Continuing to unlock the potential of new and existing data sources

Leigh Merrington, Australian Bureau of Statistics

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Leigh Merrington
leigh.merrington@abs.gov.au
Australian Bureau of Statistics

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ABSTRACT

The Australian Bureau of Statistics (ABS) has a long history of utilising new data sources and innovative methods to produce official statistics that provide valuable insights into measuring the Australian economy, society and environment. With the increasing demand for official statistics and the growing measurement complexity, coupled with the reduction in resources available to produce these statistics, the importance of utilising new data sources and making better use of existing data is now greater than ever. This environment presents both significant challenges and opportunities for National Statistical Organisation (NSOs) to produce *better statistics for better lives*.

This paper discusses how the ABS is addressing these challenges and taking advantage of these opportunities, and provides the following case studies: the use of new data sources and innovative collection and methodological techniques to produce the Consumer Price Index and other macro-economic statistics; and the application of data integration to make greater use of existing data sources to produce new statistical insights.

Keywords: Big data, administrative data, scanner data, data integration.

1. INTRODUCTION

The environment in which statistical agencies are operating is changing. The statistical landscape is becoming more complex and National Statistical Offices (NSOs) are being challenged to deliver the best possible statistical program in more efficient and innovative ways. This changing environment is presenting both challenges and opportunities for NSOs to utilise new data sources and make greater use of existing data.

This paper discusses how the ABS is taking advantage of opportunities to enhance its statistics through access to new data sources, namely *'big data'*, and how new statistical insights are being created by unlocking the potential of existing data through the use of data integration.

Section 2 of this paper focuses on the use of administrative data to produce economic statistics. An example is discussed where the ABS is making use of retail transactions (scanner) data to produce the Consumer Price Index (CPI). The use of administrative data to produce economic statistics results in lower collection costs and enhanced accuracy compared to traditional data collection methods. Administrative data is not without its challenges, with the ABS developing innovative methods to process and analyse the data. The ABS is continuing to explore other uses of administrative data in its macro-economic statistics, in particular measures of Retail Trade and Household Financial Consumption Expenditure in the National Accounts. Section 2 also discusses the development of innovative collection techniques to not only replace manually collected data, but increase the coverage and frequency of the collection. These enhancements have opened up new possibilities for the ABS, including positioning the organisation to produce a monthly CPI (ABS, 2018b).[1]

Section 3 of this paper discusses the ABS's focus on data integration to unlock the potential of existing data sources. The ABS considers *"data integration as the new frontier for statistical organisations"* (ABS, 2018c). The ABS is currently leading several cross agency data integration projects to make greater use of administrative data sets in order to produce new statistical insights. Analysis to date of large integrated data sets has informed a broad range of important policy areas, including: the contribution of small businesses to employment growth; the role of health services and education on life outcomes; and data insights to support needs based school funding. Section 3 will discuss two examples of ABS data integration and how these have led to new statistical insights: the Business Longitudinal Analytical Data Environment (BLADE) and the Linked Employer Employee Dataset (LEED).

2. USE OF NEW DATA SOURCES AND INNOVATIVE COLLECTION TECHNIQUES TO COMPILE ECONOMIC STATISTICS

2.1 Introduction

The use of administrative data to produce official statistics is not new in the ABS. In fact, administrative data has been in use since the ABS's inception where statistics on international trade have been compiled from Australian customs import and export data since 1905. Other examples of administrative data used to produce the ABS's economic and social statistics include: government

[1] Australia is currently one of only two OECD countries that produce their CPI on a quarterly basis.

financial data; taxation data; information from State Registrars of births, deaths and marriages; and immigration data. These examples demonstrate the long history the ABS has of making use of new data sources that are less expensive to collect and produce more accurate statistics.

What is similar with these examples are they are all based on administrative data collected by various levels of the Australian government. With the *Digital Transformation* seeing rapid changes and vast amounts of data being produced, the ABS has recently explored making use of administrative (or 'big') data produced by businesses and households in its official statistics. Examples of where the ABS is investigating the use of these types of data include: telematics data from trucks to provide regular road freight statistics; telecommunications data to inform estimates of temporary populations and population mobility; and satellite imagery to produce crop statistics through combining satellite data with small validation samples.

Where the ABS has made the most progress in utilising big data produced from the private sector is in its use of retail transactions (scanner) data to produce the CPI. The rest of Section 2 of this paper will focus on the use of scanner data in the Australian CPI.

2.2 Background

2.2.1 Introduction to the CPI

The CPI is an important economic indicator that informs monetary and fiscal policy. It plays a crucial role in the setting of interest rates and is used by government to index social welfare payments. The CPI is also used widely by the private sector for the setting of wages and the prices of the goods and services they produce. The CPI is regularly the most visited statistical product on the ABS's website and attracts significant media attention when it's released each quarter. With this in mind, the CPI is an important measure that informs the decisions of government, businesses and households that improve the lives of Australians.

2.2.2 Explaining scanner data

Scanner data refers to the transactions that are recorded (or 'scanned') at the retailer's point of sale. Barcode scanner technology was first launched in Australia during the 1970s, which has enabled retailers to capture detailed information on transactions at the point of sale. Scanner data is high in volume and contains detailed information about individual transactions including: date of purchase, quantities purchased, product descriptions, and value of products purchased (ABS, 2017a). Like other forms of administrative data, scanner data is a rich data source that enables NSOs to enhance their statistics, reduce provider burden, and reduce associated costs of physically collecting data.

2.3 Use of transaction data to compile the CPI

2.3.1 Challenges of using scanner data

The challenges of utilising scanner data, or any big data for that matter, range from obtaining the data in the first place, to storing it securely, and finally, having the ability to process and assess the quality of the data for statistical purposes.

Securing the data

The first challenge is obtaining the data in the first place. ABS experience has shown it takes approximately six months of negotiations with each retailer to secure the scanner data. These negotiations were crucial in determining data requirements such as the type of data, timing, frequency and mode of delivery, as well as the cost of accessing the data.

Receiving and storing the data

The next challenge is ensuring the NSO has the IT infrastructure in place that enables the receiving and storing of the data in a secure fashion. The NSO's IT systems also need to have the ability to process large data sets in a timely manner.

Processing the data

New processes may need to be developed in order to process big data in an automated fashion. In the case of the scanner data, the ABS developed automated methods that make use of both the price and expenditure information to produce the CPI outputs.

Assessing the quality of the data

Not all big data is fit for purpose. There may be over or under-coverage in some cases, or the data may not align to the statistical concepts or classifications being measured. For the scanner data, the use of traditional CPI aggregation methods resulted in a downward bias (also known as *chain drift*) in the price indexes. This was determined through the use of a benchmark for which you could compare the scanner data price index. In this case, the published CPI measure was used as the benchmark. In order to address this bias, the ABS adopted innovate (*multilateral index*) methods, which are recognised internationally as the best approach to dealing with this challenge. Through robust testing and significant consultation with stakeholders, the development of multilateral index methods has enabled the use of scanner data in the Australian CPI (ABS, 2017a).

2.3.2 Benefits of using scanner data

Once an NSO is able to overcome the challenges of using a big data set such as scanner data, the benefits that are realised are significant and wide ranging. The ABS has seen the following benefits to the Australian CPI as a result of making use of the scanner data.

Reduced cost of collection

While the resources required to negotiate the acquisition of the scanner data and the subsequent testing are not negligible, once this development work has been completed, the ongoing costs of using the scanner data is greatly reduced compared to manual modes of collection and data processing. The

manual modes of collection traditionally used by the ABS for the CPI include having field officers visit retailers to collect prices, and telephone and online collection. In totoal, the ABS collected approximately 100,000 prices each quarter for the CPI. The implementation of scanner data saw around 20,000 manually collected prices directly replaced with the scanner data. This obviously significantly reduced the ABS's collection costs, but it also saw a reduction in the amount of data editing required due to the higher quality scanner data.

Increased size of sample and collection

The availability of scanner data enables an increase in the coverage of the sample. In-store visits would see a retailer visited once a month (or once a quarter in some cases) by an ABS field officer, with a small sample of products chosen to be priced. The scanner data received by the ABS is for a census of products from each retailer, and is based on all the transactions that have occurred in the reference period. This allows the CPI to use a much larger range of products from the retailer and a more frequent price collection of these prices - at no additional cost. The increase in coverage in terms of both number of products and frequency of price collection has resulted in a significant enhancement of the Australian CPI.

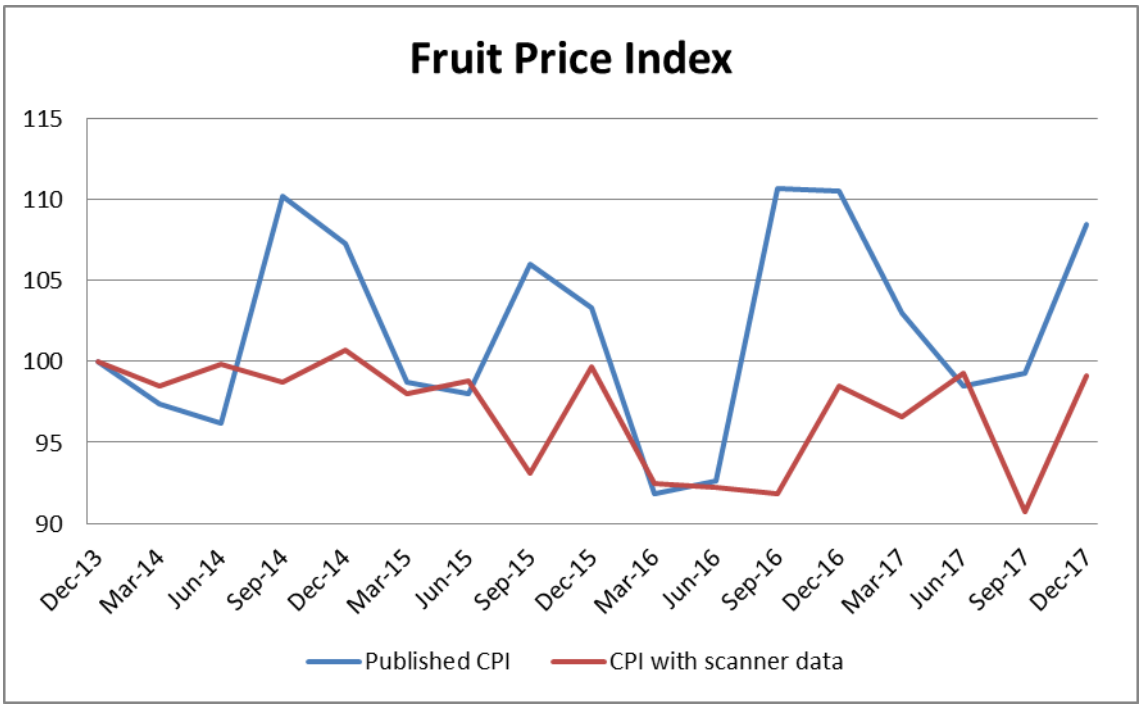
Increased accuracy of the CPI

In addition to the increased coverage discussed previously, there are also additional benefits to the CPI derived from the use of scanner data. Firstly, the scanner data is based on actual transactions that occur. This means the average price being derived is far more representative than a relatively infrequently collected point-in-time price. For example, one thing the scanner data has shown is that when non-perishable products like toilet paper or canned soup go on special, the amount of quantities purchased by consumers increases by multiple factors. This phenomenon is accurately captured in the scanner data.

Traditional modes of CPI collection are only able to collect information on prices. Scanner data contains information on both prices and expenditure. Recently, the ABS has introduced innovative methods, known as *multilateral index* methods, to process the price and expenditure information from the scanner data. This allows the CPI to be 're-weighted' each quarter and results in a closer approximation of the *cost of living*. The traditional CPI uses a fixed-basket approach which assumes that households don't alter their consumption behaviour in response to changes in relative prices. What we know in reality is that households respond to a change in relative prices by substituting to products with relatively lower price change. The use of the fixed-basket approach leads to an upward bias in the CPI known in the price index theory literature as *product substitution bias*.

To understand the benefits of using scanner data to re-weight the CPI basket each quarter, it's best explained using empirical evidence. Households tend to purchase fruit when it is in season, where it is more available and less expensive than at other times. The fixed-basket approach used in the CPI assumes households purchase the same type and amount of fruit all year round. The blue line in figure 1 shows how this leads to a volatile measurement of price change for fruit. What the scanner data captures is the fact that households purchase less of the fruits that are not in season and down-weights their contribution based on the expenditure information contained in the scanner data. The red line in figure 1 shows this results in a much less volatile, and ultimately, more accurate measurement of the price change of fruit in the CPI.

Figure 1: Price change of fruit in the CPI (Dec-13 = 100.0)



Source (van Kints, de Haan and Webster, 2018)

2.3.3 Potential uses of scanner in other macro-economic statistics

The ABS is continuing to investigate opportunities to utilise the available transactions data in other macro-economic statistics. Two areas where there is potential for this are:

1. Household Final Consumption Expenditure data in the National Accounts - scanner data is currently being used as a quarterly indicator for tobacco.
2. Retail trade – similar to the CPI, the expenditure information in the scanner data could be used to replace the traditional use of a survey for these retailers.

2.4 Use of web-scraping data collection methods in the CPI

The ABS uses several modes of collection to obtain prices for the Australian CPI. These include: personal visits, telephone and administrative data, including scanner data. More recently, with the growth of online retailing, pricing information is able to be obtained from websites. Advances in technology and automated scraping software enables large scale data collection from the websites of retailers.

While scanner data has replaced a large part of the CPI's manual collection, the majority of the CPI continues to rely on traditional modes of collection such as personal visits and telephone. Recently the ABS has investigated the use of an automated collection technique known as *web-scraping*. The ABS uses the following explanation to explain web-scraping:

Web-scraping is a technique employed to extract large amounts of data from websites. Prices can be collected as frequently as desired for all products using purpose-built programs that scan the websites of retailers, find the relevant information and store the information in a time series. The process can be run automatically and as frequently as desired (daily / weekly), providing high frequency information (ABS, 2017c).

While the use of web-scraping isn't a new data source, it does allow the volume of data being collected that previously would not have been feasible. The ABS has utilised web-scraping since 2016, which has allowed approximately 500,000 prices to be collected per week compared to 1,000 prices with traditional in-field collection. Similar to the scanner data, this has provided an opportunity to significantly increase the size of the sample of products and the frequency of price collection. From the June quarter 2017 the ABS implemented web-scraped data into the CPI.

2.5 Utilising new data sources to deliver statistical solutions

While utilising new data sources has resulted in significant enhancements to the Australian CPI, it has also opened up opportunities to deliver new statistical solutions. This has led to the ABS conducting a feasibility study into producing a monthly CPI. There has long been demand for the ABS to produce a monthly CPI from the Reserve Bank of Australia and economists in general. The cost to producing a monthly CPI has significantly reduced as a result of the investment made by the ABS to lower the CPI data collection costs over the past three or four years (ABS, 2018b).

With greater coverage of CPI data collection, other statistical solutions the ABS may explore in the future include:

1. Expanding the scope of the Australian CPI from capital cities to regional areas.
2. Producing spatial price indexes for price level comparisons across Australia.
3. A monthly CPI enables the production of monthly retail trade volume measures.

3. MAKING GREATER USE OF EXISTING DATA THROUGH DATA INTEGRATION

3.1 Introduction

The ABS is embarking on a period of major organisational transformation to respond to the new opportunities and challenges of a dynamic statistical landscape. Maximising the value of administrative data through integration and improved access is a strategic priority for the ABS in order to deliver high quality official statistics in efficient and innovative ways.

Data integration has the potential for NSOs to lower collection costs, reduce respondent burden and deliver important statistical insights. While data integration is not a costless exercise, by making use of existing data sources both within the ABS and other government agencies, it is far cheaper than conducting additional bespoke surveys to collect information from households or businesses.

3.1.1 Addressing privacy concerns

Government agencies are operating in an environment with heightened sensitivities around personal information and a public who are suspicious and lack trust in the government. A key challenge for the ABS is to meet the ever growing demand for more complex and detailed micro data integration and to provide access to these data assets. Coupled with this is the need to uphold the privacy of individuals and businesses in order to maintain a '*social licence*' to undertake this work. A social licence ensures the use of data aligns to the expectations of the community around how their data is handled and concerns for their privacy.

Actively engaging with the community and being transparent with data integration activities helps the community understand how their data is used, stored, and importantly, the benefits and outcomes that it produces. Highlighting the benefits to government and business are useful, however to gain community support, benefits need to be demonstrated at the individual level. The ABS is working with other government agencies to develop a unified strategy to deal with this challenge. In addition to this, for each new data integration initiative, an independent *Privacy Impact Assessment* is conducted to ensure the ABS has put in place strong measures to protect the privacy of individuals and businesses.

3.1.2 Data integration in the ABS

Data integration involves bringing together different data sets for statistical and research purposes. The ABS has used this statistical technique for some time dating back to 1966 where Census returns were matched with the post enumeration survey in order to produce more accurate population estimates (ABS, 2017b).

Over the last decade, the ABS has been expanding its data integration activity. Through this expansion new statistics have been produced to inform important policy issues. Some recent examples include:

- the importance of small and medium sized enterprises to overall employment growth and innovation across the economy;
- new insights into the employment and income outcomes for migrants;
- and new information on the outcomes achieved by participants in a number of government programs.

One example where the ABS is playing a leading role in data integration across government agencies is the Data Integration Partnership for Australia (DIPA). The DIPA brings together data assets from multiple sources from across government to create high-value, enduring national statistical assets to build longitudinal datasets about populations, businesses, the environment and government. Analysis of these data assets provides new insights into important and complex policy questions to improve the social and economic welfare and security of all Australians through the use of more targeted evidence-based government policies, programs and services.

The rest of Section 3 will focus on two examples of ABS data integration and how these have led to new statistical insights: the Business Longitudinal Analytical Data Environment (BLADE) and the Linked Employer Employee Dataset (LEED).

3.2 The ABS's Business Longitudinal Analytical Data Environment (BLADE)

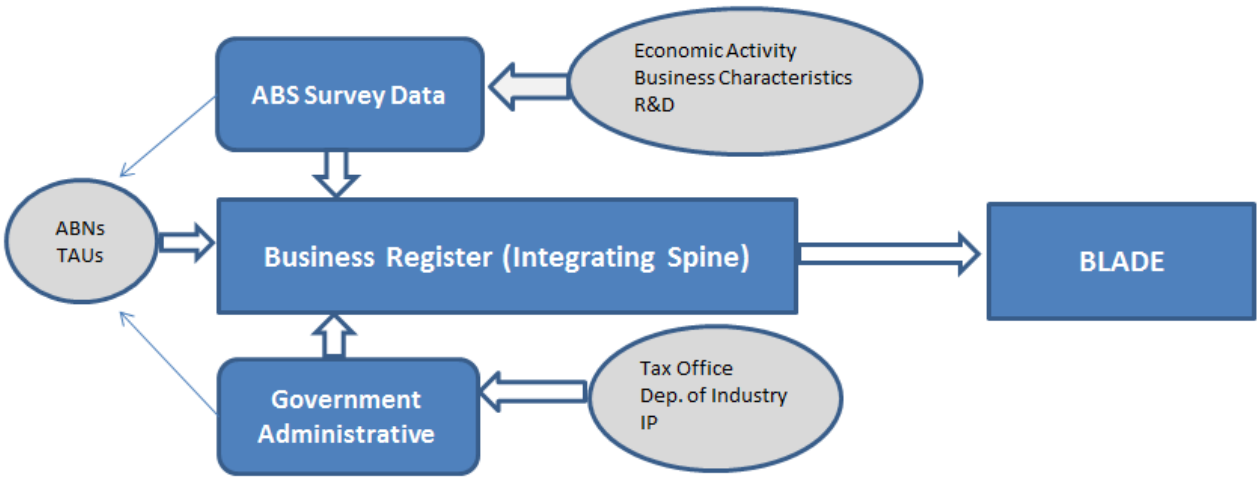
3.2.1 Introduction

There is a wealth of information about businesses held across all levels of government in the form of administrative data. Coupled with this is the increasing demand for longitudinal data which enables sophisticated analysis for researches interested in the relationships between productivity, innovation and competition.

Created by the ABS in 2015, the BLADE is a new methodology of integrating and linking business longitudinal data sets across multiple Australian government agencies to help understand the economic drivers of business performance. The BLADE is an example of a new statistical asset that utilises existing data both within the ABS and other government agencies. The BLADE dataset is a reference to a frame which is used to integrate financial and business characteristics data for all active businesses in the Australian economy. The BLADE frame is updated each year to enable the addition of new businesses and longitudinal analysis of existing businesses. The ABS's Business Register is used as the '*integrating spine*' to link the ABS survey data and administrative data. This makes the *BLADE "the most comprehensive firm level statistical asset in Australia"* (Hansel and Rafi, 2018). In total, the BLADE dataset has established over 83 million observations of businesses and the capacity to link 8 million unique firms for longitudinal analysis from 2002-2016.

Figure 2 shows how ABS survey data and government administrative data are linked to the ABS's Business Register through the use of Australian Business Numbers (ABNs). ABS data currently incorporated into the BLADE includes surveys on: Economic Activity; Business Characteristics; and Business Research and Development. Government administrative data is predominately business tax data from the Australian Tax Office (ATO), but also includes data from Intellectual Property Australia and National Greenhouse and Energy Reporting data.

Figure 2: Basic structure of the BLADE



The purpose of the BLADE is to enable research on firm level analysis of micro-economic drivers of performance, competitiveness and productivity. Research such as this results in better information being available to enable greater evidence-based policy development and evaluation, leading to more targeted expenditure of government funds.

3.2.2 Research conducted using the BLADE

The initial motivation for the development of the BLADE was to use in cross country comparisons, where data for Australia was often lacking. The creation of the BLADE has enabled Australia to take part in two OECD distributed microdata projects looking at the Dynamics of Employment and Micro Drivers of Productivity, which previously had not been possible (ABS, 2015a).

While the BLADE is still in its infancy in terms of its use for Australian research purposes, research conducted to date utilising the BLADE includes:

- a statistical overview of exporters and an empirical analysis of the performance of exporters relative to non-exporters;
- measurement of firm mark-ups to assess the level of competition within the retail industry;
- a report on the dynamics of employment growth, which investigated the contribution of firms of different ages and sizes to aggregate employment growth; and
- a study of the business dynamics of a Clean Energy policy.

An important piece of research that used data from the BLADE to analyse the dynamics of entrepreneurship in Australia from 2002-2015 was recently conducted by the Department of Industry, Innovation and Science. The research found that "*the Australian entrepreneurial landscape has become less dynamic and more hazardous over the observed period. With time passing, relatively fewer entrepreneurs are entering the market, and those that enter are more likely to exit than their counterparts that entered in earlier years."* (Bakhtiari. 2017)

Through analysis of the BLADE data, the research was able to show that the rate of new business entering the Australian market has been declining since 2005, with new businesses facing more risks and a higher probability of exit. The research also showed that the decline in new businesses relative to existing businesses has been greater in Australia than in comparable countries such as the US, UK, New Zealand and Canada. What this decline in new businesses means for the Australian economy is it has implications on the level of competition, innovation and productivity growth, which ultimately leads to fewer jobs being created and lower economic growth. This research is important to understanding the reasons behind the declining firm entry and to inform the development of policies to assist entrepreneurs.

3.3 ABS's development of a Linked Employer Employee Dataset (LEED)

3.3.1 Introduction

The development of the LEED by the ABS is the first time administrative data on individuals and business has been integrated. The LEED integrates Personal Income Tax (PIT) data from the Australian Tax Office (ATO), with business data from the ABS's BLADE, to produce a linked employee-employer data set. The LEED addresses a longstanding information gap in Australian labour statistics by being a single database capable of addressing complex and varied questions about employer-employee relationships (ABS, 2015b).

Linked employer-employee datasets are uniquely positioned to provide information about both sides of the labour market. Using a LEED, studies into determinants of labour market outcomes and productivity can refer to both the characteristics of employees – such as where they live, their sex, age and occupation, and characteristics of employing organisations – such as its size, age, profitability and industry. By integrating these perspectives, determinants of employer outcomes can be separated from those associated with employees, and vice-versa.

To date, the ABS has successfully produced and used a prototype LEED to demonstrate the importance of considering both firm and employee dynamics in the analysis of labour productivity; and have produced coherent experimental statistics using the LEED that may be further developed to replace higher-cost direct-collection based statistics or to complement existing statistics.

Building on this, the ABS will soon publish a supplementary set of official statistics using cross-sectional LEEDs to describe Australia's filled jobs, including information about job-holders and their employing organisations. In response to user feedback on this experimental work, the ABS has expanded the population to include owner managers of unincorporated enterprises (self-employed persons) as well as employees. A time series has also been established commencing in 2011-12.

The integration of PIT data from the ATO with business data from the ABS's BLADE produces linked employee-employer data sets, which includes:

1. A person file containing data relating to each person with recorded employment-related income. This includes demographic and aggregate earnings information, and selected information about any employee or self-employed jobs held.
2. An employer file containing information relating to each organisation to which an individual employee dataset record is linked.
3. A job file containing data relating to each job. This includes unique identifiers for persons and employers, information about each job, whether the job is held concurrently with another job, and information about the employing organization to which each job links.

The current LEED uses deterministic links to integrate approximately 18.5 million jobs with 15 million persons and over 8 million employers. This is primarily deterministic linking of jobs to persons and legal entities using linkage keys.

3.3.2 Uses of the LEED

The LEED can supplement and enhance directly collected statistics from households and businesses and it facilitates new ways to analyse and conduct research on the Australian labour market. Because it is based on large and comprehensive datasets, some examples of potential research using the LEED include: micro-labour markets; examine how specific events, such as the impact of a mining boom on a mining town, impact employees and employers; and understanding structural changes in the labour market.

Recently, data from the LEED has been used as a key input into the ABS's recently developed Labour Account. The Australian Labour Account has been developed to provide a framework for combining different data sources such as household and business surveys, and administrative data to provide internally consistent estimates of key labour market variables related to jobs, persons, hours and payments for labour (ABS, 2018a).

Data from the LEED are used in the Labour Account to determine the industry of secondary jobs and applied to the industry of main job in the Labour Force Survey data to produce the total jobs by industry. A key finding from the Australian Labour Account analysis shows stronger growth in secondary jobs in recent quarters when compared to growth in main jobs. This provides insights into the rise of multiple job holders in Australia and reflects the dynamic nature of the labour market and the impact of the *Digital Transformation* is having on how people are employed.

3.4 Summary of ABS data integration

The BLADE and LEED are valuable statistical assets for Australia whose potential is continuing to be realised. Through the method of data integration, the BLADE and LEED provides valuable data for research purposes which is important to informing evidence-based policy formation by governments and decisions by businesses.

4. CONCLUSION

The ABS has a rich history of making use of new data sources and methods of data integration to produce official statistics to inform policy and research. With the growing importance of evidence-based policy by governments and businesses, the demands on NSOs to produce a broader range and more accurate statistics are increasing. This paper highlights how the ABS is one of the leading NSOs in the world in making use of administrative data form the private sector (scanner data) and web-scraping collection techniques to compile the CPI, both more accurately and at a lower cost. The paper also discusses recent data integration work conducted by the ABS that makes better use of existing data to enable more sophisticated research to provide new insights on the Australian economy and society.

With the *Digital Transformation* producing ever increasing volumes of data, the opportunities and challenges for NSOs are significant. This is set against the backdrop of increasing demand and fewer resources in many cases. It is incumbent on NSOs to ensure they grasp these opportunities and meet these challenges to ensure they continue to produce *better statistics for better lives.*

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