Australia Post's Corporate and Reserved Service Total Factor Productivity

Report prepared for Australia Post

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EXECUTIVE SUMMARY

Australia Post has requested Economic Insights to review the methodology used in measuring its total factor productivity (TFP) at the enterprise and reserved service levels and to provide updated estimates of TFP growth.

The last study of Australia Post's TFP growth was Economic Insights (2009a). This and earlier studies used data relating to a period of increasing postal volumes and used the traditional 'billed' outputs specification which is based on competitive market assumptions. Under this approach output is measured purely based on what the business sells.

Since around 2009, however, the throughput volumes of a number of Australia's key infrastructure networks, including postal services, have started to decline due to technological change and other factors. At the same time, however, these service providers have been required to make their networks available to an ever–increasing number of geographically dispersed customers. To more accurately capture the outputs being provided by networks, recent studies of network productivity have moved to measuring output on a 'functional' basis which recognises the services the network business is required to provide and not just those it directly charges customers for.

Over the last several years the fall in postal volumes has accelerated with the number of reserved service postal articles falling by around 10 per cent annually. At the same time, however, Australia Post has been required to service more delivery points, the number of which has increased broadly in line with population growth.

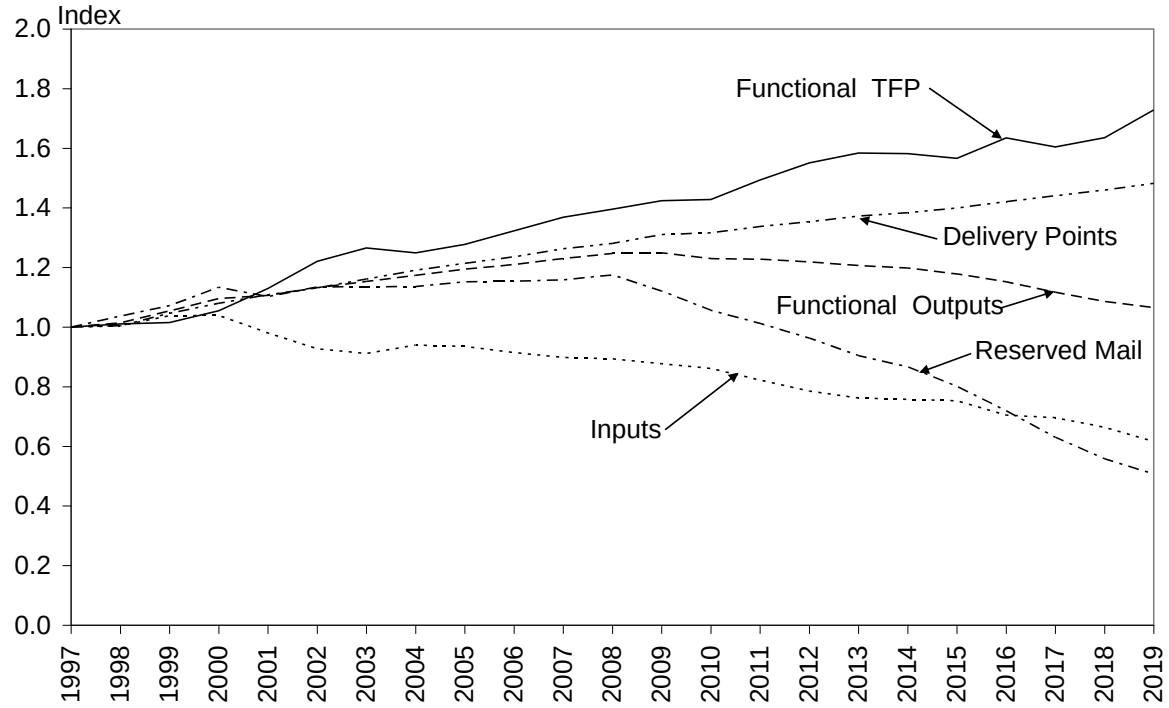
This report develops functional outputs frameworks for measuring Australia Post's aggregate and reserved services TFP. Productivity growth based on these frameworks is calculated at the aggregate level for 1992 to 2019 and at the reserved services level for 1997 to 2019.

At the corporate level, we include three functional outputs: mail billed output, non–mail billed output and delivery points. Mail billed output is formed by aggregating 15 separate mail articles components using their revenue shares. Non–mail billed output is formed by aggregating 5 separate components using their revenue shares. Delivery points are included as the best available proxy measure for the network size Australia Post is required to maintain. The three functional outputs are aggregated into a total output measure using output cost shares derived from estimating an econometric cost function. The total input measure is formed from four components: labour, mail contractors, capital and other inputs.

Australia Post's functional TFP grew by an average 1.7 per cent per annum over the last 28 years. Average annual TFP growth in the 17 years to 2008 was somewhat higher at 2.7 per cent. Average annual TFP growth reduced to a still quite strong 1.3 per cent for the period 2008 to 2013 as flat to slightly negative output growth was more than offset by reductions in input use. For the period from 2013 to 2019 average annual TFP growth turned to –0.7 per cent as continued input reduction could not offset the larger fall in functional output in that period. However, in the most recent five year period, 2015 to 2019, average annual TFP growth returned to a quite healthy 0.9 per cent as reductions in input use again exceeded the larger falls in functional output as recent reform efforts took effect.

At the reserved service level, we include two functional outputs: reserved service mail billed output and delivery points. Reserved service mail billed output is formed by aggregating 5 separate mail articles components using their revenue shares. Delivery points are again included as the best available proxy for the network Australia Post is required to maintain.

Figure A: **Australia Post's reserved service functional output and input quantity indexes and TFP index, 1997–2019**



In figure A we plot the two reserved service functional outputs, total output, total input and TFP. Reserved mail output increased from 1997 to 2002 but then flattened out through to 2009 before falling sharply after that. Delivery points, on the other hand, increased steadily over the whole period, moderating the reduction in total functional output after 2013. Total input use has trended down markedly since 2000.

Reserved service functional TFP grew at a very strong average annual rate of 2.5 per cent over the 23 year period from 1997 to 2019. It grew at an exceptionally high average annual rate of 3.9 per cent between 1997 and 2003 as output grew strongly at the same time input use decreased. As output average annual growth declined after 2003 and the level of functional output started to fall after 2009, TFP average growth has slowed somewhat but still remained quite high due to the large reduction in input use. Average annual TFP change was 2.2 per cent for the period 2003 to 2013 and 1.5 per cent for the period after 2013. In this latter period average annual functional output change of –2.1 per cent was considerably more than offset by average annual input change of –3.5 per cent.

The reserved services functional TFP index has outperformed the ABS market sector productivity index which only had an average annual growth rate of 0.5 per cent for the period after 1997. Given that Australia Post's reserved services mail output has fallen substantially since 2008, being able to outperform the productivity performance of the economy as a whole has been an impressive achievement.

1 INTRODUCTION

Australia Post has requested Economic Insights to review the methodology used in measuring its total factor productivity (TFP) at the enterprise and reserved service levels. It has also requested updated estimates of its TFP growth to be provided building on the data used in previous studies but utilising appropriate methodological refinements.

There has been a relatively long history of measuring Australia Post's TFP growth commencing with Swan Consultants (Canberra) (1992a,b). In 2002 the Australian Competition and Consumer Commission (ACCC) commissioned a report quantifying Australia Post's aggregate total factor productivity (TFP) performance over the preceding five years and the following five year regulatory period (Lawrence 2002). This report was input to the ACCC's review of Australia Post's draft notification of proposed increases in the price of a range of reserved postal services.

Australia Post later commissioned the Lawrence (2007) report which included Australia Post's actual aggregate and reserved service productivity performance up to 2007. Improvements to Australia Post's information systems over the intervening period meant that it was then possible to include considerably more detail on the outputs provided by Australia Post and to better allocate inputs between reserved and non–reserved services. This work was further updated and refined in Economic Insights (2009a).

All of these studies used data relating to a period of increasing postal volumes and used the traditional 'billed' outputs specification. Under a billed outputs framework, output is measured based on the items the business actually sells and changes in those outputs are weighted together using observed revenue shares. This approach is based on competitive market assumptions.

Since around 2009, however, the throughput volumes of a number of Australia's key infrastructure networks have started to decline due to technological change and other factors. This has particularly been the case for postal services and energy distribution and transmission networks. At the same time, however, these service providers have been required to make their networks available to an ever–increasing number of geographically dispersed customers. This has led to a delinking of revenue and costs. To more accurately capture the outputs being provided by networks, recent studies of energy network productivity have moved to measuring output on a 'functional' basis which recognises the services the network business is required to provide and not just those it directly charges customers for.

Although the throughput of energy networks has tended to stabilise over the last few years, albeit at levels below their peak of several years earlier, the fall in postal volumes has accelerated with the number of reserved letters falling by 11 per cent between 2017 and 2018. At the same time Australia Post has been required to service more delivery points, the number of which has increased broadly in line with population growth.

This report develops functional outputs frameworks for measuring Australia Post's aggregate and reserved services TFP. Productivity growth based on these frameworks is calculated at the aggregate level for 1992 to 2019 and at the reserved services level for 1997 to 2019.

We commence by briefly reviewing the earlier Lawrence (2002, 2007) and Economic Insights (2009a) reports in the remainder of this section. We then review the TFP methodology in section 2 before examining the specification of outputs and inputs and productivity results for Australia Post as a whole in section 3. In section 4 we review the TFP performance of providing the reserved services.

1.1 Previous TFP studies of Australia Post

Lawrence (2002)

Lawrence (2002) examined Australia Post's overall TFP performance using price and quantity data for 7 outputs (reserved letters, other addressed mail, unaddressed mail, money orders, agency services, accommodation and other outputs) and 4 inputs (labour, contractors, capital, and materials and services) covering the 27 year period 1976 to 2002.

Australia Post's aggregate output quantity was found to have grown strongly over the period but levelled out in 2001 and declined marginally in 2002. The average growth rate of aggregate output was a very high 4.5 per cent per annum between 1976 and 2002. This resulted from strong growth in the non–reserved output categories of other revenue, other addressed mail, agency services and unaddressed mail. Aggregate input quantity, on the other hand, was found to have grown far less strongly with an average growth rate of 1.5 per cent per annum for the entire period.

TFP grew by an average 3 per cent per annum over the whole period from 1976 to 2002. Strong TFP performance then continued through the 1990s with an average TFP growth rate of 3.5 per cent per annum for the decade to 2002. However, in line with the flattening out in both outputs and inputs at the end of the decade, TFP flattened after 2000 and declined marginally in 2002.

Lawrence (2007)

Significant improvements in Australia Post's information systems enabled some significant enhancements to be incorporated in the Lawrence (2007) study compared to earlier studies. These included:

- increased number of output categories – from 7 to 25 for the aggregate analysis and from one to five for the reserved services analysis;
- better allocation of revenue to output components reducing the size of the residual other revenue component;
- direct information on the number of full–time equivalent employees removing the need to make assumptions regarding part–time and casual staff utilisation;
- use of depreciation rates more closely linked to actual asset life experience;
- more consistent investment and retirements data available to form capital stock series; and,
- improved information on allocation of costs to reserved services which also allowed inclusion of more input categories for the reserved services analysis.

Australia Post as a whole exhibited strong TFP growth from 1990 with an average TFP increase of 2.4 per cent per annum between 1990 and 2007. This resulted from strong output growth up to 2000. After stalling in 2001 and 2002, output growth continued but at a slower rate of growth than before 2000. Combined with a levelling off in the quantity of total inputs after 2000, this resulted in TFP growth of 1.7 per cent per annum over the 5 years up to 2007.

A similar picture emerged for Australia Post's reserved services. Australia Post's reserved service output quantity grew strongly between 1997 and 2000, increasing by 12 per cent before flattening out and fluctuating around this level for the remainder of the period through to 2007. The average growth rate of reserved service output was a modest 0.7 per cent per annum between 1997 and 2007 and only 0.3 per cent per annum for the last 5 years of this period. Reserved service input quantity, on the other hand, declined over the 11 years up to 2007 with an average growth rate of –1.2 per cent per annum. TFP average growth in the 6 years to 2002 was 2.9 per cent per annum. This strong TFP performance then reduced to an average growth rate of 0.7 per cent per annum for the last five years to 2007 due to virtually unchanged output levels.

Economic Insights (2009a)

This study analysed Australia Post's aggregate and reserved service productivity performance up to 2009 and forecast productivity performance through to 2012.

Australia Post as a whole exhibited strong TFP growth with an average TFP increase of 1.8 per cent per annum between 1990 and 2009. After stalling in 2001 and 2002, output growth continued up to 2008 but at a slower rate of growth than before 2000. Output fell markedly in 2009 and was forecast to continue to decline over the next three years with a negative impact on TFP growth. Combined with a levelling off in the quantity of total inputs after 2002, this resulted in TFP growth of 1.2 per cent per annum over the 7 years to 2009 but this was forecast to reverse to –1 per cent per annum over the following three years. A reduction in the volume of letters was the main contributor to the actual and forecast fall in productivity.

A similar picture emerged for Australia Post's reserved services. Australia Post's reserved service output quantity fell markedly in 2009 and was forecast to continue falling over the next three years. The average growth rate of reserved letter output was a modest 0.6 per cent per annum between 1997 and 2009 and only 0.2 per cent per annum for the last 7 years of this period. Reserved service input quantity, on the other hand, declined over the last 13 years to 2009 with an average growth rate of –1.1 per cent per annum.

Reserved service TFP grew by an average rate of 1.7 per cent per annum over the 13 year period from 1997 to 2009. This strong TFP performance reduced to an average growth rate of 0.8 per cent per annum for the last seven years to 2009 due to virtually unchanged output levels. However, reserved service TFP fell markedly in 2009 and was forecast to fall further with a growth rate of –1.3 per cent per annum forecast over the following three years as output continued to fall under the billed outputs framework used.

2 TFP METHODOLOGY

TFP growth is defined as the proportional change in total output divided by the proportional change in total inputs used between two periods. It is usually measured using index number methods.

Productivity indexes are formed by aggregating individual output quantities into a measure of total output quantity and aggregating individual input quantities into a measure of total input quantity. The productivity index is then the ratio of the total output quantity to the total input quantity or, if forming a measure of productivity growth, the change in the ratio of total output quantity to total input quantity.

2.1 Functional versus billed outputs

Measuring the output of network businesses such as Australia Post presents a number of challenges, especially where charging formats may not well reflect the cost of producing the various services provided. Outputs can be measured on an 'as billed' basis or on a broader 'functional' basis.

'Billed' outputs are those outputs the network business explicitly charges users for. 'Functional' outputs, on the other hand, are outputs of value to the user – such as the availability of daily deliveries – but which are not explicitly charged for by the network business. Because network industries are generally natural monopolies, the price of billed outputs will typically not equal their marginal cost (as would be the case in a competitive industry). Furthermore, some key output dimensions that would be charged for in competitive industries may not be charged for at all in networks.

Like all network infrastructure industries, a major part of Australia Post's output is providing the capacity for people to send and receive postal articles. In this sense, there is an analogy between a postal network and a road network. Australia Post has the responsibility of providing the 'road' and keeping it in good condition but has little, if any, control over the amount of 'traffic' that goes down the road. The 'non–traffic' (or functional) outputs Australia Post provides are directly related to its network availability as reflected by its number of delivery and collection points and its frequency and speed of service.

The distinction between billed and functional outputs is important because network business charging practices have typically evolved on an ease of implementation and historical precedent basis or, in some cases, a political constraints basis rather than on a network cost reflective basis. Hence, Australia Post levies a high proportion of charges on postal articles (ie 'traffic' in the above road analogy) even though changes in the volume of postal articles now have a relatively small impact on the costs it faces (see the Economic Insights 2018a study of output cost elasticities) and dimensions that customers value highly such as daily availability of delivery and universal coverage are not explicitly charged for at all.

While basing charges on postal articles may have provided a reasonable proxy for overall network functional outputs and costs in years gone by when all dimensions of postal services were increasing, this is no longer the case with the total number of postal articles having fallen each year since 2008. At the same time, however, Australia Post has been required to

daily service a continually increasing number of delivery points, the growth of which has been broadly inline with population growth. Hence, while earlier TFP studies of Australia Post have used a billed outputs approach to measuring TFP growth, doing so now would significantly underestimate its output and, hence, its TFP growth.

Economic Insights' (2009b) technical report for the New Zealand Commerce Commission shows that TFP can be decomposed into a pure technical change term and terms showing the divergence between price and marginal cost for each output and the divergence between capital prices and the marginal saving in operating costs from capital investment where the industry is characterised by non–competitive conditions, as is the case for network industries. This means the most appropriate measure of output to use in measuring the TFP of network industries is one that includes all relevant functional outputs irrespective of whether they are explicitly billed for or not. Billed outputs will then be a subset of functional outputs. The appropriate weights to apply to these outputs when forming the total output measure are the difference between price and marginal cost for each output. Since marginal costs are not readily observable, their estimation requires the use of econometric methods.

Diverging growth rates between billed and other functional outputs has been a common situation for several major network industries in recent years, including electricity networks. In a series of reports for the Australian Energy Regulator, Economic Insights (2013, 2014a,b, 2018b) has used a functional outputs specification with five outputs when measuring electricity network TFP. The functional outputs included energy throughput, ratcheted peak demand, customer numbers, network length and reliability.

While one of the main billed outputs of energy networks – throughput – declined after around 2009, it subsequently stabilised and has, in most cases, increased in recent years although by 2017 it was generally still below its earlier peak levels. Postal articles throughput, on the other hand, has declined steadily over the same period and by 2017 was 36 per cent below its 2008 peak level. Given this change in circumstances since the Economic Insights (2009a) analysis of Australia Post's TFP growth which used the traditional billed outputs approach, in this report we change to using the functional outputs specification now commonly used in other network industry TFP studies.

2.2 Indexing methodology

As noted above, TFP growth is defined as the proportional change in total output divided by the proportional change in total inputs used between two periods. Mathematically, this is given by:

(1) $$TFP = \Delta Q / \Delta I$$

where ΔQ is the proportional change in the quantity of total functional output provided by Australia Post between the current period and the base period and ΔI is the corresponding proportional change in the quantity of total inputs used by Australia Post.

Most firms have a diverse range of outputs (eg Australia Post provides access to the mail network, letter carriage, financial transaction processing, retail stationery sales, etc) and a diverse range of inputs (eg labour, capital, materials and fuel). Calculating TFP requires a

means of adding together these diverse output and input quantities into measures of total output and total input quantity. The different types of outputs and inputs cannot be simply added (eg it is not meaningful to add the number of employees to the number of delivery motorbikes). Index number theory is used to overcome this problem.

The selection of the functional form for the input and output indexes has traditionally been based on two principal approaches.

The 'exact index number' approach selects index number formulations on the basis of an assumed underlying production function and assuming price–taking, profit–maximising behaviour on the part of producers. For example, the Törnqvist index used extensively in past TFP studies can be derived by assuming the underlying production function has the 'translog' form and assuming producers are price–taking revenue maximisers and price–taking cost minimisers.

The 'axiomatic' approach to the selection of an appropriate index formulation specifies a number of desirable properties an index formulation should possess. Potential indexes are then evaluated against the specified properties and the index that passes the most tests would be preferred for the analysis.

Diewert (1993) reviewed alternate index number formulations to determine which index was best suited to TFP calculations. An axiomatic procedure was used and Diewert proposed certain tests to evaluate the alternate indexes. These included:

- the constant quantities test: if quantities are the same in two periods, then the output index should be the same in both periods irrespective of the price of the goods in both periods;
- the constant basket test: this states that if prices are constant over two periods, then the level of output in period 1 compared to period 0 is equal to the value of output in period 1 divided by the value of output in period 0;
- the proportional increase in outputs test: this states that if all outputs in period t are multiplied by a common factor, λ, then the output index in period t compared to period 0 should increase by λ also; and
- the time reversal test: this states that if the prices and quantities in period 0 and t are interchanged, then the resulting output index should be the reciprocal of the original index.

The four most popular index formulations were evaluated against these tests. The indexes evaluated included:

- the Laspeyres base period weight index;
- the Paasche current period weight index;
- the Fisher ideal index which is the square root of the product of the Paasche and Laspeyres index; and
- the Törnqvist index which has been used extensively in previous TFP work.

When evaluated against the tests listed above, only the Fisher ideal index passed all four tests. The Laspeyres and Paasche index fail the time reversal test while the Törnqvist index fails the constant basket test.

On the basis of his analysis, Diewert recommended that the Fisher ideal index be used for TFP work although he indicated that the Törnqvist index could also be used as it closely approximates Fisher's ideal index.

In this exercise the Fisher ideal index is again chosen as the preferred index formulation. The technical specification of the Fisher ideal index is given in appendix A. To implement the TFP methodology, data is required on the price and quantity of all Australia Post's outputs and inputs. The method used to derive output cost shares is outlined in appendix B. Comparisons with earlier studies are discussed in appendix C.

3 AUSTRALIA POST'S CORPORATE OUTPUTS, INPUTS AND PRODUCTIVITY

This study uses the Economic Insights (2009a) database as a starting point which included a number of enhancements based on ongoing improvements to Australia Post's information systems and cost allocation processes compared to the earlier TFP studies. Separate TFP analyses were presented for the aggregate business level and for reserved services. In recent years Australia Post's acquisition of other businesses (such as the StarTrack courier business) makes it difficult to compile consistent data at the overall 'consolidated' business level. These businesses have little impact on Australia Post's core network operations but have had a significant impact on consolidated accounting and reporting systems. To enable a more like–with–like coverage with earlier studies and the construction of consistent data series over time, in this report we use data at the 'corporate' level for our higher level or aggregate TFP analysis which excludes recent business acquisitions such as StarTrack.

We use actual data for the 28 financial years (ending in June) 1992 to 2019. Price and quantity data were assembled for 21 individual outputs and 4 inputs which are described in the following sections. The 21 outputs are divided into three broad functional outputs – mail outputs, non–mail outputs and other functional outputs. Individual mail and non–mail outputs are aggregated to the functional mail and non–mail output levels, respectively, using revenue shares (as these are all billed outputs). The three functional outputs are then aggregated using output cost shares derived from estimation of an econometric cost function.

3.1 Mail outputs

There are 15 separate mail output components across 5 broad groups covering letters, parcels, express, international outwards and international inwards.

3.1.1 Letters

Seven different letter output components are included in the letters group as follows:

- small fullrate
- small presort
- large fullrate
- large presort
- print post
- unaddressed
- other letters.

The price for each letters group component is derived by dividing the revenue for that component by the number of articles in that component.

The letters group quantity index increased by 41 per cent between 1992 and 2002 with an average annual growth rate of 3.4 per cent. Letters growth then slowed considerably with an average annual growth rate of 0.7 per cent between 2002 and 2008. Since 2008, however,

letters growth has been strongly negative with an average annual growth rate of –7.5 per cent between 2008 and 2019. The average annual growth rate between 2015 and 2019 was more negative again at –11.3 per cent. By 2019 the letters quantity index was nearly 36 per cent below its 1992 level. This rapid turnaround in letters volumes has been due to the impact of technological change with the mass migration of both private and business communication from hard copy to electronic means.

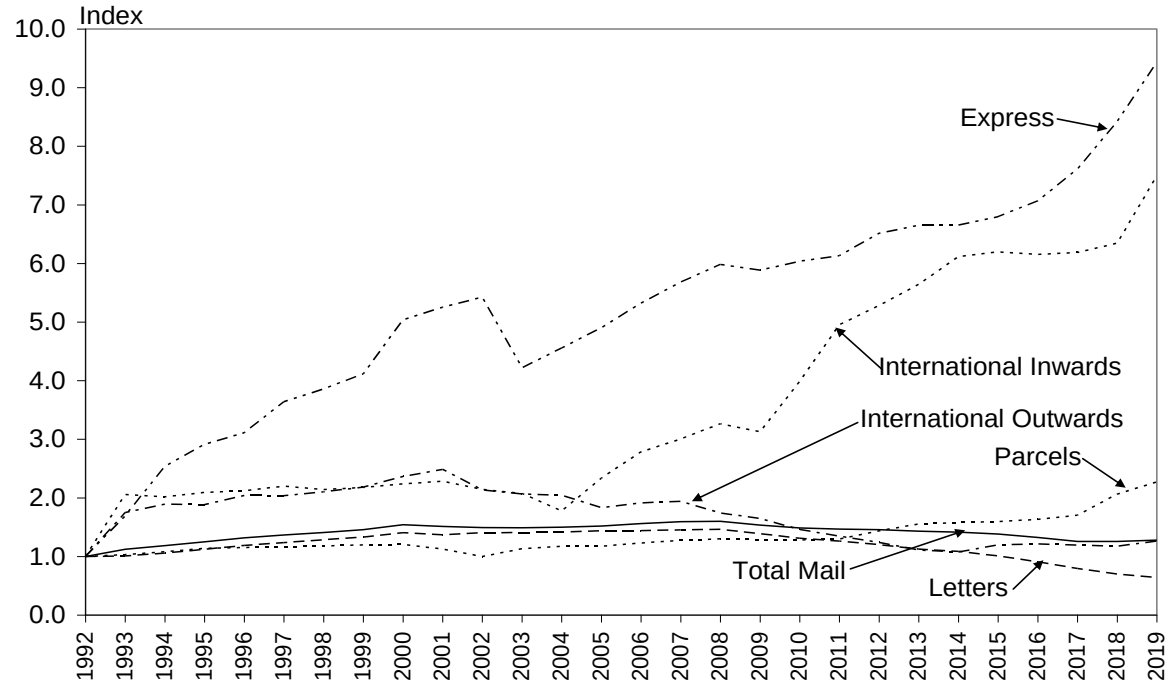
Large fullrate and large presort letters volumes and the other letters component follow a broadly similar pattern to the letters group quantity except with more variability. Although small fullrate and large presort letters volumes also follow a similar pattern, small fullrate letters volumes only increased by 16 per cent between 1992 and 2003 before rapidly falling away. In 2019 small fullrate letters volumes were nearly 70 per cent below their 1992 level. Small presort letters have fared better with a near tripling in volumes between 1992 and 2008 before falling away. By 2019 small presort volumes were still 64 per cent above their 1992 level. Print Post (publications) volumes more than doubled between 1992 and 2000 before subsequently declining. By 2019 they were still 10 per cent above their 1992 level.

Deliveries of unaddressed letters have shown a different pattern with an upwards trend over the period although volumes have fallen since 2016. By 2019 they were 60 per above their 1992 level.

The share of the letters output group in Australia Post's total corporate revenue has fallen from 65 per cent in 1992 to 36 per cent in 2019[1].

Movements in the quantity indexes for the letters group and the other mail output groups are presented in figure 1.

Figure 1: **Australia Post's mail output group quantity indexes, 1992–2019**



[1] Note total corporate revenue excludes revenue from subsidiaries such as StarTrack.

3.1.2 Parcels

Two different parcels output components are included in the parcels group as follows:

- card rate
- contract.

The parcels group quantity index increased by 21 per cent between 1992 and 2000 before falling back somewhat in the following two years and then increasing steadily through to 2018 with the growth in online shopping and associated delivery requirements. The average annual growth rate since 2002 has been 4.8 per cent. The increase in the quantity index for this group has been driven by contract parcels which have increased steadily over the period and at a strong average annual rate of 8.8 per cent since 2002. Deliveries of card rate parcels, on the other hand, have trended downwards since 1992 and by 2019 were 35 per cent below their 1992 level.

The share of the parcels output group in Australia Post's total corporate revenue has increased from 13 per cent in 1992 to 25 per cent in 2019. The share of the group's revenue contributed by contract parcels has more than doubled from 32 per cent in 1992 to 75 per cent in 2019.

3.1.3 Express

Two different express output components are included in the express group as follows:

- letters
- parcels.

The express group quantity index has grown steadily since 1992 with only a brief downturn in 2003. It increased by over nine fold between 1992 and 2019 and had an average annual growth rate of 8.3 per cent over that period[2]. Express letters volumes grew rapidly between 1992 and 2007 with a fourteen fold increase but have fallen back since although in 2019 volumes were still nearly nine times what they were in 1992. Again, the fall in Express letters volumes after 2007 likely reflects the increasing willingness of businesses to accept formal documents in electronic rather than hard copy format. Express parcels, on the other hand, have grown steadily over the period and in 2019 their volume was nearly eight times what it was in 1992.

The share of the express output group in Australia Post's total corporate revenue has increased from just under one per cent in 1992 to over 9 per cent in 2019. Most of this growth has been attributable to Express parcels with Express letters' share having fluctuated around 2 per cent since 2000.

3.1.4 International outwards

Two different international outwards output components are also included in the international outwards group as follows:

- letters
- parcels.

[2] Express Post was launched around 1990 so strong initial growth in our time period was from a small base.

The international outwards group quantity index grew from 1992 to 2001 before falling by 57 per cent between 2001 and 2014. Since 2014 it has again increased by 17 per cent. This recent increase has been driven by a reversal in the trend decline in the parcels component which has increased by 64 per cent since 2014, likely reflecting increasing activity by Australian online sellers supplying overseas customers. The outwards letters component, on the other hand, has trended downwards since 2001.

The share of the international outwards output group in Australia Post's total corporate revenue was 9.6 per cent in 1992 but had fallen to 5.7 per cent by 2019 with over three quarters of the 2019 share attributable to parcels – up from just under one quarter in 1992.

3.1.5 International inwards

Two different international inwards output components are also included in the international inwards group as follows:

- letters
- parcels.

The international inwards group quantity index fluctuated between 1992 and 2004 but has increased strongly since 2004. By 2019 it was over seven times its 1992 level. Again, this increase can be attributed to the inwards parcels component which has increased by nearly nine fold since 2004 whereas inwards letters volumes fell by nearly 60 per cent over the same period. The strong growth in inwards parcels over the last 14 years likely reflects the strong growth in overseas online shopping purchases by Australian consumers.

The share of the international inwards output group in Australia Post's total corporate revenue has increased from 3.3 per cent in 1992 to 6.3 per cent in 2019 with well over four fifths of the 2019 share attributable to parcels – up from just over one quarter in 1992.

3.2 Non–mail billed outputs

There are 5 separate non–mail billed output components covering BillPay, banking, identity services, private boxes and bags, and other billed outputs. The composition of non–mail billed outputs has changed since the Economic Insights (2009a) study as some components such as money orders are no longer significant due to technological change and others such as accommodation services are no longer offered as a significant output by Australia Post. The first four components now used have been available for the entire period and other items, including those no longer significant, are captured in the residual other billed outputs component.

Movements in the quantity indexes for the non–mail output groups are presented in figure 2.

3.2.1 BillPay

The quantity of BillPay transactions is measured by the number of transactions while the price is derived by dividing the revenue obtained from BillPay by the number of transactions. The quantity of BillPay transactions increased by over three fold between 1992 and 2004 before decreasing steadily through to 2019 to end up 49 per cent above its 1992 level.

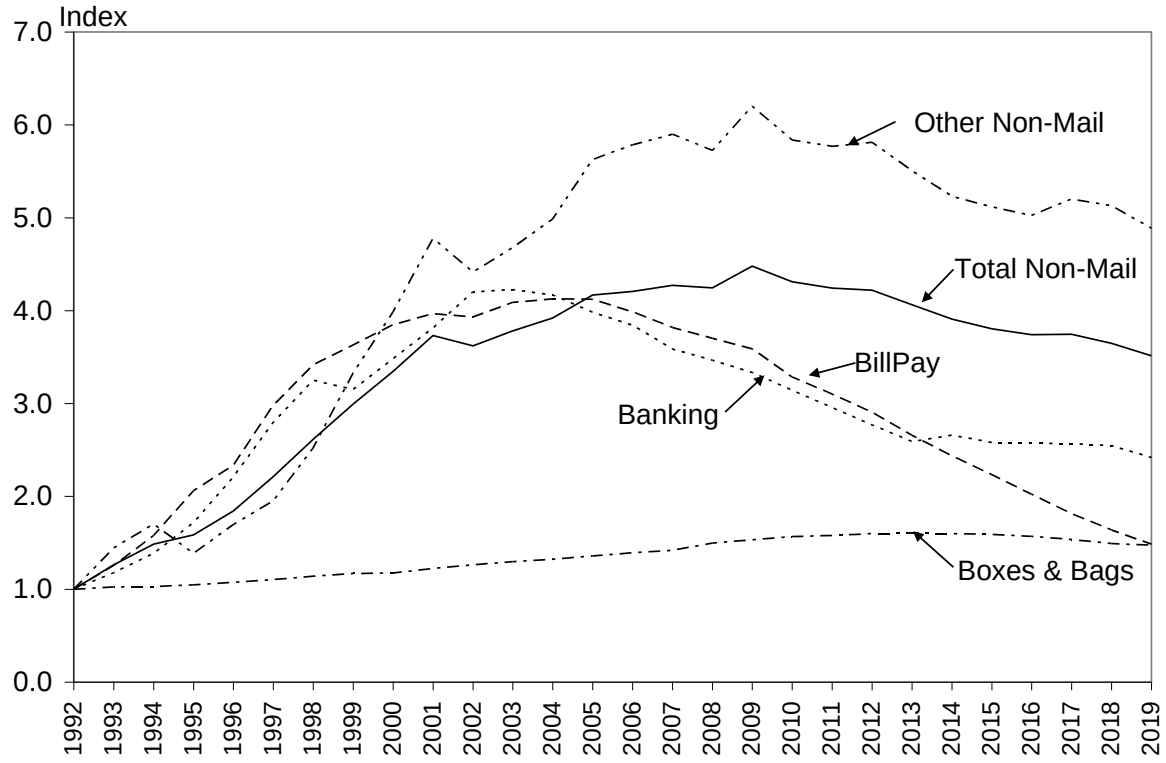
The share of BillPay transactions in Australia Post's total corporate revenue started at 3 per cent and finished the 28 year period at around 2 per cent after peaking at 6.2 per cent in 2004.

3.2.2 Banking

The quantity of banking services is measured by the number of transactions while the price is derived by dividing the commission revenue obtained from these transactions by their number. The number of banking transactions increased by over 320 per cent between 1992 and 2003. This rapid increase reflected Australia Post's success at becoming a centre for financial transactions. Between 2001 and 2005 the quantity of banking services levelled out before starting to fall. By 2019 the quantity of banking services was still 140 per cent above its 1992 level.

The share of banking services in Australia Post's total corporate revenue initially increased from around one per cent in 1992 to around 1.3 per cent in 2003 before falling back to 0.8 per cent by 2019.

Figure 2: **Australia Post's non–mail billed output group quantity indexes, 1992–2019**



3.2.3 Identity services

The quantity of identity verification services provided by Australia Post was measured by the number of services provided while the price is derived by dividing the revenue obtained from these services by their number. The quantity of identity verification services provided by Australia Post has grown rapidly over the period, and particularly since 2007. The quantity increased over 25 fold over the period and, for this reason, is not plotted in figure 2. This rapid increase reflects increased security requirements in recent years associated with issuing passports and minimising fraud risks in financial transactions, among other things.

The share of identity services in Australia Post's total corporate revenue has increased from 0.3 per cent in 1992 to 2.1 per cent in 2019.

3.2.4 Private boxes and bags

The quantity of private post box and bag rentals is measured by their number while the price is derived by dividing the revenue obtained from these services by their number. The quantity of private boxes and bags increased steadily up to 2013 before levelling off and declining somewhat in the last three years. In 2019 the quantity of private boxes and bags was 47 per cent higher than it was in 1992.

The share of private boxes and bags in Australia Post's total corporate revenue has increased from 1.4 per cent in 1992 to 2.9 per cent in 2019.

3.2.5 Other billed outputs

The other billed outputs category comprises a range of revenue sources for Australia Post including envelope and stationery sales, philatelic sales and redirection fees. The quantity of other outputs is measured by deflating the relevant revenue received by the consumer price index excluding volatile items (ABS 2018a). The quantity of other billed outputs grew strongly between 1992 and 2009, increasing by 520 per cent. It has since fallen back to be 390 per cent above its 1992 level in 2019.

The share of other billed outputs in Australia Post's total corporate revenue also increased strongly from around 2.6 per cent in 1992 to around 11.9 per cent in 2009 before falling back to 9.6 per cent in 2019.

3.3 Other functional outputs

The two preceding sections have demonstrated that since around 2008 the volumes of Australia Post's key mail and non–mail billed outputs have been in decline in the face of accelerating technological change and competition from electronic forms of communication. While increased online shopping using these same electronic platforms has facilitated growth in some of Australia Post's billed outputs such as parcel delivery, the growth in these items has not been sufficient to offset the decline in major billed outputs such as letters. At the same time, however, Australia Post has been required to make its collection and delivery networks available to an ever–increasing number of geographically dispersed customers.

As discussed in section 2.1, similar situations in other network industries such as electricity distribution have been addressed by including other functional outputs that measure the tasks the network is required to perform but which it does not explicitly charge for. In the case of energy networks, the outputs included are energy throughput, ratcheted maximum demand, customer numbers, network length and reliability. In the case of Australia Post, equivalent outputs would be postal articles and non–mail transactions, peak monthly postal articles handled (usually occurring in December) observed over the period up to that point in time, delivery points, postal delivery route length and on–time delivery performance.

Detailed data are available for postal articles and non–mail billed transactions as described in the preceding sections. Australia Post is required to meet strict on–time performance

standards and is not generally subject to major outages that more capital–intensive networks are prone to. Delivery performance has been stable in recent years. Consequently, at this point we see including a reliability output as a low priority for the postal network. For the other functional outputs, at this time the most reliable data are available for the number of delivery points. Peak demand is likely to be correlated with the total number of postal articles handled in a year and peaks can be more readily managed in postal networks by taking on temporary staff at peak times compared to, say, energy networks that are much more capital–intensive and that capital is very long–lived. Consequently, we also do not see including a peak demand variable as a high priority at this time for postal network TFP measurement.

This leaves the two indicators of (delivery) network size: the number of delivery points and route length. At this time limited reliable data are available on a consistent basis for postal network length as different state reporting systems have only been integrated into a national reporting system relatively recently. It is likely there will be a high degree of correlation between the number of delivery points that have to be served and network route length. If population growth were concentrated in inner city areas then network density would increase somewhat and route length may increase less than proportionately with the number of delivery points. However, even in this case, the number of routes would have to increase due to constraints on the amount of mail that can be carried and handled on a route, which in turn increases total distance travelled (ie including distance to the start of and from the end of each round). And, for population growth occurring in suburban land developments and rural areas, extra distance will need to be covered to pass new delivery points.

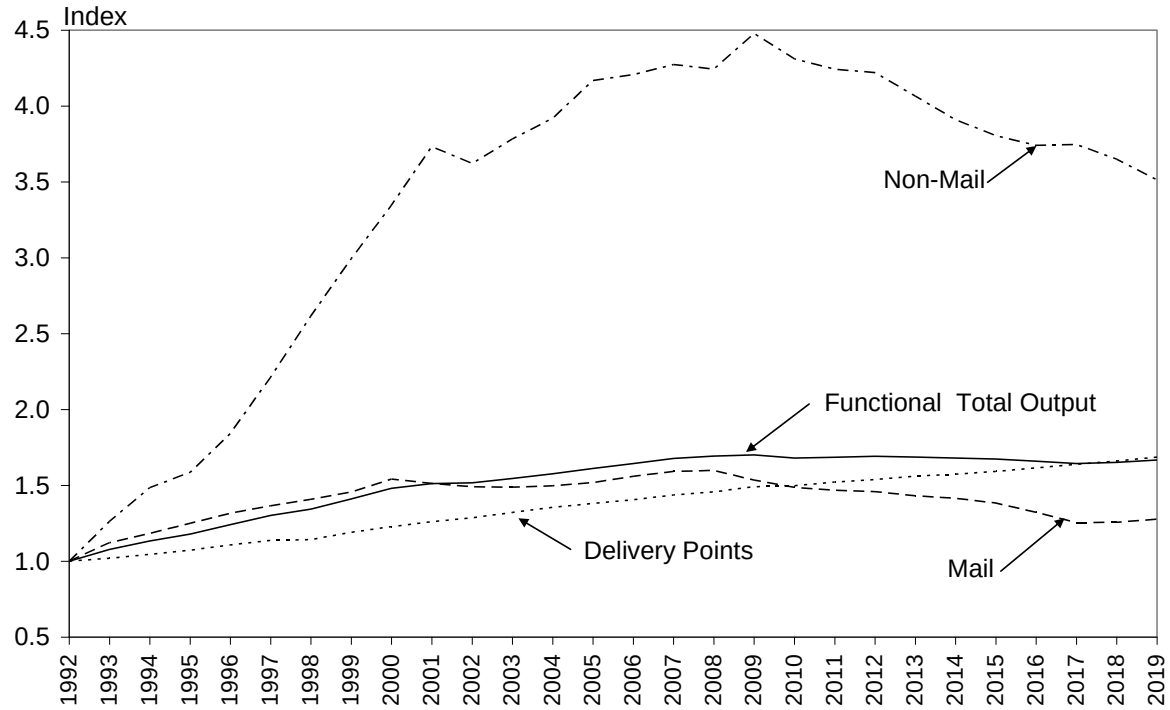
Based on the limited information currently available, Economic Insights (2018a) found that for the 115 mainly urban delivery centres covered in its analysis, total reported route length between the months of July 2012 and July 2016 increased at roughly the same rate as the number of delivery points. While we support ongoing efforts to improve data collection on route lengths covered, at this point we are of the view that the number of delivery points provides a reasonable proxy for other functional outputs Australia Post has to supply.

The TFP analysis presented in this report consequently includes three functional outputs: mail billed outputs, non–mail billed outputs and the number of delivery points. Individual mail and non–mail billed output components are aggregated up to the total mail and non–mail billed output levels, respectively, using revenue shares. But to aggregate the three functional outputs into a measure of total output, we need information on output cost shares. These shares have to be estimated using econometric cost functions given information constraints. As we only have 27 actual time–series observations, this produces a number of econometric challenges as there are insufficient observations to reliably estimate commonly used flexible functional forms such as the translog function. In similar situations we have found the more restrictive Leontief cost function method developed in Lawrence and Diewert (2003) to provide a reliable means of estimating output cost shares. This method has been used in recent work for the Australian Energy Regulator (see Economic Insights 2014a,b, 2018b) and is also used in this report. The methodology is set out in appendix B.

Estimating the Leontief cost function system of equations using data for 1992 to 2018 produces average output cost shares of 33.3 per cent for mail billed outputs, of 11.1 per cent for non–mail billed outputs and of 55.6 per cent for delivery points.

The three functional output quantity indexes and the total functional output index are graphed in figure 3.

Figure 3: **Australia Post's functional output quantity indexes, 1992–2019**



The mail billed output and non–mail billed output indexes are the same as presented in figures 1 and 2, respectively. Non–mail output increases rapidly compared to mail output up until around 2009 but both then decline steadily after this. Delivery points, on the other hand, show slower but steady growth over the whole period with average annual growth rates of just under 2 per cent for the whole period, of 2.4 per cent for 1992 to 2008, of 1.4 per cent for 2008 to 2013 and of 1.3 per cent for 2013 to 2019. This compares to average annual growth rates for mail of 0.9 per cent for the whole period, of 2.9 per cent for 1992 to 2008, of –2.2 per cent for 2008 to 2013 and of –1.9 per cent for 2013 to 2019. And, average annual growth rates for non–mail of 4.7 per cent for the whole period, of 9 per cent for 1992 to 2008, of –0.9 per cent for 2008 to 2013 and of –2.4 per cent for 2013 to 2019.

Total functional output has average annual growth rates of 1.9 per cent for the whole period, of 3.3 per cent for 1992 to 2008, of –0.1 per cent for 2008 to 2013 and of –0.2 per cent for 2013 to 2019. That is, despite the higher weight given to delivery points in forming the total functional output index, ongoing increases in the number of delivery points are insufficient to offset the large reductions occurring in the mail and non–mail billed outputs after 2008 and so total functional output also declines – but at a much lesser rate – from 2008 onwards.

3.4 Inputs

3.4.1 Labour

The quantity of labour inputs is measured as the number of full–time equivalent (FTE) staff employed directly by Australia Post, employed by Australia Post on contract and employed by licensed post office (LPO) agents. The number of FTE corporate staff employed directly by Australia Post was provided by Australia Post for the years from 2008 onwards.

The price of labour is taken to be Australia Post's corporate wages and salary costs (including superannuation and staff–associated costs) divided by the number of FTE Australia Post corporate staff. Before 2008 the price of labour is spliced with the corresponding series from Economic Insights (2009a). Australia Post provided corporate wages and salary costs back to 1998. These were also indexed back to 1992 by splicing with the corresponding series from Economic Insights (2009a). This enabled corporate FTEs for the years prior to 2008 to be formed by dividing the wages and salary variable by the price of Australia Post's directly employed labour.

Australia Post provided (non–mail delivery) corporate contract labour costs back to 1998. These were extended back to 1992 by splicing with the corresponding series from Economic Insights (2009a). Contract labour was assumed to be paid the same wage as Australia Post employees up to 1998. After 1998 this price was rolled forward using changes in the Australian Bureau of Statistics (ABS 2018b) wage price index for the transport, postal and warehousing sector. FTEs were formed by dividing contract labour costs by the composite price of labour.

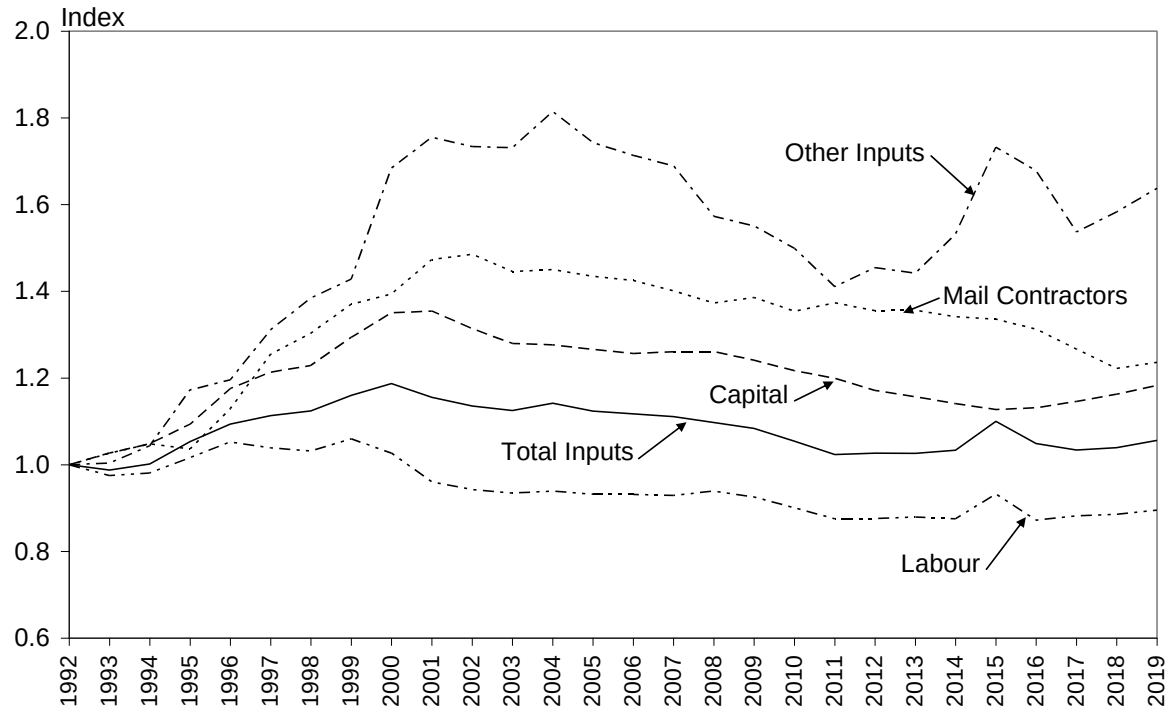
Estimating the number of LPO FTEs presents a number of challenges as from around 2012 onwards compensation to LPOs has increased faster than the Australia Post wage rate to cover increased costs being incurred by LPOs to perform additional tasks. Australia Post holds no information on the number of staff employed by LPOs. Australia Post provided total LPO costs back to 1998. These were extended back to 1992 by splicing with the corresponding series from Economic Insights (2009a). Up until 2011 the number of LPO FTEs was estimated by dividing the cost of LPOs by the same composite wage series as used for contract labour. However, from 2012 onwards we assume that LPO FTEs increased by one per cent annually with the exception of 2015 where LPO FTEs are assumed to increase by 5 per cent to allow for additional tasks such as carding allocated to the LPO level. The implicit wage rate for LPO staff is then derived for the period after 2011 by dividing LPO costs by the estimated number of LPO FTEs. As a check on the LPO assumptions, we compared the directly adjusted LPO FTE series with that obtained by dividing LPO costs by the composite wage rate for the period after 2011. The two series end at similar levels in 2018 but the directly adjusted series has a smoother pattern and so is used as the preferred series.

The total labour quantity index is graphed in figure 4 along with quantity indexes for the other three input groups and total inputs.

Labour usage initially fluctuated after 1992 before peaking at 6 per cent above its 1992 level in 1999 and then progressively declining through to 2014 before temporarily increasing and then flattening out. In 2019 labour usage was 11 per cent below its 1992 level. Labour usage declined at an average annual rate of 0.4 per cent over the whole 28 year period. This

increased to an annual rate of decline of 1.0 per cent after 2015. Total labour costs averaged 61 per cent of Australia Post's total corporate costs over the 28 year period. This share has varied within a very narrow band over the last two decades.

Figure 4: **Australia Post's corporate input quantity indexes, 1992–2019**



3.4.2 Mail contractors

The delivery and cartage of mail by contractors is an important part of postal operations. The quantity of contractor input is measured by the number of contracts while the price of contractors is derived by dividing the resource cost of delivery contracts by their number. Australia Post provided data on the number of contracts back to 2008. These were extended back to 1992 by splicing with the corresponding series from Economic Insights (2009a). The number of contracts used increased by 49 per cent between 1992 and 2002 but has since decreased to finish 24 per cent above its 1992 level in 2019. The share of contractors in total costs has increased from 3.4 per cent to 13 per cent over the last 28 years. The price of contracts was tightly held in check up to 2004 but has increased more rapidly since as Australia Post has had to pay more to retain contractor services.

3.4.3 Capital

Capital inputs are different to other inputs in that they are not fully consumed in the year of purchase. Rather, they provide a flow of services over their lives. The quantity and cost of using capital must take this phenomenon into account. The flow of services provided by capital employed by Australia Post was assumed to be a fixed proportion of the capital stock. The capital stock used by Australia Post was estimated using data on yearly investment, asset retirements, assumed depreciation rates and a point estimate of the market value of the capital stock.

The point estimates of market value used as starting points were the same as those used in Lawrence (2002) for 1990. The real stock of capital employed by Australia Post in years other than 1990 was calculated using the declining balance method summarised in the following relationship:

(2) $$S_{jt} = S_{jt-1}(1-d_j) + I_{jt} - R_{jt}$$

where: S_{jt} is the end of period real capital stock of asset class j in period t;

d_j is the declining balance rate of economic depreciation on asset class j;

I_{jt} is real investment in asset class j in period t; and

R_t is real retirements in asset class j in period t.

Corporate capital stock estimates were formed for four asset classes: land, buildings, plant and equipment, and motor vehicles. Real investment and retirement series were obtained by deflating the current price series by the National Accounts Implicit Price Deflator for net capital stocks of non–dwelling construction for land and buildings and by that for plant and equipment for the other two asset classes (ABS 2018c). The investment series used was on an assets commissioned basis (rather than an annual expenditure basis). Other assets such as software are rolled in with plant and equipment. An index of the total quantity of capital inputs was formed from the four separate capital stock estimates using the Fisher ideal index and current price stock values as weights.

Following Economic Insights (2009a), depreciation rates of zero for land, 6 per cent for buildings, 14 per cent for motor vehicles and 15 per cent for plant and equipment were used.

Economic Insights (2018a) uses an alternative method of estimating the quantity of capital inputs using constant price annuity series built up from detailed asset register data for Australia Post's mail centres and selected delivery centres. This approach is consistent with an assumption of 'one–hoss–shay' physical depreciation that is likely to be a more accurate representation for capital items and is similar to the approach used in Economic Insights (2014a,b, 2018b) for energy networks. However, unlike energy networks, postal services use a myriad of different asset types which defy the use of higher level, common measures of capacity and there has been insufficient information available to use this method for corporate activities as a whole, particularly given the much longer time–series used in the current report. Since capital inputs only make up a relatively small part of the overall cost of postal operations and given information constraints, we use the declining balance model in this report as the only tractable option available.

Given that we are using a functional output specification in the current report and need to estimate output cost shares, we can no longer use the endogenous approach to forming capital annual user costs used in Economic Insights (2009a). The endogenous approach defines the residual between total revenue and total variable costs to be the gross return to capital or the full cost of using capital in that year. The gross return has to cover depreciation costs and a residual return on capital. Instead, we adopt an exogenous approach to specifying the annual user cost using the so–called 'Jorgenson' method. This approach parallels the declining balance method outlined in equation (1) to forming the capital stock quantity and is given by:

(3) $$AUC_{jt} = (d_j + r_t - dp_{jt} / p_{jt})\, p_{jt} S_{jt}$$

where: AUC_{jt} is the annual user cost of asset class j in period t;

d_j is the declining balance rate of economic depreciation on asset class j;

r_t is the nominal rate of return in period t; and

p_{jt} is the stock price of asset class j in period t.

The same depreciation rates are used as in equation (2). The second term in brackets, the nominal rate of return, is assumed to be 10 per cent and the third term in brackets is the rate of capital gains for the asset class. Using this approach and these parameter values produced an annual user cost that had a similar average value over the 28 year period to the endogenous annual user cost approach previously used. But the exogenous approach produces a smooth annual user cost series whereas the endogenous approach produces a much more volatile series.

The quantity of capital employed by Australia Post increased by 49 per cent between 1992 and 2002 but has declined since then to finish at 24 per cent above its 1992 level in 2019.

The share of capital costs in total costs has trended downwards from 12 per cent in 1992 to 8.5 per cent in 2019.

3.4.4 Other inputs

Other inputs cover a wide range of materials and services used by Australia Post. The cost of other inputs is formed by deducting labour and mail contract costs from total corporate non–capital costs. Non–capital costs are formed by deducting voluntary redundancy package costs, depreciation, interest and tax, notional expenses and abnormal items from total Australia Post corporate expenditure. The quantity of other inputs is formed by deflating their cost by a combination of producer price indexes (PPIs). The largest and most stable component of other inputs is accommodation costs at around 20 per cent of the other costs total. The composition of the remainder of other costs is very diverse and has tended to change over time. We consequently form a composite PPI with a 20 per cent weight given to the ABS PPI for 'Non–residential property operators' (to proxy the price index for accommodation costs) and an 80 per cent weight given to the ABS's 'Final total (source)' PPI (to proxy the price of the diverse and changing balance of other costs). This approach is a departure from our earlier TFP studies of Australia Post which used the less targeted consumer price index (excluding volatile items) as the price index for other costs.

The quantity of other inputs initially increased faster than the other three input categories with an increase of around 80 per cent between 1992 and 2004. It has since trended down to finish at 64 per cent above its 1992 level in 2019. There was a sizable temporary increase in other input usage around 2015. This was associated with one–off branding and marketing initiatives aimed at increasing Australia Post's share of the parcels and courier markets.

The share of other inputs in total costs has increased from 18 per cent in 1992 to 27 per cent in 2004 and has since fallen back to 20 per cent in 2019.

Returning to figure 4, we can see that the total input quantity index follows a similar pattern to the labour quantity index but lies somewhat above it given that the other three inputs all increased more than labour did over the period. The trend in total input use for the period as a whole has been relatively flat. Total input use increased at an average annual rate of 1.1 per cent between 1992 and 2004 but has fallen at an average annual rate of 0.5 per cent over the ensuing 19 years.

3.5 Productivity

Australia Post's corporate functional output quantity, input quantity and TFP indexes are presented in figure 5 and table 1. Average growth rates in these indexes for the 28 year period from 1992 to 2019 and for a number of subperiods are presented in table 2.[3]

Functional output quantity grew strongly up to 2009 apart from a temporary levelling out in 2002. However, output has since levelled out and started to gradually decline as the reduction in both the mail and non–mail billed output components outweighed the growth in delivery points, despite delivery points having the highest output cost weight. The average annual growth rate of functional output was 1.9 per cent between 1992 and 2019. The growth rate for the first 17 years up to 2008 was a relatively high 3.3 per cent per annum but then turned slightly negative to be –0.1 per cent per annum between 2008 and 2013 before turning a little more negative to be –0.2 per cent per annum for the period from 2013 to 2019. For the last four years of the period, 2015 to 2019, the average annual growth rate was again –0.1 per cent due to the impact of larger falls in mail volumes offsetting recent higher growth in the number of delivery points.

Corporate total input quantity, on the other hand, has shown a very different growth pattern with an average annual growth rate of 0.12 per cent for the 28 year period to 2019. The growth rate for the first 17 years up to 2008 was higher at 0.6 per cent but then fell to –1.3 per cent per annum for the period 2008 to 2013 before returning to 0.5 per cent for the period 2013 to 2018. There was a small increase in total input use in 2015, due mainly to an increase in other inputs usage in that year. Since 2015 total input use has had an average annual change of –1.0 per cent.

Australia Post's functional TFP (which is the ratio of the corporate output and corporate input quantity indexes) grew by an average 1.7 per cent per annum over the last 28 years. Average annual TFP growth in the 17 years to 2008 was somewhat higher at 2.7 per cent. Average annual TFP growth reduced to a still quite strong 1.3 per cent for the period 2008 to 2013 as flat to slightly negative output growth was more than offset by reductions in input use. For the period from 2013 to 2019 average annual TFP growth turned to –0.7 per cent as functional output fell while input use increased. However, in the most recent four years period, 2015 to 2019, average annual TFP growth returned to a quite healthy 0.9 per cent as reductions in input use again exceeded the falls in functional output as recent reform efforts took effect.

The partial productivities of the four inputs are presented in figure 6 along with the TFP index and they are also presented in table 1. Average annual growth rates are presented in table 2.

[3] All growth rates quoted in this report use the logarithmic endpoint to endpoint method.

Table 1: **Australia Post's corporate functional output, input, TFP and partial productivity indexes, 1992–2019**

	Output Quantity Index	*Input Quantity Index*	*TFP Index*	*Partial productivity index of:*			
				Labour	*Contract*	*Other cost*	*Capital*
1992	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1993	1.077	0.988	1.091	1.105	1.050	1.073	1.049
1994	1.133	1.002	1.131	1.155	1.081	1.086	1.081
1995	1.179	1.053	1.120	1.160	1.137	1.006	1.078
1996	1.241	1.094	1.135	1.180	1.100	1.038	1.056
1997	1.302	1.113	1.169	1.253	1.038	0.993	1.073
1998	1.344	1.124	1.195	1.302	1.031	0.970	1.093
1999	1.410	1.160	1.216	1.330	1.029	0.988	1.090
2000	1.481	1.187	1.248	1.443	1.062	0.880	1.097
2001	1.512	1.156	1.308	1.574	1.026	0.861	1.116
2002	1.516	1.136	1.335	1.609	1.021	0.874	1.154
2003	1.545	1.125	1.373	1.653	1.069	0.893	1.207
2004	1.576	1.142	1.380	1.678	1.087	0.869	1.235
2005	1.611	1.124	1.434	1.729	1.123	0.924	1.273
2006	1.644	1.117	1.471	1.765	1.154	0.960	1.308
2007	1.678	1.111	1.510	1.805	1.197	0.993	1.331
2008	1.693	1.097	1.542	1.802	1.233	1.076	1.342
2009	1.701	1.084	1.570	1.838	1.228	1.097	1.371
2010	1.680	1.054	1.594	1.866	1.241	1.121	1.381
2011	1.685	1.023	1.646	1.925	1.227	1.194	1.405
2012	1.691	1.027	1.647	1.931	1.248	1.163	1.444
2013	1.687	1.026	1.643	1.918	1.243	1.170	1.458
2014	1.681	1.034	1.626	1.920	1.253	1.097	1.473
2015	1.674	1.100	1.522	1.795	1.253	0.966	1.485
2016	1.660	1.049	1.582	1.903	1.264	0.989	1.467
2017	1.644	1.034	1.590	1.864	1.298	1.070	1.435
2018	1.652	1.039	1.589	1.865	1.352	1.043	1.420
2019	1.668	1.056	1.579	1.863	1.349	1.019	1.410

Source: Economic Insights estimates

Table 2: **Australia Post's corporate functional output, input, TFP and partial productivity average annual growth rates, 1992–2019**

Period	*Output*	*Input*	*TFP*	*Partial productivity index of:*			
	% pa	*% pa*	*% pa*	*Labour*	*Contract*	*Other*	*Capital*
1992–2019	1.89%	0.20%	1.69%	2.31%	1.11%	0.07%	1.27%
1992–2008	3.29%	0.58%	2.71%	3.68%	1.31%	0.46%	1.84%
2008–2013	–0.07%	–1.34%	1.27%	1.25%	0.17%	1.67%	1.65%
2013–2019	–0.19%	0.47%	–0.66%	–0.48%	1.36%	–2.31%	–0.56%
2015–2019	–0.09%	–1.02%	0.93%	0.93%	1.85%	1.31%	–1.31%

Source: Economic Insights estimates

Figure 5: **Australia Post's corporate output, input and TFP indexes, 1992–2019**

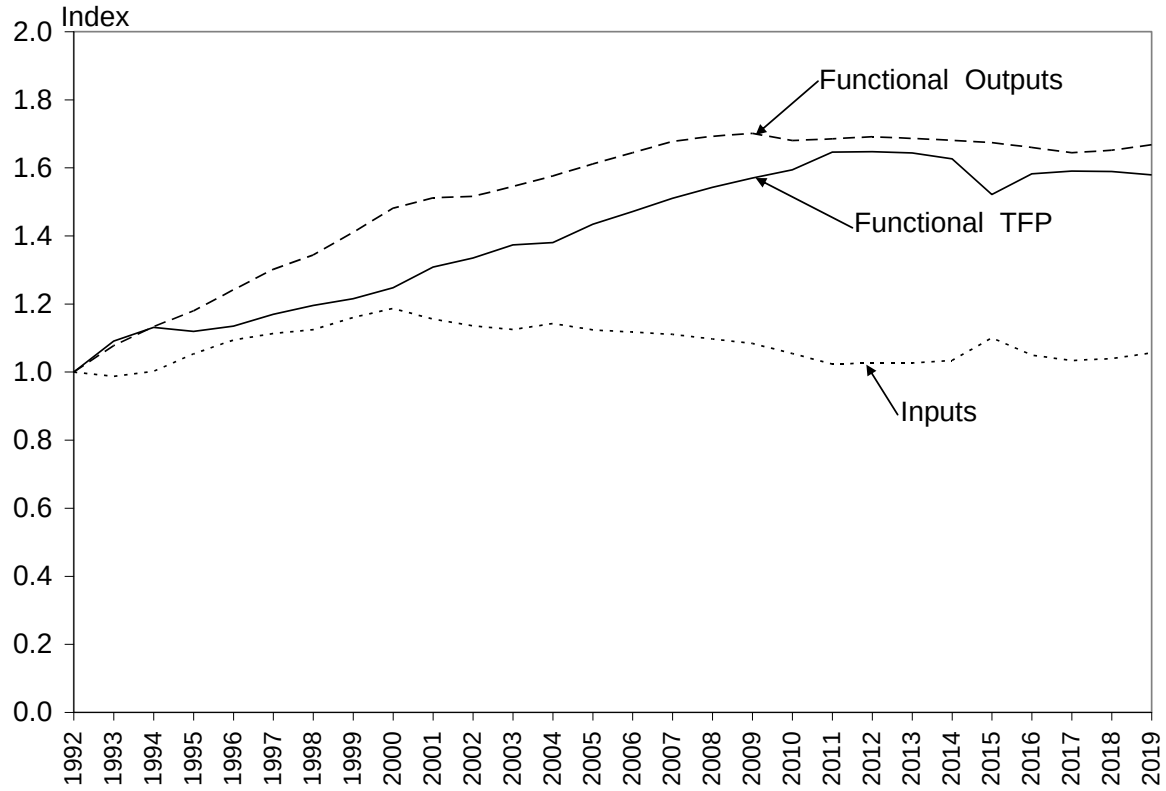
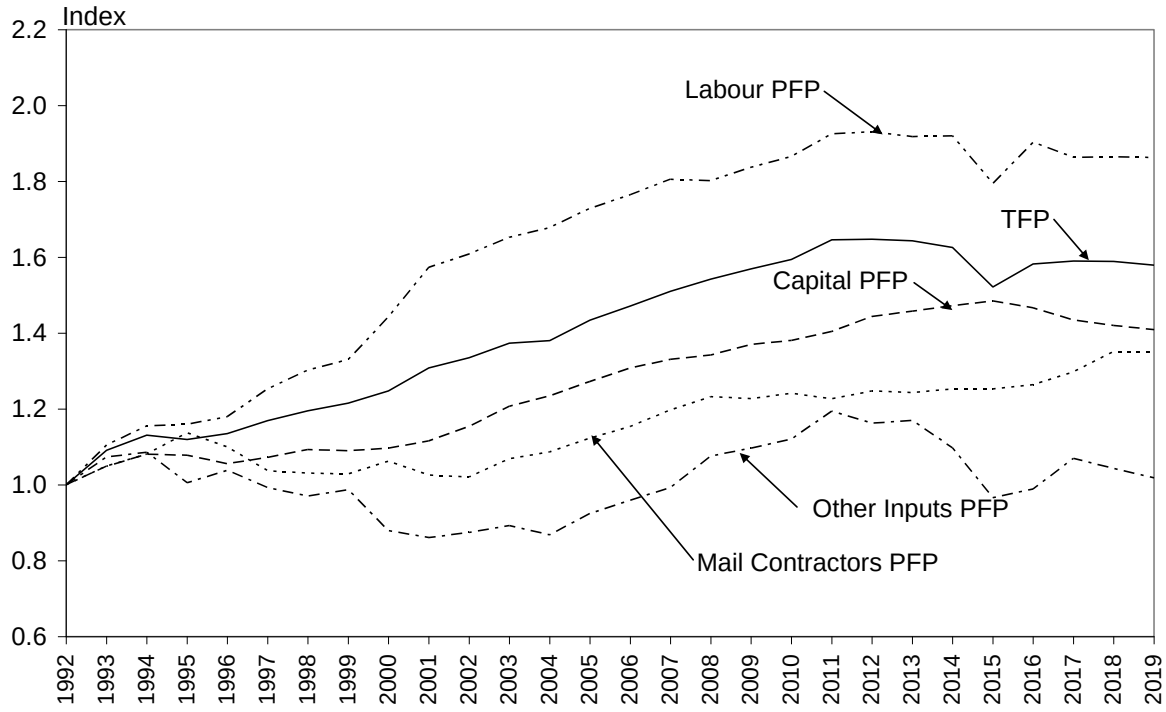


Figure 6: **Australia Post's corporate partial productivity and TFP indexes, 1992–2019**



Partial productivity indexes are derived by dividing the corporate functional output quantity index by the quantity index for the relevant input category. In simplified terms, the TFP index

is effectively a weighted average of the partial productivity indexes where the weights are complex terms involving the cost shares of the four inputs.

From figure 6 we see that labour partial productivity has increased faster than TFP which has in turn increased faster than the mail contractor, capital and other inputs partial productivities. Labour partial productivity has grown at an average annual rate of 2.3 per cent over the whole 28 year period and retained a positive growth rate of 1.3 per cent during the period 2008 to 2013 when output levelled off. For the period after 2013 average annual labour productivity growth was negative at –0.5 per cent although positive growth in labour productivity at an average annual rate of 0.9 per cent was again seen after 2015 as reforms took effect. Mail contractor partial productivity growth has also been quite strong from 2002 onwards and has remained positive in recent years as the number of mail contracts has been reduced. Capital partial productivity growth has also been quite strong although it has reduced in recent years, likely reflecting some substitution of capital for labour as reforms are rolled out. Other inputs partial productivity has shown quite strong average annual growth of 1.3 per cent since 2015.

3.6 Econometric analysis of TFP growth

Productivity improvements as measured by TFP can result from a number of factors including; technological improvements in the way mail is handled, management–induced improvements in the way operations are carried out, and changes in the market serviced. A more densely settled geographical area, for example, would be cheaper to deliver mail to on a per unit basis than a sparsely settled area. If the market being serviced by Australia Post is changing through time, measured productivity could be affected even if there has been no underlying technical improvement in postal operations.

Swan Consultants (Canberra) (1992a), Lawrence (2002, 2007) and Economic Insights (2009a) estimated the underlying rate of technological improvement in postal operations by decomposing TFP using an econometric model. The model confirmed that Australia Post's productivity growth was influenced by the growth in its network. The earlier studies used a billed outputs framework rather than a functional outputs framework. While the move to a functional outputs framework in the current study largely addresses the key issues identified in the earlier econometric analyses, we update the earlier analysis here for completeness. We again look at the effects of two technological developments which can be expected to impact on Australia Post.

The first of these concerns changes in Australia Post's outputs and methods of service delivery. Since 1991 Australia Post has continued to enhance its productivity through the establishment of agencies and expansion in its range of activities to include shopfronts and the development of specialised services.

The second technological development concerns the growth in the use of the internet, and more recently broadband services, which have introduced a low–cost alternative to traditional forms of communications such as letters. These technological advances have significantly reduced Australia Post's output growth although greater use of internet based shopping and associated home deliveries has also opened up some opportunities for parcel delivery services.

In Swan Consultants (Canberra) (1992a) the factor requirements function proposed by Diewert (1974) was used to derive the underlying rate of technological change. The factor requirements function is given by:

(4) $$I = C/W = f(Y, NS, T)$$

where I is a measure of corporate total input use, C is total cost, W is a measure of unit input prices, Y is a measure of billed output, NS is the number of delivery points serviced by Australia Post, and T is time.

When estimating this model, account needs to be taken of the possibility that technological change in Australia Post has varied through time. Four periods of technological change are specified in the current model which covers the period since 1992:

- 1992 to 1997 – a period when technical improvements were enhanced through better industrial relations and the corporatisation of Australia Post in 1989;
- 1998 to 2002 – a period of possible lower technological growth caused, in part, by reduced billed output growth emanating from the introduction of the internet and broadband services[4];
- 2003 to 2012 – a period of lower billed output growth up to 2008 and then falling billed output after that with a similar pattern of (billed) productivity growth due to little change in input use up to 2010 and reduced input use after that; and
- 2013 to 2018 – a period of larger reductions in billed outputs as use of the competing electronic communication platforms matures but Australia Post is required to service an expanding delivery and collection network.

As in the previous studies, a logarithmic form of equation (4) was specified to account for the above technological changes. Specifically, the model estimated is given by:

(5) $$\ln I = \sum_{i=1}^{4} \alpha_{0i} \cdot D_i + \sum_{i=1}^{4} \beta_{0i} \cdot D_i \cdot T + \varepsilon_y \cdot \ln Y + \varepsilon_{NS} \cdot \ln NS + \varepsilon$$

where D_i are dummy variables corresponding to the four hypothesised periods of differential technological growth and the parameters ε_y and ε_{NS} measure the cost elasticities of billed output and delivery points, respectively. This specification of changes in the structure of cost is very flexible in that both the average levels of technology and the rate of technological growth can differ between periods.

The model was estimated with constant returns to scale imposed and the results are given in table 3. Estimation was carried out over the 27–year period actual data are available. The estimated model fits the data relatively well as indicated by the R–squared figure of 0.91 although some variables have lower significance levels than previously. The elasticity of cost with respect to output is estimated at 0.17. It follows that the elasticity of cost with respect to network size is 0.83.

[4] Clarke (2004) noted: "By late 1998, the claim was made that 1.27 million households were online, 'a jump of almost 50 per cent in 12 months' (DCITA 1998). By November 2000, more than 50% of Australian adults were online and nearly 40% of households had Internet access. There were 696 ISPs, and 3.92 million user-accounts with those ISPs, 87% of which were home-based."

The model results can be used to decompose Australia Post's billed productivity performance. Specifically, it can be shown that:

(6) $$\dot{TFP} = \dot{TGR} + \left(1 - \varepsilon_y\right)\dot{Y} - \varepsilon_{NS}\,\dot{NS}$$

where: $\dot{TFP}$ is growth in unadjusted billed TFP;

$\dot{TGR}$ is technological growth;

$\dot{Y}$ is growth in billed output;

$\dot{NS}$ is growth in the size of Australia Post's network;

ε_y is the elasticity of input use with respect to billed output; and

ε_{NS} is the elasticity of input use with respect to the size of the network serviced.

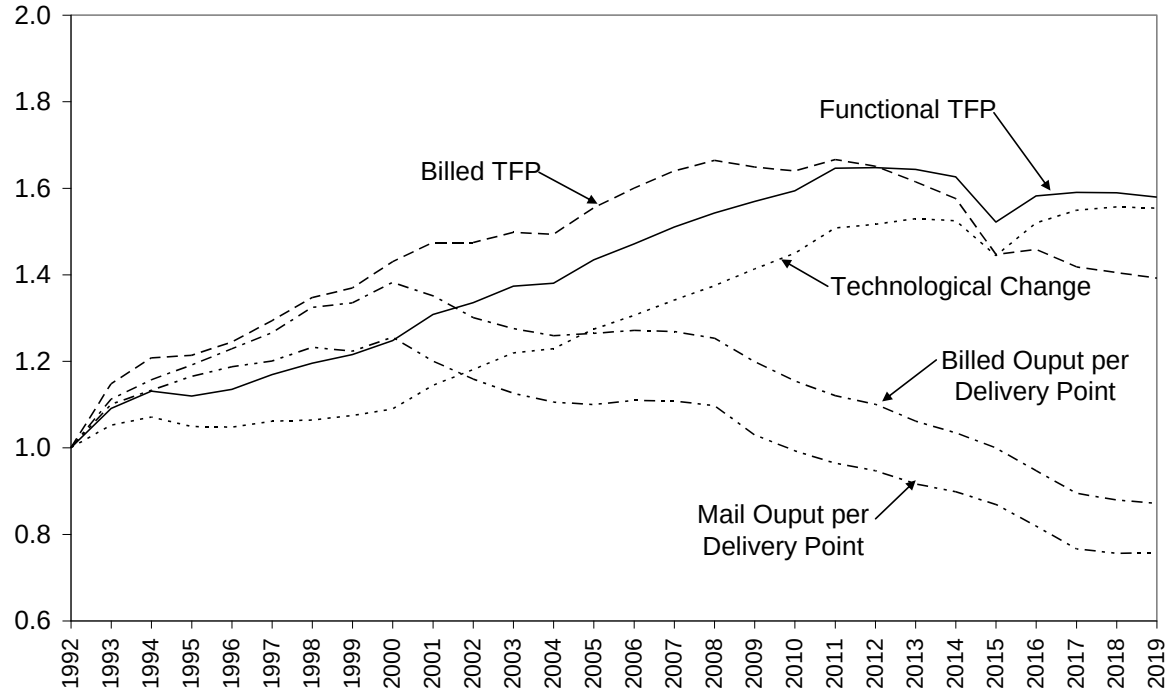
Table 3: **Estimated parameters of Australia Post's factor requirements function with constant returns to scale imposed**

Parameter	*Parameter estimate*	*t–statistic*
α_{01}	2.174	0.682
α_{02}	0.141	2.156
α_{03}	0.123	1.642
α_{04}	–0.290	–1.725
β_{01}	–0.008	–1.132
β_{02}	–0.027	–5.242
β_{03}	–0.026	–8.585
β_{04}	–0.005	–0.775
ε_y	0.166	1.157
ε_{NS}	0.834	1.157
R–squared	0.91	
Number of observations	27	

Equation (6) can be rearranged to provide an estimate of technological change which is effectively billed TFP growth adjusted for the effects of billed output and network size changes. The results of implementing this formula are given in figure 7 where it can be seen that Australia Post recorded significant technological change (or adjusted billed TFP growth) over the 27 year period. Functional TFP is also plotted in figure 7. The patterns of functional TFP and of technological change or adjusted billed TFP growth are very similar over the period, particularly from 2000 onwards, providing additional support for our move to using the functional outputs approach to measuring productivity performance.

We also plot billed output per delivery point and mail output per delivery point in figure 7. Both these network density measures grew strongly between 1992 and 1994 but then at a slower rate until 2000 at which point both reversed in direction and started to decrease. The

Figure 7: **Australia Post's technological change and functional TFP growth, 1992–2019**



fall in both measures accelerated after 2008 and again after 2015 although both levelled off somewhat after 2017. By 2019 the billed output per delivery point measure had fallen back to 13 per cent below its 1992 level after having been 38 per cent higher than its 1992 level in 2000. By 2019 the mail output per delivery point measure had fallen back to 24 per cent below its 1992 level after having been 26 per cent higher than its 1992 level in 2000. The initial divergence of these two measures between 1992 and 2000 shows the success of Australia Post in diversifying away from mail products over this period. After this, however, both mail and non–mail billed outputs grew less strongly and have both consistently fallen since 2009 in the face of increased competition from electronic communication platforms, while the number of delivery points that have to be served has exhibited steady growth over the whole period. Despite this adverse movement in its operating environment conditions, Australia Post has been able to achieve good growth in its functional TFP over the period.

4 RESERVED SERVICE OUTPUTS, INPUTS AND PRODUCTIVITY

The preceding section examined the TFP performance of Australia Post at the corporate level over the last 28 years. In this section we examine the TFP performance of Australia Post's reserved letter service over the last 23 years, 1997 to 2019. The analysis updates the earlier Lawrence (2002, 2007) and Economic Insights (2009a) reserved services TFP studies. Since the original Lawrence (2002) study Australia Post has made significant advances with its information systems and Lawrence (2007) included improved information on the allocation of costs to reserved services which also allowed inclusion of more input and output categories for the reserved services analysis. This study uses the same framework as Economic Insights (2009a) but with ongoing improvements in the accuracy of both input and output allocations to reserved services. The current study allocates Print Post (publications) to reserved services and excludes International inwards from reserved services over the whole period to better reflect recent changes in reserved categories while allowing more like–with–like comparisons over time. In this study we also move to using a functional outputs specification for measuring reserved services productivity.

4.1 Reserved service outputs and inputs

4.1.1 Reserved service billed outputs

Australia Post's reserved services cover 5 of the 20 individual billed output components included in the corporate level TFP analysis discussed in section 3. Australia Post provided data on the reserved service parts of the following 5 letters output components:

- small fullrate
- small presort
- large fullrate
- large presort
- Print Post (publications).

The quantity of reserved services mail is measured by forming an index of the quantities of the five letters components using revenue weights. Prices for each of the 5 components are derived by dividing the revenue obtained for each component by the relevant number of articles. The quantity of reserved services mail output increased by nearly 18 per cent between 1997 and 2008 but then fell by well over 50 per cent between 2008 and 2019. The movements in the 5 output component quantities have followed a broadly similar pattern over the last 23 years and all declined after 2008. The quantities of small fullrate and large fullrate reserved letters have both fallen by around 70 per cent since 1992 while Print Post has fallen by 40 per cent over the same period. The quantities of small presort and large presort reserved letters increased substantially between 1992 and 2008 but have both subsequently fallen substantially with small presort ending up 9 per cent above its 1992 level and large presort ending up 29 per cent below its 1992 level. The mail output quantity indexes are graphed in figure 7.

Figure 7: **Australia Post's reserved service billed output quantity indexes, 1997–2019**

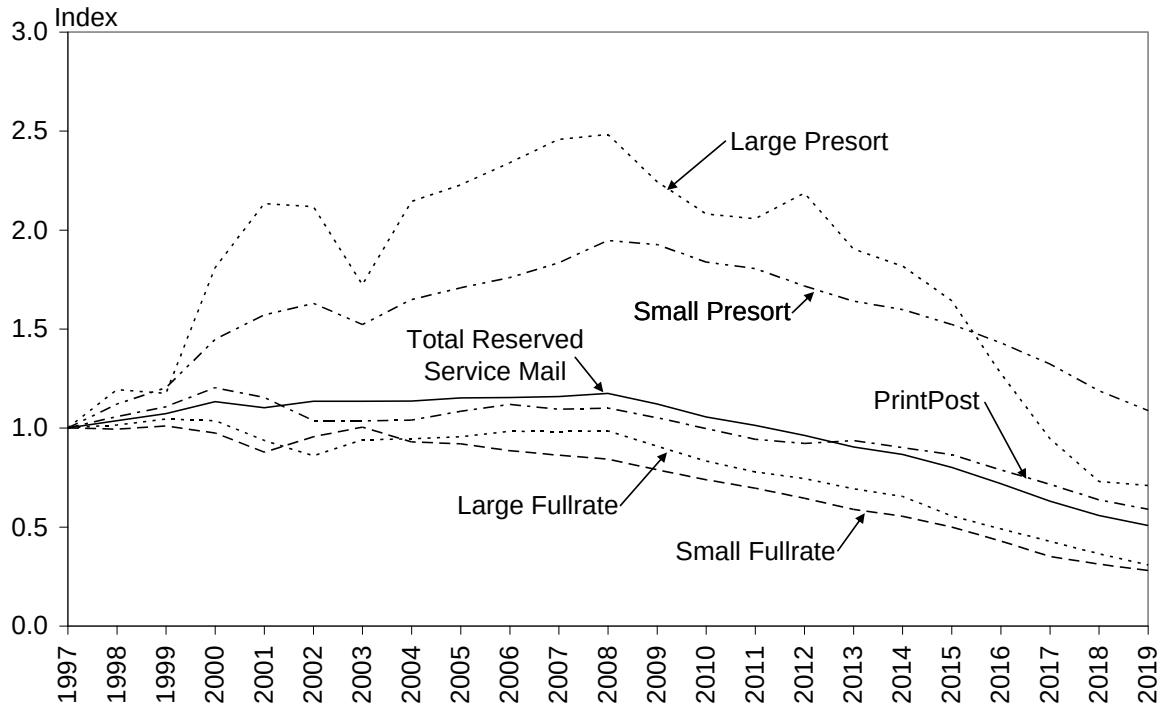
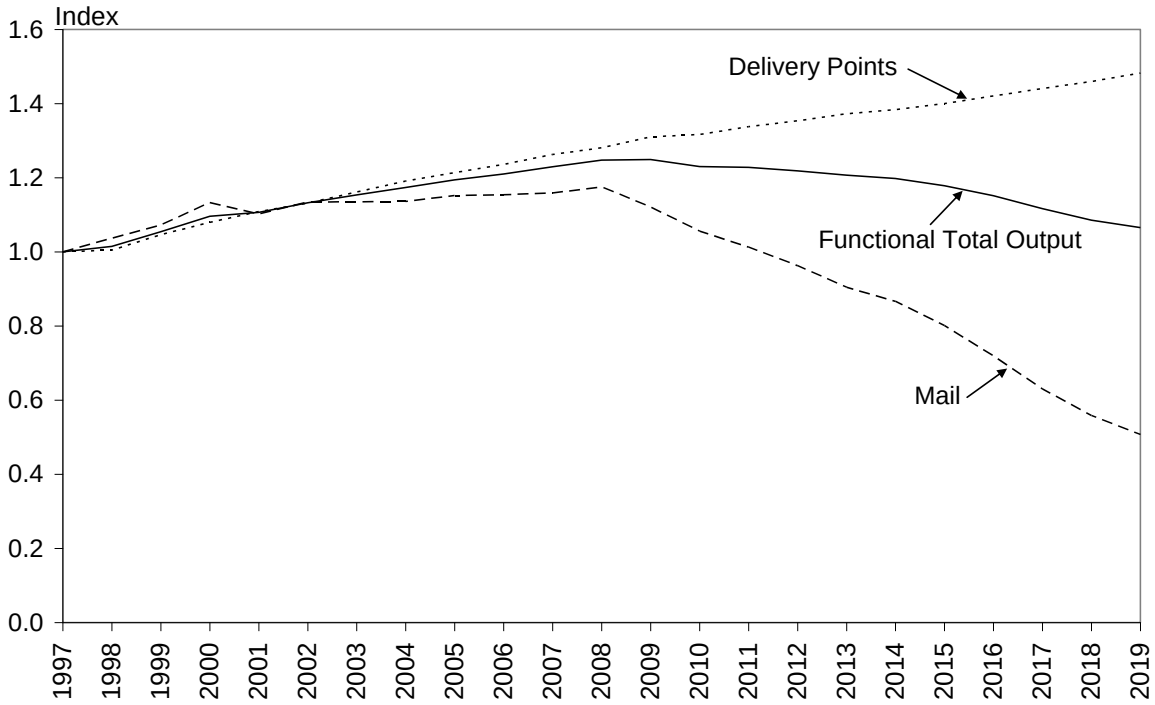


Figure 8: **Australia Post's reserved service functional output quantity indexes, 1997–2019**



Relative to the corporate level (ie excluding subsidiaries such as StarTrack), reserved service mail outputs accounted for 59 per cent of corporate revenue in 1992 but only 33 per cent in

2019. Within reserved services since 1997, the revenue share of small fullrate letters has fallen from 54 per cent to 28 per cent over the 23 year period while that of small presort letters has increased from 24 per cent to 52 per cent. The revenue share of Print Post fluctuated between 8 and 10 per cent and that of large presort letters fluctuated between 3 and 5 per cent while the share of large fullrate letters fell.

4.1.2 Reserved service other functional outputs

Given the large fall in reserved service mail output since 2008 but the need for Australia Post to service a steadily increasing number of delivery points, it is important to move to using a functional outputs framework for measuring reserved services productivity, just as we have done for the corporate level. As was the case with the corporate level, we are currently constrained to using the number of delivery points as a proxy for the size of the network Australia Post has to provide reserved services coverage to. Consequently, our functional output specification for reserved services contains two outputs: reserved service mail (formed by aggregating the five reserved service letters components using revenue shares) and the number of delivery points. The two functional outputs are aggregated using output cost shares obtained by estimating a Leontief cost function using the approach outlined in appendix B. This produced output cost shares of 30.8 per cent for reserved service mail and 69.2 per cent for delivery points. The higher output cost share for delivery points in the reserved service analysis relative to the corporate level analysis reflects the greater importance of the postal network to the delivery of reserved letters compared to total corporate output which also includes parcels and non–mail outputs.

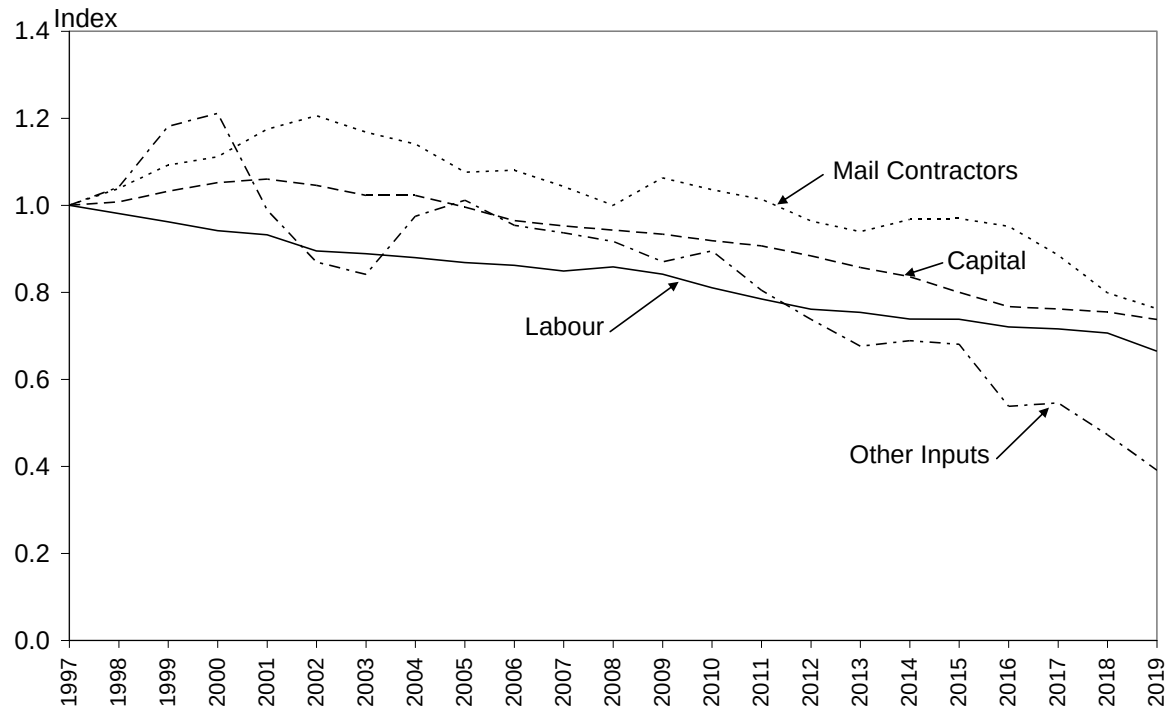
The two functional output component quantity indexes are graphed in figure 8 along with the quantity index for total functional output. The mail output quantity index increased at an average annual rate of 3.1 per cent between 1997 and 2003 before flattening out and then reversing direction to change at an average annual rate of –2.3 per cent between 2003 and 2013. This average annual rate of change has been considerably more negative at –9.6 per cent for the period after 2013. The average annual growth rate for delivery points, on the other hand, has remained positive and varied between 2.5 per cent for the period up to 2003 and 1.3 per cent for the period after 2013. Aggregating these two components using their output cost shares leads to a total functional output index that increases at an average annual rate of 2.4 per cent for the period up to 2003, then at an average annual rate of 0.5 per cent from 2003 to 2013 before reversing and changing at an average annual rate of –2.1 per cent after 2013. Again, despite the relatively high weight allocated to the delivery points output, this is more than offset by the large reductions in reserved mail output after 2013 to produce a reduction in total functional output.

4.1.3 Labour

Australia Post provided data on the FTE labour allocated to reserved services for the period from 2008 to 2019. The FTE labour input to reserved services from Economic Insights (2009a) for the period 1997 to 2008 was spliced onto the latest data to provide a consistent time series from 1997 to 2019. Reserved service labour costs were calculated by multiplying the FTEs series by the overall wage rate for Australia Post used in the corporate level analysis.

The quantity of labour used in reserved services operations fell by 35 per cent between 1997 and 2019. The rate of reduction in reserved services labour has increased somewhat in recent years with an average annual rate of change of –1.9 per cent for the 23 year period as a whole but of –2.1 per cent for the period after 2013. Labour costs as a share of total costs have varied between around 50 and 62 per cent over the last 23 years.

Figure 9: **Australia Post's reserved service input quantity indexes, 1997–2019**



Movements in the quantity indexes for the four reserved services input categories are presented in figure 9.

4.1.4 Mail contractors

Australia Post provided information on the resource cost of mail contractors used in the delivery of reserved services for the years from 2009 to 2018 based on the allocation of disaggregated mail contract cost categories. The price (resource cost) per mail contract was assumed to be the same for reserved services as for Australia Post corporate and the number of mail contracts attributable to reserved services was derived by dividing the cost by the price. For the years prior to 2009, reserved services mail contractor costs and numbers from Economic Insights (2009a) were spliced onto the later series.

The quantity of mail contract input used in reserved services operations increased by 20 per cent between 1997 and 2002 but then trended downwards to finish 24 per cent below its 1997 level in 2019. The average annual rate of change was –1.2 per cent for the 23 year period as a whole but was –1.4 per cent for the period after 2013. Contractor costs as a share of total reserved service costs have increased from 6 per cent in 1997 to 16 per cent in 2019.

4.1.5 Capital

Australia Post provided detailed data on its reserved service asset purchases and retirements from 2001 to 2019. Data prior to 2001 was taken from Economic Insights (2009a). We work at the same level of aggregation as in the corporate Australia Post analysis reported in section 3 and have four asset groups: land, buildings, plant and equipment, and motor vehicles. Real investment and retirement series were obtained by deflating the current price series by the National Accounts Implicit Price Deflator for net capital stocks of non–dwelling construction for land and buildings and by that for plant and equipment for the other two asset classes (ABS 2018c). The point estimates of reserved service asset stocks are taken to be those developed by the ACCC for the year 2001 during its 2002 pricing review. These point estimates are updated and backdated using equation (2) and the constant price asset purchases and retirements series. An index of the total quantity of capital inputs was then formed from the four separate capital stock estimates using the Fisher ideal index and current price stock values as weights. The annual user cost of capital is again formed using the 'Jorgenson' approach outlined in equation (3).

The quantity of capital used in the provision of the reserved letters service increased by 6 per cent between 1997 and 2001 before trending downwards for the remainder of the period to finish up 26 per cent below its 1997 level in 2019. The share of capital in total reserved service costs started at 12 per cent in 1997 before trending down to 9 per cent in 2019.

4.1.6 Other costs

Materials and services costs are derived by subtracting labour costs, contractor costs and depreciation from total domestic reserved letter expenditure. Australia Post was able to supply domestic reserved letter expenditure from 2013 to 2019. Another series for total reserved letter expenditure was spliced onto this series back to 2009 and the corresponding series from Economic Insights (2009a) was spliced on for earlier years. The price of other inputs is taken to be the same composite PPI as at the corporate level with a 20 per cent weight given to the ABS PPI for 'Non–residential property operators' (to proxy the price index for accommodation costs) and an 80 per cent weight given to the ABS's 'Final total (source)' PPI (to proxy the price of the diverse and changing balance of other costs). The quantity of other inputs is again derived by deflating the estimated cost by the composite PPI.

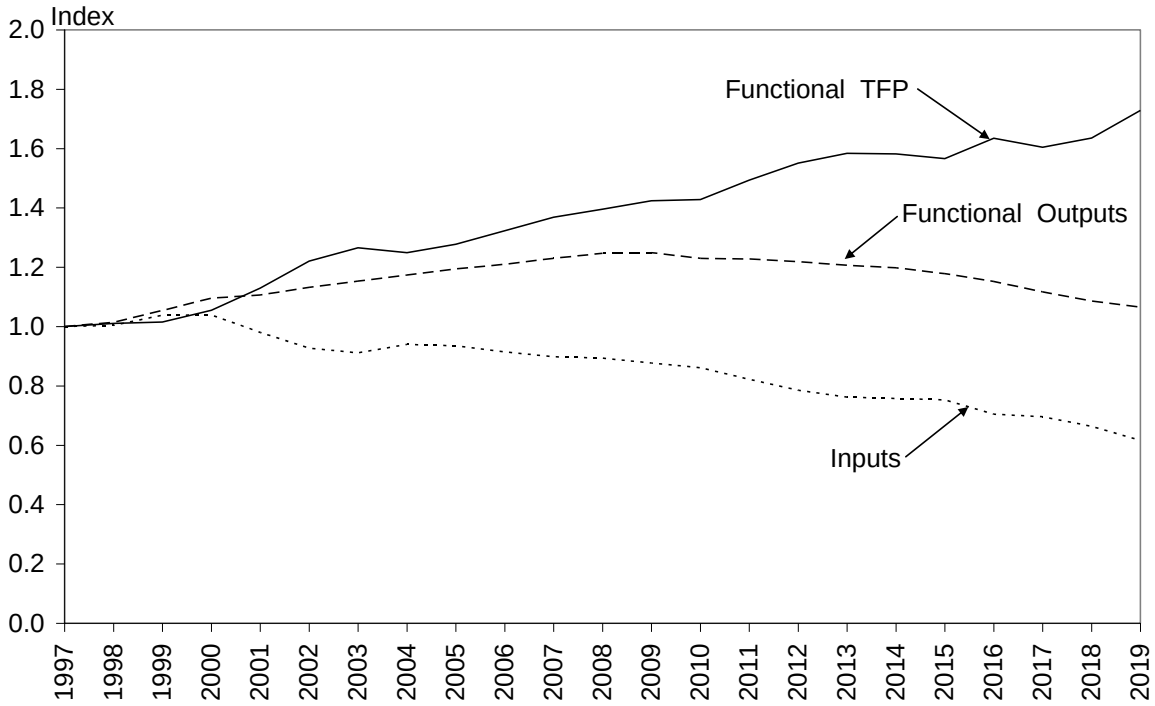
The quantity of other inputs increased by 20 per cent between 1997 and 2000 and then trended downwards to finish up at 39 per cent of its 1997 level in 2019. The share of other inputs in total reserved service costs trended downwards from 28 per cent in 1997 to 14 per cent in 2019.

4.2 Reserved service productivity

Australia Post's reserved service functional output quantity, input quantity and TFP indexes are presented in figure 10 and table 4. Average annual growth rates in these indexes for the 23 year period 1997 to 2019 and for subperiods up to and after 2003 and 2013 are presented in table 5.

The reserved service total functional output index grew at an average annual rate of 0.3 per cent over the 23 year period to 2019. However, as noted above, there are three distinct phases over this period starting with strong average annual growth of 2.4 per cent for the period up to 2003 as reserved mail output and delivery points both increased. This then reduced to an average annual rate of 0.5 per cent from 2003 to 2013 as reserved mail output flattened out and started to decline from 2009 onwards. With the acceleration in the rate of decline in reserved mail after 2013, total functional output's average annual change declined to –2.1 per cent, despite the ongoing increase in delivery points and the high weight they receive in forming the functional output index.

Figure 10: **Australia Post's reserved service functional output and input quantity and TFP indexes, 1997–2019**



Reserved service input quantity, on the other hand, has declined over the last 23 years with an average annual growth rate of –2.2 per cent. In this case, the average annual growth rate has progressively become more negative over the period. It was –1.6 per cent for the period up to 2003, then –1.8 per cent for the middle period from 2003 to 2013 and then –3.5 per cent for the period after 2013 as reform efforts have taken effect.

Reserved service functional TFP grows at a very strong average annual rate of 2.5 per cent over the 23 year period from 1997 to 2019. It grew at an exceptionally high average annual rate of 3.9 per cent between 1997 and 2003 as output grew strongly at the same time input use decreased. As output average annual growth declined after 2003 and the level of functional output started to fall after 2009, TFP average growth has slowed somewhat but still remained quite high due to the large reduction in input use. Average annual TFP change was 2.2 per cent for the period 2003 to 2013 and 1.5 per cent for the period after 2013. In this latter period average annual output change of –2.1 per cent was considerably more than offset by average annual input change of –3.5 per cent.

Table 4: **Australia Post's reserved service functional output, input, TFP and partial productivity indexes, 1997–2019**

	Output Quantity	*Input Quantity*	*TFP*	*Partial productivity index of:*			
	Index	*Index*	*Index*	*Labour*	*Contract*	*Other cost*	*Capital*
1997	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1998	1.015	1.004	1.010	1.034	0.977	0.974	1.007
1999	1.054	1.038	1.015	1.096	0.965	0.892	1.021
2000	1.096	1.039	1.055	1.164	0.986	0.905	1.042
2001	1.107	0.980	1.129	1.187	0.942	1.119	1.044
2002	1.132	0.928	1.221	1.265	0.939	1.302	1.083
2003	1.153	0.911	1.266	1.298	0.987	1.371	1.128
2004	1.174	0.940	1.249	1.334	1.029	1.205	1.148
2005	1.194	0.935	1.277	1.376	1.110	1.181	1.199
2006	1.210	0.915	1.323	1.404	1.120	1.268	1.254
2007	1.230	0.898	1.369	1.448	1.179	1.313	1.291
2008	1.247	0.894	1.395	1.453	1.248	1.361	1.323
2009	1.249	0.877	1.424	1.484	1.175	1.435	1.338
2010	1.230	0.862	1.428	1.518	1.188	1.375	1.339
2011	1.228	0.822	1.494	1.564	1.212	1.526	1.354
2012	1.219	0.786	1.551	1.601	1.264	1.653	1.379
2013	1.207	0.762	1.584	1.601	1.285	1.786	1.408
2014	1.198	0.757	1.582	1.623	1.238	1.739	1.433
2015	1.179	0.753	1.566	1.597	1.216	1.732	1.473
2016	1.152	0.704	1.635	1.598	1.210	2.140	1.502
2017	1.117	0.696	1.605	1.560	1.261	2.046	1.466
2018	1.086	0.664	1.636	1.537	1.359	2.299	1.438
2019	1.065	0.616	1.729	1.603	1.397	2.725	1.444

Source: Economic Insights estimates

Table 5: **Australia Post's reserved service functional output, input, TFP and partial productivity growth rates, 1997–2019**

Period	*Output*	*Input*	*TFP*	*Partial productivity index of:*			
	% pa	*% pa*	*% pa*	*Labour*	*Contract*	*Other*	*Capital*
1997–2019	0.29%	-2.20%	2.49%	2.14%	1.52%	4.56%	1.67%
1997–2003	2.38%	-1.55%	3.93%	4.35%	-0.21%	5.26%	2.01%
2003–2013	0.45%	-1.79%	2.24%	2.09%	2.63%	2.64%	2.22%
2013–2019	-2.08%	-3.54%	1.46%	0.02%	1.40%	7.04%	0.42%

Source: Economic Insights estimates

The partial productivities of the four inputs are presented in figure 11 along with the reserved service TFP index and are also reported in table 4. Growth rates are reported in table 5. Labour partial productivity follows a similar pattern to TFP and lies very close to it. The capital and contractor partial productivities also follow a similar pattern to TFP but lie slightly below it. As is to be expected, the other inputs partial productivity index is more

volatile than those of the other three inputs and increases strongly after 2010 as significant reductions in the use of other inputs take effect.

Figure 11: **Australia Post's reserved service partial productivity and TFP indexes, 1997–2019**

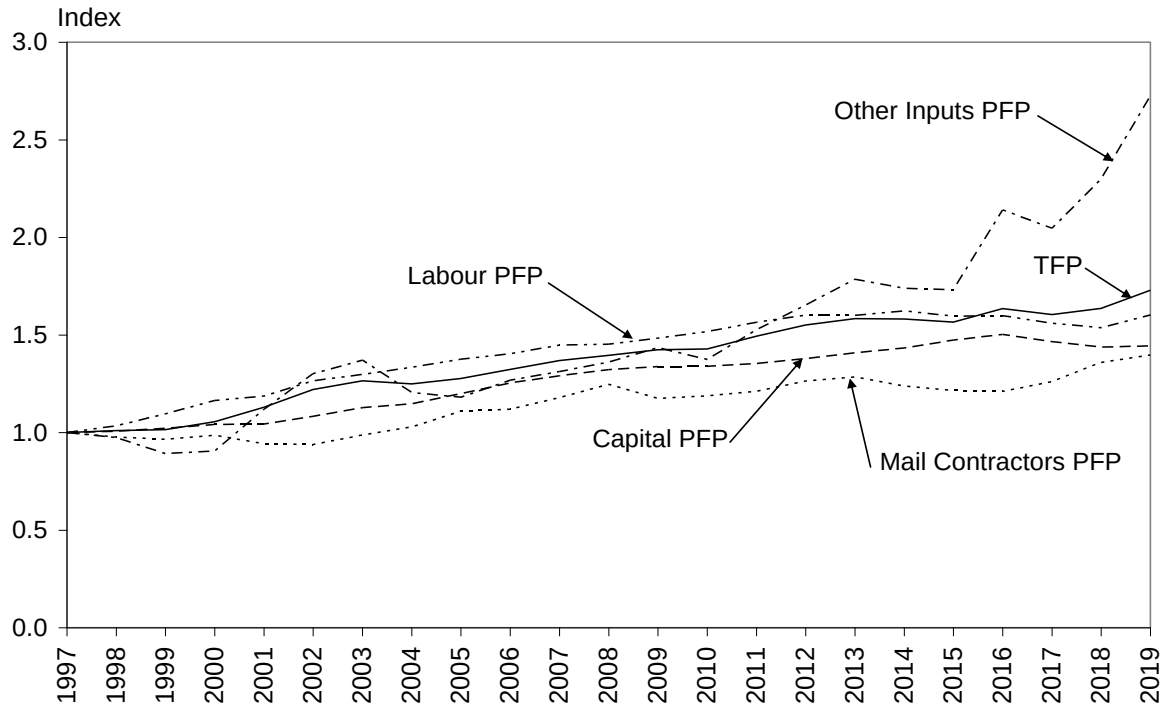
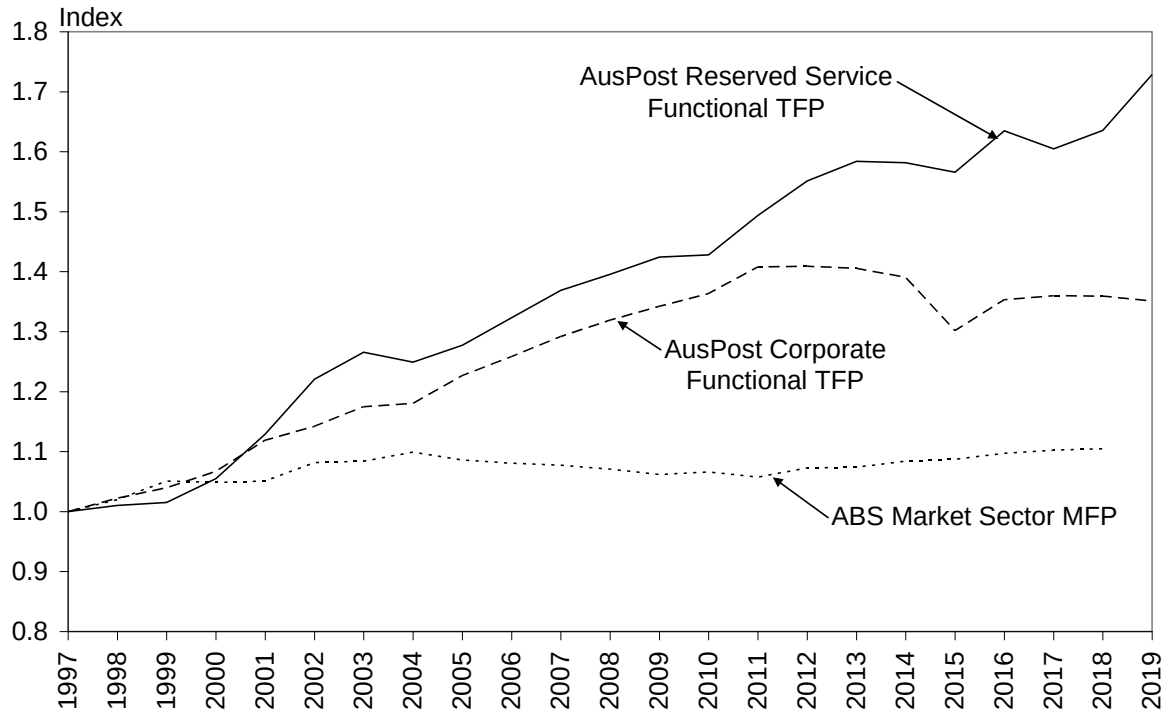


Figure 12: **Australia Post's functional TFP and ABS MFP indexes, 1997–2019**



In figure 12 we compare Australia Post's reserved service and corporate functional TFP indexes with the ABS's market sector 'multifactor' productivity (MFP) (ABS 2019d) for the period 1997 to 2019. The MFP index is the ratio of the constant price value added of the ABS's 16 market sectors divided by an index of labour and capital inputs. The MFP index is a 'net' productivity index in that intermediate inputs are deducted from the numerator and the denominator only includes the primary inputs of labour and capital. The TFP indexes, on the other hand, are 'gross' productivity indexes in that only outputs are included in the numerator and all inputs, including intermediate inputs, appear in the denominator. All else equal, a net productivity index such as the MFP index will report a higher productivity growth rate as it has a smaller denominator than the corresponding gross productivity measure.

Over the period 1997 to 2019 the reserved services functional TFP index has increased by more than the corporate Australia Post TFP index with an average annual growth rate of 2.5 per cent compared to 1.4 per cent. Both indexes have increased more than the ABS market sector MFP which only had an average annual growth rate of 0.5 per cent for the period 1997 to 2018 (the latest year the index is currently available for). If we look at the period up to 2010, the Australia Post reserved service and corporate functional TFP indexes also outperform the ABS market sector MFP index by a wide margin with average annual changes of 2.7 per cent and 2.4 per cent, respectively, compared to 0.5 per cent. For the period from 2010 to 2018, the Australia Post reserved services functional TFP index continues to outperform the ABS economy–wide index by a wide margin with an average annual change of 1.7 per cent compared to 0.4 per cent. For the same period the Australia Post corporate functional TFP index has an average annual change somewhat below that for the ABS economy–wide index at zero per cent.

Given that Australia Post's reserved services mail output has fallen substantially since 2008 and to such an extent that the negative impact has outweighed the impact of increasing delivery point numbers on total functional output, being able to outperform the productivity performance of the economy as a whole has been an impressive achievement.

4.3 Allowing for changes in service quality

As part of ongoing reform initiatives, in January 2016 Australia Post introduced a two speed delivery service for all customers similar to that only available to business customers up to that point. As part of the reform package the stamped product was aligned to the slower (or 'regular') timetable and if a customer chooses to send their letter to the faster (or 'priority') timetable, they need to purchase a priority label. Before this, all stamped letters were sent according to the faster timetable.

Australia Post's relatively strong reserved service total and partial productivity performance measured on a functional outputs basis will have been assisted in recent years by these changes which have provided all senders a choice of delivery speed. That is, if all stamped mail was required to meet the priority timetable after January 2016 as it had been prior to then, this would have likely required more resources and consequently reduced Australia Post's reserved service productivity growth to some extent from 2016 onwards.

As Australia Post has consistently achieved the required levels of on–time delivery service quality, these service changes were not included in the current study. With the 2016 reforms there is now more interest in allowing for the impact of service quality changes on measured productivity. This could be done by either including a quality of service output directly in the TFP specification or by making a second stage regression–based adjustment to the existing reserved services productivity indexes. Of these two approaches, including a service quality output directly is likely to be the more robust option.

Economic Insights' (2014a) electricity distribution economic benchmarking undertaken for the Australian Energy Regulator includes total customer minutes off–supply as a negative output. Unlike postal services, electricity supply reliability can vary substantially from year to year and across distribution businesses. The weight applied to this electricity distribution output is based on official estimates of the value consumers place on reliability. These are in turn derived from extensive surveys. To include service quality as an output in measuring Australia Post's reserved services' productivity would require a dollar value to be assigned to this output – no estimates of how much consumers value fast delivery are currently available, It would also require development of a service quality output measure compatible with the productivity measurement framework. This involves measuring the service quality output in levels form rather than as a ratio. Hence, developing both the quantity and value of a service quality output for reserved services would require some development work.

The second possible way of allowing for changes in service quality over time is by second stage adjustment. This typically involves regressing the productivity index against a relevant quality of service indicator, a time trend and other relevant variables. The second stage regression results could then be used to derive an adjusted (presumably slightly lower) productivity index that reflected continuation of the same higher level of quality of service for the last 3 years as in the earlier period. The small number of annual observations currently available for reserved services and the consequently limited number of degrees of freedom would hamper robust application of this method, as would concurrence with other significant changes impacting postal services.

Future updates of Australia Post's TFP performance will investigate the scope to explicitly allow for changes in the quality of service as reforms progress. Development work will concentrate initially on the scope to include service quality as an additional output.

APPENDIX A: THE FISHER IDEAL TFP INDEX

Mathematically, the Fisher ideal output index is given by:

(A1) $$Q_F^t = [(\sum_{i=1}^m P_i^B Y_i^t / \sum_{j=1}^m P_j^B Y_j^B)(\sum_{i=1}^m P_i^t Y_i^t / \sum_{j=1}^m P_j^t Y_j^B)]^{0.5}$$

where:

- Q_F^t is the Fisher ideal output index for observation t;
- P_i^B is the price of the ith output for the base observation;
- Y_i^t is the quantity of the ith output for observation t;
- P_i^t is the price of the ith output for observation t; and,
- Y_j^B is the quantity of the jth output for the base observation.

Similarly, the Fisher ideal input index is given by:

(A2) $$I_F^t = [(\sum_{i=1}^n W_i^B X_i^t / \sum_{j=1}^n W_j^B X_j^B)(\sum_{i=1}^n W_i^t X_i^t / \sum_{j=1}^n W_j^t X_j^B)]^{0.5}$$

where:

- I_F^t is the Fisher ideal input index for observation t;
- W_i^B is the price of the ith input for the base observation;
- X_i^t is the quantity of the ith input for observation t;
- W_i^t is the price of the ith input for observation t; and,
- X_j^B is the quantity of the jth input for the base observation.

The Fisher ideal TFP index is then given by:

(A3) $$TFP_F^t = Q_F^t / I_F^t .$$

The Fisher index can be used in either the unchained form denoted above or in the chained form used in this study where weights are more closely matched to pair–wise comparisons of observations. Denoting the Fisher output index between observations i and j by $Q_F^{i,j}$, the chained Fisher index between observations 1 and t is given by:

(A4) $$Q_F^{1,t} = 1 \times Q_F^{1,2} \times Q_F^{2,3} \times .... \times Q_F^{t-1,t} .$$

APPENDIX B: DERIVING OUTPUT COST SHARE WEIGHTS

This study uses a multi–output Leontief cost function to estimate output cost shares, using a similar procedure to that used in Lawrence and Diewert (2003). This functional form essentially assumes that Australia Post uses inputs in fixed proportions for each output and is given by:

(B1) $$C(y^t, w^t, t) = \sum_{i=1}^{M} w_i^t [\sum_{j=1}^{N} (a_{ij})^2 y_j^t (1+b_i t)]$$

where there are M inputs and N outputs, w_i is an input price, y_j is an output and t is a time trend representing technological change. The input/output coefficients a_{ij} are squared to ensure the non–negativity requirement is satisfied, ie increasing the quantity of any output cannot be achieved by reducing an input quantity. This requires the use of non–linear regression methods. To conserve degrees of freedom a common rate of technological change for each input across the three outputs was imposed but this can be either positive or negative.

The estimating equations were the M input demand equations:

(B2) $$x_i^t = \sum_{j=1}^{N} (a_{ij})^2 y_j^t (1+b_i t)$$

where the i's represent the M inputs, the j's the N outputs and t is a time trend representing the 27 years of actual data, 1992 to 2018.

The input demand equations were estimated separately using the non–linear regression facility in Shazam (Northwest Econometrics 2007) and data for the years 1992 to 2018. Given the absence of cross equation restrictions, each input demand equation is estimated separately.

We then derive the output cost shares for each output and each observation as follows:

(B3) $$h_j^t = \{\sum_{i=1}^{M} w_i^t [(a_{ij})^2 y_j^t (1+b_i t)]\} / \{\sum_{i=1}^{M} w_i^t [\sum_{j=1}^{N} (a_{ij})^2 y_j^t (1+b_i t)]\} .$$

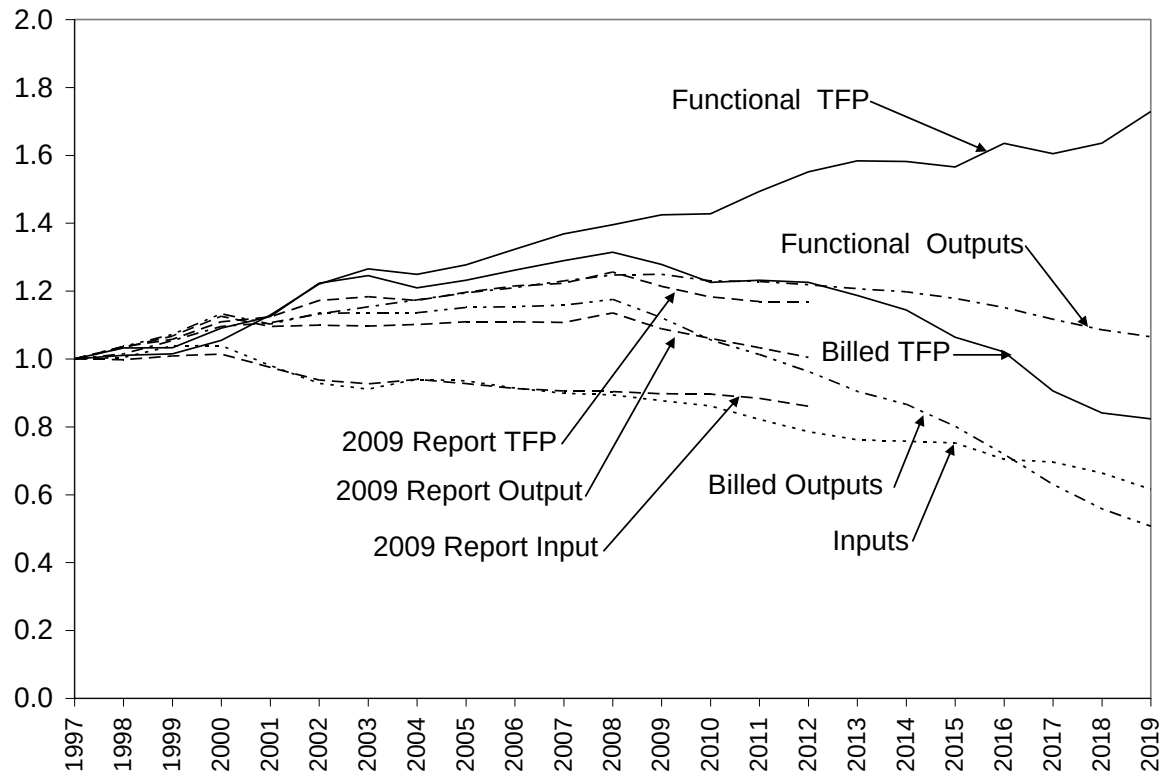
We then take the average of the estimated output cost shares across the 27 observations.

APPENDIX C: COMPARISON WITH EARLIER STUDIES

Economic Insights (2009a) found that Australia Post's reserved service TFP fell markedly in 2009 and was forecast to fall further over the ensuing three years. In contrast, the current study finds that reserved service TFP growth has slowed but remained quite high since 2009. There are several differences between the two studies that explain this difference in results.

The major difference is that the current study has moved from using a billed to a functional outputs specification. This brings measurement of Australia Post's TFP into line with TFP measurement in other network industries such as electricity distribution (see Economic Insights 2018b) by recognising the increasing functions the firm still has to provide, even when actual throughput is declining. As shown in figure E1, it leads to a divergence between the billed and functional output indexes from 2002 onwards. For the period from 2008 to 2019 average annual change for billed outputs is –7.6 per cent whereas it is –1.4 per cent for functional outputs. This leads to functional TFP growing at an average annual rate of 2.0 per cent over this period whereas the annual change for billed TFP is –4.3 per cent.

Figure E1: **Australia Post's reserved service output, input and TFP indexes, 1997–2019**



There are a number of additional differences between the current study and Economic Insights (2009a). The coverage of reserved services has changed since 2009 with reserved services now focusing on domestic letters operations. Consequently, PrintPost is included as an output in the current study and International inwards letters are excluded. The opposite was the case in Economic Insights (2009a). To allow like–with–like comparisons over time, the current study adopts the current reserved services classification for the entire time period.

The current study also uses actual data for the years 2010 to 2012 whereas Economic Insights (2009a) had to rely on forecasts for those years. The 2009 forecasts slightly underestimated falls in output and significantly underestimated falls in inputs for those years (see figure E1).

Ongoing improvements in Australia Post's record keeping and data systems have led to minor revisions to output data and these historic revisions are used in the current study. This mainly leads to a somewhat higher growth rate for small full rate letters. Revisions to input data have also been included but these have a minor impact up to 2009, as shown in figure E1. They mainly affect the Other inputs variable throughout the period and investment from 2001 onwards.

A comparison of the current study's reserved service results could also be made with one aspect of the Economic Insights (2018a) econometric cost function models used to estimate Australia Post's key cost elasticities. The Economic Insights (2018a) mail centre total and variable cost functions estimate time trend coefficients of 1.2 and 1.4 per cent, respectively, implying negative productivity growth (ie cost increases each year, all else equal). No time trend was included in the Economic Insights (2018a) delivery centre cost functions due to the shortness of the data period for delivery centres (4 years) and the less mature state of the delivery centre data.

In comparing the Economic Insights (2018a) mail centre econometric model results with the current study's reserved service TFP growth results, it should be noted that the mail centre cost function outputs are all throughput based and cover the period of declining volumes. They are thus more akin to the billed output TFP specification used in Economic Insights (2009a) rather than the functional TFP specification used in the current study and so would be expected to more heavily reflect the impact of negative billed output growth. Furthermore, mail centre costs only account for only around 19 per cent of reserved service costs.

There are also some minor differences in input measurement between the two studies with Economic Insights (2018a) using an Australia Post–specific labour price index formed from Enterprise bargaining agreement data and using a constant price annuity approach to measuring the quantity of capital inputs. The latter is akin to incorporating a one hoss shay physical depreciation assumption rather than the current report's (high level) declining balance assumption. It was feasible to use the much more detailed annuity approach for mail centres but data requirements make this approach infeasible for application to reserved service operations as a whole. Capital inputs are a relatively small component of overall reserved service costs in any case.

The major reason for differences between the current study and the Economic Insights (2009a) TFP study and one aspect of the Economic Insights (2018a) mail centre cost function models is the adoption of a functional approach to measuring outputs in the current study versus a narrow billed outputs approach to measuring outputs in the other two studies.

REFERENCES

Australian Bureau of Statistics (2019a), *Consumer Price Index, Australia*, Cat. No. 6401.0, Table 8 CPI: Analytical Series, Weighted Average of Eight Capital Cities, Canberra.

Australian Bureau of Statistics (2019b), *Wage Price Index, Australia*, Cat. No. 6345.0, Table 5a Total Hourly Rates of Pay Excluding Bonuses: Sector by Industry, Original (Financial Year Index Numbers for year ended June quarter), Canberra.

Australian Bureau of Statistics (2019c), *Australian System of National Accounts*, Cat. No. 5204.0, Table 56 Capital Stock, by Type of asset, Canberra.

Australian Bureau of Statistics (2019d), *Estimates of Industry Multifactor Productivity, Australia*, Cat. No. 5260.0.55.002, Canberra.

Clarke, R. (2004), *Origins and Nature of the Internet in Australia*, Xamax Consultancy Pty Ltd, Canberra, 29 January, Available at http://www.rogerclarke.com/II/OzI04.html

Department of Communications, Information Technology and the Arts (DCITA) (1998), *Australia's e–commerce report card*, Canberra, December.

Diewert, W.E. (1974), 'Functional forms for revenue and factor requirements functions', *International Economic Review* 15(1), 119–150.

Diewert, W.E. (1993), *The Measurement of Productivity: A Survey*, Swan Consultants (Canberra) conference on *Measuring the Economic Performance of Government Enterprises*, Sydney.

Economic Insights (2009a), *Australia Post's Aggregate and Reserved Service Productivity – 2009 Update*, Report prepared for Australia Post by Denis Lawrence, Canberra, 1 July.

Economic Insights (2009b), *The theory of network regulation in the presence of sunk costs*, Technical Report by Erwin Diewert, Denis Lawrence and John Fallon to the Commerce Commission, Canberra, 8 June.

Economic Insights (2013), *Economic Benchmarking of Electricity Network Service Providers*, Report prepared by Denis Lawrence and John Kain for the Australian Energy Regulator, Eden, 25 June.

Economic Insights (2014a), *Economic Benchmarking Assessment of Operating Expenditure for NSW and ACT Electricity DNSPs*, Report prepared by Denis Lawrence, Tim Coelli and John Kain for the Australian Energy Regulator, Eden, 17 November.

Economic Insights (2014b), *Economic Benchmarking Assessment of Operating Expenditure for NSW and Tasmanian Electricity TNSPs*, Report prepared by Denis Lawrence, Tim Coelli and John Kain for the Australian Energy Regulator, Eden, 10 November.

Economic Insights (2018a), *Updated Estimates of Australia Post's Mail Centre and Delivery Centre Cost Elasticities*, Report prepared by Denis Lawrence, Tim Coelli and John Kain for Australia Post, Eden, 30 January.

Economic Insights (2018b), *Economic Benchmarking Results for the Australian Energy*

Regulator's 2018 DNSP Benchmarking Report, Report prepared by Denis Lawrence, Tim Coelli and John Kain for the Australian Energy Regulator, Eden, 9 November.

Lawrence, Denis (2002), *Australia Post – Past and Forecast Productivity Growth*, Report by Meyrick and Associates for the Australian Competition and Consumer Commission, Canberra, 27 August.

Lawrence, Denis (2007), *Australia Post's Aggregate and Reserved Service Productivity Performance*, Report by Meyrick and Associates for Australia Post, Canberra, 22 November.

Lawrence, Denis and Erwin Diewert (2003), *Regulation of Electricity Lines Businesses, Analysis of Lines Business Performance – 1996–2003*, Report prepared by Meyrick and Associates for the New Zealand Commerce Commission, Canberra, 19 December.

Swan Consultants (Canberra) (1992a), 'Performance measures for Australia Post: 1975–76 to 1990–91', in Steering Committee on National Performance Monitoring of Government Trading Enterprises, *Measuring the Total Factor Productivity of Government Trading Enterprises*, Canberra.

Swan Consultants (Canberra) (1992b), *A Disaggregated Analysis of Australia Post's Total Factor Productivity*, Report prepared for Australia Post, Canberra.

Northwest Econometrics (2007), *SHAZAM User's Reference Manual Version 10*, Vancouver.