Comparing approaches to compiling macro and micro productivity measures using Statistics New Zealand data

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Abstract

This study seeks to assess both macro- and micro-economic approaches to productivity measurement in the New Zealand context. It highlights the key similarities, differences, and assumptions of the two approaches, and how they can be used in tandem to make meaningful conclusions. This study is intended to be a starting point for how a better understanding of the drivers of aggregate productivity growth can be developed from micro-level data.

1 Introduction

Productivity measures are vital to a better understanding of long-term improvements in New Zealand's living standards, economic performance, and international competitiveness. Productivity is about how efficiently firms, industries, or economies can turn their inputs, such as labour and capital, into outputs in the form of goods and services. Growth in productivity means that more value is added in production, and therefore, more income is available to be distributed. For this reason, there has been growing interest in gaining a better understanding of New Zealand's productivity performance.

Macro-economic productivity measures inform users by:

- providing an indicator of living standards (assuming that productivity increases are matched by wage increases)
- tracing the effect of technological change
- assessing the economy's underlying productive capacity
- enabling international comparisons of productivity
- enabling assessment of policies, programmes, or economic events over time.

Aggregate or industry productivity growth rates often hide substantial variation in growth for firms within industries. Productivity data at the industry level goes some way to disentangling the relatively smooth aggregate trends. Industry-level estimates allow researchers and policy makers to address broad questions like 'which industries are performing well in terms of productivity growth?'

Macro-economic measures can only go so far in enriching the understanding of the drivers of growth. The primary reason for interest in examining productivity from a micro-economic perspective is to gain a better understanding of aggregate growth. Microdata can be used to illustrate some of the variation in firm and sub-industry productivity underlying an aggregate industry measure. Microdata can also be used to highlight the firm characteristics that are important to productivity growth.

Statistics NZ's prototype Longitudinal Business Database (LBD) stores a large amount of micro-level information that can be used for longitudinal analysis. Compiling productivity measures using microdata can answer specific research questions and support analysis on firm behaviour, business practices, and policy implications at the firm level. There is increasing demand from policymakers to better understand what is driving firm-level productivity performance as well as the distribution of performance within industries.

Micro-economic studies into productivity inform users by providing information on the drivers of productivity growth, such as:

- technical efficiency (within firm)
- reallocation of resources (between firms)

- firm entry and exit.

They also provide information on characteristics of firms, such as:

- size
- location
- competition
- managerial practices
- research and development expenditure
- input/output mix.

To ensure the relevance of productivity statistics, it is important to unpick the data at a lower level. This provides a better understanding of what is driving aggregate productivity growth. In this paper, we outline how it might be possible for users to answer questions such as ‘how do we measure the productivity of firms and how is this different from aggregate measures?’ and ‘how can we explain some of the dispersion in productivity growth between firms?’

The aim of this study is not to reconcile the macro- and micro-productivity measures that are available from Statistics NZ data. Instead, the two approaches are compared, while acknowledging that there are different objectives in compiling macro- and micro-measures. Section 2 outlines some background information about productivity measurement and interpretation as well as Statistics NZ work so far. Section 3 describes the data sources and calculation methods of macro- and micro- productivity estimates using Statistics NZ data, citing examples of work using the Statistics NZ LBD. Section 4 summarises the similarities and differences in the data sources and methodology between the macro and micro approaches, breaking these into methodological and conceptual differences. Finally, section 5 outlines future work using macro- and micro-data.

2 Background

Productivity measurement and interpretation

Productivity is a measure of how efficiently inputs (ie capital and labour) are being used to produce outputs. Productivity is commonly defined as a ratio of a volume measure of output to a volume measure of input. Growth in productivity means that a firm, industry, or economy can produce more output from the same amount of input, or the same level of output from fewer inputs.

Productivity analysis aims to meaningfully show how production factors contribute to growth in output. Growth in output can be attributed to either an increase in input, more efficient utilisation of inputs, or a combination of these. Productivity measures can be either single factor (ie relating a measure of output to a single measure of input), or multifactor (ie relating a measure of output to a bundle of inputs).

Labour and capital productivity are single (or partial) factor productivity measures; they show productivity growth in terms of a particular input relative to output. Multifactor productivity (MFP) takes into account substitution between labour and capital inputs, and is therefore not directly affected by a change in the mix of total inputs.

There are many different productivity measures. The choice between them depends on purpose and, in many instances, on the availability of data. It is important for users to understand how productivity is measured and the assumptions and limitations underlying different productivity measures. Users are not always aware of the conceptual and empirical reasons for differences between them. Until recently, the focus in New Zealand tended towards macro-economic productivity measures, mainly due to the availability of suitable data.

To provide a complete picture of the industrial dynamics of an economy, the aggregate measures of productivity need to be supplemented by micro-level measures. Productivity can, in principle, be calculated for every level of economic activity, from an individual factory to the total economy. At any level of detail, the basic principals remain – productivity estimates are simply the relationship between a measure of output and a measure of input. These estimates are not independent of each other because, for example, the productivity of a firm reflects the productivity of its component plants. Similarly, the productivity of the aggregate economy is determined at the industry level. As a result, productivity at the aggregate level will increase if productivity in each constituent industry rises, or if the market share of the high productivity industries increases (and so on, down the aggregation hierarchy). A full picture would include a mutually consistent measure of productivity at each level of the economy, and of the linkages used to connect levels (Hulten, 2001). In practice, it is impossible to construct this full picture. A complex array of firm-level drivers and market selection factors inhibit the researcher's ability to fully account for aggregate productivity growth by simply combining the productivity of the constituent parts.

What is productivity not?

To interpret productivity statistics it is also important to remember what productivity is not. In particular, productivity is not:

- just about efficiency, it represents other factors such as technological change and measurement error
- economy or 'value-for-money' – this concept reflects cost per output while productivity examines input to output; productivity measures volume changes with price effects removed
- a measure of effectiveness – productivity reflects how much extra output is produced per unit of input, not whether that input has an effective outcome.
- the same as production – productivity growth may occur even when output (production) remains the same
- a measure of competiveness or profitability.

What determines productivity?

A key policy question when looking at productivity in New Zealand revolves around why industries (and firms within industries) differ so much in their ability to convert inputs into output. Policymakers want to understand what it is that determines the productivity of New Zealand's economy – is productivity something that producers can control or is it simply a product of the operating environment?

Micro-evidence has suggested a wide heterogeneity of firms' behaviour in most markets (Bartlesman & Doms, 2000). Firms have different characteristics and behave differently, even in narrowly defined markets. Heterogeneity between firms reflects a combination of product market conditions, as well as choices concerning technologies, goods, and production driven by market conditions and profitability (Scarpeta, Hemmings, Tressel & Woo, 2002).

Aggregate productivity depends on a combination of within-firm performance and firm dynamics. Firm performance and firm dynamics are influenced by factors relating either to firm-level choices or practices as well as broader market factors (Svyerson, 2011). For example, R&D subsidies may increase innovative activity within a firm (given a firm chooses to use those subsidies), but they may also alter the strategic interactions between firms that determine market shares.

Scarpetta et al (2002) propose that in a given industry, productivity growth is the result of different combinations of:

i) productivity growth of existing firms

ii) changes in market shares among them

iii) the entry and exit of firms to the market.

Within-firm productivity growth depends on changes in efficiency and the intensity with which inputs are used in production. Shifts in market shares among continuing firms reflect resource reallocation, and affect aggregate productivity trends if, for example, market shares of high or low productivity firms change. The process of entry and exit of firms is another form of reallocation, which contributes to aggregate productivity growth to the extent that more productive new firms displace the low productive exiting ones. The overall contribution of reallocation to productivity growth is generally viewed as reflecting a competitive process taking place in the market, although it may also reflect changes in demand conditions and may also be an aspect of technological progress (Scarpetta et al, 2002).

There may also be important interactions between these components of productivity growth. For example, the entry of highly productive firms in a given market may stimulate productivity-enhancing investment by existing firms trying to preserve their market shares (Scarpetta et al, 2002).

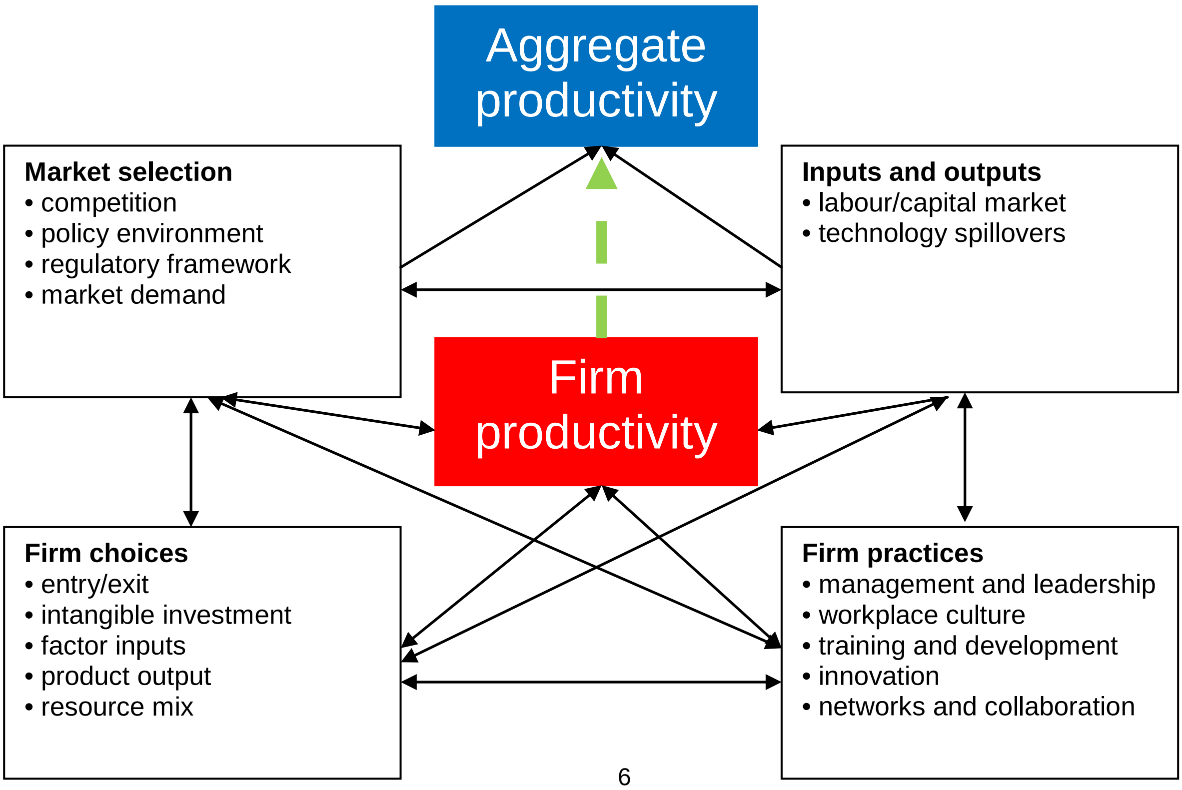
Research has suggested a simple storyline that provides an understanding of how changes in policy or environmental factors affect aggregate productivity, although the truly exogenous causes of productivity are not easily identifiable (Bartlesman & Doms, 2000).

The key to this storyline is that while aggregate productivity growth is largely determined by within-firm growth influenced by firm choices and practices, environmental factors also play a part in influencing within-firm and between-firm decisions. Research has also suggested that although aggregate productivity patterns are largely the result of within-firm performance, the contribution from firm dynamics (such as entry and exit of firms), which are largely influenced by market factors, should not be overlooked (Scarpetta et al, 2002).

Figure 1 attempts to characterise some of these factors into those that are controllable (to some extent) at the firm level, and those which are determined by external factors. This is discussed further in the section 'Bringing it all together'.

Figure 1

What determines productivity?



Aggregate productivity measures can only go so far to enriching the story around growth (or lack of growth) in productivity. Microdata provides information that can inform better understanding of the drivers of change in industry and aggregate productivity.

3 Macro- and micro-productivity at Statistics NZ

Statistics NZ productivity work to date

In March 2006, Statistics NZ published the first official estimates of productivity for New Zealand. These estimates were for a subset of the market industries in New Zealand, referred to as the ‘measured sector’. This comprised Australian and New Zealand Standard Industrial Classification 1996 (ANZSIC96) divisions A to K, plus P.[1] In 2008, more industries (ANZSIC96 industries LC and QA) were included in the scope of this aggregate measure.

Since the first release of productivity estimates for the measured sector, there has been extensive user demand for further disaggregated industry productivity statistics to help interpret aggregate productivity growth. To meet this demand, industry-level productivity statistics were first released in June 2010, for 25 industries/aggregates covering the 1978–2008 period. This was updated in March 2011 to include property services (ANZSIC96 industry LA) from 1996 on. In March 2012, volume estimates of hours paid for industries in the measured sector were released for the first time enabling users to calculate levels of labour productivity.

Despite the release of industry productivity data, users continued to demand further industry disaggregation to a more ‘useful’ industry breakdown, citing the diverse nature of some of the industries for which productivity statistics had been released. Examples of this are the construction or business services industries, in which fairly heterogeneous activity takes place.

To address this demand, in March 2012 Statistics NZ published summary findings from a feasibility study that investigated the suitability of current data and methodology for calculating sub-industry productivity statistics. The findings of the study showed that meaningful disaggregated industry productivity statistics cannot be produced with the current data available. This is due to constraints in not just the data itself, but also the applicability of the current methodological framework for productivity measurement at a detailed industry level. The study directed users towards the microdata path (through the LBD) to glean information around firm-level productivity and the drivers of industry productivity growth (Statistics NZ, 2012).

Statistics NZ currently has no formal programme of work around micro-productivity or firm-level research. Statistics NZ has developed the LBD as a rich source of firm-level data. As a priority, in order to support the widest range of users, Statistics NZ maintains, updates, and supports the database, but has not undertaken any research themselves so far. Instead, micro-productivity studies have predominantly been carried out by researchers, external to Statistics NZ, or on secondment at the statistics office. Researchers from organisations such as Motu Economic and Public Policy Research and the Ministry of Economic Development have led the field in micro-data research in New Zealand. Some of this research is referred to in the ‘Uses of the LBD’ section.

Industry and aggregate productivity measures

Statistics NZ’s method of estimating productivity statistics is based on OECD guidelines, as outlined in *Measuring productivity: Measurement of aggregate and industry-level productivity growth* (OECD, 2001). The approach used is referred to in the manual as “the index number approach in a production theoretic framework.”[2]

At an industry or aggregate market sector level, productivity statistics inform the user by simply showing the growth in production of output (goods and services) from a given set of inputs

[1] For details on the coverage of official Statistics NZ productivity estimates see appendix A.
[2] For further detail on how Statistics NZ compiles macro-productivity estimates see *Productivity Sources and Methods* (2012).

(capital and labour). The most widely used productivity measures are labour and multifactor productivity.

The calculation of productivity statistics begins with a production function of the form:

$Vi = Ai(t) \times f(Li, Ki)$

where Vi = chain-volume value added

Li = labour inputs

Ki = capital inputs

f(Li,Ki) = a production function of L and K that defines an expected level of output for a specific industry or aggregate

Ai(t) = a parameter that captures disembodied technical shifts over time, that is, outward shifts of the production function allowing output to increase with a given level of inputs (= MFP)

Given the existence of index values for labour volume and value added, it is possible to calculate labour productivity as:

$LPi = Vi / Li$

Where LP = an index of labour productivity. This is an index of chain-volume value added divided by a volume index of labour inputs.

Similarly, a capital productivity index KP is calculated as:

$KPi = Vi / Ki$

Where KP = an index of capital productivity. This is an index of chain-volume value added divided by a volume index of capital inputs.

Care is needed in interpreting the partial measures of productivity. For example, labour productivity only partially measures 'true' labour productivity, in the sense of capturing the personal capacities of workers or the intensity of their efforts. Labour productivity reflects the level of capital available per worker and how efficiently labour is combined with the other factors of production. Labour productivity may change due to a substitution of capital for labour (capital deepening) or due to a change in MFP, with no change occurring in the labour input itself. Similarly, capital productivity measures have their constraints.

Capital services in production analysis are assumed to be proportional to the capital stock. If the factor of proportionality does not change over time, the growth rate of capital services is identical to the rate of growth of the capital stock. This is clearly an unrealistic assumption, given the variations in the rates of capacity utilisation of capital stocks. Consequently, swings in the rates of capacity utilisation are picked up by the residual productivity measure, that is, MFP.

The final productivity index that can be calculated is for MFP. The technological parameter that represents disembodied technological change (or MFP) cannot be observed directly. By rearranging the production function equation, it can be shown that the technology parameter can be derived residually as the difference between the growth in an index of outputs to an index of inputs:

$Ai(t) = Vi / f(Li,Ki)$

Limitations of industry and aggregate productivity measures

Assuming the measurement of labour hours at an aggregate level is accurate, aggregate labour productivity growth means that for an industry or group of industries, more output can be produced from a given level of labour input. However, it can also reflect several factors:

- increasing capital available per worker
- better quality of labour
- more efficient use of existing capital or labour (or MFP).

MFP reflects the growth in output not attributable to increases in measured inputs. MFP is measured as a residual, and it captures any growth in output above and beyond growth in measured inputs.

Certain assumptions must be met for MFP to be a measure of disembodied technological change. The key assumptions are that the production function must exhibit constant returns to scale, capital and labour markets must be perfectly competitive, and all inputs need to be included in the scope of the production function.

In practice, these conditions will not be met and the resulting MFP residual needs to be interpreted with some caution. Given the importance of technological progress as an explanatory factor in economic growth, attention often focuses on the MFP measure as though it was a measure of technological change. However, this is not the case. When interpreting MFP, the following should be noted:

- Not all technological change translates into MFP growth. Embodied technological change, such as advances in the quality of capital or improved human capital, will be captured in the measured contributions of the inputs, provided they are measured correctly (ie the volume input series includes quality change).

- MFP growth is not necessarily caused by technological change. Other non-technology factors will be picked up by the residual, including economies of scale, cyclical effects, inefficiencies, and measurement errors (which predominantly stem from the difficulties in capital measurement).

There are also some other, more fundamental limitations of macro-productivity measures. For example, macro- productivity measures also make assumptions around the homogeneity of production functions, inputs, and outputs of firms within industries which put simply is not true in the real world.

Explaining aggregate or industry productivity growth is an essential part of understanding the performance of an industry or economy. What happens at an aggregate level is driven by what happens on the shop floor. However, research points towards a high degree of dispersion of productivity rates within any given industry (ie Bartlesman & Doms, 2000). Economic growth models are usually based on the assumption of representative producers and consumers. They don't take into account the heterogeneity of producers even at a detailed industry level. This is problematic when searching for the factors contributing to growth in productivity.

This is where microdata and micro-productivity studies can assist in identifying drivers of aggregate productivity growth.

Microdata and productivity

Historically, the focus of most productivity studies (especially in New Zealand) has been at a macro-market economy level or at an aggregated industry level. Empirical studies using firm-level or microdata have only taken off in the last decade or so around the world (and more recently in New Zealand). Both macro- and micro-studies of productivity use varying methodology to answer their own set of questions. Different approaches to research on a common topic generally lead to answers that are not directly comparable as a consequence of the different strategies used to specify the problem and identify the results.

More recently, firm-level data has become available in New Zealand. These data allow researchers to avoid having to rely on the representative firm by providing firm-level information, which can uncover some of the dispersion of productivity within aggregated industries. Microdata allow one to extend the underlying model to include new routes through which policy can affect productivity, namely through selection and resource allocation. Micro-productivity research enhances aggregate industry productivity data by adding information on the characteristics of firms.

The Longitudinal Business Database

Fabling (2009, p 2) provides a detailed description of the Statistics NZ Longitudinal Database (LBD):

> The prototype Longitudinal Business Database (LBD), maintained by Statistics NZ, is a rich resource for understanding the behaviour and performance of New Zealand firms. The primary selling point of the database is wide coverage administrative sources of financial performance, employment and wage data, coupled with a variety of sample survey and other (notably Customs merchandise trade) data providing a detailed view of firm practices across a broad range of topics. In addition, through the integration of the Business Operations Survey (BOS), researchers have the opportunity to design and integrate entirely new content that can be used with panels of BOS data and other longitudinal information held on the LBD. The database is a work-in-progress and is continuing to expand as new research needs are identified, and as new data become available.
>
> The LBD comprises tax- and survey-based financial data, merchandise and services trade data, a variety of sample surveys on business practices and outcomes, and government programme participation lists. The database has expanded organically to meet the needs of agencies whose researchers use the data, and now includes a substantial proportion of the business data that Statistics NZ holds and uses to compile official statistics.

Producing output from the LBD is currently the domain of researchers, who come in to Statistics NZ under strict protocol and confidentiality guidelines. Statistics NZ does not have any formal programme of work on micro-productivity, but is instead acting in a support, maintenance, and peer-review role for researchers. Table 1 provides a summary of the components of the LBD.

Table 1
Datasets in the Longitudinal Business Database (LBD)

Administrative data in the LBD	Years available
Government assistance programmes (GAP)	2000–09
Company tax returns (IR4)	1999–2010
Tax filed financial accounts (IR10)	1999–2010
Intellectual property data (IPO)	1996–2010
Survey or other output data in the LBD	
Annual Enterprise Survey (AES)	1993–2010
Agricultural Production Survey (APS)	2002–10
Business activity indicators (BAI)[1]	1999–2011
Business Finance Survey (BFS)	2004
Business Operations Survey (BOS)	2005–11
Business Practices Survey (BPS)	2001
Overseas merchandise trade data (Customs)	1988–2011
Innovation Survey	2003
International Trade in Services Survey (ITSS)	1998–2010
International Trade in Services Census	1999, 2005, 2011
Longitudinal Business Frame (LBF)	2000–11
Linked Employer–Employee Data (LEED)	1999–2010
Manufacturing Energy Use Survey (MEUS)	2006
Quarterly International Investment Survey (QIIS)[2]	1998–2010
Research and Development Survey (R&D)	1996–2010

1. This contains income and expenditure that include GST.
2. Will be available for researchers to use from July 2012.
Source: Statistics NZ

Uses of the Longitudinal Business Database

The LBD is used to measure and report on a wide and complex range of firm characteristics and performance metrics. The large number of datasets and variables within the LBD allow for a plethora of metrics to be calculated, and they can be tailored to individual research questions.

Productivity is one of these metrics, and sits alongside other common metrics such as expenditure per employee, firm entry and exit rates, and import/export behaviour of firms.

Productivity is commonly defined as a ratio of output to one or more inputs. Microdata researchers can interpret this definition broadly, and over time, different measures of productivity have been calculated from the LBD, depending on the research question. Measures of productivity have been used in several LBD papers over the past three to four years.

Maré and Fabling (2011), Productivity and local workforce composition

This paper examines the link between firm productivity and the population composition of the areas in which firms operate. The paper combines annual firm-level microdata on production, with area-level workforce characteristics obtained from population censuses. A key finding is that local workforce skills contribute most strongly to productivity for small firms, and for firms in industries with high levels of R&D.

Approach to measuring productivity: the authors use a gross output-based Cobb-Douglas production function, augmented with area-level workforce characteristics. Gross output is a function of capital services, labour input, intermediate consumption, and local workforce measures. Labour input is measured using headcount, while labour quality is included as part of local workforce measures.

Maré (2008), Labour productivity in Auckland firms

This paper examines labour productivity in Auckland, New Zealand's largest city. It documents a sizeable productivity premium in Auckland, calculating that around half of this is due to industry composition. That is, Auckland firms have a disproportionately high share of their activities included in high-productivity industries.

Approach to measuring productivity: Maré is calculating labour productivity only, and uses a value-added per worker approach. Value-added data comes from the Annual Enterprise Survey where available, and where not, from GST net sales, adjusted for changes in stocks. Labour input is a simple headcount measure, covering both employees and the self-employed

Fabling and Sanderson (2011), Foreign acquisition and the performance of New Zealand firms

This paper examines the firm-level determinants of foreign acquisitions of New Zealand companies, and the consequences for the purchased firms. Acquired firms exhibit higher growth in average wages and output, relative to similar domestic firms. However, they do not appear in general to increase their productivity or capital intensity as a result of being acquired. The paper considers six firm outcomes which may be affected by foreign investment: labour productivity, multifactor productivity, gross output, capital-labour ratio, average wages, total employment.

Approach to measuring productivity: need to see methodology in Fabling and Maré (forthcoming)

Fabling and Grimes (2009), The 'suite' smell of success: Complementary personnel practices and firm performance

This paper examines the issue of how personnel practices affect firm performance. To examine this issue, a panel of 1,500 firms from a diverse range of industries is analysed, based on data from management practice surveys run in 2001 and 2005. The main finding is that suites of complementary human resource management-related practices impact positively on firm employment and wages. Effects on employee turnover depend on the practices considered.

Approach to measuring productivity: the paper calculates both multifactor and labour productivity. MFP is calculated by way of ordinary least-squares regression, assuming a Cobb-Douglas production function with industry-year-specific coefficients, and the potential for non-constant returns to scale. Labour productivity is calculated as the difference between log value-added and log total employment. For both MFP and labour productivity, a dummy is included to control for differences between data sources.

Grimes, Ren, and Stevens (2009), The Need for speed: Impacts of Internet connectivity on firm productivity

This paper cites evidence that fast Internet access is widely considered to be a productivity-enhancing factor. It then uses the LBD to determine the impact that differing types of Internet access have on firm productivity. Broadband adoption is found to boost productivity, but the authors find no productivity differences across broadband type. The data comes from 2006, so is somewhat dated.

Approach to measuring productivity: the paper measures labour productivity only, using a value-added per employee approach. Value-added data comes from the IR10s, while labour input is firm-level employee count.

Each firm's labour productivity is expressed as a ratio of the four-digit sector average. The sector average is calculated for all firms within the industry. Also, the firm- and sector-level measures are two-year averages. This is done to reduce noise in the data due to the timing of reporting.

Each of these five papers is unique – in the technique used to calculated productivity, and the firms and industries for which productivity has been calculated. These five papers are by no means an exhaustive list.

Table 2
Summary of selected Longitudinal Business Database research

Paper	Type of productivity calculated	Unique aspect of calculation
Maré and Fabling (2011)	Labour productivity Multifactor productivity	Gross-output based measures Area-level workforce characteristics specified in the production function Labour quality differences accounted for
Maré (2008)	Labour productivity	Breaks down productivity premiums into a composition effect, a capital deepening effect, and MFP effect, and a price effect
Fabling and Sanderson (2011)	Labour productivity Multifactor productivity	Various assumptions used within the cost-of-capital calculation
Fabling and Grimes (2009)	Labour productivity Multifactor productivity	A dummy is included in the regression calculations, to control for differences between the data sources used to derive value-
Grimes, Ren and Stevens (2009)	Labour productivity	Labour input data is solely from IR10s Productivity expressed as a ratio of a four-digit average

Limitations of LBD-based productivity measures

Measuring productivity within the LBD allows researchers to adopt a flexible approach, but naturally there are limitations with this. There are almost as many research papers as there are measures of productivity, meaning the productivity data themselves cannot be compared across studies.

One implication for researchers is the time required to develop and calculate the productivity measures for each study. Compiling the measures, particularly when a capital services dataset is required for the calculation of multifactor productivity, is a complex and resource-intensive process.

By nature, the LBD dataset is raw and unedited – there are gaps, there are outliers in the data, and within the vast amount of data available, there are complexities which are difficult to understand. However, the different types of microdata allow researchers to select which data is most appropriate for answering their research questions. Researchers need to develop measures that are fit-for-purpose. This often means working within the limitations of the dataset, while still producing measures that are of the desired quality. The methodology used to compile firm-level productivity measures has drawbacks when compared against the macro measures. While the LBD is an incredibly rich resource of firm-level data, it lacks aggregate data used in compiling macro-measures. Currently, there are no price indexes built into the database, and no firm-level price data are included. The implication is that most studies of productivity have used current price value-added as the output measure. This is not consistent with the macro measures, which apply a price deflator, and use changes in the volume of value-added. However, this is not a big limitation of micro measures, because many studies calculate productivity using regressions with industry-year dummies.

Further, there are currently no measures of hours within the LBD. Micro studies commonly use job counts as the unit of labour input, which account for differences over time in the number of jobs, but not in the number of hours worked. This limitation needs to be viewed in the context of the research being carried out. Many studies are not trying to measure productivity by itself, but to estimate a relationship between productivity and another variable. If the inclusion of hours worked data were to confound that correlation, it would be problematic to have hours data feeding into the analysis.

4 Bringing it all together

Compilers and users of productivity data are best-placed when they recognise macro and micro measures of productivity can complement each other, but will always contain fundamental differences which hinder any attempt to reconcile them. Macro and micro productivity data play important and complementary roles in aiding our understanding aggregate productivity growth, and the drivers behind it.

There are both conceptual and measurement issues which must be considered when examining macro and micro productivity statistics side-by-side.

Conceptual

Firms make choices regarding: their entry into a market, or exit from it; intangible investment; the mix of factor inputs in their production function; and the level of output they produce. At a surface level, the results of these choices can be observed and measured, and productivity metrics calculated for the firm. Lying behind this, there are a number of firm-level drivers which affect their choices. These drivers are generally more difficult to observe and measure, and include leadership and management structure, the culture of the workplace, the use of technology within the firm, and their ability and focus on networking and collaboration. Such drivers impact on the productivity performance of the firm and by association, the aggregate. Microdata can help to inform users on such practices through surveys of business opinion, or other linked data sources that inform users about the behaviours and practices at a firm level.

Each firm operates within a market, and often within multiple markets. Within the aggregate productivity measure, the between-firm effects will be picked up as part of the productivity residual. These between-firm market effects will often be caused by price changes. In this case, they can be picked up within micro studies of productivity, because the output measure is commonly not deflated by a price index. Market effects include, for example, the degree and nature of the competition within the market, which is a factor in its productivity performance. Similarly, the regulatory framework within which firms operate will be a key determinant of the aggregate productivity level – through both factors that influence firm level practices, and factors that influence the market as a whole. Further, the policy environment will also affect the productivity growth of a market.

These factors and others imply that aggregate and firm-level measures of productivity are difficult to compare. A complex series of dynamic interactions, only some of which can be measured, take place in a market. They will be represented to some extent in aggregate productivity data, and often to a differing extent in firm-level data.

Measurement

At a fundamental level, macro productivity is measured in the same manner as micro productivity - as a ratio of output to one or more inputs.

At Statistics NZ, the comprehensive suite of macro productivity data is compiled in line with international best practice, as set out in the OECD's *Measuring Productivity* manual. In some areas of measurement, the manual leaves interpretation open to each country, and decisions are often dependent on the availability and robustness of data. However, New Zealand's macro productivity measures are broadly comparable with other OECD countries, particularly at the total economy level.

At the micro-level, the standard productivity equation is open to considerable interpretation. Researchers use different methodologies, often according to the research questions they are attempting to answer or the data available to them. Often, productivity is only one of a number of firm-level performance metrics that the researcher is calculating, and the specifics of the methodology are tailored to fit the research questions. Macro-productivity studies tend to adopt a more consistent and standardised framework based on macro-economic assumptions.

Tied in with this, Statistics NZ's macro productivity measures are official statistics, and a component of the Official Statistics System (OSS). By contrast, the LBD is a research database; currently, outputs published from the LBD are not official statistics.

Also, as the range of data in the LBD extends, and the literature is added to, more sophisticated measures of firm-level productivity can be developed. For example, Fabling and Maré (forthcoming) build on Fabling and Grimes (2009), by making industry-level adjustments to improve the comparability of the AES and IR10 data, using alternative production functions, and changing the cost-of-capital assumption, among others.

So far, there have been no formal attempts to reconcile micro measures of productivity from the LBD with official macro statistics published by Statistics NZ annually. Attempts to reconcile the two, even at the 1-digit industry level, will be clouded by obvious methodology and data source differences. For example, macro-economic statistics include macro-level adjustments made to balance across accounts which will not be reflected in micro-statistics.

Table 3
Macro- and micro-productivity measurement differences

Component	Macro measures		Micro measures	
	Methodology	**Data sources**	**Methodology**	**Data sources**
Output	Chain-volume value added	Published estimates of chain-volume GDP.	Mainly value-added in value terms	Annual Enterprise Survey
				GST
		For some industries, AES is used as the key data source	Occasionally gross output in value terms	IR10
Labour input	Paid hours for all employees and self-employed	Employee and self-employed counts from LEED	Monthly average headcounts for employees and headcounts for self-employed	Longitudinal Business Frame
		Average paid hours from the QES, HLFS and Census		LEED
Capital input	Capital services approach.	National Accounts capital stock data, supplemented by external sources.	Mainly a capital services approach.	Annual Enterprise Survey
				IR10
	Productive capital stock is derived from gross capital formation, with adjustments for efficiency decline. User costs are a function of the asset price, depreciation, a cost-of-capital charge, and the implicit tax rate on production	The National Accounts data are collected via the Annual Enterprise Survey	Productive capital stock calculated using averages in opening and closing book values of stocks. User costs are a function of rental and leasing costs, depreciation, and a cost-of-capital charge for owned assets.	
Weights	Income-based, for aggregating from industry level to 'measured sector'	National Accounts, income measure of GDP	No weights are used when constructing either firm-level or industry-level measures	N/A

Source: Statistics NZ

There are a number of fundamental differences to note in table 3:

- Output is measured in volume terms in the macro measures, and therefore reflects changes in quantities only over time. However, in micro measures, output is commonly measured in value terms, reflecting changes in both price and volume over time
- Labour input is measured in units of hours paid in the macro measures, using survey-based data from both organisations and households. However, in micro measures, labour input is commonly measured in units of headcounts. There are currently no measures of hours paid or worked in the LBD. Using headcounts as a proxy for labour input can skew productivity metrics, especially in cases where there is a high proportion of part-time workers.
- In the measurement of capital input, productive capital stock is derived from capital formation data in the macro measures. However, it is calculated directly within the micro measures.
- In the macro measures, income-based weights are used when aggregating from industry level to 'measured sector' or total economy level. However, in the micro measures, there are no firm-level (or industry-level) weights used. This means that aggregating across firms can be problematic.

The combination of these differences clearly leads one to conclude that macro and micro measures cannot be reconciled. Breaking down the differences into the components of productivity – output, labour input, capital input, and weights – would be a challenging task.

5 Future work

This paper has provided an introduction to the compilation of macro and micro productivity data using Statistics NZ data, explaining the ways in which they complement each other, while remaining fundamentally different from a measurement viewpoint.

Statistics NZ will complete the development of the macro productivity measures by mid-2013. This involves adding health and education to the industries for which productivity measures are estimated; updating the industry classification; and incorporating methodology enhancements around the allocation of financial intermediation services indirectly measured to industries, which will keep the official statistics at best practice level. All of this work will be completed independently of micro data research.

Using firm-level data from the LBD, researchers will continue to compile measures of productivity to answer their research questions. Statistics NZ has an opportunity to provide statistical input and leadership into this micro productivity work program. As custodians and compilers of the firm-level database, Statistics NZ is well-positioned to take on such a role, which may extend to partnering with Government researchers on particular projects.

Statistics NZ is also considering the feasibility of producing official statistics from the LBD, and productivity is one of a number of metrics to consider. The production of any official statistics from the LBD will be driven by user need. The value of the LBD is that it integrates many data sources and so enables information to be produced on the relationships between activities and their outcomes. Productivity is one of these components which can be influenced by a number of factors. If any productivity statistics were produced from the LBD, it would be in this context.

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Appendix

The following table outlines the industry coverage of the measured sector and each industry's contribution to nominal GDP.

Measured sector industry coverage

New Zealand (ANZSIC96-based)	Proportion of GDP
A – Agriculture, forestry, and fishing	5.6
B – Mining	1.3
C – Manufacturing	14.9
D – Electricity, gas, and water	2.9
E – Construction	5.7
F – Wholesale trade	7.0
G – Retail trade	6.1
H – Accommodation, cafes, and restaurants	2.0
I – Transport and storage	4.4
J – Communication services	2.9
K – Finance and insurance	6.9
LA – Property services(1)	7.4
LC – Business services(1)	9.3
P – Cultural and recreational services	2.4
Q – Personal and other community services(1)	1.6
Total measured sector	80.4

1. Included in the measured sector from 1996.

Note: ANZSIC96 = Australian and New Zealand Standard Industrial Classification 1996

Source: Statistics NZ