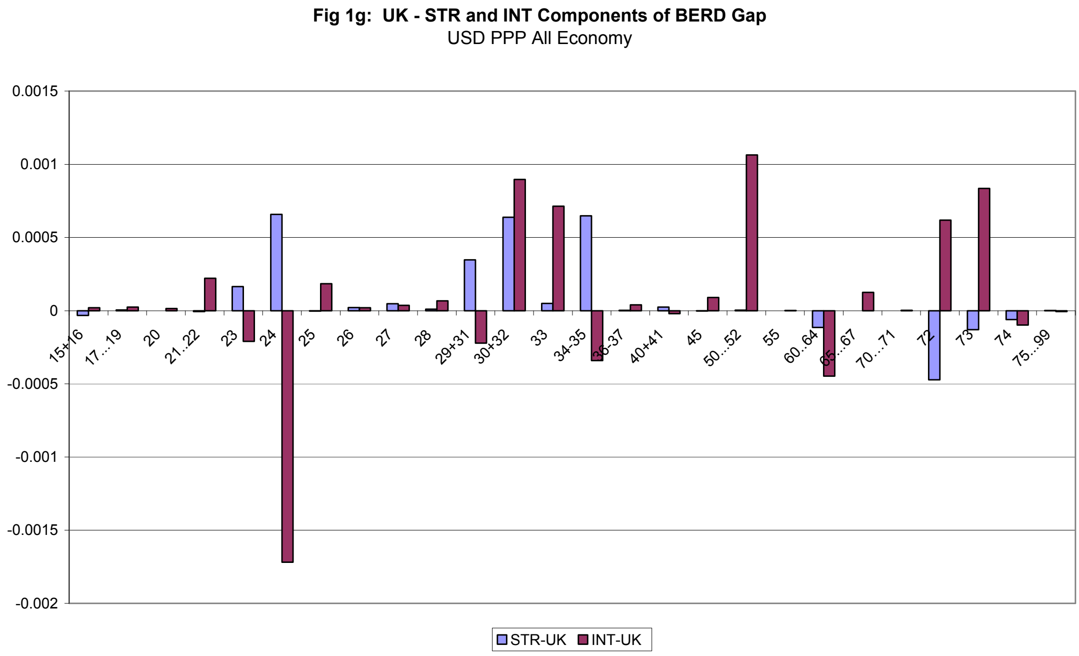


Fig 1g: UK - STR and INT Components of BERD Gap
USD PPP All Economy
0.0015
0.001
0.0005
0
-0.0005
-0.001
-0.0015
-0.002
15+16
17…19
20
21..22
23
24
25
26
27
28
29+31
30+32
33
34-35
36-37
40+41
45
50…52
55
60..64
65…67
70…71
72
73
74
75…99
STR-UK
INT-UK