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FROM THE EDITORS

This issue of *EcoNZ@Otago* has its usual eclectic mix of articles, but something they have in common is they are all authored or co-authored by your humble editors. The other thing that makes this issue (number 43) unique is that, sadly, it's our last ... The first issue appeared in July 1998 – two months before Google was founded! – and two issues, usually with four articles and Alan King's commentary on the New Zealand economy (40 of them!), have appeared every year since then. What germinated as a "magazine for schools" ripened into "a magazine about contemporary economic issues for everyone". But time (and technology) moves on, and so it is with smiles on our faces and tears in our eyes that we bid you farewell. From all seven editors over the last 22 years, thank you to our authors and especially to our readers for having supported *EcoNZ@Otago*, proudly brought to you by the University of Otago's Department of Economics. And many thanks to Judy Robinson for her excellent design work. Güle güle and goodbye!

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Rare-earth elements: A primer

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For many of us, smartphones and other battery-powered and electronic equipment are indispensable in our daily lives. Many of these devices and other technologies, such as hybrid electric vehicles (see Figure 1), depend on rare-earth elements. This article introduces the rare-earth elements and discusses the roles played by China and the US, the world's main producers.

Figure 1: Rare-earth elements used in a hybrid electric vehicle

Source: http://americanresources.org/what-the-auto-industry-rare-earth-elements-have-in-common

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Depending on how they are defined, there are 17 rare-earth elements – each with a place on the periodic table divided into 'light' and 'heavy' elements reflecting their atomic numbers. Table 1 presents the rare-earth elements and examples of their uses.

Table 1: Rare-earth elements and examples of their uses

Rare-earth element	Uses
Scandium	Aerospace components, aluminium alloys
Yttrium	Lasers, TV and computer displays, microwave filters
Lanthanum	Oil refining, hybrid-car batteries, camera lenses
Cerium	Catalytic converters, oil refining, glass-lens production
Praseodymium	Aircraft engines, carbon arc lights
Neodymium	Computer hard drives, cell phones, high-power magnets
Promethium	Portable x-ray machines, nuclear batteries
Samarium	High-power magnets, ethanol, PCB cleansers
Europium	TV and computer displays, lasers, optical electronics
Gadolinium	Cancer therapy, MRI contrast agent
Terbium	Solid-state electronics, sonar systems
Dysprosium	Lasers, nuclear-reactor control rods, high-power magnets
Holmium	High-power magnets, lasers
Erbium	Fibre optics, nuclear-reactor control rods
Thulium	X-ray machines, superconductors
Ytterbium	Portable x-ray machines, lasers
Lutetium	Chemical processing, LED lightbulbs

Source: www.scientificamerican.com/article/dont-panic-about-rare-earth-elements

NEITHER RARE NOR EARTHY

Rare-earth elements – often referred to simply as 'rare earths' – are neither rare nor earth elements. The name dates from the 18th and 19th centuries, with most rare earth discovered in the 19th century, except for yttrium, lutetium and promethium (Voncken 2016, p. 4).

Why are 'rare earths' called *rare*? Because, in the 19th century, only one deposit of rare-earth elements was known: in a quarry near the town of Ytterby in Sweden. And so they were thought to be rare. Adunka and Orna (2018, p. 17) note:

> When Johan Gadolin (1760-1852) took up the challenge of examining a small sample of a strange mineral found in the feldspar mine near the little Swedish village of Ytterby in 1788, little did he realise that he would set in motion a search that would last for over a century.

Why are 'rare earths' called *earth* elements? Because most rare-earth elements were first extracted as oxides. And in French (a major scientific language in the 19th century), an oxide of an element was known as the "terre" of that element, meaning "earth". Also in German, another major scientific language at that time, an oxide of an element was called the "Erde" (earth) of that element (Voncken 2016, p. 4).

Despite their names, rare-earth elements aren't truly rare geologically; and many rare earth *metals* are quite common. Even the two least abundant, thulium and lutetium, are nearly 200 times as abundant as gold (National Research Council 2008, p. 133).

Although rare-earth elements are relatively abundant in the Earth's crust, the discovered minable concentrations are less common than for most other ores (U.S. Geological Survey 2019). They are seldom found in sufficient amounts to be economically extracted, meaning that they are expensive to mine and process.

USEFUL

The first commercial use of rare-earth elements was probably the invention of Auer-Light and Auermetal used for lighter flints; both products were discovered and merchandised by Austrian chemist Carl Auer von Welsbach around 1900 (Zepf 2016, p. 6).

Today, as illustrated in Figure 1, rare-earth elements play a critical role in many sophisticated technologies in the automotive, renewable and defence sectors, and contribute to the increased efficiency and performance of products.

For example, yttrium is broadly used in fluorescent lamps, plasma display panels, energy efficient lighting, optical glasses and batteries, as well as for high-tech applications, such as lasers, superconductors, nuclear reactors and electronic components for missile defence systems (Favot and Massarutto 2019).

FIRST THE US, THEN CHINA

Until the mid-1990s, the US dominated production of rare-earth elements. The Mountain Pass Mine in California's high desert supplied most of the world's demand for rare earths. Production from the Mountain Pass mine began in 1964 and remained the main source of light rare earths in the West until the mid-1990s (Voncken 2016, p. 108).[1]

Then China moved in. In 1992, Deng Xiaoping, the late Chinese leader, reportedly declared: "There is oil in the Middle East; there is rare earth in China" (Krugman 2010).

Von Gosen et al. (2017) argue that China has been the leading producer of rare earths for decades, and since the late 1990s has accounted for more than 90% of global production. *The Economist* magazine (2019) notes that by the early 2000s China accounted for almost all of the world's production.

1 Rare earth elements have been found in New Zealand but not in mineable quantities. Rare earth geochemical concentrations and minerals are associated with igneous rocks in Nelson, Westland, Fiordland and Stewart Island (Christie and Barker 2013).

The Mountain Pass mine in California was closed in 2002. China accounted for 80% of all rare earth minerals imported by the US between 2014 and 2017 (U.S. Geological Survey 2019, p. 132). This is why rare earths now figure in the trade war between these two countries.

Mountain Pass mine in California

Photograph: David Becker/Reuters
Source: www.theguardian.com/business/2019/may/29/us-china-trade-what-are-rare-earth-metals-and-whats-the-dispute

THE US WANTS TO BE A PLAYER AGAIN

In 2017, President Donald Trump signed an executive order instructing US federal agencies to ensure the availability of critical minerals.[2] Rare-earth elements are considered critical to the US's economic and national security. In May 2018, the US Department of the Interior published a list of 35 critical minerals,[3] including rare earths.

Also in 2018, Mountain Pass resumed mining and concentrating rare earth ores. The concentrate is currently shipped to China for refining. But Mountain Pass is tooling up for refining on-site and claim they'll be fully self-sufficient from Chinese refiners by 2020 (Maloney 2019).

Australia's Lynas Corporation, a major producer of rare earth minerals outside China, signed a memorandum of understanding with Texas-based Blue Line Corp to set up a rare earths separation facility in the US.[4] In the raw materials part of the Societal Challenge 5 of Horizon 2020, the European Commission identified criticality of raw materials along with addressing the entire raw materials value chain.[5]

Rare-earth elements are considered as strategic resources. No matter what the future brings in terms of new technologies, the importance of rare earths cannot be under-estimated.

QUESTIONS TO CONSIDER

1. What are rare-earth elements, and why are they important? Why are they called *rare*, and why *earth* elements?
2. Should China control the export of its rare natural resources?
3. Will future supply of rare-earth elements be able to meet future demand? Will there be enough rare-earth elements to continue today's high-tech lifestyle?
4. Is there any environmental conundrum associated with rare-earth elements?

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2 www.whitehouse.gov/presidential-actions/presidential-executive-order-federal-strategy-ensure-secure-reliable-supplies-critical-minerals
3 Aluminum (bauxite), antimony, arsenic, barite, beryllium, bismuth, cesium, chromium, cobalt, fluorspar, gallium, germanium, graphite (natural), hafnium, helium, indium, lithium, magnesium, manganese, niobium, platinum group metals, potash, the rare-earth elements group, rhenium, rubidium, scandium, strontium, tantalum, tellurium, tin, titanium, tungsten, uranium, vanadium and zirconium. (www.federalregister.gov/documents/2018/05/18/2018-10667/final-list-of-critical-minerals-2018)
4 www.reuters.com/article/us-lynas-corp-jv-us-idUSKCN1SP0SX
5 www.universiteitleiden.nl/en/research/research-projects/science/cmlrare-earth-supply-chain-and-industrial-ecosystem-a-material-flow-assessment-of-european-union

An online tool for valuing people's health, including valuing 'dead'

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How is your health today? Are you in any pain? Anxious or depressed? Any problems walking around or looking after yourself? Are you able to perform your usual activities? And, on a scale from 0 to 1, where 0 = dead and 1 = perfect health, how would you rate your *health-related* quality of life (HRQoL)?

As explained in more detail later below, measuring a patient's HRQoL is useful for assessing how unwell they are and also their benefit from being treated. More than a dozen systems for representing HRQoL, known as 'health descriptive systems', are available, of which the EuroQol Group's EQ-5D is one of the most widely used systems in New Zealand and internationally.[1]

EQ-5D

The EQ-5D represents HRQoL on five dimensions: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. Two versions of the EQ-5D exist, differentiated by how many levels they have on each dimension: (1) the EQ-5D-3L, with three levels (Brooks 1996); and its successor introduced in 2009, the EQ-5D-5L, with five levels (Herdman et al. 2011). The EQ-5D-5L is presented in Figure 1. *(How would you represent your HRQoL on the EQ-5D-5L; i.e. which level for each dimension best describes your health today?)*

The EQ-5D-5L, whose five dimensions have five levels of performance each, is capable of representing 3125 (i.e. 5^5) health states – i.e. all combinations of the levels on the five dimensions. Each health state can be denoted by a 5-digit number relating to the relevant level for each dimension listed in Figure 1; e.g. 11111 = no problems on all dimensions, 55555 = extreme problems on all dimensions, etc.

VALUING HEALTH STATES

In addition to being able to *represent* 3125 different health states using the EQ-5D-5L, it's useful to *value* the states too. A 'value set' consists of a value for each state (all 3125 of them), with most values ranging between 1 for full health (no problems on the five dimensions: 11111) and zero for 'dead', with negative values for states worse than dead.

Thus, for example, we would be interested to know what is the value for state 22222 (slight problems on all dimensions) – which for most people is likely to lie somewhere in the range 0-1 (between dead = 0 and 11111 = 1). And so on for the other health states.

Value sets are useful for calculating 'Quality-Adjusted Life Years' (QALYs).[2] QALYs are used in economic evaluations whereby the costs and benefits of various types of spending on health procedures, pharmaceuticals, devices, equipment, etc are compared. For example, NZ's Pharmaceutical Management Agency (PHARMAC) calculates QALYs (and 'cost per QALY' estimates) in order to evaluate the pharmaceuticals it's considering buying on behalf of all citizens.

Another use of value sets is for calculating 'patient-reported outcome measures' (PROMs) for the purpose of evaluating the effectiveness of treatments (often for individual patients).

Figure 1: EQ-5D-5L health descriptive system

DIMENSION
Mobility
I have no problems in walking about
I have slight problems in walking about
I have moderate problems in walking about
I have severe problems in walking about
I am unable to walk about
Self-Care
I have no problems washing or dressing myself
I have slight problems washing or dressing myself
I have moderate problems washing or dressing myself
I have severe problems washing or dressing myself
I am unable to wash or dress myself
Usual Activities (e.g. work, study, housework, family or leisure activities)
I have no problems doing my usual activities
I have slight problems doing my usual activities
I have moderate problems doing my usual activities
I have severe problems doing my usual activities
I am unable to do my usual activities
Pain/Discomfort
I have no pain or discomfort
I have slight pain or discomfort
I have moderate pain or discomfort
I have severe pain or discomfort
I have extreme pain or discomfort
Anxiety/Depression
I am not anxious or depressed
I am slightly anxious or depressed
I am moderately anxious or depressed
I am severely anxious or depressed
I am extremely anxious or depressed

1 EQ-5D stands for EuroQoL, 5 Dimensions. Other health descriptive systems include the HUI (Health Utilities Index), SF-6D (Short Form, 6 Dimensions), 15D (15 Dimensions) and AQoL (Assessment of Quality of Life).

2 As an example of how QALYs are calculated, imagine an elderly woman who needs a hip replacement and is expected to live a further 10 years, but her sore hip reduces her (health-related) quality of life such that each of those years is considered to be worth just 0.6 of a year of 'full health' (valued at 1 QALY). Her *quality-adjusted* life expectancy is therefore 10 × 0.6 = 6 QALYs. After the hip replacement operation, her life expectancy is unchanged, but suppose her quality of life rises from 0.6 to 0.9. She now has 10 × 0.9 = 9 QALYs, and so the surgery produced a gain of 9 – 6 = 3 QALYs.

Value sets are usually created at the population level, intended to represent a population (e.g. New Zealand) 'on average'. Such *social* value sets are usually created using online questionnaires, often supported by specially-trained interviewers, administered to a large sample of the population (e.g. more than 1000 people). Accordingly, producing a social value set is usually an expensive and time-consuming exercise.[3]

NOW IT'S PERSONAL!

As well as a *social* value set for New Zealanders as a whole (on average), it would be ideal to be able to create *personal* value sets for individual patients – i.e. one value set for each patient, based on their personal preferences.

Doing so would enable the fact that people have different preferences with respect to how they feel about the HRQoL dimensions to be more systematically recognised. For example, some people care about pain more than other dimensions, other people care most about being able to walk around, others to being able to care for themselves, etc.

Being able to incorporate a person's HRQoL preferences into decisions about the best treatment for them – from all possible treatments – is consistent with 'personalised' or 'precision' medicine whereby treatments are tailored to the individual based on their risk of disease or predicted treatment response (Mirnezami, Nicholson & Darzi 2012). Enabled by advances in diagnostic approaches, especially genomics, personalised medicine has so far focused on what is *technically possible* – without systematically including information about the patient's *preferences* (until now!).

This article reports on a new online tool for creating *personal* and *social* value sets quickly and relatively cheaply. All the person has to do is spend about 5-10 minutes answering some simple questions and then the tool generates their own EQ-5D-5L value set, as well as contributing to a social value set for the group of participants overall.

The tool can be seen as a breakthrough in the HRQoL value set 'industry'. Its user-friendliness and online delivery could massively reduce the cost of producing value sets for the EQ-5D-5L – or for any other health classification system (see footnote 1).

The tool can be deployed 'in the field' to quickly and cheaply generate the HRQoL preference data required to produce value sets at the population (social) level.

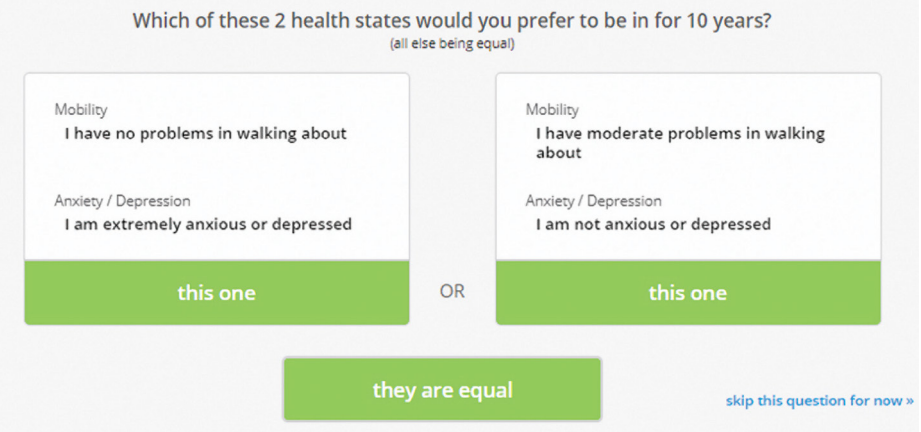
The tool could also be available on computer tablets in doctor waiting rooms or as a mobile app for patients to quickly create their own personal value sets. The easy availability of personal value sets opens up the possibility of individual patient preferences being more systematically incorporated into treatment decisions.

'PAIRWISE RANKING' AND 'BINARY SEARCH'

Powered by 1000minds software (www.1000minds.com), the tool has two main components: (1) a pairwise ranking exercise to determine the 3125 health state values for each participant, and (2) a binary search algorithm to identify any health states they consider to be worse than dead. Both components are described below, but if you would rather experience the tool immediately, please jump to the link to the tool in the second-last section below.

The pairwise ranking exercise is based on the PAPRIKA method (Hansen & Ombler 2008) – an acronym for ***P***otentially ***A***ll ***P***airwise ***R***an***K***ings of all possible Alternatives.[4] In the present context, PAPRIKA involves the participant being repeatedly asked to choose between two hypothetical health states defined on just two dimensions at a time with respect to which state they would prefer to be in for 10 years. Each choice involves a trade-off between the levels for the two dimensions, where implicitly the levels on the other three dimensions are the same for both states (i.e. "all else being equal"). An example of a pairwise-ranking question appears in Figure 2.

Figure 2: Example of a pairwise-ranking question from the 1000minds software



Such simple questions are repeated with different pairs of hypothetical health states – always involving trade-offs between different combinations of attributes, two at a time – until enough information about the person's preferences has been collected to determine their weights on the attributes, thereby generating a value set for that person.

Central to the PAPRIKA method is that it learns from and *adapts* to each person's preferences. Each time a person ranks a pair of health states, all other states that can be pairwise ranked via the logical property of 'transitivity' are identified and eliminated, thereby minimising the number of questions asked.

For example, if a person prefers health state *A* to *B* and *B* to *C*, then – by transitivity! – *A* is also preferred to *C* (and is not asked about). Each time a person answers a pairwise-ranking question, based on all preceding answers, PAPRIKA adapts with respect to choosing the next question (always one whose answer is not implied by earlier answers).

3 The expense involved in creating social value sets is one reason why the value set for the EQ-5D-3L version of the EQ-5D (with just three levels on each dimension instead of five, as for the EQ-5D-5L) created in 1999 (Devlin, Hansen, Kind & Williams 2003) has not been updated since then (until now!).

4 Since 2004, this method and 1000minds software have been used in a wide range of health applications: health technology prioritisation (e.g. Martelli et al. 2016, Sullivan & Hansen 2017), patient prioritisation (Fitzgerald et al. 2011, Hansen, Hendry, Naden, Ombler & Stewart 2012), disease classification and diagnosis (Shiboski et al. 2017) and prioritising diseases for R&D (Tacconelli et al. 2018).

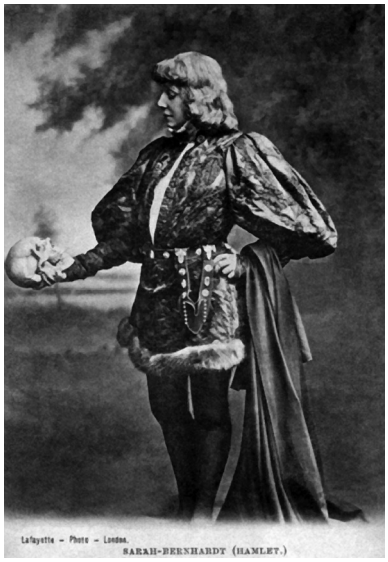
PAPRIKA's adaptivity ensures that the number of questions a person is asked is minimised while ensuring they end up having pairwise ranked all possible health states defined on two dimensions at a time, either explicitly or implicitly (by transitivity).[5] Most people need to answer just 20 questions on average, taking 5-10 minutes in total.

Also, to check the quality of each person's data, two or three repeated questions can be included to assess the person's consistency. Checks can also be made of how long the person took for their answers and for any other evidence that they answered questions unreliably.

TO BE, OR NOT TO BE

Enabled by the existence of a personal value set for each individual, the 1000minds software implements an 'interactive binary search' (or bisection) algorithm for people to identify any health states they consider to be worse than dead. The algorithm developed for the tool is explained in detail here because it is novel compared to more traditional implementations of such algorithms.

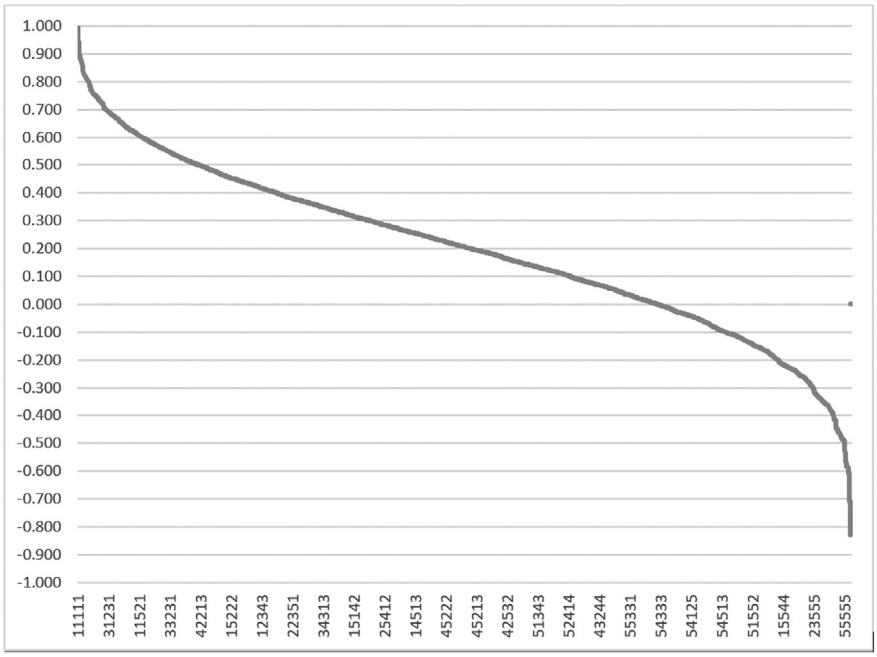
Prince Hamlet: "To die, to sleep, perchance to Dream; aye, there's the rub"



The binary search algorithm begins with the participant being asked if they think that being in the lowest-ranked heath state, 55555 (extreme problems on all dimensions), for 10 years would be better than dead (BTD) or worse than dead (WTD); this question is shown in Figure 3. If the person answers 55555 is BTD, the algorithm stops. If instead they answer 55555 is WTD, the algorithm proceeds to search for, in effect, the 'dividing line' that splits their ranking of the 3125 states into ones BTD and WTD respectively.

Figure 3: Example of a binary search question to identify states worse than dead

Figure 4: The 3125 health state values (means), from highest (11111=1) to lowest (55555=−0.830)



Thus, if the person answers 55555 is WTD, they are asked if another, higher-ranked health state – set by the tool to 33333 (moderate problems on all dimensions) – is BTD or WTD. Depending on their answer, another higher- or lower-ranked state is evaluated: if 33333 is WTD, 22222 (slight problems on all dimensions) is posed next; instead if 33333 is BTD, 44444 (severe problems on all dimensions) is posed next. Having identified the range of health states in which dead lies, the algorithm proceeds to repeatedly bisect (halve) the participant's personal ranking of states.

For example, with reference to the questions above, suppose the person answers 33333 is BTD and then 44444 is WTD; they are then asked if the state in the middle of *their* ranking of 33333 to 44444 – e.g. perhaps 34432 (it depends on *their* ranking) – is BTD or WTD. Suppose 34432 is BTD; they are then asked if the state in the middle of their ranking of 34432 to 44444 – e.g. perhaps 44433 – is BTD or WTD. This process continues: repeatedly halving the range of values until the dividing line is found that splits their ranking of the 3125 states into ones BTD and WTD respectively.

5 To further reduce the number of questions asked, only levels 1, 3 and 5 of each of the EQ-5D-5L dimensions were included in the pairwise ranking exercise. The weights for levels 2 and 4 are interpolated using Bézier interpolation (Farin, Hoschek & Kim 2002) – in essence, fitting a monotonic smoothed curve through the weights for levels 1, 3 and 5. Also, five combinations of levels (health states) deemed to be unrealistic to most people were suppressed: e.g. "no problems doing my usual activities" and either "extreme pain or discomfort" or "extremely anxious or depressed" or "unable to wash or dress myself" or "unable to walk about".

In summary, three results with respect to the location of dead within the 3125 health states are possible for each participant: either dead is worse than 55555, and so dead and 55555 are both valued at 0 (customary for EQ-5D valuations); or 11111 is WTD (uncommon), and so dead = 1; or (most often) dead is spanned by two adjacent states in the person's ranking (one BTD, the other WTD), and so dead's value (before rescaling) is the average of these two states' values.

NEW ZEALAND SURVEY

A sample of the NZ adult population, representative with respect to age, gender, ethnicity and geographic location, was recruited. After extensive checks of the quality of participants' data, a high-quality sub-sample of 2468 people was chosen from which a social value set for NZ was created (as well as 2468 personal value sets). This value set is summarised graphically in Figure 4, where 780 (25%) of the 3125 states are worse than dead.[6]

GO ON, GIVE IT A WHIRL!

To experience the tool yourself – and generate your own EQ-5D-5L value set of 3125 values – open this link: www.1000minds.com/go/eq5d-interpolation-test.[7]

WHAT'S NEXT?

Possible areas for future research include trialling the new tool in other countries – including leveraging the tool's cost advantages for low and middle-income countries – and testing the tool against other methods for creating EQ-5D-5L value sets.

The tool can also be adapted to create value sets for other health descriptive systems. The researchers are also keen to work with medical specialists who see value in applying the tool to personalised medicine.

QUESTIONS TO CONSIDER

1. What is a QALY?
2. Do you think that the five dimensions included in the EQ-5D-5L presented in Figure 1 adequately represent health-related quality of life (HRQoL)? Are there any dimensions missing, in your opinion?
3. With references to Figure 1, what combinations of the five dimensions (i.e. health states) would be worse than dead, in your opinion?

USEFUL WEBSITE

Conference presentations and a discussion paper about the tool: www.1000minds.com/about/news/eq5d-value-sets

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6 An article fully describing the tool and presenting the results from the survey is currently under review at an academic journal. The social value set for NZ is available on request from the authors.

7 This demonstration version of the tool is intended for a somewhat 'knowledgeable' audience (as you will see at its conclusion). The tool developed for patients has more user-friendly instructions, simplified results, and finishes with questions for collecting demographic information too.

New free trade agreements in the age of Trump[1]

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The role played by global trade in international relations has received a lot of attention over the last couple of years. Uncertainty has increased dramatically as a result of events such as the United States' withdrawal from the North American Free Trade Agreement (NAFTA) and the Trans-Pacific Partnership (TPP), as well as repeated US threats to increase tariffs on imports from China, the European Union and Mexico. Also, events such as 'Brexit' have helped fuel the rise of protectionism in many nations, increasing uncertainty about the future of global trade.

This article provides an overview of some of the changes in two major trade agreements since the election of US President Donald Trump: the North American Free Trade Agreement (NAFTA) and the Trans-Pacific Partnership (TPP).

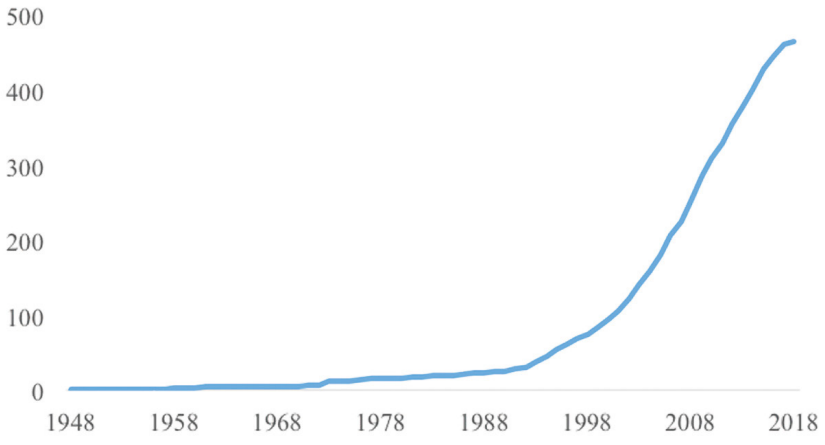
TPP was set to become the world's largest free trade deal

Source: www.cfr.org/backgrounder/what-trans-pacific-partnership-tpp

TRADE AGREEMENTS

The number of regional trade agreements (RTAs) – defined as reciprocal trade agreements between two or more countries – has grown exponentially over the past three decades. Global trade in the 21st century has been characterised by the proliferation of RTAs. Figure 1 shows the number of RTAs notified to the General Agreement on Tariffs and Trade (GATT)/ World Trade Organization (WTO) between 1948 and 2018.[2] From fewer than 100 in the 1990s, there are now more than 450 active RTAs.[3]

Figure 1: Cumulative notifications of RTAs, 1948-2018



Source: https://rtais.wto.org/UI/Charts.aspx#

1 The views expressed in this article are those of the authors. They do not necessarily reflect the views of the New Zealand Treasury.
2 Partly in response to trade disruptions during the Great Depression, the US and some of its allies sought to impose order on trade flows after World War II. These countries met together to develop international agreements, such as the GATT, which was signed in 1947. From 1948 to 1994, the GATT provided the rules for much of world trade. In 1995, GATT was transformed into the WTO, which marked the biggest reform of international trade since World War II (www.wto.org/english/thewto_e/whatis_e/tif_e/fact4_e.htm). The WTO is the only global international organisation dealing with the rules of trade between nations.
3 Detailed information on RTAs is available at www.wto.org/english/tratop_e/region_e/region_e.htm.

NORTH AMERICAN FREE TRADE AGREEMENT

On 1 January 1994, the North American Free Trade Agreement (NAFTA) was ratified between the US, Canada and Mexico. Under NAFTA, the parties progressively eliminated tariffs on imports of each other's goods. NAFTA created the world's largest free trade area, linking around 500 million people producing roughly US$ 22.2 trillion worth of goods and services.[4]

Both before[5] and after the 2016 US presidential election, Donald Trump dismissed NAFTA as "the worst trade deal ever made by any country in the world."[6] He repeated the claim that thousands of US manufacturing firms were put out of business because of NAFTA.[7]

FROM NAFTA TO USMCA

In August 2017, the US began negotiations with Canada and Mexico for the first time since NAFTA's inception in 1994. Months of feverish negotiations and ongoing uncertainty yielded a new trade deal, known as the US-Mexico-Canada Agreement, or USMCA. These three countries agreed to replace NAFTA with USMCA at the G20 summit in Argentina on November 30, 2018.[8]

On that day, President Trump tweeted:

> "Just signed one of the most important, and largest, Trade Deals in U.S. and World History. The United States, Mexico and Canada worked so well together in crafting this great document. The terrible NAFTA will soon be gone. The USMCA will be fantastic for all!"

Trump signs a new trade agreement with Mexico and Canada to replace NAFTA

Source: www.vox.com/2018/10/3/17930092/usmca-nafta-trump-trade-deal-explained

WHAT DID THE US GAIN FROM USMCA?

Although the new US-Mexico-Canada Agreement preserves many elements of its NAFTA predecessor, some changes were made, especially affecting the automobile sector (Hufbauer and Globerman 2018). For example, North American rules of origin for autos and parts are now tightened.[9]

The US initially made a series of harsh demands, including raising the total North American content requirements from 62.5% to 85%, of which 50% had to be US content. Compromises were ultimately reached and the North American "regional value content" was raised from 62.5% to 75%.

In addition, 40% of the value of cars and 45% of the value of trucks must be contributed by assembly plants that pay wages of $16 an hour or more. For Mexico, this is a serious challenge as typical auto industry wages in Mexico are around $4 per hour (Gantz 2018). Higher domestic content requirements and an implicit minimum wage will likely increase the costs of producing autos in Mexico (Hufbauer and Globerman 2018).

USMCA also brought changes to the dairy sector. For example, the Canadian market will be opened up for more American dairy products. Following the announcement, Canadian consumers expressed concerns over growth hormones used in US dairy production and responded by urging Canadians to buy local.[10]

According to University of Minnesota economist Tim Kehoe, the lower tariffs on US dairy imports "were meant to be a slap in the face of Mr Trudeau. To just embarrass him with the dairy lobby, which is pretty important in Canada, and to get nothing in return for Canada's concessions."[11]

CONGRESSIONAL RATIFICATION OF USMCA

Although the US, Mexico and Canada have agreed to USMCA, NAFTA still remains in effect. USMCA won't take effect until it is approved by the legislatures of all three countries. Domestic processes towards USMCA's ratification and implementation will now take place.

Prospects for congressional ratification of USMCA dimmed after the Trump administration issued the latest threat by claiming that the president could invoke national security as the basis for imposing the tariffs.[12] It's unclear what the future holds for USMCA.

4 www.wto.org/english/tratop_e/tpr_e/g382_e.pdf
5 www.bloomberg.com/news/videos/2016-09-27/trump-nafta-is-worst-trade-deal-ever-signed
6 www.youtube.com/watch?v=s5hIBNw0qj0
7 Hufbauer and Globerman (2018) list Trump's many anti-NAFTA statements and tweets, starting in 2015.
8 This link provides the full text of the agreement between the US, Mexico and Canada: https://ustr.gov/trade-agreements/free-trade-agreements/united-states-mexico-canada-agreement
9 Rules of origin are the criteria needed to determine the national source of a product. Free-trade areas have complex rules of origin that specify what type of goods can be shipped duty-free within the free-trade area.
10 www.dairyglobal.net/Market-trends/Articles/2018/12/USMCA-and-its-effect-on-Canadas-dairy-industry-370079E
11 https://cla.umn.edu/heller-hurwicz/news-events/news/economics-trade-agreements
12 https://piie.com/blogs/trade-investment-policy-watch/usmca-newly-jeopardized-was-never-free-trade-agreement

TRANS-PACIFIC PARTNERSHIP

The Trans-Pacific Partnership (TPP) was a free trade agreement designed to liberalise trade and investment between 12 Pacific-rim countries: New Zealand, Australia, Brunei Darussalam, Canada, Chile, Japan, Malaysia, Mexico, Peru, Singapore, the US and Vietnam.[13]

The finalised TPP Agreement was signed on 4 February 2016 following the conclusion of TPP negotiations in October 2015. After agreeing to TPP, which was not of itself legally binding, TPP signatories turned their focus to domestic processes necessary to ratify TPP. New Zealand ratified TPP in May 2017.

Even before formally announcing his candidacy, Trump was critical of TPP. On 22 April 2015, he tweeted: "The Trans-Pacific Partnership is an attack on America's business." During his 2016 presidential campaign, Trump told Americans he would end US participation in TPP.

After winning the election on 8 November 2016, President Trump shared an outline of some of his policy plans for the first 100 days[14]: "On trade, I'm going to issue a notification of intent to withdraw from the Trans-Pacific Partnership", and called the deal a "potential disaster for our country."

On just the third day of his presidency, President Trump signed an executive order withdrawing the US from TPP. "Great thing for the American worker, what we just did," President Trump said as he signed the order.[15]

FROM TPP TO CPTPP

When the US dropped out of TPP, it was widely viewed as the end of the partnership. However, the 11 remaining countries signed an amended agreement – now known as the Comprehensive and Progressive Trans-Pacific Partnership (CPTPP)[16] – on 8 March 2018 in Chile.

Australia achieved domestic ratification of CPTPP on 30 December 2018. With Australia's ratification, CPTPP has met the threshold requirements to enter into force.

Remaining members of TPP gather at the signing agreement ceremony in March 2018

Source: www.cfr.org/backgrounder/what-trans-pacific-partnership-tpp

The changes to NAFTA and TPPA reflect a turbulent couple of years for global trade. Heightened trade policy uncertainty, and the rise of protectionist political parties in different areas of the world show that trade is at the forefront of many nations' agendas. The next couple of years are likely to bring many interesting developments to the global trade landscape.

QUESTIONS TO THINK ABOUT

1. Was NAFTA in need of renegotiation?
2. Can bilateral trade agreements help induce free trade?
3. What are the protectionist measures and can they have adverse consequences?
4. Is President Trump's protectionist mentality the right approach to boost growth in the US?

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13 www.tpp.mfat.govt.nz
14 www.youtube.com/watch?v=7xX_KaStFT8
15 www.washingtonpost.com/business/economy/withdrawal-from-trans-pacific-partnership-shifts-us-role-in-world-economy/2017/01/23/05720df6-e1a6-11e6-a453-19ec4b3d09ba_story.html?utm_term=.30aad1e906d7
16 CPTPP is called *comprehensive* and *progressive* because it also includes commitments to safeguard and enforce high labour and environmental standards across the Asia-Pacific region.

Some highlights from recent research on economic growth[1]

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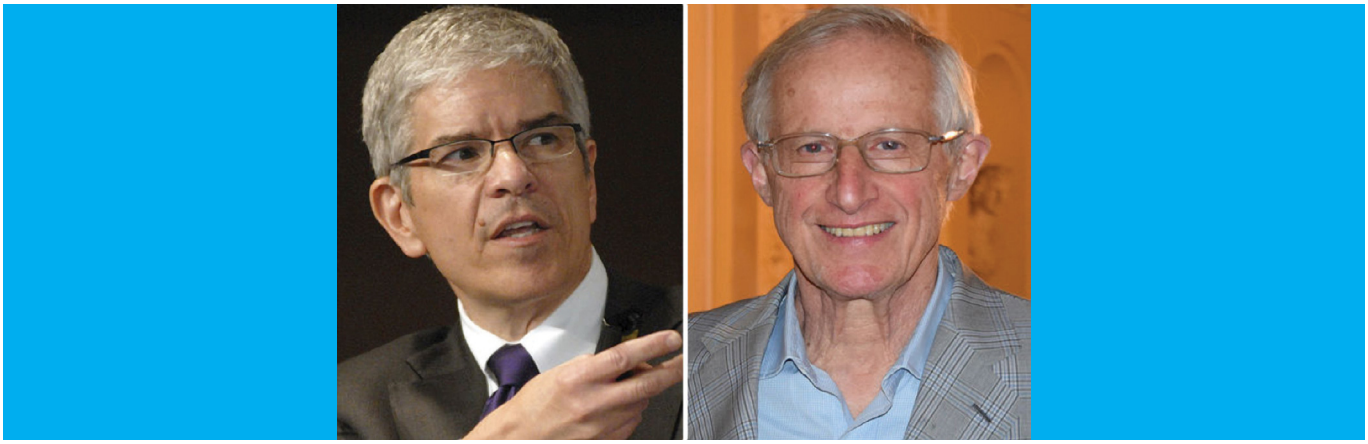
Research in the field of economic growth bloomed following Robert Solow's[2] seminal contributions in the 1950s. This was followed in the 1960s and 70s by a surge of empirical and theoretical discoveries. Scholars such as Edward Denison, Dale Jorgenson, Zvi Griliches and John Kendrick pursued research into the measurement and sources of economic growth. The application of optimal control theory[3] to economic dynamics was at the centre of important contributions from Hirofumi Uzawa, Karl Shell, David Cass and others.

Understanding of the mechanics of economic growth expanded considerably during the 1980s and 90s thanks to the work of Robert Lucas,[4] William Nordhaus, Paul Romer,[5] Philippe Aghion, Peter Howitt, Elhanan Helpman, Gene Grossman and others.

Philippe Aghion and Steven Durlauf assembled an impressive collection of research papers in the *Handbook of Economic Growth*, Volume 1 (published in 2005) and Volume 2 (2014). They provide comprehensive assessments of research into economic growth (and its determinants) and summaries of key theoretical and empirical advances. Since then there have been new developments in the area, and today the literature on economic growth is as vibrant as ever.[6]

This article highlights some of the exciting and important current research in the field of economic growth.

Paul Romer and William Nordhaus, winners of the Nobel Prize in Economic Sciences 2018



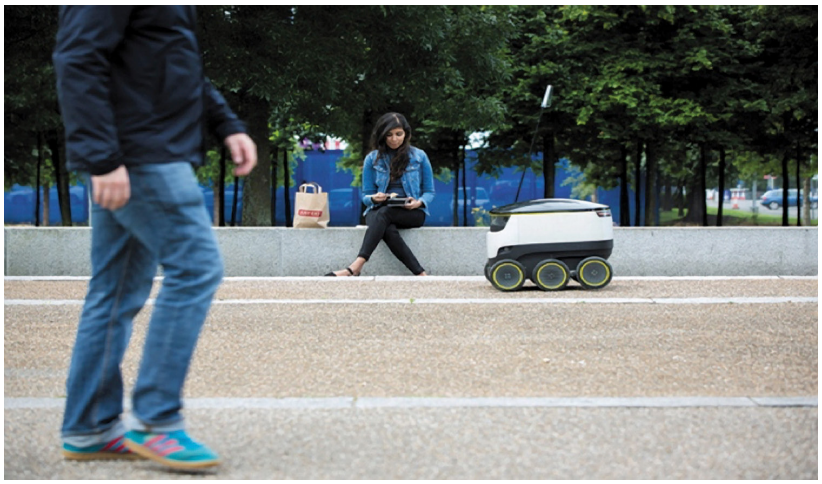
Source: www.wsj.com/articles/nobel-in-economics-goes-to-american-pair-1538992672

AI, ROBOTS AND ECONOMIC GROWTH

Developments in the areas of Artificial Intelligence (AI), Big Data, nanotechnology, driverless vehicles, automated factories and other new technologies have already started to transform business models all over the world. Many companies are interested in opportunities resulting from AI.

Are robots coming to steal our jobs? Will AI replace human decision-making? Much of the popular discussion around AI, automation and robots focuses on the labour-market impacts of these new technologies.[7,8]

A robot delivers takeaway food to customers in a trial in London



Source: www.nature.com/news/track-how-technology-is-transforming-work-1.21837

1 This article expands and updates the author's piece he wrote for the newsletter of the New Zealand Centre for Macroeconomics (Üngör 2018).
2 Robert Solow received the 1987 Economics Nobel Prize "for his contributions to the theory of economic growth."
3 Optimal control theory is typically applied in economics for the solution of dynamic problems.
4 Robert Lucas received the 1995 Economics Nobel Prize "for having developed and applied the hypothesis of rational expectations, and thereby having transformed macroeconomic analysis and deepened our understanding of economic policy."
5 The 2018 Economics Nobel Prize was divided between William Nordhaus "for integrating climate change into long-run macroeconomic analysis" and Paul Romer "for integrating technological innovations into long-run macroeconomic analysis."
6 Akcigit (2017) discusses the past, the present, and the future of economic growth. Jones (2016) presents a comprehensive tour of the growth literature from the perspective of basic data.
7 In 2018, the Massachusetts Institute of Technology (MIT) launched its *Task Force on the Work of the Future*, an institute-wide effort to understand how emerging technologies are transforming the nature of human work during an age of innovation in the digital economy (https://workofthefuture.mit.edu).
8 The Centre for Artificial Intelligence and Public Policy (CAIPP) was launched in 2018 to draw together the University of Otago's considerable research expertise on the social effects of AI, providing a hub for collaboration between initiatives at the University (www.otago.ac.nz/caipp).

Automation enables capital to replace labour in doing tasks it was previously engaged in. Recent studies introduce new frameworks for conceptualising automation. Acemoglu and Restrepo (2018a) model automation as the (endogenous) expansion of the set of tasks that can be performed by capital replacing labour.[9]

Aghion et al. (2019) put together these two ideas: (1) economic growth may be constrained not by what we do well but rather by what is essential and yet hard to improve; and (2) AI is a new form of automation that may allow additional tasks to be automated that previously were thought to be out of reach of automation. The authors discuss how such a combination can yield a rich description of the growth process, including the consequences for future growth and income distribution.

DANGER, WILL ROBINSON!

Carefully designed empirical studies have started to use data from the International Federation of Robotics (IFR) to study the implications of automation. Acemoglu and Restrepo (2018c) connect the adoption of industrial robots to lower employment and wages in local labour markets, utilising a model where robots and workers compete in the performance of different tasks. The authors analyse the effect on labour markets of increases in industrial robot usage in 19 industries between 1990 and 2007 in the United States; they estimate that one more robot per thousand workers reduces the employment to population ratio by about 0.18-0.34 percentage points and wages by 0.25-0.5%.

Acemoglu and Restrepo (2019) show that demographic change is associated with greater adoption of robots and other automation technologies across countries. Using US data, they document that industrial robots substitute for middle-aged workers.

On the other hand, a study of German data suggests that the picture isn't quite so bleak. Dauh et al. (2018) estimate the effect of industrial robots on employment, wages and the composition of jobs in German labour markets between 1994 and 2014.[10] Robot exposure has even increased job stability, but many incumbent workers end up performing different tasks than before. The authors find sizable employment reductions in manufacturing industries with industrial robots. But these losses were fully offset by job gains outside manufacturing, most importantly in business services. In other words, robots have strongly changed the composition but not the aggregate level of employment in Germany.

ARE WE RUNNING OUT OF IDEAS?

Can technological progress be sustained in today's most developed countries? Are the best years for US growth and productivity in the past?

Robert Gordon, in his book *The Rise and Fall of American Growth* (Gordon 2016), contends that today's technological innovation cannot drive economic growth as past innovation did. And US productivity growth will be held back by the headwinds of rising inequality, stagnating education, an ageing population, etc.

Similarly, Bloom et al. (2019) argue that new ideas are getting more expensive to find. The authors estimate that research productivity in the US has fallen 5.3% per year on average. This means that the economy has to double its research efforts every 13 years just to maintain the same overall rate of economic growth.

MAYBE NOT

Not everyone is so pessimistic, however. Joel Mokyr, one of the most celebrated economic historians of our time, argues that new technologies such as AI and nanotechnology can be considered as general purpose technologies (GPTs).[11] GPTs take a long time to fully affect the economy, because they require complementary innovations and investments (Mokyr 2018). This view suggests that the recent productivity slowdown may be temporary.

In a related vein, some researchers argue that traditional metrics like GDP and productivity can become more difficult to measure and interpret in today's digital economy.[12] Brynjolfsson et al. (2017) argue that the intangible assets associated with AI can be more than the direct investments in these technologies themselves. In summary, measuring and accounting for innovation have become an active research area.

Daron Acemoglu, Erik Brynjolfsson, Robert Gordon and Joel Mokyr

Source: http://uk.pcmag.com/feature/92091/ais-implications-for-productivity-wages-and-employment

9 Acemoglu and Restrepo (2018b) provide an insightful theoretical discussion of modelling automation.
10 Clement (2018) provides a very insightful review of the findings of Dauh et al. (2018).
11 A drastic innovation qualifies as a GPT "if it has the potential for pervasive use in a wide range of sectors in ways that drastically changes their modes of operation" (Helpman 1998, p. 3). Examples of GPTs are the steam engine, electricity and the computer.
12 http://papers.nber.org/books/corr-2

LARGE-SCALE DIGITISATION OF HISTORICAL RECORDS

Innovation is one of the key determinants of economic growth. Unfortunately, however, there is not much empirical evidence on the long-run patterns of innovation and inventions due to the paucity of historical data.

Assembling new and rich data sets from archival sources has yielded very promising research findings in the fields of international trade, economic development, and economic history.[13] There have also been interesting recent efforts to investigate the determinants of economic growth and innovation using historical records.

Akcigit et al. (2017a,b) utilise a dataset matching millions of investors from patent records to individuals in Federal Censuses and present suggestive evidence that the contributions of foreign-born inventors have provided a long-term boost for American innovation. The authors show that foreign-born people were more prevalent among inventors active in the US than in the non-inventor population and provide suggestive evidence that immigrant inventors were of central importance to American innovation since the 19th century.

IN CLOSING

The list of work covered here is by no means exhaustive, and the area of economic growth is a subject of active research. It is always exciting to see new theoretical frameworks and carefully designed quantitative analyses.

QUESTIONS TO THINK ABOUT

1. What caused American growth in income and productivity to accelerate starting in the mid-1990s?
2. Which technologies are already eliminating, augmenting or transforming which types of jobs?
3. What are the main drivers of technology diffusion? What obstacles prevent the most productive technologies from spreading to less developed economies from more developed nations?
4. If AI increases automation in the production of goods and services, how will it affect economic growth?

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13 Donaldson (2018) is a perfect example of this type of research.

Commentary on the New Zealand economy

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	Mar 2019	Dec 2018	Sep 2018	Sep 2017	Sep 2016
GDP (real growth rate, %)	2.5	2.5	2.7	3.0	4.1
Consumption (real growth rate, %)	3.1	2.9	2.6	4.0	5.2
Investment (real growth rate, %)	−3.7	0.1	6.9	2.4	3.5
Persons Employed (full- and part-time, 000s)	2658	2662	2661	2588	2487
Unemployment (% of labour force)	4.2	4.3	4.0	4.7	4.9
Estimated Net Migration (year to date)	55,102	52,136	49,975	55,762	63,121
Consumer Price Inflation (annual rate, %)	1.5	1.9	1.9	1.9	0.4
Food Price Inflation (annual rate, %)	1.3	0.6	0.0	2.8	−0.2
Producer Price Inflation (outputs, annual rate, %)	2.6	3.3	3.6	5.3	0.1
Producer Price Inflation (inputs, annual rate, %)	3.1	4.7	4.0	4.5	0.1
Salary and Wage Inflation (annual rate, %)	2.0	1.9	1.8	1.8	1.7
90-day Bank Bill Rate (% p.a.)	1.88	1.98	1.90	1.95	2.23
10-year Govt Bond Rate (% p.a.)	2.02	2.45	2.60	2.91	2.40
2030 Inflation-Indexed Bond Rate (% p.a.)	1.06	1.33	1.35	1.88	1.63
Lending to Households (annual growth, % [1])	5.9	5.9	5.9	6.7	8.8
Real Exchange Rate (trade-weighted index [2])	72.7	73.4	70.5	74.7	76.5
Exports (volume growth rate, %)	7.4	0.1	2.1	−0.2	4.5
Imports (volume growth rate, %)	0.8	−0.1	7.5	3.9	5.2
Terms of Trade (June 2002 = 1000)	1414	1401	1447	1451	1289
Merchandise Trade Balance (year to date, $m)	−5,740	−6,161	−5,309	−2,925	−3,354
Visitor Arrivals (growth rate, %)	1.3	3.5	3.6	8.6	11.4
Current Account Balance (year to date, % of GDP)	−3.6	−3.8	−3.6	−2.7	−2.4

Notes: [1] Housing and consumer loans made by registered banks and non-bank lending institutions. [2] Trade-weighted index (average value over March 1985-March 2005 = 62.2).
Sources: Statistics New Zealand (www.stats.govt.nz), Reserve Bank of New Zealand (www.rbnz.govt.nz).

The rate of economic growth continued to ease gradually over the last six months and appears to be converging to 2-2.5% p.a. This is as good as it is likely to get in the short term, as the recent slowdown in tourism growth counter-balances stronger exports and consumption spending. The current growth rate is just about sufficient to keep pace with growth in the country's productive capacity, which means that the lacklustre growth in employment of recent quarters seems set to continue for the time being and the unemployment rate will either remain at its current level or rise slightly.

The recent drop in investment spending might be taken as a sign of trouble down the track, but it is primarily due to cuts in inventories and reduced spending on transport equipment. Given that transport equipment is almost entirely imported (note the recent slowdown in import volume growth), such a change has relatively little immediate impact on demand for domestically-produced goods.

In other respects, the investment-spending picture is reasonably encouraging. Activity in the construction sector has been generally strong with significant recent growth occurring in non-residential building. In addition, though real spending on plant, machinery and equipment has been largely static for the last six quarters, the actual level of this spending is as high as it has ever been.

There are even some early signs that inflation is starting to pick up, in particular in relation to the prices of "non-tradables" – i.e. goods and services that are neither exported nor imported, and so are less subject to the vagaries of the exchange rate and global commodity markets. About half of the goods covered by the CPI are classified as non-tradables and traditionally they account for most of the rise in NZ's overall cost of living. For example, since 2008, the cost of tradables (on average) has barely changed, whereas the cost of non-tradables has risen by 32%.

The rate of inflation for non-tradables has been slowly rising since early 2018 and is on track to hit 3% in the June quarter. If we ignore the effect on inflation of the 2010 increase in GST, that would be its fastest rate of increase since the 2008 Global Financial Crisis.

Some of our great students
(what better note to end on?)

Hamish Fitchett, Lewis Gillon and Andrew Kennedy graduated with a Masters of Economics (with distinction).

PhD students Anh Nguyen (far right) and Leon Stirk-Wang (beside Anh) attended the 60th Annual Conference of the New Zealand Association of Economists.

Good night, and good luck.

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