Australia Post
Letter Volume Demand Update

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Note

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Table of Contents

Australia Post Letter Volume Demand Update

1. Overview

This brief outlines the key results from Diversified Specifics 2022 econometric demand update of Australia Post's domestic addressed letter business. The research is aimed at updating the estimated statistical models and price elasticity estimates by extending the underlying sample data to December 2021 period.

Additionally, the models are used to generate volume projections throughout 2021/22 to 2023/24 incorporating rate rises proposed by Australia Post. These rate rises are headlined by a 9.1% increase in the basic postage rate (BPR) from $1.10 to $1.20. As these projections are based upon historical associations, the overlay of emergent trends and forthcoming events are an essential component in deriving a final set of forecasts.

2. Historical trends

Addressed letter volumes in Australia have fallen by 65% since 2006/07 within annual declines accelerating throughout the period, see Table 1. Fundamentally, this decline is being driven by the forces of e-substitution which has gained momentum following the economic downturns of the global financial crisis and, more recently, the COVID-19 pandemic.

Table 1 Australia Post's letter volume fluctuations at 5-year intervals – AAGR

	2006/07-10/11	*2011/12-15/16*	*2016/17-20/21*
Ordinary/Other Small	-5.2%	-10.0%	-12.5%
PreSort Small	-0.4%	-4.3%	-9.8%
Ordinary/Other Large	-5.8%	-9.7%	-12.2%
PreSort Large	-5.0%	-12.7%	-12.3%
Print Post	-3.0%	-5.2%	-13.4%
Total Letters	**-2.9%**	**-6.9%**	**-10.9%**

Over this same period, the Australian population has increased by 24%, expanding the number of delivery points Australia Post is required to service under its universal service obligations. This creates a sustainability dilemma for Australia Post's letters business as letter volume demand shrinks whilst the costs associated with a delivery footprint continually increasing in size.

Letter volume erosion is a worldwide issue and in response most postal authorities have increased their BPR dramatically in recent times. Comparatively, the Australia Post BPR is among the most inexpensive due to a lack of any substantive rate rises over the last five years, as highlighted in Table 2.

Table 2 Increases in the BPR by country (2017 to 2022)

Country	% change	Country	% change	Country	% change
Finland	165%	Slovakia	43%	Germany	21%
Greece	164%	UK	41%	Malta	15%
Romania	163%	Poland	36%	Luxembourg	14%
Belgium	139%	Bulgaria	30%	Hungary	12%
Estonia	131%	Portugal	28%	Switzerland	11%
Latvia	111%	Canada	26%	Australia	10%
Slovania	81%	Ireland	25%	Denmark	7%
Sweden	73%	Austria	25%	Iceland	2%
Czech Republic	71%	Netherlands	23%	Italy	0%
France	68%	United States	22%	Croatia	0%
Spain	50%	Lithuania	22%	Cyprus	0%

Source: Deutsche Post DHL Group, Canada Post, United States Postal Service and Australia Post.

3. COVID-19 impact

From March 2020, restrictions on social mobility, aimed at limiting the spread of COVID-19, altered the behaviours and lifestyle patterns of Australians. This resulted in dramatic declines in letter volumes linked to discretionary spending, especially the Promo Post sub-segment of PreSort small letter volumes and Print Post.

Australia Post's ability to fulfil its universal service obligation also became increasingly difficult as its operational network was increasingly impacted by lockdowns, quarantining requirements, and infection rates. As a result, Australia Post was granted temporary regulatory relief (TRR) in the form of extended timeframes for delivery in addition to a temporary halting of the '*Priority*' letter service, essentially resulting in a slower service. For some of Australia Post's customers, this wider delivery window may have resulted in a process failure accelerating movements away from letter communication into digital. This combination of pandemic led effects resulted in total letter volume declines of -12.3% and -11.4% in 2019/20 and 2020/21 respectively, representing a significant deterioration from the pre-COVID domestic letter volume erosion of -7.6% in 2018/19. Diversified Specifics estimated the additional decline in domestic letter volumes at Australia Post in 2020 and 2021 to be -7.5% (or -3.7%p.a.), see Table 3. These estimates indicate the pandemic impacted letter segments in differing magnitudes due to a heterogeneity of content and communication properties.

Table 3 Estimated impact of COVID-19 on Australian domestic letters
From January 2020 to December 2021[1]

Letter segment	Total volume impact (mil)	Volume impact as a % of the total
Ordinary/Other small	-57	-6.5%
PreSort small	-131	-6.7%
Ordinary/Other large	-6	-4.8%
PreSort large	-7	-8.8%
Print Post	-38	-20.4%
Total letters	**-239**	**-7.5%**

[1] Percentage changes in Table 3 reflect a comparison of total volumes across January 2020 to December 2021 as against those for January 2018 to December 2019.

Despite the recent issues confronting Australia Post's capacity to deliver letters throughout the pandemic, the technological progress that facilitates e-substitution has continued to advance at unprecedented levels. Australia's high speed NBN network has unlocked real time video communications for a larger proportion of the Australian working population. Software applications such as Microsoft Teams, allows meeting participants to share files and documentation in real time, further limiting the need for the transmission of paper-based communications that were previously in the domain of the letter. Advances in smartphone technologies combined with increased penetration rates suggest these devices now represent the preferred medium for Australians to communicate, access and share digital content. As these waves of e-substitution continue to multiply further letter volume erosion is expected.

4. Price effects and volume projections

All estimated price elasticities of demand are inelastic whilst several are statistically insignificant, see Table 4. This is unsurprising given recent volume erosion has been due to accelerating pandemic induced e-substitution pressures during a period whereby the price of a letter item has remained largely stable. Baseline projections, as derived from the set of econometric models, suggest declining total letter volumes should be anticipated every year to 2023/24, see Table 5. Scenario testing implies the imposition of the proposed rate rises are likely to have minimal material impact upon volume demand fluctuations

Table 4 Price elasticity of demand

Small letter	Ordinary / Other	-0.15
	PreSort	-0.55*
Large letter	Ordinary / Other	-0.18
	PreSort	-0.47*
Print Post		-0.06*

** denotes statistically insignificant*

Table 5 Percentage changes in total letter volume inclusive of proposed rate rises
actual *(a)* & projected *(p)* baseline
(Projections without proposed rate rises presented in parentheses)

	Pre COVID-19	Post COVID-19				
	2018/19*(a)*	**2019/20*(a)***	**2020/21*(a)***	**2021/22*(a&p)*[2]**	**2022/23*(p)***	**2023/24*(p)***
Ordinary/Other Small	-8.5	-12.5	-13.6	-10.4	-10.1 *(-9.9)*	-10.8 *(-9.9)*
PreSort Small	-7.7	-11.0	-10.1	-4.6	-8.4 *(-7.5)*	-9.2 *(-7.3)*
Ordinary/Other Large	-10.6	-10.5	-12.4	-2.5	-10.7 *(-10.7)*	-8.2 *(-7.8)*
PreSort Large	16.6	-20.1	-15.2	11.0	-13.8 *(-13.8)*	-8.9 *(-8.3)*
Print Post	-9.1	-21.3	-12.9	-4.7	-11.6 *(-11.4)*	-5.2 *(-5.0)*
Total letters	**-7.6**	**-12.3**	**-11.4**	**-5.7**	**-9.3 *(-8.7)***	**-9.3 *(-7.9)***

[2] The 2021/22 percentage changes reported in Table 5 is constructed by utilising nine months of actual values and three months of econometric projected values.

5. Concluding remarks

The key finding is that e-substitution remains, and is expected to remain, the leading statistical and economic driver of letter volumes over the foreseeable future. In the interim, increasing postage rates can assist in ensuring the sustainability of Australia Post's letters business without considerably adding to the volume erosion.

It is recommended that the econometric projections be augmented by further intelligence on emerging trends and known future events that are not directly measurable empirically. The changing dynamic of e-substitutive, economic, and pandemic related impacts reinforces the need for regular model updates and trend re-assessments to ensure strategic decision making at Australia Post continues to be based upon a reliable, structured, and scientific methodology.

For further detail please consult the source documentation.

1. INTRODUCTION

1.1 OVERVIEW

For over twenty years Diversified Specifics product segmented econometric models have explained and projected fluctuations in domestic letter volumes at Australia Post.[3] This research has allowed Australia Post to quantify letter volume erosion expectations whilst also permitting an informed, structured and scientific approach to understanding the drivers of letter volume demand within Australia.[4] Over this period e-substitution has consistently registered as the primary statistical driver of letter volume fluctuations explaining a large part of the 65% decline in total volume since 2006/07. However other factors such as changes in the price of a letter, the state of the Australian economy and delivery service performance have also been important, albeit less potent, explainers of volume demand fluctuations.

In March 2020 the COVID-19 pandemic emerged as a significant threat to consumer and commercial demand worldwide. This represented an important event for the postal industry because empirical studies have suggested periods of economic instability have a tendency towards accelerating letter volume declines.[5] The underlying rationale suggests downturns, such as the 2007/08 global financial crisis (GFC) and the 2020/21 COVID-19 pandemic, initiate a greater propensity for economic agents to engage in cost containment strategies as their profit margins are squeezed. In this environment Australia Post's key customers are therefore more likely to pursue digital alternatives in communication and this accelerates domestic letter volume erosion.

The econometric letter volume models can account for these income effects explicitly via an accelerator linked to lower levels of GDP. However, the restrictions on social mobility resulting from the COVID-19 pandemic impacted the economy and the behavioural lifestyle patterns of Australians in a manner different to downturns previously observed. This update therefore quantifies the additional 'pandemic' impact upon letter volumes after the combined effects of all the usual drivers have been accounted for.

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[3] The econometric methods deployed throughout the study vary. Vector error correction modeling (VECM) and dynamic ordinary least squares (DOLS) represent the primary modelling techniques. The VECM framework nests the structural and cyclical components of letter volume trends into a methodology that allows an examination of short and long-run fluctuations of letter volumes and their relevant drivers. DOLS techniques are also employed to improve the precision of the long-run parameter estimates for some letter segments because of data availability or the presence of structural breaks.

[4] In this context the term 'erosion' primarily refers to a shift towards digital modes of communication and away from a physical letter item. Although these switching characteristics are commonly termed 'e-substitution', the term 'substitution' for the purposes of this study also extends to other forms of erosion such as letter volume consolidation and the rationalization of mailing cycles.

[5] Paterson, CJ, Martin, VL, Nikali, H & Li, Q (2012), see bibliography.

The research process, as summarized by this documentation, estimates an updated set of econometric models aimed at explaining recent volume movements across Australia Post's five key domestic letter segments. Baseline projections of the segmented letter volumes are constructed across the 2021/22 to 2023/24 period utilising the estimated models in conjunction with forecasted values on the demand drivers. Differing scenarios underpin the projections generated, depending on the inclusion, or exclusion, of proposed changes to letter prices as provided by Australia Post. The econometric nature of this study implies each model is a function of empirical associations. It is therefore important that the projections generated by the econometric models are augmented with any additional intelligence relating to future events or emerging trends not adequately observed across the historical data.[6] Further amendments based on sound institutional knowledge and emerging trends must be continually considered.[7]

The structure of this report proceeds as follows. Section 1 outlines the research objectives and project scope. Section 2 illustrates trends in Australia Post's reserved letter segments, highlighting recent letter volume erosion. Also included in Section 2 is a presentation of the demand hypotheses and driver proxies deployed within the econometric analysis. Sections 3 to 7 contain individual summaries of the descriptive statistics, elasticities, and projections for the five key reserved letter segments that comprise total domestic addressed letters at Australia Post. Section 8 summarises the key outcomes at a total letter level and makes concluding statements. Finally, the appendices contain a technical summary of statistical outputs, data descriptions and an outline of the caveats associated with interpreting the outcomes of this econometric process.

[6] As an example, the letter volumes associated with the 2022 Australian Federal election were not included within the sample used to estimate the econometric models. The 2021/22 volume underlining the modeling is based upon nine months of actual values and 3 months of projected values. This implies April and May letter volumes attributable to the election should be considered an overlay upon the set of econometric projections for 2021/22.

[7] See Appendix D for a list of caveats on the baseline econometric projections.

1.2 OBJECTIVES

1.2.1 Primary objective

Econometrically estimate a set of segmented domestic addressed letter volume models on behalf of Australia Post to:

1) *identify the key letter volume demand drivers.*
2) *estimate a robust set of own-price elasticity estimates; and*
3) *assist with the generation of volume projections to 2023/24.*

1.2.2 Objective set

This research project aims to:

- Use Australia Post's revenue-based volumes (RBV) data to identify a comprehensive, five-dimension, product-delineated view of Australia Post's domestic addressed letters business.

- Present a numerical, tabular, and graphical descriptive summary of the trends pertaining to letter volume demand movements at a segmented level.[8]

- Specify hypotheses about the drivers of letter volume demand at a product segmented level and obtain tractable data proxies.[9]

- Use dynamic econometric techniques to model letter volume fluctuations at a product segment level where data permits and estimate parameters (elasticities) on the statistically significant volume drivers. [10]

- Quantify the impact of the socio-economic effects of COVID-19 on letter volumes by contrasting actual volume fluctuations with the counterfactual case that assumes the pandemic did not occur. [11]

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[8] See Section 2.1 for a total letter volume trend summary and Section 2.2 for a discussion of historical volume fluctuations per segment.

[9] See Appendix A for data descriptions and Appendix B for the list of hypotheses tested.

[10] See Appendix D for information on the econometric processes and Appendix E for test results and preferred models.

[11] See Sections 2.3 for a broad quantification of pandemic related impacts. Additional evaluations of the impact of the pandemic are pertinent at a segment level and are contained within different sections of this document.

- Deploy the segmented models, combined with forecasted future values on the drivers, to project letter volumes for each of the five segments across the 2021/22 to 2023/24 period. [12]

- Acknowledge a requirement to segmented baseline econometric projections with further intelligence on emerging trends and material off-model future events.[13]

- Aggregate the segmented projections to obtain projections on total letter volumes and dissect the projections into components explained by price and non-price effects. [14]

- Conduct sensitivity analysis on differing assumptions regarding e-substitution extrapolation. [15]

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[12] See Sections 3 to 7 for the generation of segment specific letter volume projections.
[13] See Appendix C for all qualifications on the use of econometric models for forecasting purposes.
[14] See Section 8 for a summary of projections and implications at a total letter volume level. Information on proposed percentage changes in letter prices were provided by Australia Post, headlined by a January 2023 9.1% increase in the BPR.
[15] See Table B.1.2.12 in Appendix B for an evaluation of volume projections according to alternative specifications of the e-substitution variable.

1.3 PROJECT SCOPE

Australia Post's addressed domestic letter service constituted the scope of this project. This encompasses the letter product offerings that facilitate the sending of personal messages, business correspondence, public notices, documents, magazines, and catalogues within Australia. The items can include business and consumer items such as letters, cards, postcards, self-mailers, annual reports, receipts/invoices or other financial information, government notifications, and any other mail customers send that meets the prescribed size and weight requirements. As a characteristics-based demand study, the drivers of letter volume movements are determined via a series of discriminatory statistical tests that establish linkages to each of the in-scope service offerings. As highlighted in Table 1.3.1, the letter service offerings appeal to different types of customers depending on their ability to meet the minimum lodgement requirements of Australia Post.

Table 1.3.1 In-scope Australia Post domestic letter product segment definitions

Product	Definition
Ordinary / Other small	The Ordinary / Other small letter segment category consists of full rate business mail and other consumer correspondence that satisfy the relevant small letter category size and weight requirements as set by Australia Post. The Ordinary / Other letter classifications consist of non-bulk business-to-business and business-to-household mailings; and individual mailings from household-to-business and household-to-household.
PreSort small	The PreSort small segment consists of bulk (300+) lodgements that satisfy the relevant small letter category size and weight requirements: 1) Business transactional presentment letter volumes such as bills, statements, share notices and letters advising customers of price increases, policy changes, etc; 2) Public sector notifications and correspondence related to welfare, elections, etc; 3) Promotional mail including direct mail, brochures and other addressed advertising material; and 4) Charity mail aimed at fundraising and increasing awareness of charitable institutions/causes.
Ordinary / Other large	The Ordinary / Other large segment consists of full rate large letters up to a maximum size, weight, and thickness of 360x260mm, 500g, and 20mm respectively. Other large letter content skews towards ad-hoc non-standard size documents, including legal contracts and reports as sent by individuals and commercial entities.
PreSort large	The PreSort large segment consists of bulk (300+) lodgements that satisfy the relevant large letter category size and weight requirements. It includes items sent by business and the public sectors including prospectuses, annual reports, outbound census forms and promotional material.
Print Post	This segment consists of lodgements that satisfy the relevant Print Post category size and weight requirements. Volumes in this segment consist of publications such as magazines, periodicals, and catalogues.

1.4 PRICING

1.4.1 International comparisons

A key objective of this project is to assess the impact of Australia Post's proposed letter rate increases. Contemplating such price rises necessitates an investigation into the relativities of basic postage rates (BPR) internationally. For a meaningful comparison Table 1.4.1.1 converts local rate stamp prices into Australian dollars via the prevailing exchange rates. Of the 33 countries considered, the BPR in Australia is relatively inexpensive, registering as the 11th least expensive.

Table 1.4.1.1 Ranking the price of a domestic standard letter in $AU (in descending order)[16]

Country	Local rate 2022 BPR	BPR in $AU	Country	Local rate 2022 BPR	BPR in $AU
Denmark	3.88 €	$5.73	Luxembourg	0.80 €	$1.18
Finland	3.10 €	$4.58	Austria	0.80 €	$1.18
Italy	2.80 €	$4.14	Germany	0.80 €	$1.18
Greece	1.73 €	$2.56	Slovakia	0.80 €	$1.18
Iceland	1.42 €	$2.10	Romania	0.78 €	$1.15
Belgium	1.21 €	$1.79	Australia	1.10 AU$	$1.10
France	1.16 €	$1.71	Estonia	0.65 €	$0.96
Ireland	1.10 €	$1.63	Portugal	0.65 €	$0.96
Sweden	1.04 €	$1.54	Spain	0.65 €	$0.96
Czech Republic	1.01 €	$1.49	United States	0.60 US$	$0.87
Latvia	1.00 €	$1.48	Hungary	0.57 €	$0.84
Poland	0.95 €	$1.40	Bulgaria	0.56 €	$0.83
Netherlands	0.91 €	$1.34	Lithuania	0.55 €	$0.81
Switzerland	0.90 €	$1.33	Slovania	0.48 €	$0.71
Croatia	0.88 €	$1.30	Cyprus	0.41 €	$0.61
UK	0.87 €	$1.29	Malta	0.30 €	$0.44
Canada	1.07 CAD$	$1.18			

[16] Exchange rates as of July 25, 2022, 01:14 UTC as per www.xe.com. European rates all presented in terms of the Euro and sourced from Deutsche Post DHL Group (2022), see bibliography. US rate from *www.usps.com*; Canadian rate from *www.canadapost-postescanada.ca.* Australian rates supplied by Australia Post.

Letter volume erosion due to movements towards digital communication is a universal phenomenon impacting all major postal economies globally. Therefore, postal authorities worldwide have increased rates dramatically to assist with the sustainability of their letters division. Table 1.4.1.2 illustrates the extent of these dramatic increases. It also highlights the comparatively low levels of BPR increases at Australia Post over the past five years. Of the 33 countries considered, in the last five years Australia Post's BPR has risen by only 10% which ranks as the 6th lowest across all countries.

Table 1.4.1.2 Increases in the BPR by country (2017 to 2022)[17]

Country	Local rate 2017	Local rate 2022	% change	Country	Local rate 2017	Local rate 2022	% change
Finland	1.30 €	3.45 €	165%	Ireland	1.00 €	1.25 €	25%
Greece	0.72 €	1.90 €	164%	Austria	0.68 €	0.85 €	25%
Romania	0.30 €	0.79 €	163%	Netherlands	0.78 €	0.96 €	23%
Belgium	0.79 €	1.89 €	139%	United States (US$)	$0.49	$0.60	22%
Estonia	0.65 €	1.50 €	131%	Lithuania	0.45 €	0.55 €	22%
Latvia	0.57 €	1.20 €	111%	Germany	0.70 €	0.85 €	21%
Slovania	0.37 €	0.67 €	81%	Malta	0.26 €	0.30 €	15%
Sweden	0.74 €	1.28 €	73%	Luxembourg	0.70 €	0.80 €	14%
Czech Republic	0.59 €	1.01 €	71%	Hungary	0.50 €	0.56 €	12%
France	0.85 €	1.43 €	68%	Switzerland	0.92 €	1.02 €	11%
Spain	0.50 €	0.75 €	50%	Australia (AU$)	$1.00	$1.10	10%
Slovakia	0.70 €	1.00 €	43%	Denmark	3.63 €	3.90 €	7%
UK	0.79 €	1.11 €	41%	Iceland	1.46 €	1.49 €	2%
Poland	0.73 €	0.99 €	36%	Italy	2.80 €	2.80 €	0%
Bulgaria	0.43 €	0.56 €	30%	Croatia	0.86 €	0.86 €	0%
Portugal	0.58 €	0.74 €	28%	Cyprus	0.41 €	0.41 €	0%
Canada (CAD$)	$0.85	$1.07	26%				

[17] European rates all presented in terms of the Euro and sourced from Deutsche Post DHL Group (2017) and Deutsche Post DHL Group (2022), see bibliography; US rates from *www.usps.com*; Canadian rates from *www.canadapost-postescanada.ca*. Australian rates supplied by Australia Post.

1.4.2 Defining a price elasticity

Quantifying the impact of proposed changes to postage rates via econometric techniques requires an estimate of statistically robust price elasticities across each of Australia Post's letter segments.[18] An essential input into the demand modeling is therefore the domestic letter price variables that account for empirical movements in postage rates. To obtain a comprehensive measure of the unit price according to an individual transaction, Australia Post's revenue-based volume data acts as the basis for determining an average revenue factor. This enables the construction of a price proxy to associate with each observation and facilitate econometric testing.[19] The advantage of adopting this method is it provides an automatic measurement mechanism for quantifying price points irrespective of the delineation required or customer discount applied.

More formally, a '*price elasticity*' measures the change in Australia Post's domestic letter volume in response to a given change in postage rates, assuming all other factors are held constant. For the purposes of this research, a price elasticity may be derived from the following equation

$$VOL_{t,m} = VOL_{t,m}(1+\varphi)^{\beta}$$

where $VOL_{t,m}$ is volume at time t for letter segment m, φ is the price increase of an Australia Post letter, and β is the price elasticity. When interpreting the numerical value of a price elasticity, if an estimate is:

- **>|1| it is referred to as '*price elastic*'.** That is, the rate of change in volume is greater than the rate of change in the price variable. Price reductions are therefore prescribed to increase total revenue.
- **=|1| it is referred to as '*unitary elastic*'.** That is, the rate of change in volume mirrors the rate of change in the price variable. Price changes are therefore assumed to have no impact on altering total revenue.
- **<|1| it is referred to as '*price inelastic*'.** That is the rate of change in volume is less than the rate of change in the price variable. Price increases are therefore prescribed to increase total revenue.

[18] All elasticities are estimated at their mean and are applicable only to the time frame over which the econometric models have been developed.

[19] These price variables are therefore expected to yield an approximate yet indicative view on price changes over the relevant timeframe. For the purposes of econometric testing, all price variables were deflated by the headline Australian consumer price index (CPI) to ensure the specification of real, rather than nominal, price movements. CPI source: Australian Bureau of Statistics, see bibliography.

- **=0 it is referred to as '*perfectly price inelastic*'.** That is the rate of change in volume is unrelated to the rate of change in the price variable. Price increases are therefore prescribed to increase total revenue because, in this case, there will be no associated volume response.

The price elasticities estimated within this project can be '*own*' price or '*cross*' price. Own price effects reflect the percentage change in the quantity demanded of Australia Post's domestic letter volume divided by the percentage change in Australia Post's prices for those same letters. Cross price effects represent the percentage change in the quantity demanded of Australia Post's domestic letter volume divided by the percentage change in competitors' prices.

As Australia Post is granted reserved service of a standard letter, competitors are defined by entities offering substitutive platforms for communication. These alternatives tend to be digital, whose influence has been facilitated by recent growth in speed, capacity, and penetration of online mediums. The primary platforms for this e-substitution emanate from the telecommunications industry in the form of smart phones and internet connectivity. Therefore, the price of a basket of prices governing a range of services within the telecommunications industry was utilised to proxy these cross-price effects.[20] An extensive summary on the technical aspects of the model and outputs containing the various price elasticity estimations is contained in Appendix E.[21]

[20] All cross-price variables were deflated by the headline Australian consumer price index (CPI) to ensure real rather than nominal price movements were incorporated into the analysis. The CPI sources for deflation and telecommunications specific pricing characteristics can be found at the Australian Bureau of Statistics, see bibliography.

[21] For further information regarding the hypotheses and data underpinning own price and cross price effects see Section B.1.1 and Section B.1.9 of Appendix B respectively.

1.5 METHODOLOGY & ENHANCEMENTS

1.5.1 Overview

This document represents the latest update of Australia Post's domestic addressed letter volume demand as conducted by Diversified Specifics. The reader is advised to consult the source documentation of the previous update for an expanded discussion explaining the historical volume trends for each letter segment.[22] As with all reports in this series, although the core methodology remains consistent, the approach is a constantly evolving one. Continual attempts are made to improve processes in a robust, meaningful manner in accordance with the changing dynamics of the Australian postal industry and in the deployment of leading econometric techniques.[23] Appendix D contains a technical summary of the econometric process and methodological aspects implemented within this study. The techniques that underpin the development of each letter volume model are premised upon best practice econometric methods in line with internationally accepted approaches to generating letter volume projections.[24] Although historical evidence provides valuable insights into likely letter volume fluctuations in response to movements in key demand drivers, there is never any guarantee future associations will precisely replicate those observed previously. Therefore, a list of caveats pertaining to the empirical analysis that generates econometric projections is contained in Appendix C.

1.5.2 Enhancements

On this occasion, there are two factors that have led to extensions on the econometric approach deployed within the 2019 update:

- A need to incorporate the socio-economic impacts of COVID-19 on letter volumes. These impacts occurred both directly, via changes in market demand, and indirectly through the temporary regulatory relief (TRR) initiatives granted to Australia Post during the initial phases of the pandemic.

- Adjustments to the econometric approach based upon a process of continual improvement and in response to previous comments made by the Australian Competition and Consumer Commission (ACCC).[25]

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[22] Diversified Specifics (2013), (2015) & (2019), see bibliography.
[23] For more insight into these principles consult Martin VL, Hurn S. & Harris D (2013), see bibliography.
[24] Boldron, François, Catherine Cazals, Jean-Pierre Florens and Sebastien Lécou (2010), see bibliography.
[25] The Australian Consumer & Competition Commission (2019), pp. 15 & 16, see bibliography.

These methodological enhancements include:

1. Expanding the e-substitution measurement variable to account for a variety of technological developments within Australia. To accomplish this, twin e-substitution indices are constructed via principal component statistical techniques.[26] This dual approach is an acknowledgement that each letter segment contains different content and is therefore impacted by e-substitution occurring from a variety of sources with differing speeds of penetration. As distinct from the 2019 study, each index now utilises Australia-centric data and is reflective of the evolution of technological change that has facilitated the erosion of Australia Post's letter volumes. The twin e-substitution indices incorporate of a range of technology-related variables that individually explain some element of letter volume decline including:

    a) Expansions in mobile phone, broadband, wireless and high speed NBN technologies that enable online transaction resolution, digital advertising, public notification, and social media information dissemination; and

    b) Replacements of traditional modes of bill payments, such as cheques, with direct debit facilities.

2. Deploying a structured approach to variable selection that is consistent throughout the estimation of each segmented domestic letter volume model.[27]

3. The price of alternative technologies in Australia is utilised to quantify the cross-price impacts on letter volume demand.[28] On this occasion a basket of prices governing a range of services within the telecommunications industry was utilised to proxy these cross-price effects. This addition resulted in expanding the set of letter volume drivers within the Other (Ordinary) small and PreSort large volume models.

4. Adopting a structured approach to structural break testing throughout the modelling process. To this end, Section D.2 in Appendix D is dedicated to outlining the structural beak tests conducted as part of this research.

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[26] Principal component analysis involves reducing several interrelated variables into a single dimension yet retaining the underlying variation. For more detailed information on principal component development, including insights on data, techniques, and outcomes, see Section B.1.2 in Appendix B.

[27] See Step 8 In Appendix D, Section D.1 for greater detail.

[28] For further information on cross price effects see Section B.1.9 of Appendix B.

1.5.3 Projection adjustments

The projected baseline volumes generated by the econometric models represent logical and statistically valid advances on previous efforts. E-substitution pressures impact the various segments in waves of technological development, each at different stages of maturity and penetration. As a result of this unpredictability, outputs from the econometric process must be considered baseline projections only. They necessarily require an overlay of recent market and institutional intelligence to ensure the final forecasts possess optimal currency.[29]

The econometric process does not fully incorporate the impact of emergent trends and does not possess the capability of embedding the possible impact of unforeseen future events into the baseline where there is no empirical evidence contained within the sampled time series. In these instances, where segmented letter volumes are likely to be impacted, Diversified Specifics recommends Australia Post adjust the baseline projections via institutional and market intelligence to account for 'off-model' impacts not fully accounted for in the econometric process. This additional intelligence, combined with a continual process of econometric refinement will ensure the final letter volume forecasts possess optimum currency, premised upon a baseline developed via statistical principals of best practice.

[29] Although alluded to at certain points within this documentation, the overlay of additional off-model intelligence is beyond the scope of this study.

1.6 DEMAND DRIVER HYPOTHESES

Since 1997 Diversified Specifics has specified the set of potential letter volume demand drivers deemed appropriate for econometric testing. Underpinning the econometric modeling are a series of hypotheses linking fluctuations in prospective demand drivers to movements in domestic letter volume demand. Each hypothesis is accompanied by information on the primary data source or proxy deployed.[30]

Table 1.6.1 represents a summary of the key hypotheses tested within this project to associate letter volume fluctuations with movements in potential demand drivers. Appendix B expands on the hypotheses listed in Table 1.7.1 to specify underlying data proxies and trends.

[30] Interpolations and back-casting techniques were deployed where the data was deemed deficient due to misaligned frequencies, inadequate series length, or data gaps.

Table 1.6.1 Key letter volume demand hypotheses tested in this project

Hypotheses 1: *See Section B.1.1 in Appendix B* *According to the fundamental principles of economics, increases in the own price of a letter is inversely associated with movements in letter volume.*
Hypotheses 2: *See Section B.1.2 in Appendix B* *Fluctuations in the level of e-substitution are inversely associated with movements in letter volume.*
Hypotheses 3: *See Section B.1.3 in Appendix B* *Changes in the size of the Australian population or a change in the number of delivery points across the Australia Post network are positively associated with movements in letter volume.*
Hypotheses 4: *See Section B.1.4 in Appendix B* *Movements in the level of Australian economic activity (or GDP segments such as retail trade) are positively associated with movements in letter volume.*
Hypotheses 5: *See Section B.1.5 in Appendix B* *Certain individual events (COVID-19, elections, referendums, census, etc) may either increase or decrease letter demand depending upon the nature of that occurrence.*
Hypotheses 6: *See Section B.1.6 in Appendix B* *Fluctuations in the level of Australian business confidence are positively associated with movements in letter volume.*
Hypotheses 7: *See Section B.1.7 in Appendix B* *Letter volumes are prone to inherent seasonal effects that highlight regular demand movements throughout any given year.*
Hypotheses 8: *See Section B.1.8 in Appendix B* *Fluctuations in the level of Australia Post's delivery service performance is positively associated with movements in letter volume.*
Hypotheses 9: *See Section B.1.9 in Appendix B* *Fluctuations in the price of technologies that are regarded as a substitute to mail are positively associated with movements in letter volume.*
Hypotheses 10: *See Section B.1.10 in Appendix B* *Increases in the number of public offerings on the Australian share market are positively associated with movements in letter volume.*
Hypotheses 11: *See Section B.1.11 in Appendix B* *Fluctuations in the health of the Australian advertising industry are positively associated with movements in letter volume.*
Hypotheses 12: *See Section B.1.12 in Appendix B* *Fluctuations in the price of paper are inversely associated with movements in letter volume.*

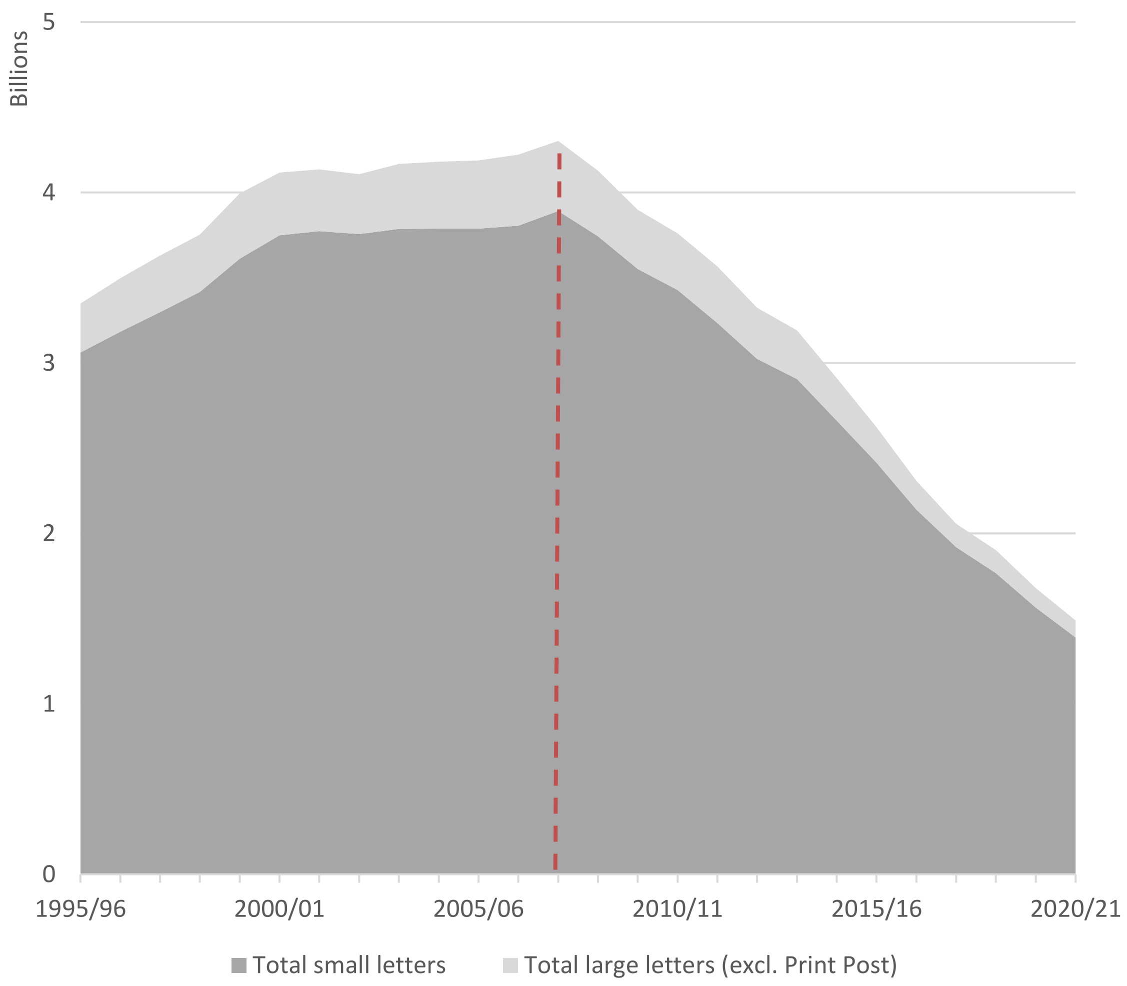
2. VOLUME TRENDS

2.1 TOTAL DOMESTIC ADDRESSED LETTERS

The erosion of Australia Post's letter volumes is reflective of broad trends characterising the postal industry worldwide.[31] Largely explained by movements towards digital alternatives that accelerated following the GFC of 2007/08, total domestic addressed letter volumes at Australia Post have eroded by 65% between 2006/07 and 2020/21, as depicted in Chart 2.1.1. Advances in technology combined with a behavioural shift towards embracing online communication have resulted in pronounced migrations away from the physical letter item. E-substitution has therefore emerged as the dominant letter volume demand driver in recent times despite the economic significance of other factors including fluctuations in the level of economic activity, population growth, delivery service performance and changes in the real price of postage.

Chart 2.1.1 Total letter volumes at Australia Post (annual)[32]

- - - - Denotes the onset of the GFC

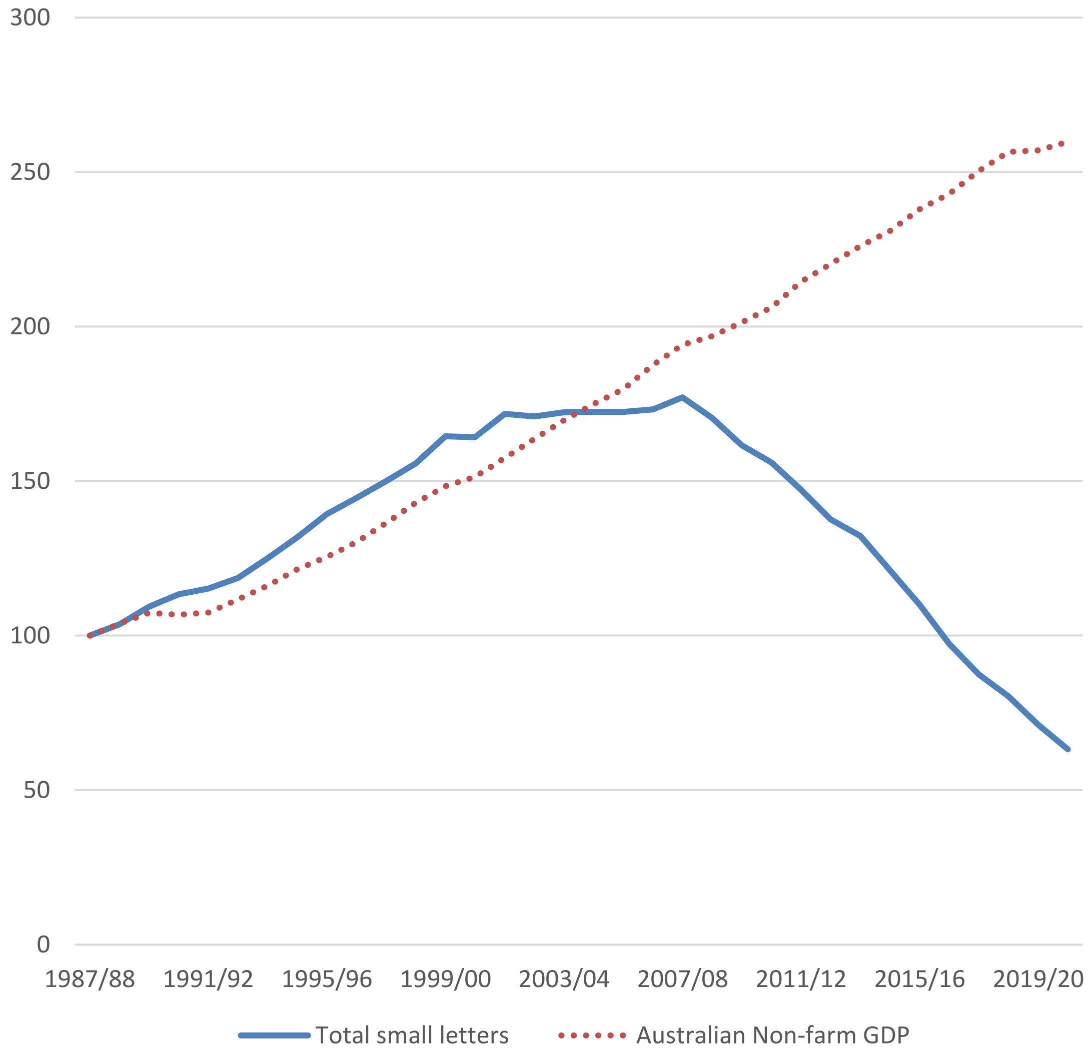


[31] Universal Postal Union (2020), see bibliography.

[32] Print Post volumes have been excluded from Chart 2.1 due to a lack of available data prior to 2006/07.

Prior to the year 2000 total small letter volumes were primarily driven by increasing annual growth in the Australian economy. Following the turn of the century, e-substitutive pressures began to emerge, initially as the customers began to develop an online relationship with the biller on the payments side of a transaction. At this point the small letter volume trend decoupled from the rate of growth in the Australian economy. The underlying mix within Australia Post's transactional small letter segments explains this 'technology wedge' observable in Chart 2.1.2. Most letter volumes tend to be commercial transactions. That is, conforming to either standard size bill presentments/statements or bill payments. Volume erosion became increasingly pronounced following the GFC as bill presentment type e-substitution became more prevalent, driving down volumes in Australia Post's largest, by volume, letter segment, PreSort small. Evidence of these changing dynamics underlined by a shift in the primary volume driver from Australian economic activity to digital substation are illustrated within Chart 2.1.2.

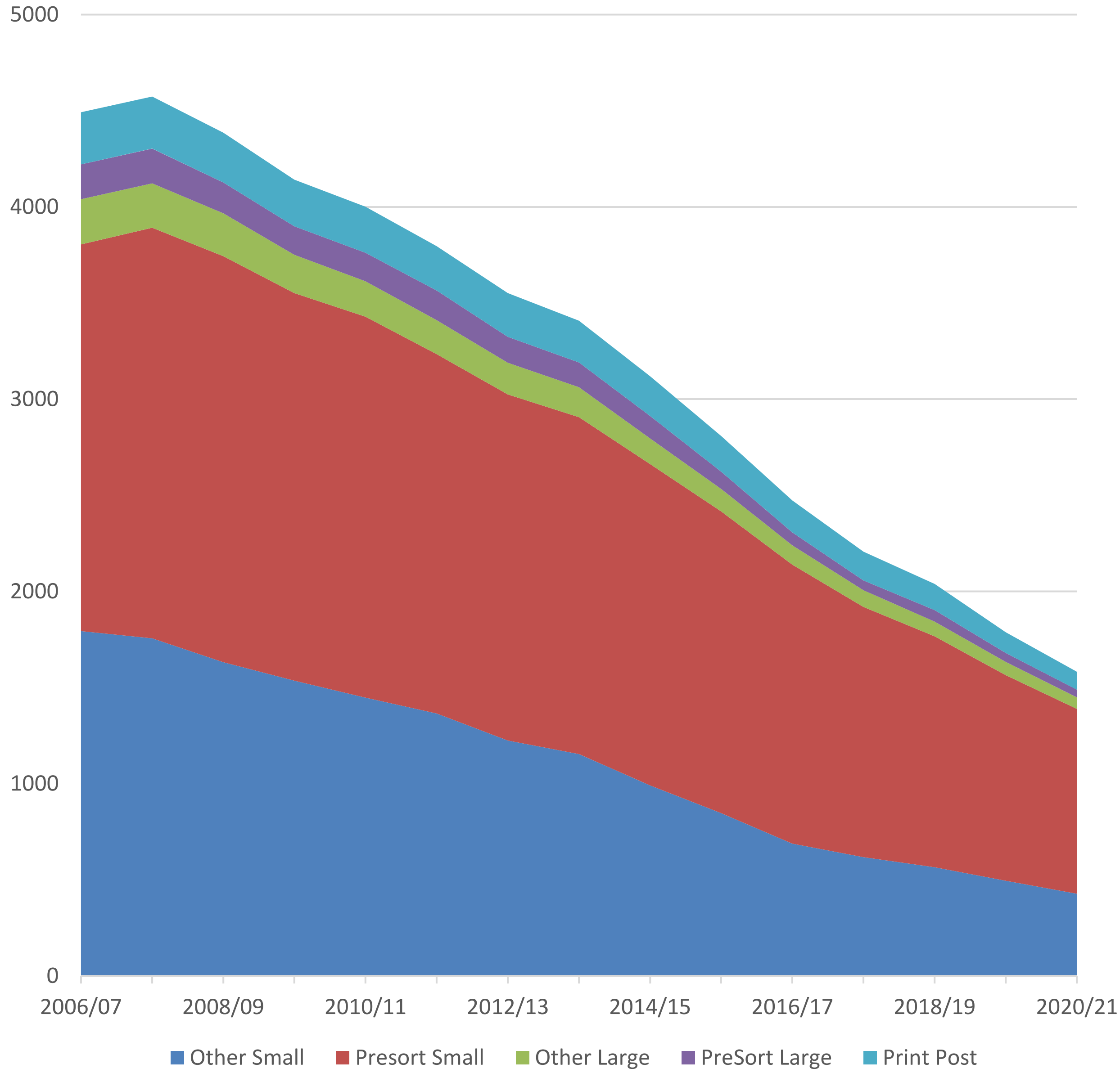
Chart 2.1.2 Total small letter volumes vs Australian Non-farm GDP (Annual, indexed, Base 100 = 1987/88)



2.2 PRODUCT SEGMENTS

The acceleration of volume erosion has been characterised by waves of technological advancements and e-substitution pressures impacting differing letter segments at varying rates of intensity as illustrated in Chart 2.2.1. This has resulted in the volume composition of Australia Post's domestic letter service altering significantly since 2006/07, as highlighted in Table 2.2.1.[33]

Chart 2.2.1. Australia Post domestic addressed letter volumes (annual, millions)



[33] Although rate rises have also contributed to the volume decline, e-substitution has consistently registered as the dominant statistical driver of total letter volume movements. Indeed, strategies incorporating rate rises, including the January 2016 43% increase in the BPR, have tended to reflect a response by Australia Post to recover the revenue required to sustain its universal service obligations in the face of the diminished letter volume demand caused by e-substitution. These requirements represent a legislated minimum service offering to all potential customers, regardless of their location.

Table 2.2.1 Percentage share of addressed domestic letter volumes by segment (annual)

Parcel Segment	2006/07	2020/21	Volume (mil) 2020/21
Other Small	40%	27%	427
PreSort Small	45%	61%	961
Other Large	5%	4%	60
PreSort Large	4%	3%	40
Print Post	6%	6%	93
Total Letters	**100%**	**100%**	**1,582**

Most of Australia Post's domestic letters now resides in the *'PreSort small"* letter service. Table 2.2.2 emphasises how, in recent years, the trend in total domestic letter volume movements at Australia Post largely mirrors the fluctuations in PreSort small volumes. Despite this compositional shift, there has been a consistent erosion of letter volumes across all key segments. The segmented volume declines contained within Table 2.2.2 illustrates different segments are driven by differing types of e-substitution. [34] This is primarily due to differing communication and content characteristics defining the demand for each letter service. Such differences therefore require a unique econometric modelling of each letter segment, rather than estimating a single total letter model, to capture the heterogeneity in demand more effectively. The disaggregated approach also leads to a richer set of insights and a more robust set of price/e-substitution elasticities.

Table 2.2.2 Total addressed domestic letter volumes

	Percentage change (%)				Percentage share of total letters (%)
Segment	**2018/19**	**2019/20**	**2020/21**	**2006/07 to 2020/21**	**2020/21**
Other Small	-8.5	-12.5	-13.6	-76.2	27
PreSort Small	-7.7	-11.0	-10.1	-52.2	61
Other Large	-10.6	-10.5	-12.4	-74.4	4
PreSort Large	16.6	-20.1	-15.2	-78.0	3
Print Post	-9.1	-21.3	-12.9	-65.5	6
Total Letters	**-7.6**	**-12.3**	**-11.4**	**-64.8**	**100**

Heterogenous demand responses are also observable for each letter segment throughout the pandemic, providing further support for modelling each letter service individually. In general, accelerated volume declines, explained by the socio-economic factors related to limiting the spread of COVID-19, proved to be impactful in 2020 and 2021. This additional COVID-19 related impact is explained and quantified in Section 2.3.

[34] A comprehensive historical summary explaining how demand and the forces of e-substitution for each letter segment has evolved over the past few decades is comprehensively explained in Section 2 of Diversified Specifics (2019) and within each of the individual letter segment sections contained within this document.

2.3 THE COVID-19 IMPACT

In 2020 the COVID-19 pandemic emerged as a significant threat to consumer and commercial demand worldwide.[35] From March 2020, policy initiatives were implemented within Australia designed to limit the spread of the pandemic and assist those members of society dealing with socio-economic COVID-19 related consequences. Initiatives included non-essential retail closures, the imposition of lockdowns / quarantining, border closures and efforts to inform Australians about vaccination procedures.[36] The combined effect was the Australian economy to fell into recession in 2020. This event had implications for the postal industry as there is historical evidence that periods of economic instability have tended to be associated with accelerated letter volume declines.[37] Table 2.3.1 highlights how a reduction in Australian non-farm GDP following the onset of the pandemic resulted in accelerated letter volume erosion.

Table 2.3.1 Australian Non-farm GDP and total letter volumes (Annual, percentage changes)[38]

	Pre-COVID-19 period					COVID-19 period	
	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21
Australian non-farm GDP	**2.2**	**3.0**	**2.1**	**3.0**	**2.4**	**0.2**	**1.1**
Total domestic letters	**-8.5**	**-9.9**	**-11.9**	**-10.8**	**-7.6**	**-12.3**	**-11.4**
PreSort							
Small	-4.7	-6.1	-7.5	-10.3	-7.7	-11.0	-10.1
Large	-9.1	-22.8	-25.3	-25.1	16.6	-20.1	-15.2
Other (Ordinary)							
Small	-14.0	-14.5	-18.8	-10.2	-8.5	-12.5	-13.6
Large	-14.5	-11.9	-13.8	-15.2	-10.6	-10.5	-12.4
Print Post	-4.7	-10.2	-10.6	-9.9	-9.1	-21.3	-12.9

35 Universal Postal Union (2020), see bibliography.

36 For a comprehensive discussion regarding the formal response to the pandemic by the Australian Government's Department of Health, consult www.health.gov.au.

37 Paterson, Martin, Nikali & Li (2012), see bibliography.

38 The heightened 2016/17 and 2017/18 total letter volume erosion followed 40%+ increases in the postage rate across all segments. Sources: Letter volumes: Australia Post; GDP percentage changes: ABS Cat. No. 5206.0 Table 6 Gross Value Added by Industry, Australia, Chain volume measures.

Lessons from the 2007/08 GFC suggest, any shock such as the one led by the pandemic, is likely to expose transactional letter volumes worldwide to two severe downside demand pressures:

1. The cyclical effects of a global and domestic slowdown leading to fewer transactions and limited discretionary spend; and

2. The structural change effects associated with an increasing propensity for e-substitution and the 'cost trimming' strategies of consolidation and rationalization.

In the presence of an economic shock, the cyclical impacts register immediately however structural change effects tend to have longer lead times and can assist in explaining why longer-term volume substitution occurs after indicators of economic health, such as GDP, signal a recovery. Both the GFC and COVID-19 resulted in a slowing of the Australia economy, as per Chart 2.3.1. However, during the pandemic the impact upon economic growth was more pronounced and volatile than the GFC.

Chart 2.3.1 The GFC vs COVID-19
Contrasting quarterly percentage changes in Australian Non-farm GDP

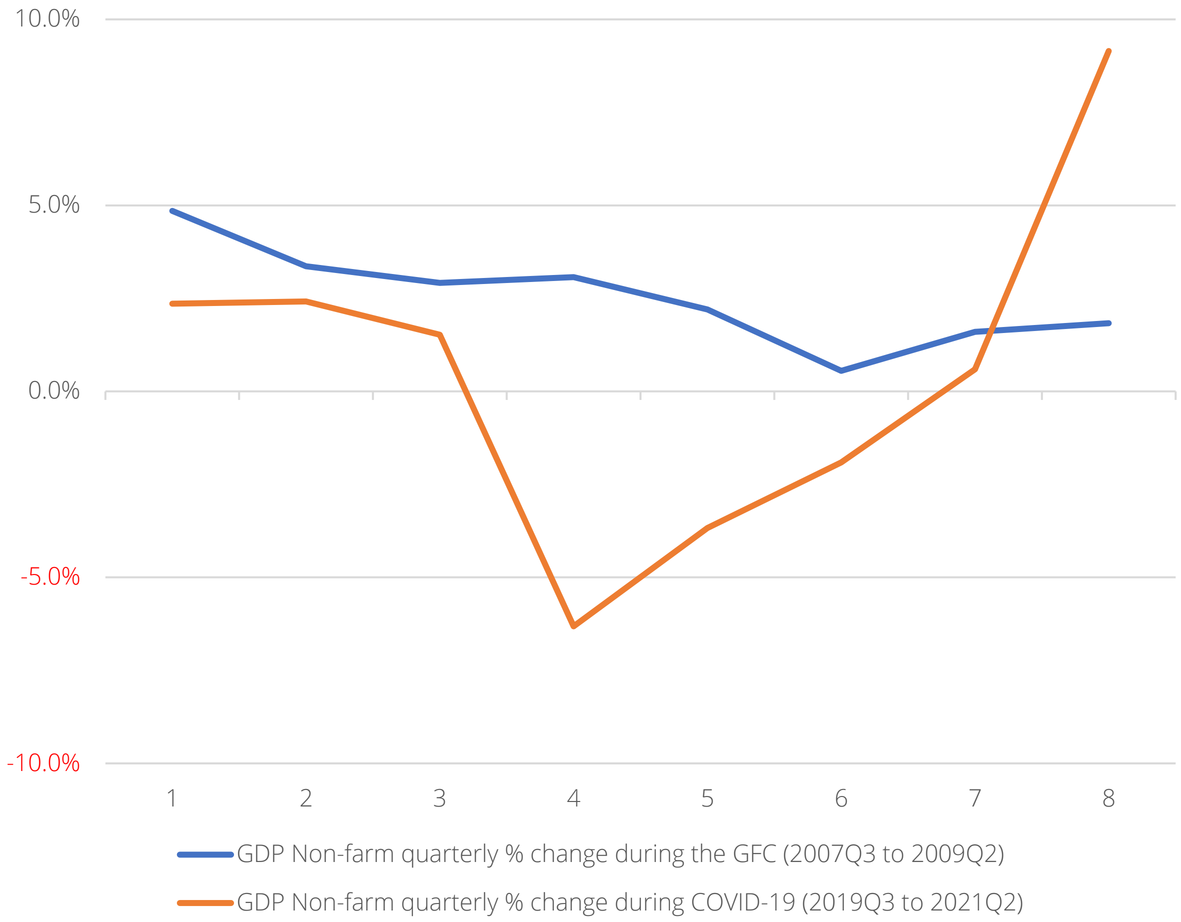
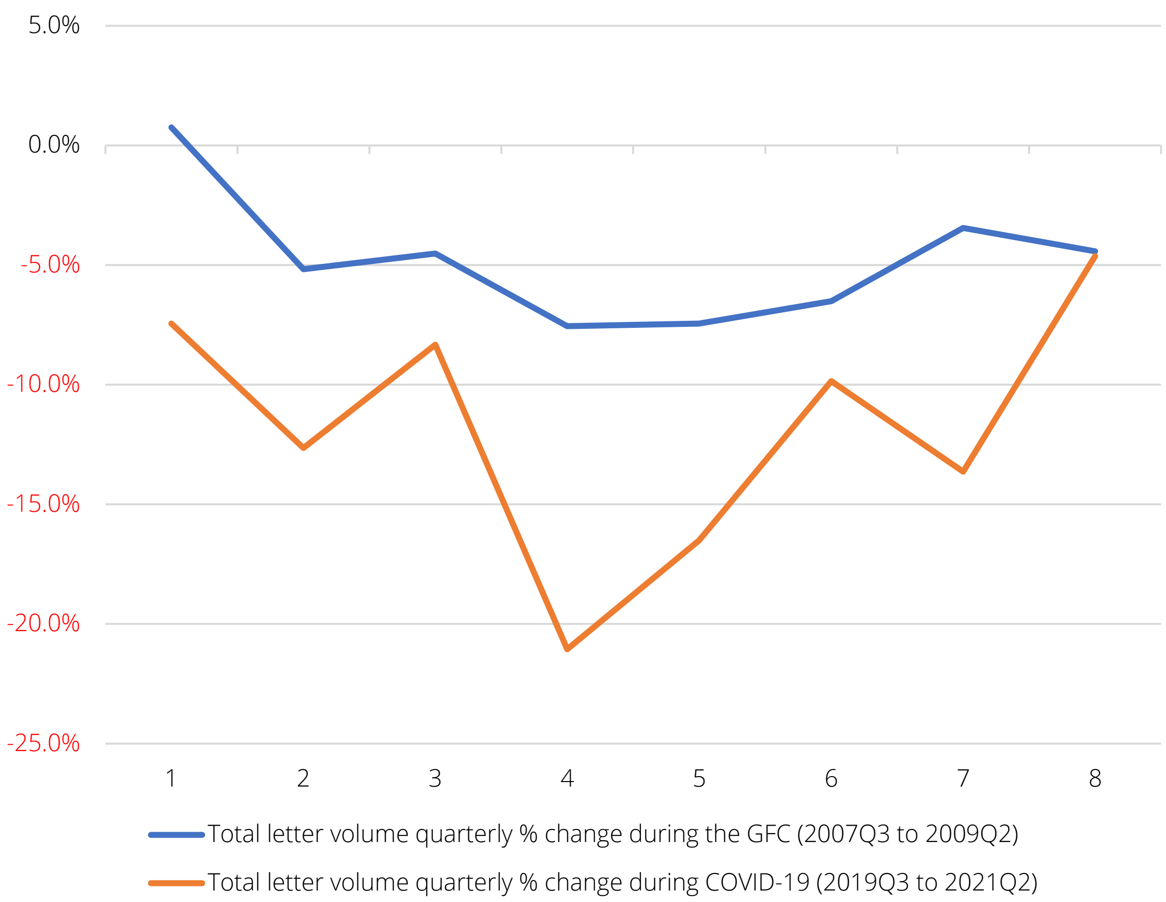


Chart 2.3.2. illustrates the increasing rates of total letter volume erosion that occurred during the pandemic when contrasted to the GFC.[39]

Chart 2.3.2 The GFC vs COVID-19
Contrasting quarterly percentage changes in total letter volumes



During downturns such as the GFC and COVID-19, there is a greater propensity for economic agents to engage in cost containment when they cannot realise their profit aspirations through sales. In such an environment, firms are more likely to pursue non-letter-based alternatives to strategically minimising transaction costs.[40] Communications via a letter is then disadvantaged because digital alternatives can be transmitted at a near zero marginal cost. The net positive cost differential is more likely to become an influential explainer of accelerating letter volume erosion during, and following, a downturn in economic activity. The econometric letter volume models explicitly contain a decline accelerator linked to lower levels of GDP in the form of dichotomous time dependant variables.

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[39] Any direct comparisons must be accompanied with the caveats of 1) a more evolved e-substitution landscape during the pandemic; and 2) the differences between a financial shock and a pandemic led downturn.
[40] For a discussion on the economics of transaction costs consult Williamson (1975), see bibliography.

Letter volume impacts throughout the pandemic are however characterised by additional factors that distinguish it from a typical economic downturn. Following the introduction of COVID-19 societal patterns of behaviour within Australia began to alter. That is, the restrictions on social mobility resulting from the pandemic impacted the economy and the behavioural lifestyle interactions of Australians in a manner different to downturns previously observed. This research update uses the econometric framework to quantify this additional '*pandemic*' impact upon letter volumes after the combined effects of all the usual drivers have been accounted for.

The presence of COVID-19 also resulted in significant changes to the specification of Australia Post's letter service as offered to its customers. That is, temporary regulatory relief (TRR) initiatives widened the delivery window as the required delivery standards were relaxed and the '*Priority*' service suspended. These changes may have increased the likelihood of process failure for some of Australia Post's customers, likely to contribute further to accelerated rates of volume erosion.

The clear data implication is that the pandemic was the dominant demand driver of letter volumes in 2020 and 2021. Based upon the modelling, each letter segment was impacted in a different manner, further reinforcing the retention of a heterogeneous approach when quantifying the impact of the pandemic within an econometric framework. The dichotomous nature of the pandemic measurement variables permits its impact to be quantified by utilising a counterfactual case where the presence of COVID-19 is hypothetically eliminated. In doing so, Table 2.3.2 highlights the estimated additional volume impacts caused by pandemic-related effects, as distinct from the influences emanating from other drivers such as e-substitution, price, etc.

The inference is, across 2020 and 2021, total letter volumes declined by an additional 7.5%, or 3.75%p.a, due to pandemic related effects. Given the learnings from the GFC, the impact of the pandemic on letter volumes at Australia Post is expected to continue over the coming years as businesses continue to migrate more communications to digital alternatives at an accelerated rate when contrasted to the hypothetical case of a world without COVID-19.

**Table 2.3.2: Estimated impact of COVID-19 on Australian domestic letters
From January 2020 to December 2021**

Letter segment	Total volume impact (mil)	Volume impact as a % of the total
Ordinary/Other small	-57	-6.5%
PreSort small	-131	-6.7%
Ordinary/Other large	-6	-4.8%
PreSort large	-7	-8.8%
Print Post	-38	-20.4%
Total letters	**-239**	**-7.5%**

3. OTHER (ORDINARY) LETTERS

3.1 OVERVIEW

Australia Post's Other (Ordinary) letter service offers the delivery of full rate mail for the weight and size specifications outlined in Table 3.1.1. These items are lodged either via a street posting box or over the counter at an Australia Post Post Office. The key lodgement characteristics of the Other (Ordinary) letter segment are minimal and include no requirement for barcoding or sorting.

Table 3.1.1 Other (Ordinary) service qualification requirements

Size details	Small	Large
Maximum weight	250g	500g
Minimum size	88 x 138mm	N/A
Maximum size	130 x 240mm	260 x 360mm
Maximum thickness	5mm	20mm

Source: www.auspost.com.au

The Other (Ordinary) letter classifications consists of non-bulk business-to-business and business-to-household mailings; and individual mailings from household-to-business and household-to-household. Generally, the Other (Ordinary) letter service is characterised by:

- Communication produced or mailed on an ad hoc or daily basis.
- Mailings in response to a one-to-one interaction.
- Lodgement sizes that are well below the threshold required to access the PreSort letter service.

This has resulted in greater, relative to bulk lodged mail, e-substitutive pressures for the Other (Ordinary) letter segments over a longer period as individuals tended to be early adopters of digital solutions when engaging in their communication activities.

3.2 OTHER (ORDINARY) SMALL

3.2.1 Service scope

The Other (Ordinary) small letter segment consists of full-rate business mail, cheque payments and other consumer correspondence that satisfies the relevant small letter category size and weight requirements. All service offerings within this segment are listed in Table 3.2.1.1.

Table 3.2.1.1: Other (Ordinary) small letter service sub-segments[41]

Ordinary Stamped Regular
Ordinary Stamped Priority
Local Rate Regular
Local Rate Priority
Metered Imprint Charge Regular
Metered Imprint Charge Priority
Clean Regular
Clean Priority
Reply Paid Regular
Reply Paid Priority
Imprint Cash Regular
Imprint Cash Priority
Seasonal Greeting Cards
Concession Stamps
Ordinary Prepaid Envelope Regular
Sample Post

For the past three decades, significant e-substitution of this type of mail has occurred to reflect individuals and SME's willingness to accept an online relationship with their biller on the payments side of a transaction. This has manifested in the traditional mode of bill payments by letter, cheque volumes, declining by an annual average rate of 13.3% since 2000/01, and by 17.6% since 2016/17. Additionally, direct debit payments within Australia have expanded by 196% since 2002/03 reflecting an acceleration in non-letter-based alternatives to transaction settlement. This leads to an Other small letter segment now containing a larger proportion of small and medium enterprise bill presentment type mail which will continue to be impacted by e-substitution, consolidation and rationalisation as individual senders seek to minimise their transaction costs by reducing their usage of the physical letter item.

[41] Sub-segment listing as per 2020/21. On occasions merged and revised/new product codes alter the historical data which may lead to data omissions beyond the control of Diversified Specifics.

3.2.2 Elasticity estimates

To construct a preferred econometric Other (Ordinary) small letter volume model, a series of lead in assessments and discriminatory tests for variable selection were undertaken. Appendix E.1 contains the key structural break and lag specification tests applied when constructing the preferred Other (Ordinary) small letter volume vector error correction model outlined in Table E.1.3.1.[42] The preferred model explains 99.33% of the total quarterly variation in Other (Ordinary) small letter volumes over the March 2011 to December 2021 time frame.[43]

The historical demand drivers of Other (Ordinary) small letter volumes together with the estimated demand elasticities are presented below. [44]

1. **E-substitution.**

Technological advancements and increases in online platform penetration/usage combined with reductions in traditional modes of bill payments, such as cheque volumes, broadly suggest a movement towards digital, which leads to declining Other (Ordinary) small letter volumes.

Elasticity: A 1% increase in e-substitution as measured via principal component analysis was associated with a 0.24% decrease in Other (Ordinary) small letter volumes on average in the long-run.

Recent trends: The use of cheques in Australia has declined by 94% since 2002/03 whilst direct debit payment numbers have grown by 196% over the same period.[45] The rollout of the Australian NBN service has been characterised by a 1,578% increase in the number of wholesale services in operation since 2014/15. Mobile phone subscriptions in Australia have increased by 104% since 2002/03.

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[42] Individual tests relating to each of the hypothesized tests are omitted from this document due to space considerations however are available on request from Diversified Specifics.

[43] Based upon Adjusted R-squared calculations:

$\bar{R}^2 = 1 - (1 - R^2)\frac{T-1}{T-K-1}$ where $R^2 = \frac{\text{Explained sum of squares}}{\text{Total of sum of squares}} = 1 - \frac{\sum e_t^{\,2}}{\sum(Y_t - \bar{Y})^2}$

[44] All elasticities reported are estimated at their mean and are applicable only to the time frame over which the econometric models have been developed. In interpreting the elasticities within this report, it is assumed all other factors are held constant.

[45] This statistic is impacted by a change in the Australian Bureau of Statistics data definition, occurring in May 2018, so interpretations should be treated with all due caution.

2. **Real price.**

Rational economic theory suggests the real cost, that is nominal price adjusted for inflationary effects, of sending Other (Ordinary) small letter mail will be inversely related to demand. Price changes over the examined time frame have been significantly associated with demand responses in the opposite direction.

Elasticity: A 1% increase in the real price of sending Other (Ordinary) small letters was associated with a 0.15% decrease in Other (Ordinary) small letter volumes on average in the long run.

Recent trend: Nominal postage rates for the Other (Ordinary) small letter service has increased at an annual average rate of 4.7% from 2000/01 to 2020/21. However, this statistic is largely a function of the substantive increase in January 2016.

3. **Cross price.**

The price of alternative technologies in Australia is utilised to assess the cross-price impacts on letter volume demand. Decreases in Other (Ordinary) small letter volumes are associated with the declining price of telecommunications services.

Elasticity: A 1% decrease in the real price of services provided in the Australian telecommunications industry was associated with a 0.70% decrease in Other (Ordinary) small letter volumes on average in the long run.

Recent trend: The nominal price of services in the Australian telecommunications industry has decreased at an annual average rate of -1.0% between 2000/01 and 2020/21. This average annual rate of decline has accelerated since 2016/17 to -2.9%.

3.2.3 Driver projections used

A series of projected values on each of the drivers within the VECM framework is required for projection. These include the following:

- E-substitution projections were derived via an endogenous process that involved forecasting the Other small letter principal components from June 2022 to June 2024.[46]

- CPI projections from the International Monetary Fund (IMF) of 3.34% at 2022, 2.52% at 2023 and 2.47% for 2024 were delineated into quarterly averages to account for inflationary pressures.[47]

- Nominal increases in the price of each Other small letter service, listed in Table 3.2.1.1, were provided by Australia Post.[48] To derive a single tractable nominal price variable, the proposed individual price points were weighted based on 2021 volume proportions. For comparative purposes, an alternative price variable was constructed to model the scenario where letter prices do not increase over the projection period.

- Future values of the telecommunications CPI, used to proxy cross price effects, were generated via an AR(1) process as outlined in Section B.1.9 of Appendix B. This resulted in annual cross price declines of -1.35% for 2021/22, -3.86% for 2022/23 and -4.03% for 2023/24.

- Although most of the election-related mail resides in the PreSort small segment, Other small letter volume projections do not include the impact of recently emerging trends or events falling outside the sample data, such as for the 2022 Federal election. Estimated volumes associated with these off-model volume impacts should be added to the baseline projections when constructing the final forecasts.[49]

- The error correction component of the VECM is augmented with two dichotomous variables to capture the effects of the relatively large increase in the BPR occurring in the March quarter of 2016 and a time dependant variable from March 2020 denoting the COVID-19 pandemic.

[46] The Other small letter principal components model is presented in Table B.1.2.8 of Appendix B. For comparison, alternative letter volume projections based upon e-substitution trends/modelling from 2019 are presented in Table B.1.2.12 in Appendix B.
[47] Source: International Monetary Fund (2022), see bibliography.
[48] Proposed rate change information supplied by Australia Post.
[49] In 2022, April and May Federal election Other small letter volumes would be regarded as potential overlays given the 2021/22 projections are comprised of nine months of actuals and three months of projections.

- During the COVID-19 pandemic temporary regulatory relief (TRR) initiatives resulted in variations in Australia Post's required small letter delivery service standards and the cancellation of the Priority service. Due to identification issues associated with service-related demand effects and measuring the impact of the pandemic, any possible cross-segment volume migration could not be evaluated.

- The structural changes to the mail flow that have occurred since the introduction of the COVID-19 pandemic into Australia are continued into the projection period as volumes losses are considered predominantly irreversible.

3.2.4 Econometric baseline volume projections

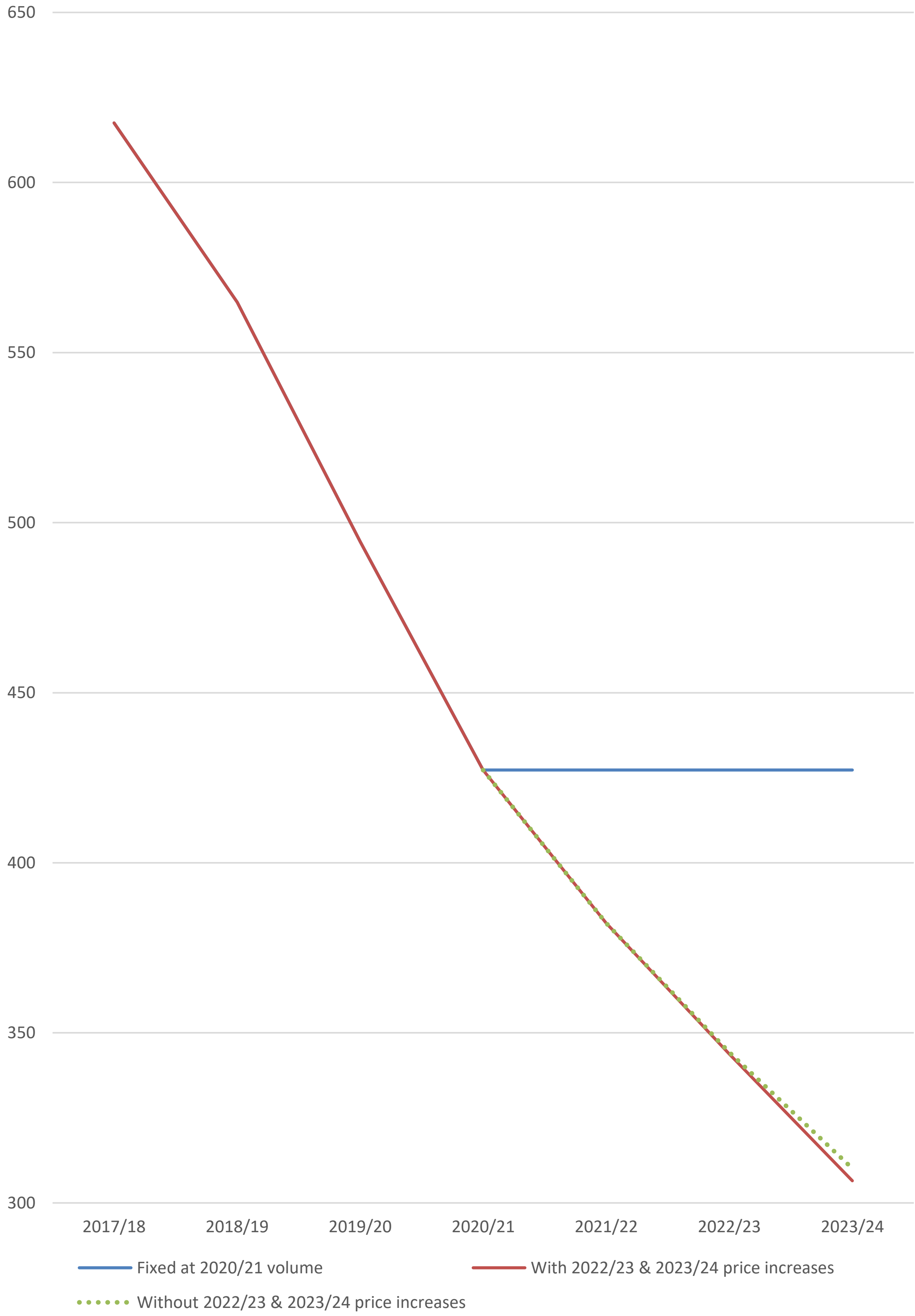
Other (Ordinary) small letter *ex-ante* baseline projections are presented in Table 3.2.4.1 and Chart 3.2.4.1. Continued Other (Ordinary) small letter volume declines of more than 9.6% per annum are predicted over the projection horizon irrespective of a price change. Over the projection horizon the dominant driver of downward Other small letter volumes is e-substitution as emphasised in Chart 3.2.4.1.

Table 3.2.4.1: Other (Ordinary) small letter volumes econometric projected percentage changes.[50]

	Baseline projected volume change (%)	
	With price increases	Without price increases
2021/22	-10.4	-10.4
2022/23	-9.7	-9.6
2023/24	-10.7	-9.9

50 2021/22 projections are comprised of nine months of actuals and three months of projections.

Chart 3.2.4.1: Other (Ordinary) small letter volumes (annual, millions)
Historical and projected



3.3 OTHER (ORDINARY) LARGE

3.3.1 Service scope

The Other (Ordinary) large letter segment consists of full-rate mail up to a maximum size, weight, and thickness – 360x260mm, 500g and 20mm respectively.[51] Volumes are hypothesised to predominantly comprise individual non-standard sized household-to-business, business-to-business, and business-to-household mailings, with post traditionally considered an effective channel for larger document delivery. All service offerings within this segment are listed in Table 3.3.1.1.

Table 3.3.1.1: Other (Ordinary) large letter service sub-segments[52]

Metered Imprint Charge 0 250g Regular
Metered Imprint Charge 0 250g Priority
Metered Imprint Charge 250 500g Regular
Metered Imprint Charge 250 500g Priority
Imprint Cash 0 250g Regular
Imprint Cash 0 250g Priority
Imprint Cash 250 500g Regular
Imprint Cash 250 500g Priority
Ordinary Stamped 0 250g
Ordinary Stamped 0 250g Priority
Ordinary Stamped 250 500g
Ordinary Stamped 250 500g Priority
Local Rate Regular
Local Rate Priority
Clean Small Plus Regular
Clean Small Plus Priority
Reply Paid Regular
Reply Paid Priority
Ordinary Prepaid Envelope 0 250g Regular
Ordinary Prepaid Envelope 250 500g Regular

Other large letter content skews towards ad-hoc non-standard size documents, including legal contracts and reports typically sent by individuals or commercial entities. Given the advances in technology much of this correspondence now takes place in digital form. Initally electronic file transmission was limited to email attachments however households and businesses in Australia have become increasingly connected online. This has resulted in an ability to transmit substantial amounts of information in electronic form, such as pdf, document, and picture files via email.

More recently, the popularity of flash drive usage, cloud storage facilities and file sharing services such as Microsoft Teams, Dropbox, iCloud, and OneDrive have facilitated instantaneous, cost-

[51] Examples of which are the rectangular B4 and C4 envelope sizes.

[52] Sub-segment listing as per 2020/21. On occasions merged and revised/new product codes alter the historical data which may lead to data omissions beyond the control of Diversified Specifics.

effective alternatives to larger document transmission. Additionally, detailed legal contracts and insurance policies now can be completed via online platforms. These manifest as websites and apps, which greatly reduce the need for large physical documents to be sent through Australia Post's large letter network.

3.3.2 Elasticity estimates

Structural break, tests for cointegration and variable selection assessments resolved a preferred econometric Other (Ordinary) large letter volume model. Appendix E.2 contains the key structural break and lag specification tests applied when constructing the preferred Other (Ordinary) large letter volume vector error correction model outlined in Table E.2.3.1.[53] The preferred model explains 99.41% of the total quarterly variation in Other (Ordinary) large letter volumes over the December 2011 to December 2021 time frame.

The historical demand drivers of Other (Ordinary) large letter volumes together with the estimated demand elasticities are presented below.

1. **E-substitution.**

Digital alternatives for this segment cover a broad range of non-descript and ad-hoc communications because the content of the Other large letter item is so broad. Behavioural adaptations to digital therefore occur through the types of technological change that have facilitated an increased usage of email, internet, cloud, and smartphone communication throughout Australia. These technologies have enabled large documentation to be transmitted or submitted in a manner that by-passes the Other large letter service. Fluctuations in Other (Ordinary) letter volumes are explained to a statistically significant degree via a negative association with the levels of growth in the e-substitution index.

Elasticity: A 1% increase in e-substitution as measured via principal component analysis was associated with a 0.6% decrease in Other (Ordinary) large letter volumes on average in the long-run.

Recent trends: The rollout of the Australian NBN service has been characterised by a 1,578% increase in the number of wholesale services in operation since 2014/15. Mobile phone subscriptions in Australia have increased by 104% since 2002/03.

[53] Individual tests relating to each of the hypothesized tests are omitted from this document due to space considerations however are available on request from Diversified Specifics.

2. Real price.

Rational economic theory suggests the real cost, that is nominal price adjusted for inflationary effects, of sending Other (Ordinary) large letter mail will be inversely related to volume demand. Price changes over the examined time frame have been significantly associated with demand responses in the opposite direction.

Elasticity: A 1% increase in the real price of sending Other (Ordinary) large letters was associated with a 0.18% decrease in Other (Ordinary) large letter volumes on average in the long run.

Recent trend: The nominal price of an Other (Ordinary) large letter item has increased at an annual average rate of 4.4% from 2000/01 to 2020/21. Since 2010/11 this annual average rate increased to 6.8%, largely influenced by increases of 27.8% and 48.7% in 2013/14 and 2015/16 respectively.

3.3.3 Driver projections used

A series of projected values on each of the drivers within the VECM framework is required for projection. These include the following.

- E-substitution projections were derived via an endogenous process that involved forecasting the principal components of numerous technology variables from June 2022 to June 2024.[54]

- CPI projections from the International Monetary Fund (IMF) of 3.34% at 2022, 2.52% at 2023 and 2.47% for 2024 were delineated into quarterly averages to account for inflationary pressures.

- Nominal increases in the prices of each Other large letter sub-segment identified in Table 3.3.1.1, were provided by Australia Post.[55] To derive a single tractable nominal price variable, the proposed individual price points were weighted based on 2021 volume proportions. For comparative purposes, an alternative price variable was constructed to model the scenario where letter prices do not increase over the projection period.

- Other large letter volume projections do not include the impact of any off-model drivers. Should any of these potential drivers possess economic significance and be anticipated into the projection period then adjustments to the econometric baseline should be undertaken.

- Four dichotomous variables are included within the error correction component of the Other large letter VECM. One captures the effects of the relatively large January 2016 increase in the BPR. The three remaining variables quantify variations in volume adjustments post March 2020 encompassing COVID-19 pandemic related impacts in addition to the inbound letter demand effects associated with the 2021 Australian census.

- During the COVID-19 pandemic temporary regulatory relief (TRR) initiatives resulted in variations to Australia Post's required large letter delivery service standards and the cancellation of the Priority service. Due to identification issues associated with service-related demand effects and measuring the impact of the pandemic, any possible cross-segment volume migration could not be evaluated.

[54] The technology-based (non-Other small) principal components model is presented in Table B.1.2.9 of Appendix B. For comparison, alternative letter volume projections based upon e-substitution trends/modelling from 2019 are presented in Table B.1.2.12 in Appendix B.

[55] Proposed rate change information provided by Australia Post.

- The structural changes to the mail flow that have occurred since the introduction of the COVID-19 pandemic into Australia are continued into the projection period as volumes losses are considered predominantly irreversible.

3.3.4 Econometric baseline volume projections

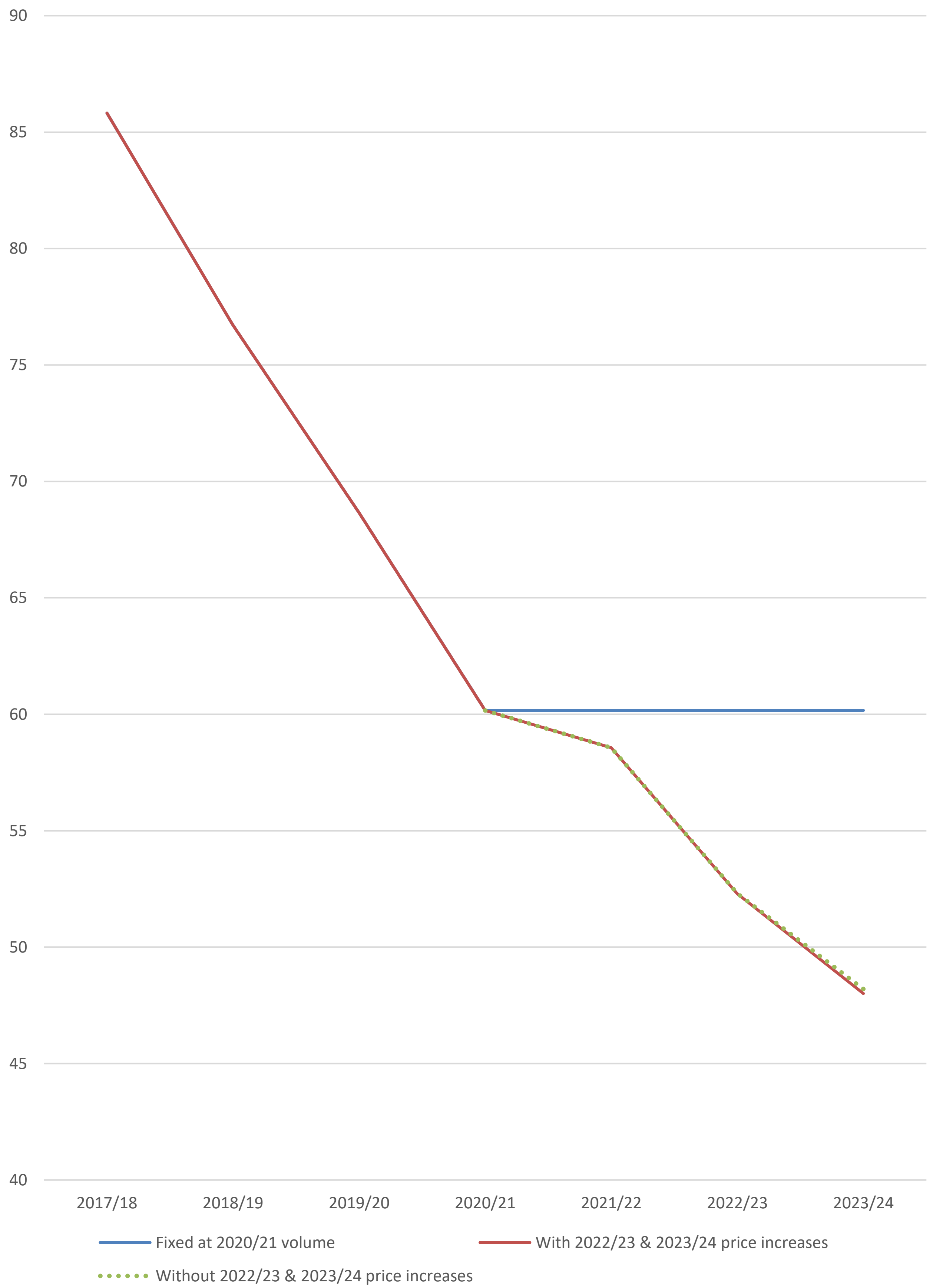
Other (Ordinary) large letter *ex-ante* baseline projections are presented in Table 3.3.4.1 and Chart 3.3.4.1. The model projects a return to the pre-2021/22 Other (Ordinary) large letter volume declines over the projection horizon. Chart 3.3.4.1. illustrates most of the projected volume decline is attributable to e-substitution, rather than price, pressures.

Table 3.3.4.1: Other (Ordinary) large letter volumes econometric projected percentage changes.[56]

	Baseline projected volume change (%)	
	With price increases	Without price increases
2021/22	-2.5	-2.5
2022/23	-10.7	-10.7
2023/24	-8.2	-7.8

56 2021/22 projections are comprised of nine months of actuals and three months of projections.

Chart 3.3.4.1: Other (Ordinary) large letter volumes (annual, millions)
Historical and projected



4. PRESORT LETTERS

4.1 OVERVIEW

Australia Post's PreSort letter service provides customers with an ability to obtain cost savings through bulk lodgements of mail via a work-sharing arrangement. This allows the customer, typically business and public sector companies, to send addressed mail barcoded and sorted providing the qualification requirements outlined in Table 4.1.1 are satisfied. In doing so, Australia Post offers the PreSort service at a discounted rate given the cost savings that accrue in the processing component of mail collection through to delivery. The PreSort letter presents as a two-speed service offering the option of Priority and Regular, the latter delivered across a potentially longer delivery window allowing for a lower cost delivery service for non-time critical mail. The Regular service embeds an allowance for an additional 2 business days for delivery when contrasted to Priority lodged mail.

Table 4.1.1 PreSort service qualification requirements

Size details	Small	Small Plus	Large
Maximum weight	125g	125g	500g
Minimum size	88 x 138mm	88 x 138mm	N/A
Maximum size	130 x 240mm	162 x 240mm	260 x 360mm
Maximum thickness	5mm	5mm	20mm

Further lodgement conditions are as follows:

- *Each lodgement must contain items in the same size and weight category*
- *the minimum quantity is 300 barcoded articles per lodgement*
- *the maximum weight for articles is 500g*

Source: www.auspost.com.au

This segment consists of bulk (300+) lodgements that typically consist of:

- Commercial transactional letter volume commonly generated by medium to large scale organisations as well as government enterprises who service substantial customer bases. These organisations use mail as an outcome of their processes to service their customers and constituents. Therefore, this type of transactional mail, which are primarily bills, statements, and public notices, tend to be distributed according to regular, structured cycles and reoccurring events; and

- Promotional or trans-promotional material such as brochures, catalogues or other addressed material that satisfies the relevant letter category, conditions, size, and weight requirements.

4.2 PRESORT SMALL

4.2.1 Service scope

The PreSort small letter segment consists of bulk (300+) lodgements of:

- Business transactional letters such as bills, statements, share notices and letters advising customers of price increases, policy changes, etc.
- Public sector notifications and correspondence related to welfare, elections, etc across all tiers of government.
- Charity mail aimed at fundraising and increasing awareness of charitable institutions/causes.
- Direct mail including promotional letters, brochures and other addressed promotional material that satisfies the relevant small letter category size and weight requirements.

All service offerings within this segment are listed in Table 4.2.1.1

Table 4.2.1.1: PreSort small letter service sub-segments[57]

PreSort Regular
Charity Mail Regular
PreSort Promo Mail Priority
PreSort Priority
Charity Mail Priority
PreSort Promo Mail Regular

Commercial transactional letters represent the dominant product category within this segment. Prior to the GFC of 2007/08 PreSort small letter volume fluctuations were positively associated with measures of Australian economic activity, such as real GDP. The GFC driven economic downturn represented a turning point for PreSort small letter volumes as retail sales growth stagnated and firms focus shifted towards cost containment initiatives in their efforts to maintain profit margins. As part of that shift there was an increasing tendency for firms to explore how they might reduce their cost of communications, including economising expenditure on mail.

In this environment, bill presentment-type mail was increasingly prone to the forces of:

- Rationalisation, involving reducing the frequency that invoices and statements are provided to the recipient. For example, moving to quarterly rather than monthly billing cycles.

[57] Sub-segment listing as per 2020/21. On occasions merged and revised/new product codes alter the historical data which may lead to data omissions beyond the control of Diversified Specifics.

- Consolidation, a process that includes the integration of multiple messages, commonly transactional and promotional, within a single letter item; and
- E-substitution, via an expansion in the proliferation and penetration of digital channels.

Post-GFC annual PreSort small letter volume erosion continued at an average of -6.3% across the 2008/09 to 2018/19 period. In 2020 and 2021, the volume declines were exacerbated by the socio-economic impact of COVID-19. As a result, annual PreSort small letter volume declines in 2019/20 and 2020/21 deteriorated to -11.0% and -10.1% respectively.

In the short run, when the pandemic hit, the transactional component of PreSort small letter volumes was more resilient than the promotional component, Promo Post. As highlighted in Table 4.2.1.2, Promo Post volumes were 58% lower in the June quarter of 2020 compared to the 2019 quarterly equivalent. This dramatic volume decline was primarily due to the COVID-19 led reduction in discretionary expenditure as the closure of non-essential retail and lockdowns diminished the need for catalogues and in-store promotions.

Transactional letter volumes were not immediately impacted by the pandemic to the same degree as promotional mail. This is explained by the large component of PreSort small letter volumes that are generated either through:

1) Fixed contractual arrangements with customers such as utility, phone, and internet billing; or

2) Reoccurring mailing cycles that include statements for bank accounts and credit cards.

However, as emphasised earlier, the 2007/08 GFC assisted in understanding why transactional volume erosion during the pandemic might lag any immediate impact. Economic shocks tend to result in a greater propensity for firms to focus on cost containment objectives.

This results in an increased tendency to deploy push and pull strategies aimed at migrating communications towards a digital alternative, reducing transactional letter volumes.[58] However, such initiatives take time to effect demand patterns because engendering a behavioural response from the recipient often requires provision of revised service terms and an acceptance of incentive

[58] Examples of these push and pull tactics can involve the imposition of a surcharge for the provision of a paper-based bill or the compulsory use of a direct debit arrangement as a condition of a new service agreement or product offering.

schemes to assist in the migration. For these reasons the impact of the pandemic on PreSort small letter volumes at Australia Post is expected to continue as businesses transfer increasing numbers of communication items to digital alternatives.

Table 4.2.1.2: PreSort small letter volumes - Transactional vs Promotional
Quarterly percentage changes in volume contrasted to the same quarter in the previous year

	Pre-COVID-19 period					Post-COVID-19 period						
	2019				2020				2021			
	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec	Mar	Jun	Sep	Dec
PreSort small transactional[59]	-7	-4	-4	-10	-6	-14	-15	-5	-10	-7	4	-9
Promo Post	-1	22	-7	-10	-20	**-58**	-23	-22	-24	20	-8	-13

[59] In Table 4.2.1.2, the PreSort small transactional segment excludes mail related to Promo Post and Charity mail.

4.2.2 Elasticity estimates

The PreSort small letter volume model is based upon a DOLS functional form. Tests for structural breaks, lag structures, cointegration and alternative specifications are outlined in Appendix E.3, with Table E.3.3.1 containing the preferred PreSort small letter volume model.[60] This model explains 97.5% of the total quarterly variation in PreSort small letter volumes between September 2016 and December 2021.

The historical demand drivers of PreSort small letter volumes together with the estimated demand elasticities are presented below.

1. **E-substitution.**

The widespread usage rates of smart devices, PCs and tablets amongst the Australian population has led to a behavioural adjustment in how Australians accept information from their billers, financial institutions, marketeers, and public agencies. There is an increased propensity to substitute away from the PreSort small letter item, in line with these technological developments.[61]

Elasticity: A 1% increase in e-substitution as measured via principal component analysis was associated with a 0.49% decrease in PreSort small letter volumes on average in the long-run.

Recent trends: The rollout of the Australian NBN service has been characterised by a 1,578% increase in the number of wholesale services in operation since 2014/15. Mobile phone subscriptions in Australia have increased by 104% since 2002/03.

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[60] Individual tests relating to each of the hypothesized tests regarding variable selection are omitted from this document due to space considerations however are available on request from Diversified Specifics.

[61] Acknowledging the existence of consolidation and rationalisation pressures, Diversified Specifics has defined strategic structural reductions in bill presentment volume under the term 'e-substitution' for simplicity.

2. **Real price.**

Rational economic theory suggests the real cost, that is nominal price adjusted for inflationary effects, of sending PreSort small letter mail will be inversely related to demand.

Given the dominant influence of e-substitution as a demand driver, price changes fail to register a statistically significant association with movements in PreSort small letter volumes. The real price variable is included in the PreSort small letter volume model for economic rather than statistical importance.

Elasticity: A 1% increase in the real price of sending PreSort small letters was associated with a 0.55% decrease in PreSort small letter volumes on average in the long run.

Recent trend: Nominal postage rates for the PreSort small letter service has increased at an annual average rate of 4.8% between 2000/01 and 2020/21. However, this statistic is largely a function of the 36.2% increase in January 2016.

3. **COVID-19.**

Policies and initiatives designed to stem the epidemiological and economic impacts of the pandemic had a statistically significant effect on the PreSort small letter service, resulting in a negative net volume outcome.

This impact manifested in multiple forms as the transactional component of PreSort small letter volumes was initially more resilient than its promotional counterpart. Promo Post losses tended to be short run because of the COVID-19 led reduction in discretionary expenditure.

Transactional letter volumes were not immediately impacted by the pandemic to the same degree due to a large component of PreSort small letter volumes generated either through fixed contractual arrangements with customers such as utility, phone, and internet billing; or reoccurring mail-out cycles that include statements for bank accounts and credit cards.

4.2.1 Driver projections used

A series of projected values on each of the drivers within the DOLS framework is required for projection. These include the following.

- E-substitution projections were derived via a modelling of the long run trends. This involved forecasting the principal components of a variety of technology variables from June 2022 to June 2024 based on an AR(1) model with a time trend.[62]

- CPI projections from the International Monetary Fund (IMF) of 3.34% at 2022, 2.52% at 2023 and 2.47% for 2024 were delineated into quarterly averages to account for inflationary pressures.

- Nominal increases in the price of each PreSort small letter service, listed in Table 4.2.1.1, were provided by Australia Post.[63] To derive a single tractable nominal price variable, the proposed individual price points were weighted based on 2021 volume proportions. For comparative purposes, an alternative price variable was constructed to model the scenario where PreSort small letter prices do not increase over the projection period.

- PreSort small letter volume projections do not completely account for the impact of recently emerging trends or events falling outside the sample data, such as the 2022 Federal election. Estimated volumes associated with these off-model impacts should be factored into any augmentations on the baseline projections when constructing the final forecasts.[64]

- The DOLS model is augmented with a series of dichotomous variables capturing the COVID-19 impact from March 2020. Although the structural change variable associated with the pandemic continues into the projection period, the isolated impacts do not as these were largely related to the short-term discretionary effects on Promo Post.

- During the COVID-19 pandemic temporary regulatory relief (TRR) initiatives resulted in variations in Australia Post's required small letter delivery service standards and the cancellation of the Priority service. Due to identification issues associated with service-related demand effects and measuring the impact of the pandemic, any possible cross-segment volume migration could not be evaluated.

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[62] The technology-based (non-Other small) principal components model is presented in Table B.1.2.9 of Appendix B. For comparison, alternative letter volume projections based upon e-substitution trends/modelling from 2019 are presented in Table B.1.2.12 in Appendix B.

[63] Proposed rate change information provided by Australia Post.

[64] In 2022, April and May Federal election PreSort small letter volumes would be regarded as potential overlays given the 2021/22 projections are comprised of nine months of actuals and three months of projections.

4.2.4 Econometric baseline volume projections

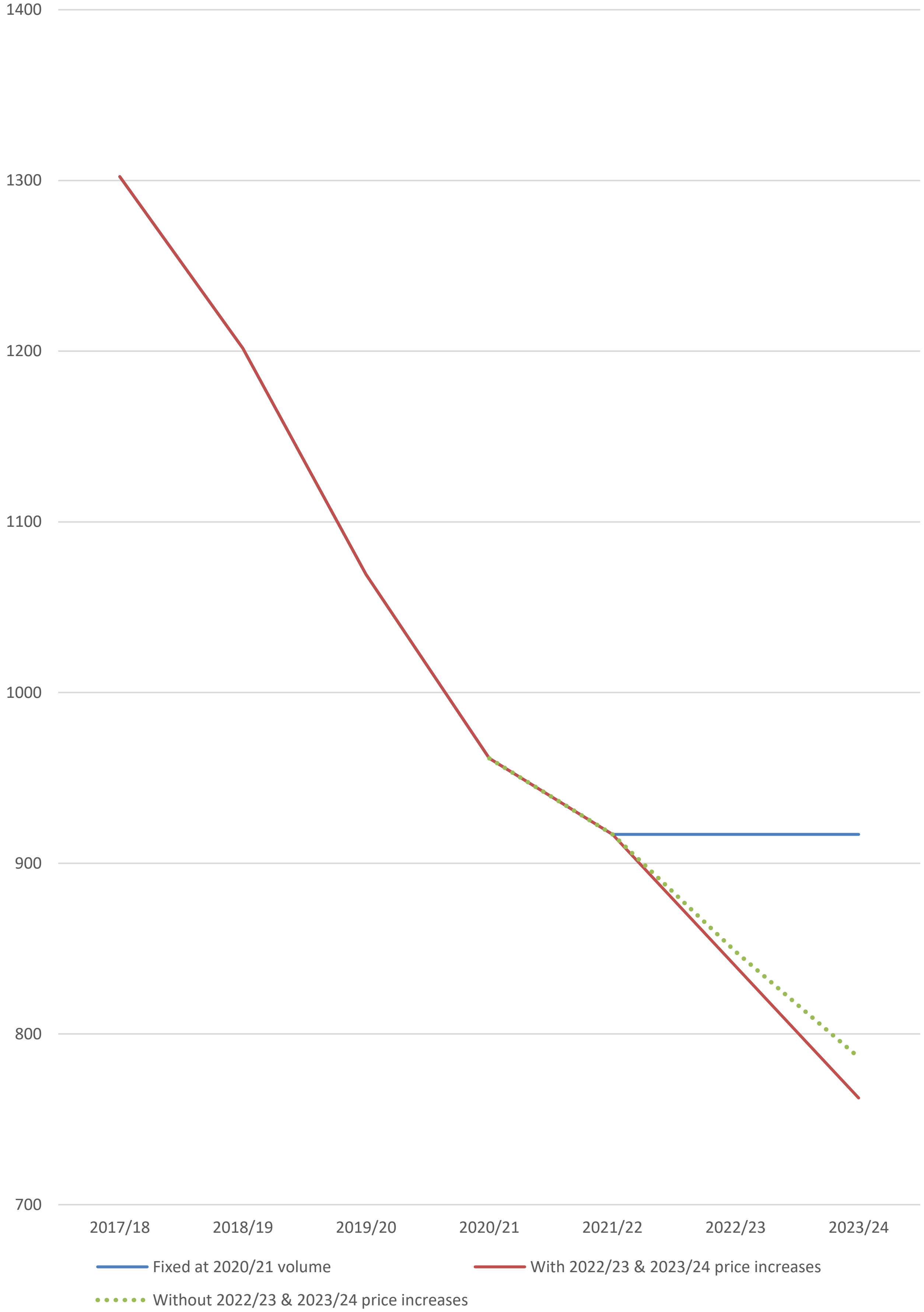
PreSort small letter *ex-ante* baseline projections are presented in Table 4.2.4.1 and Chart 4.2.4.1. The softer declines anticipated in 2021/22 are driven by a return to more typical levels of Australian economic and the pent-up demand revolving around any unused promotional expenditure held back during the pandemic. From 2022/23 PreSort small letter volume declines are expected to normalise, returning to the longer-term e-substitution trend. Chart 4.2.4.1 illustrates this anticipated outcome is largely irrespective of the imposition of the proposed price changes.

Table 4.2.4.1: PreSort small letter volumes econometric projected percentage changes.[65]

	Baseline projected volume change (%)	
	With price increases	Without price increases
2021/22	-4.6	-4.6
2022/23	-8.4	-7.5
2023/24	-9.2	-7.3

[65] 2021/22 projections are comprised of nine months of actuals and three months of projections.

Chart 4.2.4.1: PreSort small letter volumes (annual, millions)
Historical and projected



4.3 PRESORT LARGE

4.3.1 Service scope

The PreSort large letter segment consists of bulk lodgements containing 300+ large letters, typically sent by business and the public sectors.[66] It includes non-standard size items such as prospectuses, annual reports, and outbound census forms. However, the segment also includes large promotional material as per the Promo Post service. All service offerings within this segment are listed in Table 4.3.1.1.

Table 4.3.1.1: PreSort large letter service sub-segments[67]

PreSort Medium Regular
PreSort Large 0 250g Regular
PreSort Small Plus Regular
PreSort Large 250 500g Regular
PreSort Small Plus Priority
PreSort Large 0 250g Priority
PreSort Medium Priority
PreSort Large 250 500g Priority
Charity Mail Regular
Promo Post Small Plus Large Regular
Promo Post 0 125 Regular

Prior to 2006/07 PreSort large letter volumes were positively associated with the level of Australian economic activity. However, in 2007 legislative changes facilitated a migration of annual reports towards digital platforms.[68] In doing so this reduced PreSort large letter service usage involving correspondence to stakeholders in Australian public listed companies. This coincided with the GFC where Australian firms were generally reducing bulk distributions of large publications to accrue potential cost savings amidst the economic downturn. Most of this e-substitution tended to be irreversible and therefore PreSort large letter volumes have continued to erode at an accelerated rate since 2007/08. Recently, this erosion has intensified due to the increasing penetration of digital communications which can be supplied at a declining price relative to mail. From March 2020 additional contractionary forces arose when attempts to limit the spread of COVID-19 caused further declines in bulk promotional activities as non-essential retail closed. Combined, these effects led to an annual average PreSort large letter volume decline of -8.8% between 2016/17 and 2020/21.

[66] Up to a maximum size, weight, and thickness – 360x260mm, 500g and 20mm respectively.
[67] Sub-segment listing as per 2020/21. On occasions merged and revised/new product codes alter the historical data which may lead to data omissions beyond the control of Diversified Specifics.
[68] Parliament of Australia (2007), see bibliography.

4.3.2 Elasticity estimates

To construct a preferred econometric, PreSort large letter volume model, a series of lead in assessments and discriminatory tests for variable selection were undertaken. Appendix E.4 contains the key structural break and lag specification tests applied when constructing the preferred PreSort large letter volume vector error correction model outlined in Table E.4.3.1.[69] The preferred model explains 99.96% of the total quarterly variation in PreSort large letter volumes over the March 2003 to December 2021 time frame.

The historical demand drivers of PreSort large letter volumes together with the estimated demand elasticities are presented below.

1. **E-substitution.**

PreSort large letter migration to digital reflects the increasing opportunities for digital communication given the growing numbers of Australian mobile phones and internet connections across the broadband, wireless and NBN networks. As these technologies have matured, penetration across the business community has enabled large corporations to disseminate a single piece of information digitally to vast numbers of recipients in an immediate and relatively costless manner. As this type of e-substitution has gathered momentum, PreSort large letter volumes have declined.

Elasticity: A 1% increase in e-substitution was associated with a 0.16% decrease in PreSort large letter volumes on average in the long-run.

Recent trends: The rollout of the Australian NBN service has been characterised by a 1,578% increase in the number of wholesale services in operation since 2014/15. Mobile phone subscriptions in Australia have increased by 104% since 2002/03.

[69] Individual tests relating to each of the hypothesized tests are omitted from this document due to space considerations however are available on request from Diversified Specifics.

2. **Real price.**

Rational economic theory suggests the real cost, that is nominal price adjusted for inflationary effects, of sending a PreSort large letter mail will be inversely related to demand. However, the dominating demand driver of e-substitution crowds out any detectable statistical association between volume fluctuations and price. Therefore, price changes fail to register as a statistically significant demand driver in the PreSort large letter volume model. The real price variable is included in the PreSort large letter volume model for economic rather than statistical significance.

Elasticity: A 1% increase in the real price of sending PreSort large letters was associated with a 0.47% decrease in PreSort large letter volumes on average in the long run.

Recent trend: Nominal postage rates for the PreSort large letter service has increased at an annual average rate of 4.7% from 2000/01 to 2020/21. Since 2010/11 this annual average rate change has increased to 8.6% in large part due to a 42.1% price increase effective in January 2016.

3. **Cross price.**

The price of telecommunications services in Australia is utilised to assess the cross-price impacts on letter volume demand. Decreases in PreSort large letter volumes are associated with the declining price of telecommunications services.

Elasticity: A 1% decrease in the real price of services provided in the Australian telecommunications industry was associated with a 2% decrease in PreSort large letter volumes on average in the long run.

Recent trend: The nominal price of services in the Australian telecommunications industry has decreased at an annual average rate of 1% between 2000/01 and 2020/21. The average annual rate of decline has accelerated since 2016/17 to -2.9%.

4.3.3 Driver projections used

A series of projected values on each of the drivers within the VECM framework is required for projection. These include the following.

- E-substitution projections were derived via an endogenous process that involved forecasting the principal components of a variety of technology variables from June 2022 to June 2024.[70]

- CPI projections from the International Monetary Fund (IMF) of 3.34% at 2022, 2.52% at 2023 and 2.47% for 2024 were delineated into quarterly averages to account for inflationary pressures.

- Nominal increases in the price of each PreSort large letter service, listed in Table 4.3.1.1, were provided by Australia Post.[71] To derive a single tractable nominal price variable, the proposed individual price points were weighted based on 2021 volume proportions. For comparative purposes, an alternative price variable was constructed to model the scenario where letter prices do not increase over the projection period.

- Future values of the telecommunications CPI, used to proxy cross price effects, were generated via an AR(1) process as outlined in Section B.1.9 of Appendix B. This resulted in annual cross price declines of -1.35% for 2021/22, -3.86% for 2022/23 and -4.03% for 2023/24.

- PreSort large letter volume projections do not include the impact of any off-model drivers. If any of these potential drivers possess economic significance and be anticipated into the projection period, then adjustments to the econometric baseline should be undertaken.

- The error correction component of the VECM is augmented with a series of dichotomous variables to capture the PreSort large letter demand effects of 1) the relatively large increase in the BPR occurring in the March quarter of 2016; 2) the 2021 Australian Census; and 3) targeted time dependant variables from March 2020 capturing the transitory impacts from the COVID-19 pandemic.[72]

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[70] The technology-based (non-Other small) principal components model is presented in Table B.1.2.9 of Appendix B. For comparison, alternative letter volume projections based upon e-substitution trends/modelling from 2019 are presented in Table B.1.2.12 in Appendix B.

[71] Proposed rate change information provided by Australia Post.

[72] The 2021 Census was held on Tuesday 10 August 2021. See *www.abs.gov.au*

- During the COVID-19 pandemic temporary regulatory relief (TRR) initiatives resulted in variations in Australia Post's required large letter delivery service standards and the cancellation of the Priority service. Due to identification issues associated with service-related demand effects and measuring the impact of the pandemic, any possible cross-segment volume migration could not be evaluated.

4.3.4 Econometric baseline volume projections

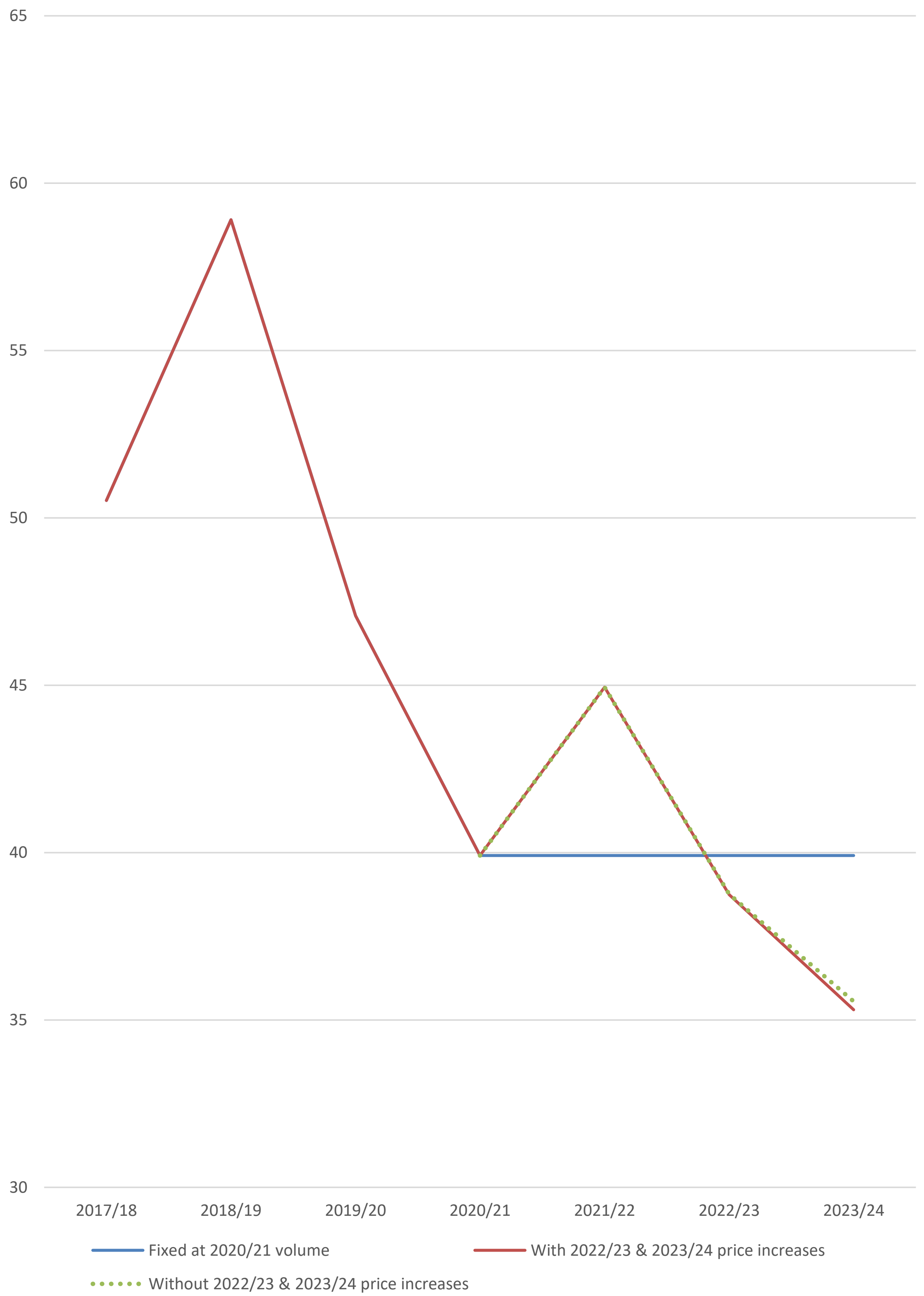
PreSort large letter volume *ex-ante* baseline projections are presented in Table 4.3.4.1 and Chart 4.2.4.1. Mail related to the August 2021 Census represents the primary explainer of an 11% increase in PreSort large letter volume growth in 2021/22. Thereafter, annual declines in volume are anticipated to return in 2022/23 and 2023/24, driven by further movements towards digital alternatives. The proportion of these projected declines explained by any PreSort large letter rate rises is negligible, as emphasised in Table 4.3.4.1 and Chart 4.2.4.1.

Table 4.3.4.1: PreSort large letter volumes econometric projected percentage changes.[73]

	Baseline projected volume change (%)	
	With price increases	Without price increases
2021/22	11.0%	11.0%
2022/23	-13.8%	-13.8%
2023/24	-8.9%	-8.3%

[73] 2021/22 projections are comprised of nine months of actuals and three months of projections.

Chart 4.3.4.1: PreSort large letter volumes (annual, millions)
Historical and projected



5. PRINT POST

5.1 OVERVIEW

Print Post consists of either small or large lodgements of 100 plus items that satisfy the relevant category content, size and weight requirements listed in Table 5.1.1. Further conditions require the publication must be a continuing printed periodical with a fixed title and published at least twice a year. Australia Post pre-approval is essential to qualify for the service and accepted customers are issued with a unique Print Post Publication Number.

Table 5.1.1 Print Post service qualification requirements

Size details	Small	Large
Maximum weight	125g	1kg
Minimum size	88 x 138mm	88 x 138mm
Maximum size	130 x 240mm	260 x 360mm
Maximum thickness	5mm	20mm

Source: www.auspost.com.au

The Print Post service is designed to offer several features to Australia Post's customers including:

- Work shared discounts on the price of mail given the sorting and labelling requirements for magazine distribution
- An allowance for personalised messages within the item to individualise the publication and content
- The possible addition of a fly sheet for additional artwork and promotional activities
- Alternative packaging in the form of envelopes or plastic wrapped solutions
- Supply within the regular mail flow providing immediate access to Australia Post's extensive delivery network.
- A return mechanism for undelivered items.

Although, Print Post items may be sent according to either a Regular or Priority speed, Australia Post does not track delivery service performance for this segment, unlike the small and large letter services discussed in Sections 3 and 4.

5.2 PRINT POST

5.2.1 Service scope

The Print Post segment mainly caters to the delivery of bulk, reoccurring letter items emanating from business and the public sector. Primarily the content ranges across magazines, periodicals, and catalogues, etc. All service offerings within this segment are listed in Table 5.2.1.1.

Table 5.2.1.1: Print Post service sub-segments[74]

Print Post Standard Size
Print Post < 500g
Print Post > 500g

Given the increasing amount of information digested, largely for free, by Australians in digital forms through social media, websites and digital publications, Print Post volumes have declined at an average annual rate of 6.8% since 2010/11 and by 10.6% since 2016/17. Firms producing magazines are also less incentivised on the supply side due to declines in print-based advertising revenue that has been cannibalised by online mediums.[75] These reflect general magazine and publication industry trends where subscription (and circulation) rates have deteriorated worldwide over the longer term.

[74] Sub-segment listing as per 2020/21. On occasions merged and revised/new product codes alter the historical data which may lead to data omissions beyond the control of Diversified Specifics.

[75] Digital advertising expenditure worldwide is expected to increase from $US 380.75 billion in 2020 to $US 785.08 billion in 2025. These types of promotional activities include advertising on internet enabled devices including PC's, tablets, and smartphones. See eMarketer, *www.insiderintelligence.com*

5.2.2 Elasticity estimates

The Print Post volume model is based upon a DOLS functional form. Tests for structural breaks, lag structures, cointegration and alternative specifications are outlined in Appendix E.5, with Table E.5.3.1 containing the preferred Print Post volume model.[76] This model explains 99.3% of the total quarterly variation in Print Post volumes between March 2015 and December 2021.

The historical demand drivers of Print Post volumes together with the estimated demand elasticities are presented below.

1. **E-substitution.**

An increasing amount of information can now be digested in a largely costless manner by Australians in digital forms through social media, websites, and digital publications. In response Print Post volumes have declined reflecting a worldwide trend in the magazine and publication industry where subscription / circulation rates have deteriorated based on these technological developments. The proliferation in mobile phone subscriptions and broadband, wireless and NBN internet connections across Australia has facilitated an increased in penetration rates enabling the quantity of users engaging with online platforms to grow at unprecedented rates. As Australians divert their attention towards online mediums, a greater proportion of promotional spend is also redirected away from printed catalogues that historically also utilised Australia Post's Print Post service.

Elasticity: A 1% increase in e-substitution as measured via principal component analysis was associated with a 0.52% decrease in Print Post volumes on average in the long-run.

Recent trends: The rollout of the Australian NBN service has been characterised by a 1,578% increase in the number of wholesale services in operation since 2014/15. Mobile phone subscriptions in Australia have increased by 104% since 2002/03.

[76] Individual tests relating to each of the hypothesized tests regarding variable selection are omitted from this document due to space considerations however are available on request from Diversified Specifics.

2. **Real price.**

Rational economic theory suggests the real cost, that is nominal price adjusted for inflationary effects, of sending Print Post mail will be inversely related to demand.

Given the dominant influence of e-substitution as a demand driver, price changes fail to register as a statistically significant association with movements in Print Post volumes. The real price variable is included in the Print Post DOLS volume model for economic rather than statistical importance.

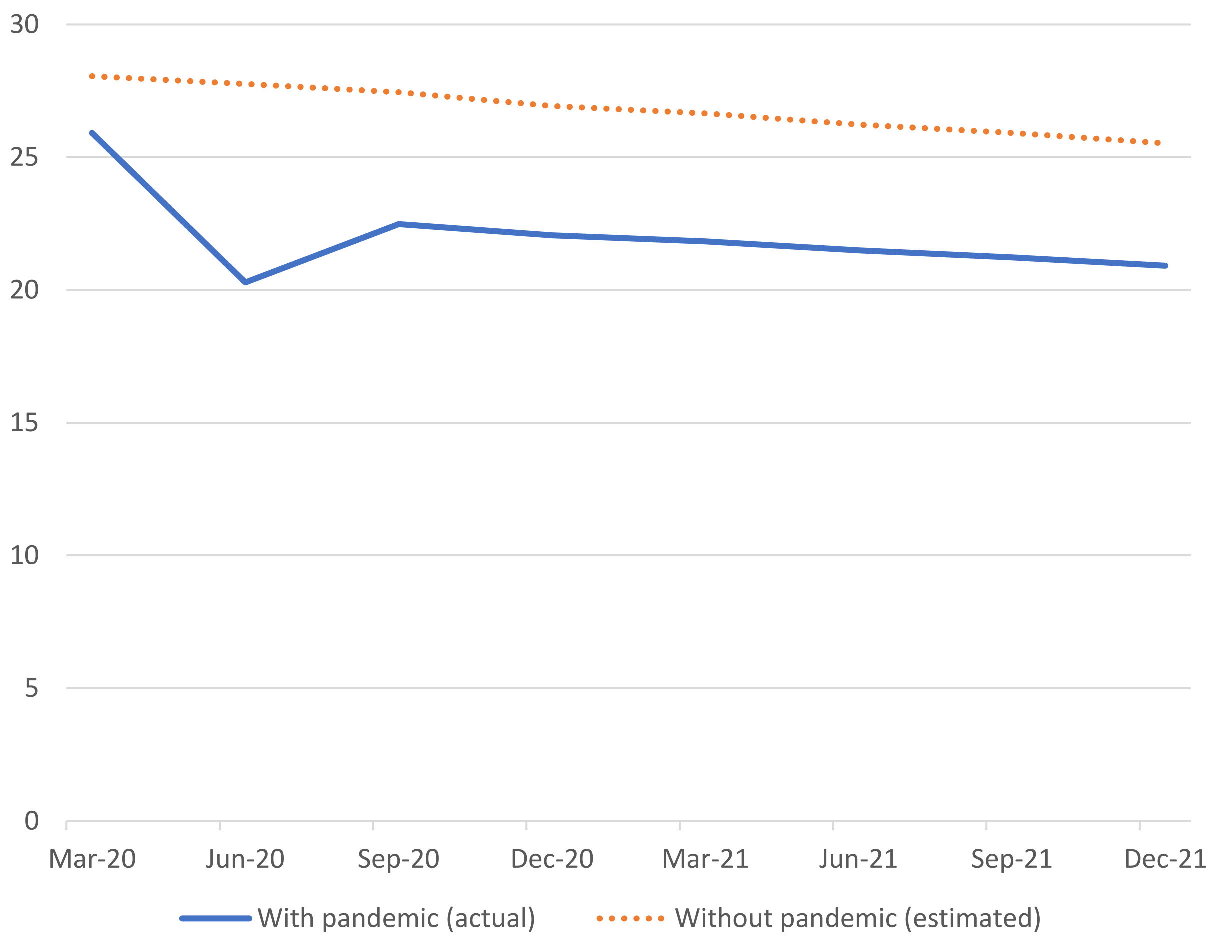
Elasticity: A 1% increase in the real price of sending Print Post items was associated with a 0.06% decrease in Print Post volumes on average in the long run.

Recent trend: Nominal postage rates for the Print Post letter service has increased at an annual average rate of 4.3% between 2000/01 and 2020/21. Across this period the largest individual annual rate rise for the Print Post service was 29.5% in January 2016.

3. COVID-19.

Accelerated annual Print Post volume erosion, from -9.1% (in 2018/19) to -21.3% (in 2019/20), was symptomatic of the pandemic-driven effects on Australian consumer discretionary expenditure. The pandemic had a statistically significant impact on reducing catalogue numbers within the Print Post service, resulting in a negative net volume outcome. Within the modelling this is captured by an over-arching dichotomous variable. The results also emphasise the importance of the March and June quarters of 2020 where a one-off decline in Print Post volumes, in the early stages of the pandemic, resulted in a consistent gap between actual, as against expected volumes. In conjunction to the overriding negative impact, targeted COVID-19 dichotomous variables focused on these quarters capture the initial Print Post volume declines linked to the dramatic declines in discretionary expenditure. A visual summary of Print Post volumes with and without the presence of the pandemic is provided in Chart 5.2.2.1.[77]

Chart 5.2.2.1. The estimated impact of COVID-19 on Print Post volumes (quarterly, millions)



[77] Counterfactual '*without pandemic*' estimates are derived via setting all COVID-19 related dichotomous variables to zero.

5.2.3 Driver projections used

A series of projected values on each of the Print Post drivers within the DOLS framework is required to generate the volume projections. These include the following.

- E-substitution projections were derived via a modelling of the long run trends. This involved forecasting the principal components of a variety of technology variables from June 2022 to June 2024 based on an AR(1) model with a time trend.[78]

- CPI projections from the International Monetary Fund (IMF) of 3.34% at 2022, 2.52% at 2023 and 2.47% for 2024 were delineated into quarterly averages to account for inflationary pressures.

- Nominal increases in the price of each Print Post sub-segment, listed in Table 5.2.1.1, were provided by Australia Post.[79] To derive a single tractable nominal price variable, the proposed individual price points were weighted based on 2021 volume proportions. For comparative purposes, an alternative price variable was constructed to model the scenario where Print Post prices do not increase over the projection period.

- Print Post volume projections do not include the impact of recently emerging trends or events of economic, rather than statistical, significance falling outside the sample data. Estimated volumes associated with these off-model impacts should be factored into any augmentations to the projections when constructing the final forecasts.

- The Print Post DOLS model is augmented with an overarching dichotomous variable designed to capture the COVID-19 impact from March 2020. Given substantial Print Post declines occurred upon the emergence of the pandemic into Australia, dichotomous variables targeted in March and June 2020 are also included within the modelling framework.

- During the COVID-19 pandemic temporary regulatory relief (TRR) initiatives resulted in variations in Australia Post's delivery service standards in addition to the cancellation of the Priority service. As Print Post delivery service performance is not measured by Australia Post the associated demand effects could not be evaluated.[80]

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[78] The technology-based (non-Other small) principal components model is presented in Table B.1.2.9 of Appendix B. For comparison, alternative letter volume projections based upon e-substitution trends/modelling from 2019 are presented in Table B.1.2.12 in Appendix B.

[79] Proposed rate change information provided by Australia Post.

[80] Diversified Specifics recommends Australia Post commence measurement of Print Post delivery service performance as preliminary testing using large letter proxies implied significant service-related demand impacts.

5.2.4 Econometric baseline volume projections

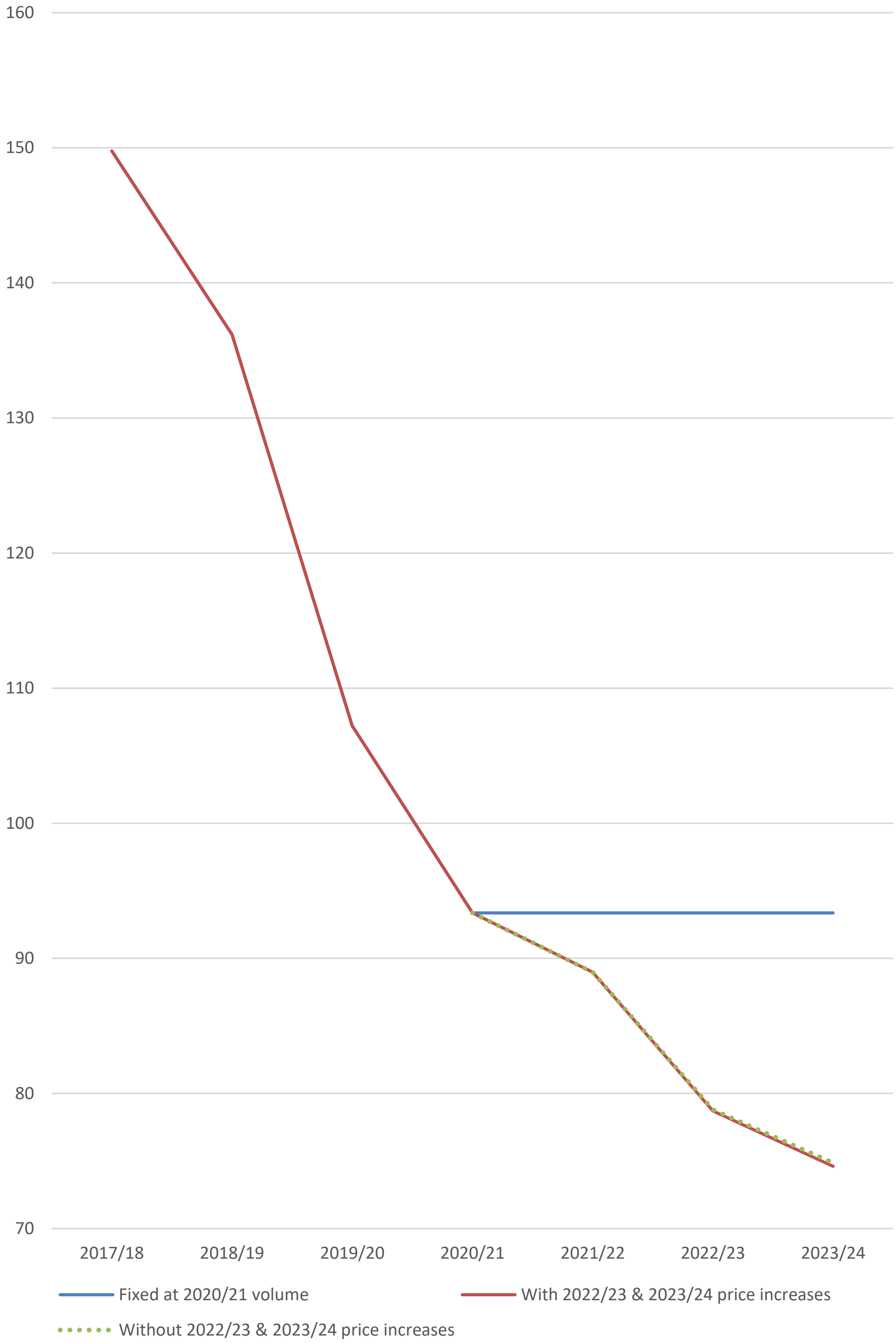
Print Post *ex-ante* baseline projections are presented in Table 5.2.4.1 and Chart 5.2.4.1. Proportionately, Print Post was impacted the most by COVID in 2020, notwithstanding the Promo Post declines that are crowded out within the PreSort small service. The softer Print Post declines anticipated in 2021/22 are driven by more typical levels of Australian economic and pent-up promotional demand effects following the re-opening of non-essential retail. From 2022/23 Print Post volume declines are expected predicted to normalise, returning to the longer-term e-substitution trend, irrespective of a price change.

Table 5.2.4.1: Print Post volumes econometric projected percentage changes.[81]

	Baseline projected volume change (%)	
	With price increases	Without price increases
2021/22	-4.7	-4.7
2022/23	-11.6	-11.4
2023/24	-5.2	-5.0

[81] 2021/22 projections are comprised of nine months of actuals and three months of projections.

Chart 5.2.4.1: Print Post volumes (annual, millions)
Historical and projected



6. CONCLUDING OBSERVATIONS

6.1 IMPLICATIONS FOR TOTAL LETTERS

The global and domestic economy has been subjected to high degrees of volatility and uncertainty following the outbreak of the COVID-19 virus. Econometric techniques estimate the additional loss in total domestic addressed letter volumes at Australia Post due to COVID-19 related effects at 239 million items between January 2020 and December 2021. This translates into an estimated additional loss in total letter volume of -7.5% (or -3.75% p.a.) primarily driven by accelerating e-substitution pressures induced by the pandemic. During this period, the price of a typical letter item has remained largely stable so cannot have contributed to the accelerated volume erosion. Reflecting this, all estimated price elasticities of demand are inelastic, and several are statistically insignificant, see Table 6.1.1.

Table 6.1.1 Price elasticity of demand

Small letter	Ordinary / Other	-0.15
	PreSort	-0.55*
Large letter	Ordinary / Other	-0.18
	PreSort	-0.47*
Print Post		-0.06*

** denotes statistical insignificance*

The key finding is that e-substitution remains, and is expected to remain, the leading statistical and economic driver of total letter volumes at Australia Post over the foreseeable future. Declining letter volumes are anticipated every year to 2023/24 across all letter segments, see Table 6.1.2.[82] Scenario testing suggests the imposition of the proposed rate rises has minimal effect on volume demand, illustrated in Chart 6.1.1.

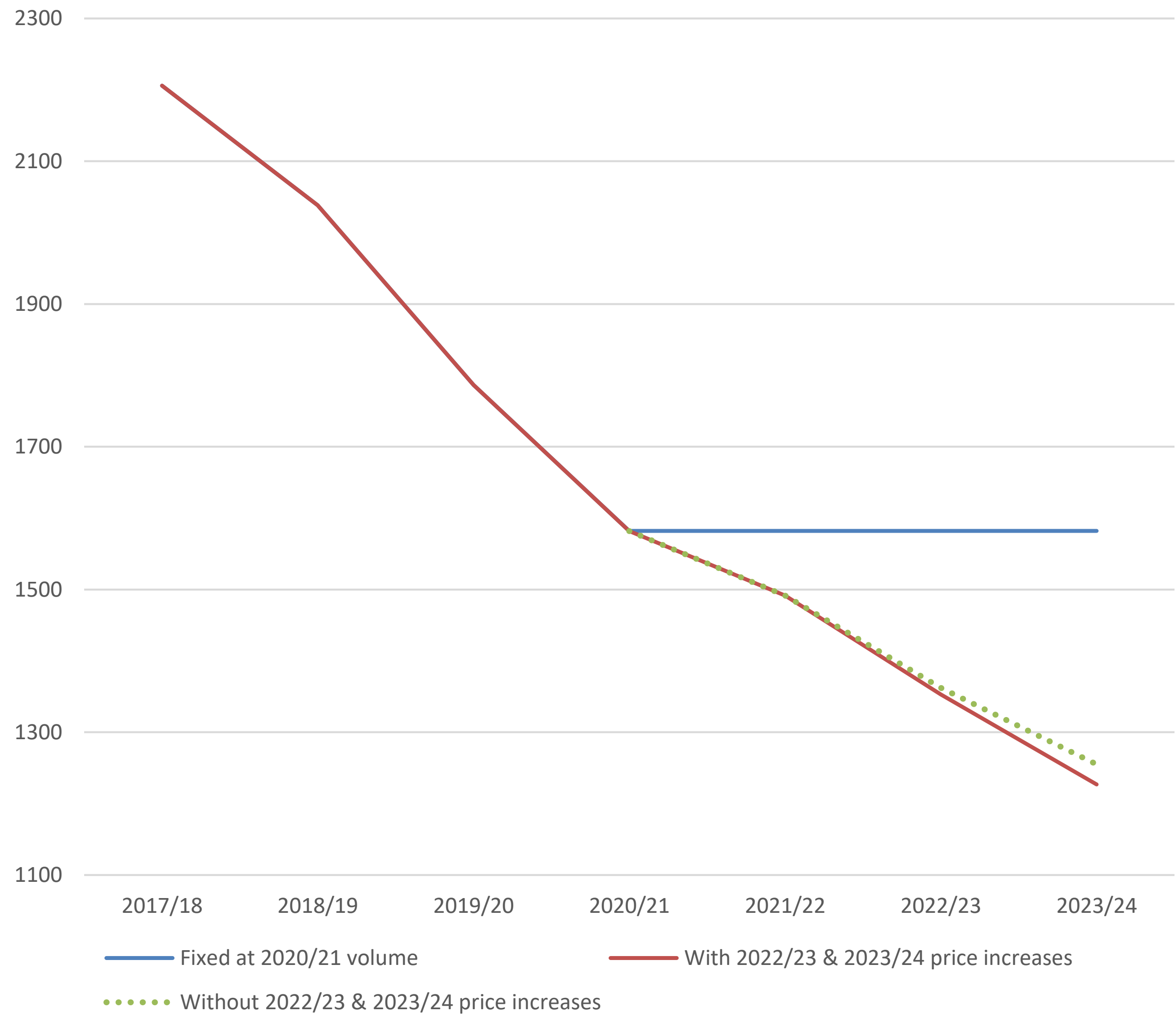
[82] Qualitatively, this inference does not alter when considering an alternative specification for the e-substitution variable. See Table B.1.2.12 in Appendix B for equivalent letter volume projections based upon e-substitution trends/modelling from 2019.

Table 6.1.2 Percentage changes in total letter volume inclusive of proposed rate rises
(Projections without proposed rate rises presented in parentheses)

	Pre COVID-19	Post COVID-19				
	2018/19*(a)*	**2019/20*(a)***	**2020/21*(a)***	**2021/22*(a&p)*** [83]	**2022/23*(p)***	**2023/24*(p)***
Ordinary/Other Small	-8.5	-12.5	-13.6	-10.4	-10.1 *(-9.9)*	-10.8 *(-9.9)*
PreSort Small	-7.7	-11.0	-10.1	-4.6	-8.4 *(-7.5)*	-9.2 *(-7.3)*
Ordinary/Other Large	-10.6	-10.5	-12.4	-2.5	-10.7 *(-10.7)*	-8.2 *(-7.8)*
PreSort Large	16.6	-20.1	-15.2	11.0	-13.8 *(-13.8)*	-8.9 *(-8.3)*
Print Post	-9.1	-21.3	-12.9	-4.7	-11.6 *(-11.4)*	-5.2 *(-5.0)*
Total letters	**-7.6**	**-12.3**	**-11.4**	**-5.7**	**-9.3 *(-8.7)***	**-9.3 *(-7.9)***

Key: actual *(a)* & projected *(p)* baseline

Chart 6.1.1: Total domestic addressed letter volumes at Australia Post (annual, millions) Historical and projected



[83] The 2021/22 percentage changes reported in Table 6.1.2 is constructed by utilising nine months of actual values and 3 months of econometric projected values.

6.2 FINAL REMARKS

Heading into 2022/23 major difficulties in predicting economic growth and inflationary patterns persist. Factors that have complicated matters include the appearance of contagious variant waves of COVID-19, challenges with take-up of booster shots, the war in Ukraine and the disruptive effects of a global rise in the general level of prices. Although significant degrees of uncertainty still exist, Diversified Specifics, in this research task, have quantified the demand effects of key letter volume drivers and generated a set of forward projections.

However, previous Diversified Specifics research, conducted in Australia, Canada, and Finland, on the letter volume demand impact of an economic shock, suggest recessionary periods are likely to accelerate e-substitutive pressures. It is this speed of digital substitution which remains the largest threat to Australia Post's letter's business over the next decade. In the interim, an increasing BPR assists in ensuring sustainability without considerably adding to the volume erosion.

It is recommended that any interpretation of the econometric projections be augmented by further internal and market intelligence. That is, the generation of baseline ex-ante projections provided in this document should necessarily represent an initial step in the volume projection process at Australia Post. Ultimately the baseline must be augmented via further market intelligence on the emerging trends and known future events that are not directly measurable within an empirical framework. The changing dynamic of e-substitutive, economic, and pandemic related impacts reinforces the need for regular model updates and trend re-assessments to ensure strategic decision making at Australia Post continues to be premised upon a robust, structured, and scientific methodology.

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United States Postal Service, *www.usps.com*

Xe Currency Converter, *www.xe.com*

APPENDIX A DATA AND DATA DESCRIPTIONS

A.1 Internal Australia Post data

Australia Post supplied, July 1995 to March 2022, letter volume and revenue data to Diversified Specifics in the form of revenue-based volumes. Information on the proposed percentage changes in the price of individual letter services were also provided by Australia Post, headlined by a 9.1% January 2023 increase in the BPR. Additionally, auxiliary data used in the econometric testing process was supplied by Australia Post including delivery service performance measurements for small and large, excluding Print Post, letter segments.

A.2 Externally sourced data

To facilitate association testing and the generation of econometric models, Diversified Specifics obtained variables from a variety of external sources. Each variable utilised within this testing process is outlined in Table A.2.1. Variables obtained were used to test developed hypothesis in an unbiased and structured manner. Externally sourced variables outlined below that were not included in the final econometric models, were not found to be statistically significant in relation to segment-specific volume movements or did not meet the test of common-sense based on the accepted principles of economic theory relating to the postal industry. Such tests do not diminish the economic significance of the associated hypotheses tested.

Table A.2.1 Data descriptions

Volume predictor	Measurement variable or proxy	Data frequency	Data source
Australian Non-farm GDP	Australian Non-farm GDP	September 1995 to March 2022 – Quarterly series	Gross Domestic Product minus Agriculture, Forestry and Fishing (A), Cat. No. 5206.0 Table 6 Gross Value Added by Industry, Australia, Chain volume measures, Australian Bureau of Statistics, *www.abs.gov.au*
Advertising industry health measure	S&P/ASX 200 consumer discretionary index	September 1995 to March 2022 – Quarterly series	Created by Diversified Specifics. Original Data from Media Index (defunct) & the S&P/ASX 200 consumer discretionary index, *www2.asx.com.au*
Australian credit card volumes	Australian credit card volumes	July 1995 to March 2022 – Monthly series	Number of accounts, Credit and Charge Cards – Original Series – Aggregate Data – C1.1, Payment System, Reserve Bank of Australia, *www.rba.gov.au*
Australian cheque volumes	Principal component index for e-substitution: Other (Ordinary) small letters only	January 2002 to March 2022 – Monthly series	Total number of cheques, Cheques – Original Series – C5.1, Payment System, Reserve Bank of Australia, *www.rba.gov.au*
Real price of Other (Ordinary) small letters	Real price of an Other (Ordinary) small letter	September 1995 to March 2022 – Quarterly series	1) Other small letter volumes (revenue based) and revenue, Australia Post 2) CPI: ABS Cat. No. 6401.0 TABLES 1 and 2. All Groups, Index Numbers and Percentage Changes, Consumer Price Index, Australia Bureau of Statistics, *www.abs.gov.au*
Real price of Other (Ordinary) large letters	Real price of an Other (Ordinary) large letter	September 1995 to March 2022 – Quarterly series	1) Other large letter volumes (revenue based) and revenue, Australia Post 2) CPI: ABS Cat. No. 6401.0 TABLES 1 and 2. All Groups, Index Numbers and Percentage Changes, Consumer Price Index, Australia Bureau of Statistics, *www.abs.gov.au*
Real price of PreSort small letters	Real price of a PreSort small letter	September 1995 to March 2022 – Quarterly series	1) PreSort small letter volumes (revenue based) and revenue, Australia Post 2) CPI: ABS Cat. No. 6401.0 TABLES 1 and 2. All Groups, Index Numbers and Percentage Changes, Consumer Price Index, Australia Bureau of Statistics, *www.abs.gov.au*

Volume predictor	Measurement variable or proxy	Data frequency	Data source
Real price of PreSort large letters	Real price of a PreSort large letter	September 1995 to March 2022 – Quarterly series	1) PreSort large letter volumes (revenue based) and revenue, Australia Post 2) CPI: ABS Cat. No. 6401.0 TABLES 1 and 2. All Groups, Index Numbers and Percentage Changes, Consumer Price Index, Australia Bureau of Statistics, *www.abs.gov.au*
Real price of Print Post	Real price of a Print Post mail item	September 2006 to March 2022 – Quarterly series	1) Print Post volumes (revenue based) and revenue, Australia Post 2) CPI: ABS Cat. No. 6401.0 TABLES 1 and 2. All Groups, Index Numbers and Percentage Changes, Consumer Price Index, Australia Bureau of Statistics, *www.abs.gov.au*
Domestic broadband index	Principal component index for e-substitution	March 2002 to December 2018 – Quarterly series	Created by Diversified Specifics. Original Data from: 1) Australia Bureau of Statistics Internet Activity, Australia, December 2009, December 2012, and June 2018, *www.abs.gov.au*; 2) Snapshot of Broadband data, Australian Competition & Consumer Commission, *www.accc.gov.au*
Wireless broadband subscribers	Principal component index for e-substitution	December 2008 to September 2013 – Quarterly series	Created by Diversified Specifics. Original Data from: 1) Australia Bureau of Statistics Internet Activity, Australia, December 2012 and June 2018, *www.abs.gov.au*; 2) Snapshot of Broadband data, Australian Competition & Consumer Commission, *www.accc.gov.au*
Number of wholesale NBN services in Australia	Principal component index for e-substitution	June 2015 to December 2021 – Quarterly series	Number of Wholesale NBN Services in Operation (SIOs) by Technology Type, Australian Competition & Consumer Commission, *www.accc.gov.au*
Australian mobile subscribers	Principal component index for e-substitution	March 2000 to December 2020 – Quarterly series	Australian annual mobile phone subscribers, International Telecommunication Union, *www.itu.int*
Australian retail trade	Australian retail trade	September 1995 to June 2018 – Quarterly series	Retail trade (G), Cat. No. 5206.0 Table 6 Gross Value Added by Industry, Australia, Chain volume measures, Australian Bureau of Statistics, *www.abs.gov.au*

Volume predictor	Measurement variable or proxy	Data frequency	Data source
Direct entry payments for debit transfers	Principal component index for e-substitution: Other (Ordinary) small letters only	January 2002 to March 2022 – Monthly series	Number of debit transfers, Direct Entry and NPP – Original Series – C6.1, Payment System, Reserve Bank of Australia, *www.rba.gov.au*
Australian population	Estimated Australian population	September 1995 to September 2021 – Quarterly series	Australia Bureau of Statistics, Cat. No. 3101.0 Table 1. Population Change, Summary - Australia ('000), *www.abs.gov.au*
Paper as an input cost	Paper as an input cost for letters	September 1995 to March 2022 – Quarterly series	Australia Bureau of Statistics, Producer Price Index, Table 14 Cat Number 6427014, 15 Pulp, paper and converted paper product manufacturing, *www.abs.gov.au*
Business confidence	NAB Business confidence index	April 1997 to March 2022 – Monthly series	NAB business confidence index, NAB Monthly Business Survey, Net balance (NSA)+100, National Australia Bank, *www.business.nab.com.au*
Post-global financial crisis	Post-global financial crisis	December 2008 to March 2022	Dichotomous Variable, Created by Diversified Specifics.
COVID-19	Post-COVID-19 & Individual quarters related to the pandemic	March 2020 to March 2022	Dichotomous Variable, Created by Diversified Specifics related to: 1) Post onset of COVID-19 within Australia 2) Individual quarters following the onset of COVID-19 within Australia
Initial public offerings	Market capitalisation associated with large initial public offerings	September 1995 to March 2022 – Quarterly series	Created by Diversified Specifics. Original Data from the Australian Stock Exchange, S&P/ASX 300, *www2.asx.com.au*
Australia Post delivery service performance	Australia Post delivery service performance for small and large letter segments	September 1998 to March 2022 – Quarterly series	Supplied by Australia Post. .

Volume predictor	Measurement variable or proxy	Data frequency	Data source
Australian consumer price index	Deflator	September 1998 to March 2022 – Quarterly series	Australia Bureau of Statistics, 6401.0 Consumer Price Index, Australia, TABLES 1 and 2. CPI: All Groups, Index Numbers and Percentage Changes, *www.abs.gov.au*
Australian consumer price index for telecommunication equipment and services	Cross-price effects	September 1998 to March 2022 – Quarterly series	Australia Bureau of Statistics, 6401.0 Consumer Price Index, Australia, TABLE 7. CPI: Group, Sub-group and Expenditure Class, Weighted Average of Eight Capital Cities, *www.abs.gov.au*
Political events	Australian Federal/State elections & referendums	Various	Australian Electoral Commission, *www.aec.gov.au*. Dichotomous variables, Created by Diversified Specifics.

APPENDIX B HYPOTHESED DEMAND DRIVERS

B.1 Hypothesised demand drivers

This Appendix outlines each hypothesis that links fluctuations in prospective drivers to movements in domestic letter volume demand. All hypotheses are accompanied by information on the primary data source or proxy deployed.[84] The following sub-sections are intended to provide a background for the justification of macro variables contemplated in the econometric modeling process.

Prior letter volume demand studies in this series have always been premised upon obtaining appropriate data that is reflective of the hypotheses developed. In some cases, the desired data was either not publicly available or, over time, became redundant. Additionally, for some of the explanatory variables assessed previously, data sources had been discontinued or were not available on a quarterly basis. Where these issues were considered problematic, the data was either not included in the econometric process or interpolations/extrapolations were undertaken.

[84] Interpolations and back-casting techniques were deployed where the data was deemed deficient due to misaligned frequencies, insufficient series length, or data gaps.

B.1.1 Own price

<u>Hypotheses:</u> According to the fundamental principles of economics, increases in the own price of a letter is inversely associated with movements in letter volume.

At Australia Post, revealed preference revenue-based volume (RBV) data on revenue and volumes is utilised to construct an average unit revenue, or rate, that is ultimately charged to the customer who responds accordingly, based upon their own budget and market alternatives. To obtain a real indicator, the Australian consumer price index (CPI) is used to deflate the nominal price series. Fluctuations in the average price across the differing segments of Australia Post's domestic addressed letters business is contained in Chart B.1.1.1.

Chart B.1.1.1 Real price of Australia Post's domestic letters by segment (Quarterly, indexed)[85]

Indexed: September Quarter 2006 = 100

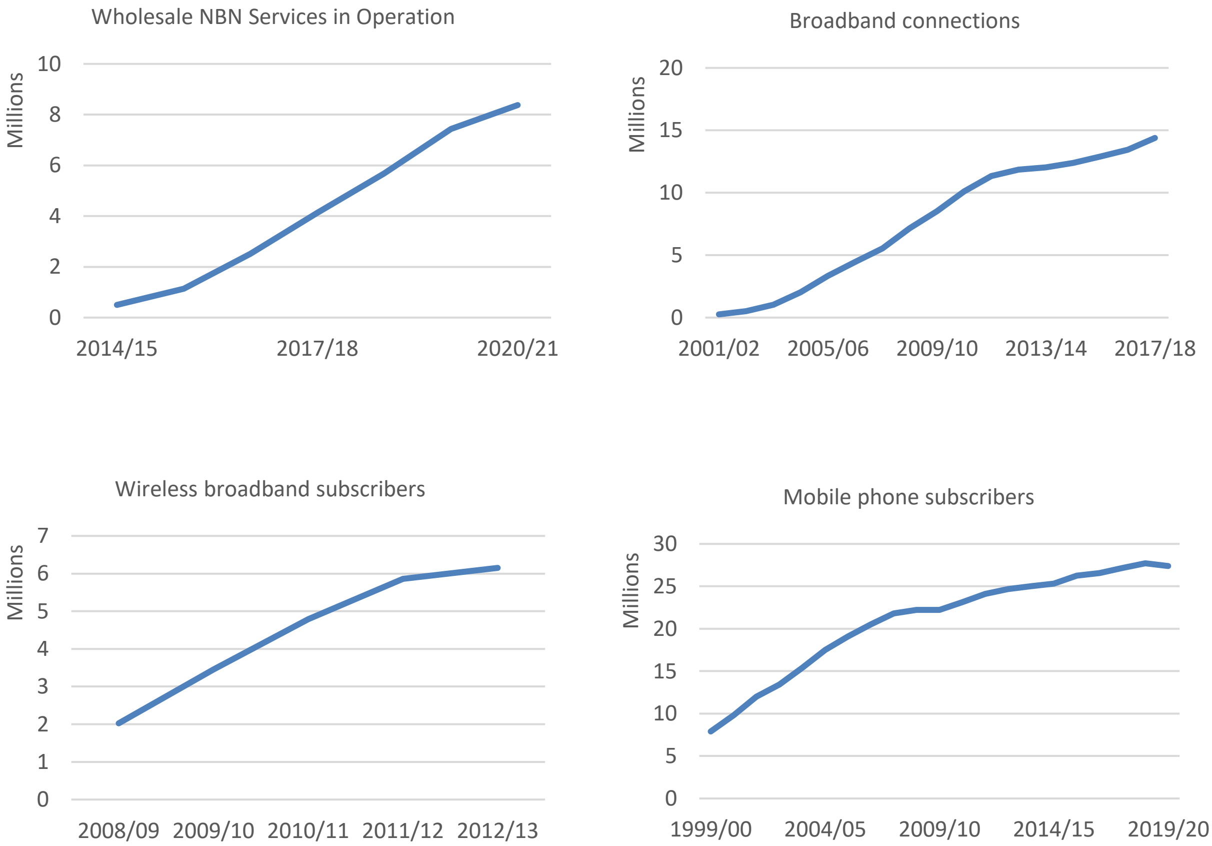
[85] For a complete list of data sources see Table A.2.1 in Appendix A.

B.1.2 E-substitution

<u>Hypotheses:</u> Fluctuations in the level of e-substitution are inversely associated with movements in letter volume.

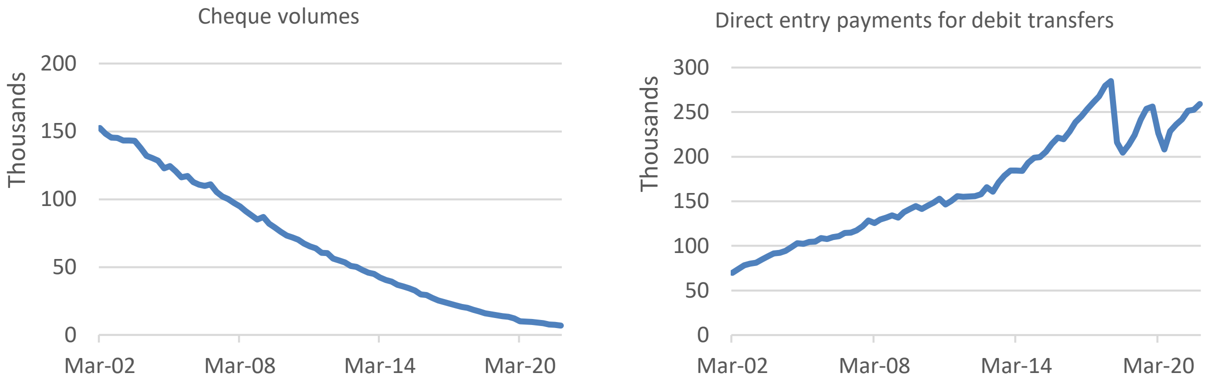
The growth and penetration in online platforms within Australia in recent times has been strong, as reflected by the raw data plots contained in Chart B.1.2.1. A combination of these variables underpins the quantification of the e-substitution impact upon letter volumes within this econometric study. In the case where the content of the letter item has skewed toward bill payments, such as for the Other small letter segment, additional variables are required to capture these auxiliary effects, see Chart B.1.2.2.

Chart B.1.2.1 Online connectivity in Australia[86]



[86] For a complete list of data sources see Table A.2.1 in Appendix A.

Chart B.1.2.2 Indicators of declining bill payments in Australia[87]



Diversified Specifics combined the underlying characteristics of the various measures of Australian e-substitution into two summary variables using principal component techniques. This method reduces the number of interrelated variables into a single dimension whilst retaining the underlying variation of the individual series.

Undertaking the construction of each principal component index requires a series of interpolations and approximations to ensure the data is uniformly distributed across the entire timeframe for model development. The techniques deployed to undertake these data transformations are explained as follows:

Direct entry payments for debit transfers

There are two direct debit variables available defined broadly by a pre-May 2018 series and a post-May 2018 series, where the latter arises because of a change in data definitions adopted by the Australian Bureau of Statistics. To splice the two series together, because there is no common observation under the prevailing definitions, the approach is to estimate a model for the post May 2018 series and back cast this model by one observation, generating a value for June 2018 to be used in splicing the two data sets together. The estimated model using the post May 2018 data is presented in Table B.1.2.1.

[87] For a complete list of data sources see Table A.2.1 in Appendix A.

Table B.1.2.1 Trend model for direct entry payments for debit transfers (Post May 2018)

Dependent Variable: LOG(DIRECTDEBIT_POSTMAY)
Method: Least Squares
Date: 05/19/22 Time: 15:24
Sample (adjusted): 9/01/2018 3/01/2022
Included observations: 15 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	11.55928	0.280765	41.17070	0.0000
@TREND(2002Q1)	0.010980	0.003788	2.898771	0.0124

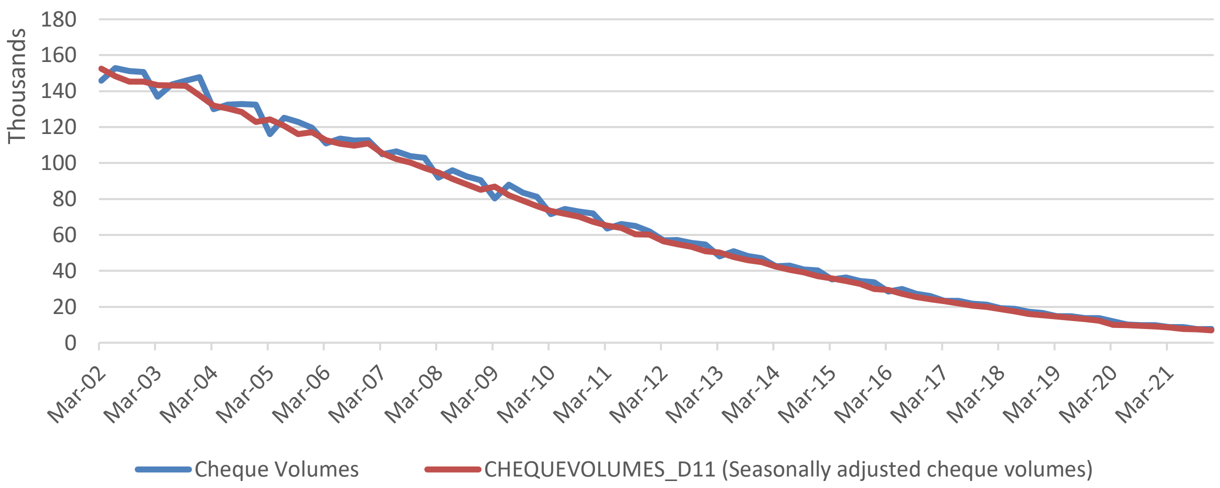
R-squared	0.392605	Mean dependent var	12.37177
Adjusted R-squared	0.345882	S.D. dependent var	0.078365
S.E. of regression	0.063380	Akaike info criterion	-2.555778
Sum squared resid	0.052221	Schwarz criterion	-2.461371
Log likelihood	21.16833	Hannan-Quinn criter.	-2.556783
F-statistic	8.402873	Durbin-Watson stat	0.853860
Prob(F-statistic)	0.012437		

The back casted value for June 2018 is, 216193.4019, contained in the series DIRECTDEBIT. This value is then used to splice the pre and post series together from March 2002 to March 2018, where the March 2018 value of the pre-May series is 251087.5.

Cheque Volumes

Although Australian cheque volumes are available across the entire time frame required, that is from March 2002, there is strong evidence of seasonality which tends to dissipate over time. To correct for the seasonal component the X-13 program in EViews facilitates a correction based on the log-filter option. The seasonally adjusted series is titled CHEQUEVOLUMES_D11. The raw and seasonally adjusted series are depicted in Chart B.1.2.3.

Chart B.1.2.3 Number of cheque volumes within Australia[88]



[88] For a complete list of data sources see Table A.2.1 in Appendix A.

Domestic broadband

The domestic broadband series commences in March 2002 and extends to December 2018. To extrapolate this series for principal component analysis, the approach is to estimate a deterministic (nonlinear) trend AR(1) model with the variable expressed in natural logarithms across the March 2002 to December 2018 period. The estimated model, as presented in Table B.1.2.2, is used to extrapolate the series to March 2022.

Table B.1.2.2 Australian domestic broadband connections - Deterministic (nonlinear) trend AR(1) model

Dependent Variable: LOG(DOMESTICBROADBAND)
Method: Least Squares
Date: 05/19/22 Time: 12:04
Sample (adjusted): 6/01/2002 12/01/2018
Included observations: 67 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.960678	0.068626	13.99872	0.0000
LOG(DOMESTICBROADBAND(-1))	0.942296	0.004243	222.0695	0.0000
@TREND(2002Q1)^(-1)	-0.094026	0.063664	-1.476907	0.1446

R-squared	0.999633	Mean dependent var	15.49914
Adjusted R-squared	0.999622	S.D. dependent var	1.126711
S.E. of regression	0.021911	Akaike info criterion	-4.759888
Sum squared resid	0.030727	Schwarz criterion	-4.661170
Log likelihood	162.4562	Hannan-Quinn criter.	-4.720825
F-statistic	87225.71	Durbin-Watson stat	0.853134
Prob(F-statistic)	0.000000		

Mobile phone subscriptions

Australian mobile phone subscription data commences in March 2000, extending to December 2020. To estimate the remaining observations in 2021 an AR(1) model is estimated with the variable expressed in natural logarithms. The results presented in Table B.1.2.3. with the final series named, MOBILE within the final driver data sets.

Table B.1.2.3 Australian mobile phone subscriptions - AR(1) model

Dependent Variable: LOG(MOBILEPHONESUBS)
Method: Least Squares
Date: 05/19/22 Time: 12:12
Sample (adjusted): 6/01/2000 12/01/2020
Included observations: 83 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.732858	0.043248	16.94555	0.0000
LOG(MOBILEPHONESUBS(-1))	0.957304	0.002573	372.1109	0.0000

R-squared	0.999415	Mean dependent var	16.82250
Adjusted R-squared	0.999408	S.D. dependent var	0.330598
S.E. of regression	0.008043	Akaike info criterion	-6.784274
Sum squared resid	0.005240	Schwarz criterion	-6.725989
Log likelihood	283.5474	Hannan-Quinn criter.	-6.760858
F-statistic	138466.5	Durbin-Watson stat	0.290965
Prob(F-statistic)	0.000000		

Wholesale NBN Services

Data on wholesale NBN services in operation within Australia are available to March 2022, however, commence in June 2015. A time series model is estimated then deployed to back cast the series to March 2002, from March 2015, purely to enable inclusion within the principal component index. The estimated model is given in Table B.1.2.4 which is based on an exponential nonlinear trend equation. The forecasted series is titled NBN.

Table B.1.2.4 Time trend model for Australian wholesale NBN services in operation

Dependent Variable: LOG(NBNWHOLESALE)
Method: Least Squares
Date: 05/19/22 Time: 15:05
Sample (adjusted): 6/01/2015 3/01/2022
Included observations: 28 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-13.93989	0.650578	-21.42691	0.0000
@TREND(2002Q1)	0.753713	0.019469	38.71411	0.0000
@TREND(2002Q1)^2	-0.004754	0.000144	-33.01427	0.0000

R-squared	0.998035	Mean dependent var	14.96379
Adjusted R-squared	0.997878	S.D. dependent var	0.963537
S.E. of regression	0.044387	Akaike info criterion	-3.290784
Sum squared resid	0.049255	Schwarz criterion	-3.148048
Log likelihood	49.07098	Hannan-Quinn criter.	-3.247149
F-statistic	6349.003	Durbin-Watson stat	0.257590
Prob(F-statistic)	0.000000		

Wireless broadband

The wireless broadband series begins in December 2008, extending to September 2013, necessitating the estimation of a model to generate both projections and back casts. The estimated model is provided in Table B.1.2.5 based on a nonlinear exponential trend framework. The results constitute the series WIRELESS. The back casted series spanning March 2002 to September 2008 are given in the series WIRELESS_BACKCAST. These observations are then combined with the WIRELESS dataset to generate a revised WIRELESS series from March 2002 to March 2020. The generated series WIRELESS is combined with the raw data given by WIRELESSBROADBAND to form the final series deployed in the principal component analysis.

Table B.1.2.5 Nonlinear exponential trend model for Australian wireless broadband

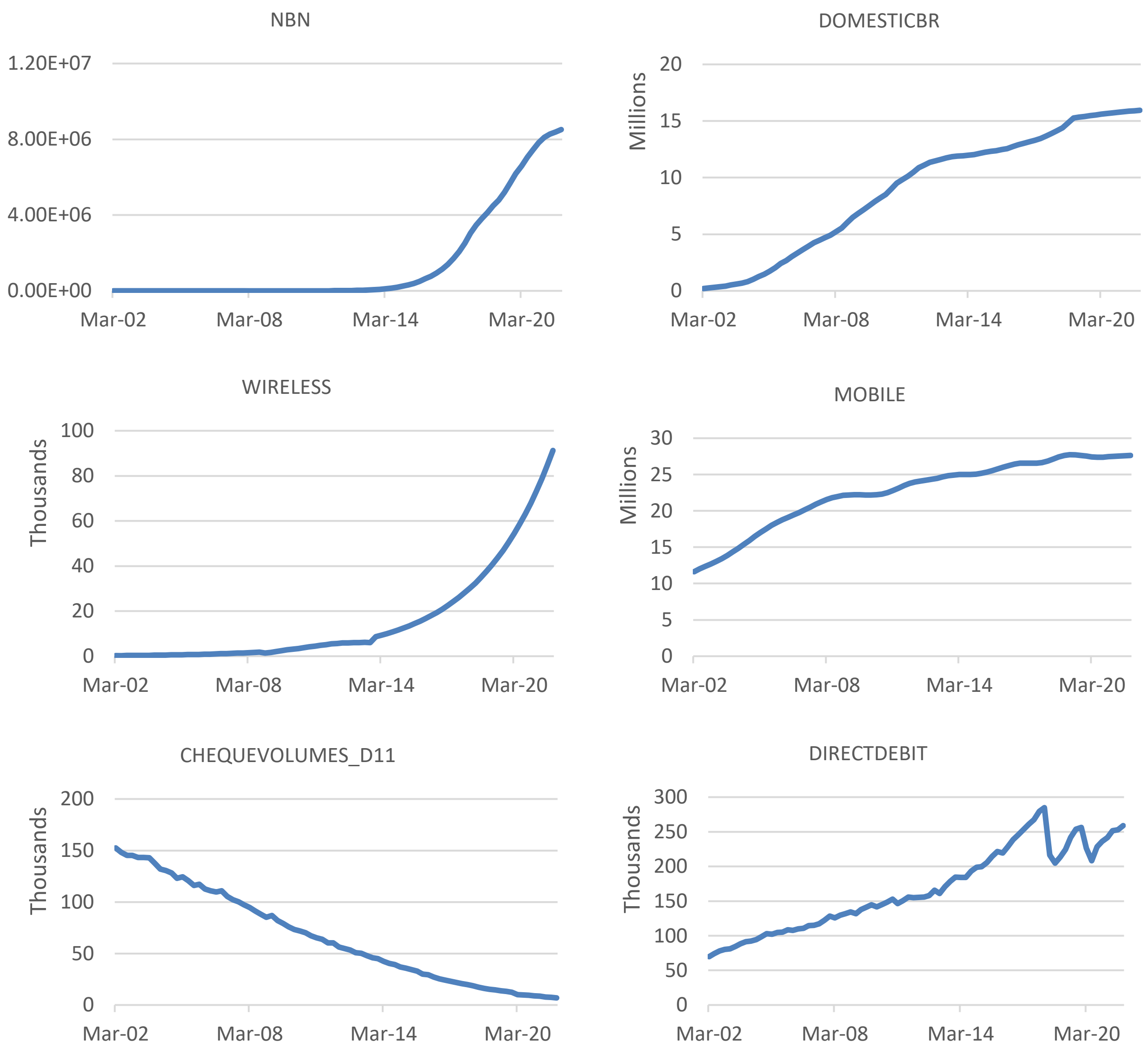
Dependent Variable: LOG(WIRELESSBROADBAND)
Method: Least Squares
Date: 05/19/22 Time: 12:33
Sample (adjusted): 12/01/2008 9/01/2013
Included observations: 20 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.818372	0.288593	-6.300821	0.0000
@TREND(2002Q1)	0.474608	0.015644	30.33724	0.0000
@TREND(2002Q1)^2	-0.005344	0.000208	-25.68171	0.0000

R-squared	0.996873	Mean dependent var	8.286056
Adjusted R-squared	0.996505	S.D. dependent var	0.466429
S.E. of regression	0.027574	Akaike info criterion	-4.206434
Sum squared resid	0.012925	Schwarz criterion	-4.057074
Log likelihood	45.06434	Hannan-Quinn criter.	-4.177277
F-statistic	2709.857	Durbin-Watson stat	0.538546
Prob(F-statistic)	0.000000		

The expanded set of variables appropriate for principal component analysis based upon the transformation of the raw data via projection and back casting techniques are presented in Chart B.1.2.4.

Chart B.1.2.4 Expanded e-substitution variables for principal component analysis by variable name



Principal component variable for Other small letters

The e-substitution variable for other small letters is based on the individual principal components derived from all six e-substitution variables. This reflects the need to augment an expansion in online connectivity with the behavioural trends of a decline in paper-based billing mechanisms, as proxied by the decline in cheque volumes and the increasing usage of direct debit facilities within Australia. The results of the eigenvalue decomposition are given in Table B.1.2.6 based on the correlation matrix of the logarithm pertaining to the six e-substitution variables displayed in Chart B.1.2.4. The first principal component explains just under 94% of the total variance whilst the loadings on the first principal component regarding all series, except for cheque volumes, are positive with similar magnitudes. The estimated loading on cheque volumes is negatively signed also with a similar magnitude to the remaining five variables.

Table B.1.2.6 Eigenvalue decomposition for other small letter principal component analysis

Principal Components Analysis
Date: 05/20/22 Time: 15:43
Sample: 3/01/2002 12/01/2021
Included observations: 80
Computed using: Ordinary correlations
Extracting 6 of 6 possible components

Eigenvalues: (Sum = 6, Average = 1)

Number	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
1	5.612157	5.279298	0.9354	5.612157	0.9354
2	0.332859	0.292812	0.0555	5.945015	0.9908
3	0.040047	0.028626	0.0067	5.985062	0.9975
4	0.011421	0.008917	0.0019	5.996483	0.9994
5	0.002504	0.001491	0.0004	5.998987	0.9998
6	0.001013	---	0.0002	6.000000	1.0000

Eigenvectors (loadings):

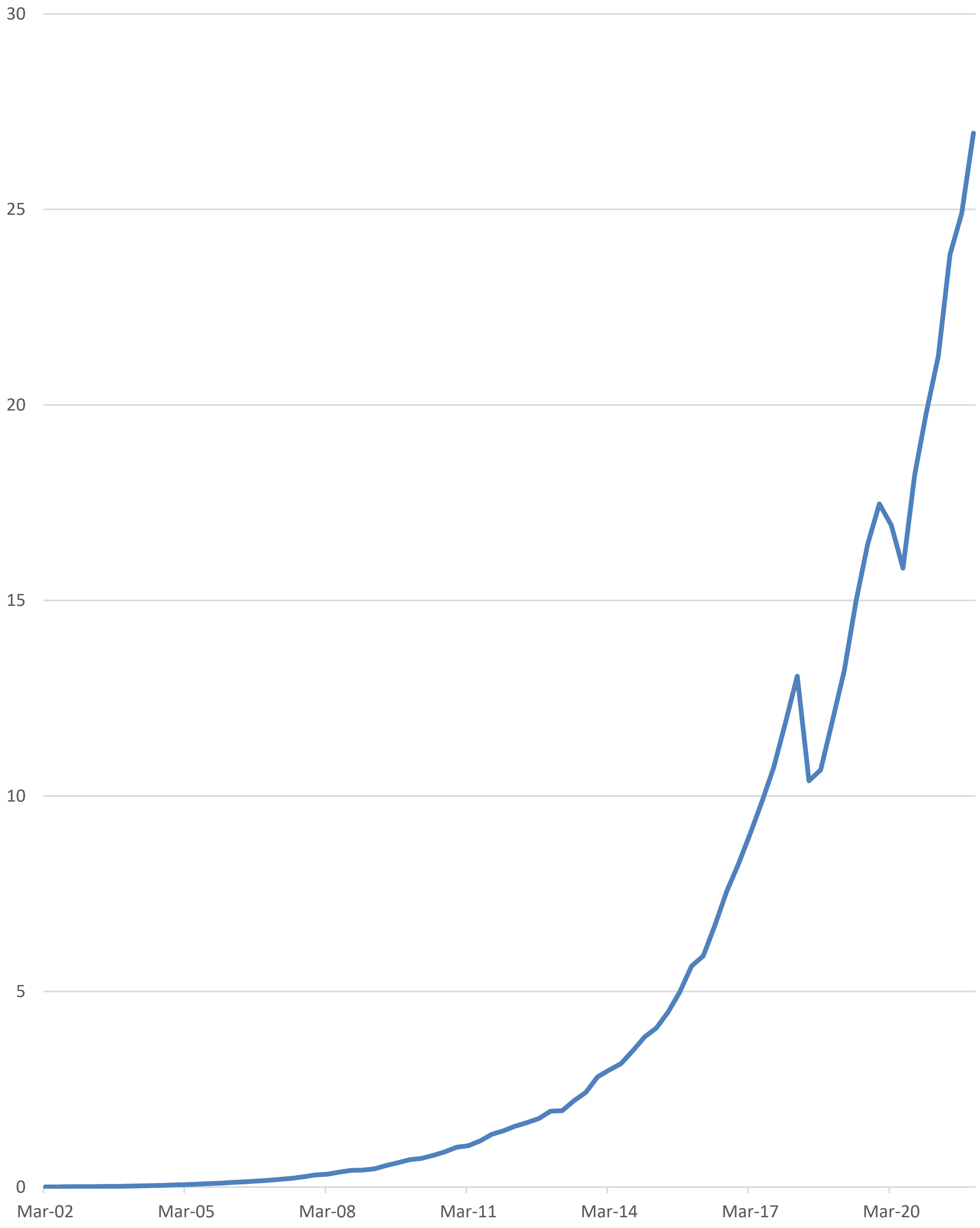
Variable	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6
Y1	-0.390273	0.642359	0.407158	0.299337	0.062968	0.419185
Y2	0.415350	-0.097794	0.825158	-0.339190	0.141599	-0.043978
Y3	0.398876	0.555716	-0.283376	-0.069858	0.620672	-0.248318
Y4	0.410382	0.389498	-0.197562	-0.389069	-0.607930	0.346256
Y5	0.419794	0.106254	0.141322	0.721922	-0.367024	-0.369638
Y6	0.414039	-0.325563	-0.118455	0.343395	0.294051	0.710044

Ordinary correlations:

	Y1	Y2	Y3	Y4	Y5	Y6
Y1	1.000000					
Y2	-0.918340	1.000000				
Y3	-0.759695	0.902832	1.000000			
Y4	-0.820069	0.938673	0.992232	1.000000		
Y5	-0.892187	0.976844	0.956730	0.976719	1.000000	
Y6	-0.976879	0.970554	0.867978	0.910590	0.965567	1.000000

This results in a log-substitution variable for Other small letters, titled as LSUBST_OTHER SL. The final substitution variable, called SUBST_OTHERSL is obtained by transforming the LSUBST_OTHER SL series using the exponential function within the set of variables utilised in the econometric testing, see Chart B.1.2.5.

Chart B.1.2.5 Principal component variable for Other small letter e-substitution (SUBST_OTHERSL)



Principal component variable for non-Other small letter segments

The e-substitution variable for the remaining four letter segments is based upon using principal components applied to each of the four online connectivity variables depicted in Chart B.1.2.1, that is domestic broadband connections, mobile phone subscriptions, NBN services in operation and wireless connections. The results of the eigenvalue decomposition are given in Table B.1.2.7 based on the correlation matrix for the natural logarithm of the four series. The first principal component explains just under 96% of the total variance.

Table B.1.2.7 Eigenvalue decomposition for non-Other small letter principal component analysis

Principal Components Analysis
Date: 05/20/22 Time: 15:55
Sample: 3/01/2002 12/01/2021
Included observations: 80
Computed using: Ordinary correlations
Extracting 4 of 4 possible components

Eigenvalues: (Sum = 4, Average = 1)

Number	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
1	3.835876	3.682849	0.9590	3.835876	0.9590
2	0.153027	0.145049	0.0383	3.988903	0.9972
3	0.007978	0.004858	0.0020	3.996880	0.9992
4	0.003120	---	0.0008	4.000000	1.0000

Eigenvectors (loadings):

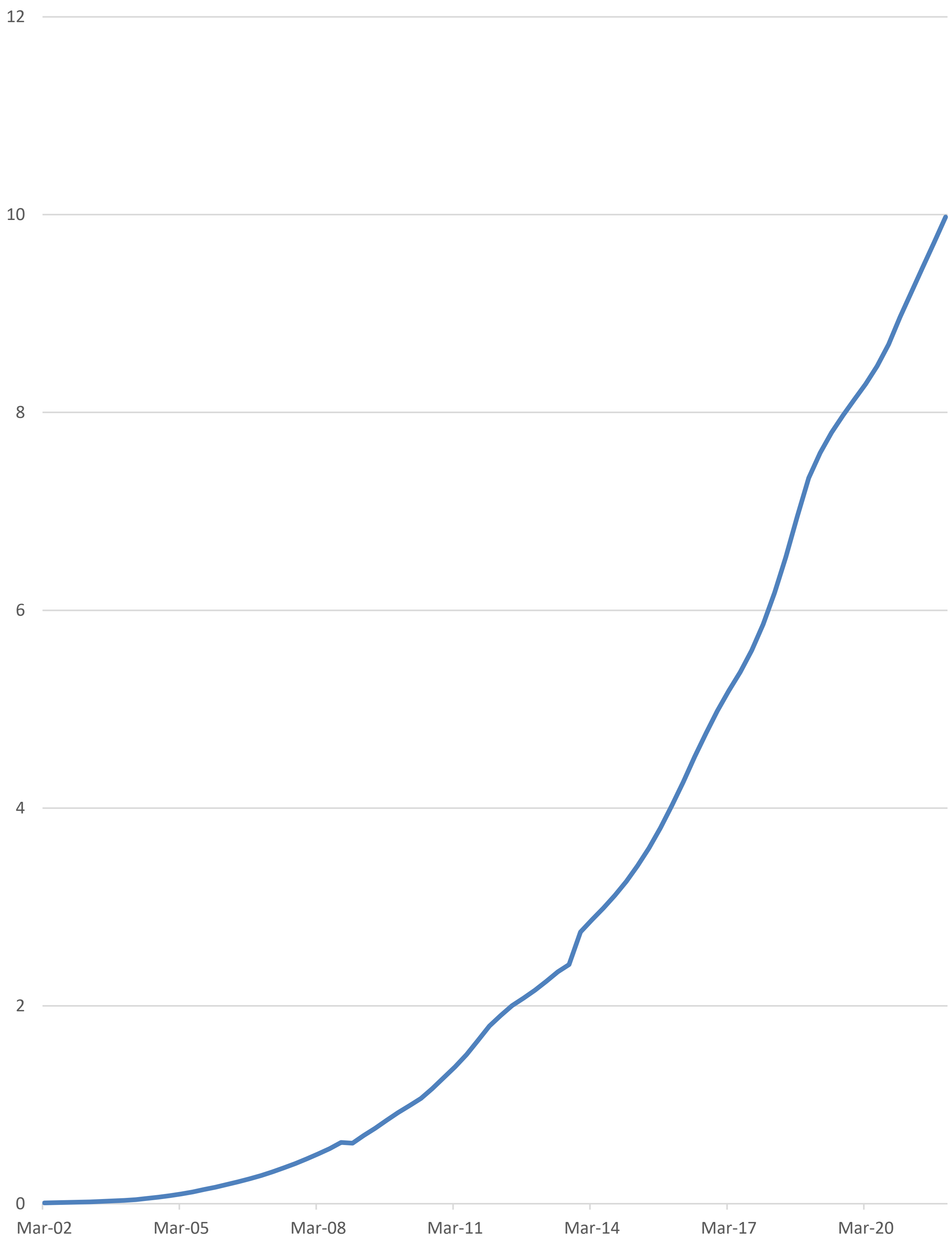
Variable	PC 1	PC 2	PC 3	PC 4
Y3	0.497779	-0.560820	0.087859	0.655727
Y4	0.505863	-0.320622	0.373660	-0.708296
Y5	0.508262	0.149975	-0.835446	-0.145627
Y6	0.487841	0.748458	0.393305	0.217100

Ordinary correlations:

	Y3	Y4	Y5	Y6
Y3	1.000000			
Y4	0.992232	1.000000		
Y5	0.956730	0.976719	1.000000	
Y6	0.867978	0.910590	0.965567	1.000000

This results in a log-substitution variable for all non-Other small letter segments, titled as LSUBST_ALLOTHERS which is transformed into the final e-substitution variable via the exponential function creating the variable called SUBST_ALLOTHERS, depicted in Chart B.1.2.6.

Chart B.1.2.6 Principal component variable for e-substitution - Non-Other small (SUBST_ALLOTHERS)



Generating future values of the e-substitution variable

In the case of a letter segment modelled using a VECM framework, future values on the e-substitution variable are derived via an endogenous process. In the case of a DOLS construct, to obtain projections for e-substitution is modelled across the entire set of quarterly observations spanning June 2002 to December 2021. Doing so provides a basis for extrapolation that is underlined by the long-run evolution of technologies related to the migration of letter-based communications towards the digital alternatives.

In each case, a second scenario is generated, restricting the trends used for the construction of an e-substitution model to the 2019 calendar year. This results in an extrapolated e-substitution variable that is free from any redundancies associated with the early phases of technological progress, the accelerated erosion effects emanating out of the GFC and any distortive impacts emanating from the COVID-19 years of 2020 and 2021.

Adopting the two alternative extrapolations on the e-substitution variable permits an assessment on the sensitivity of the final baseline projections to contrasting values on the e-substitution variable. In the sub-sections to follow, the application of each technique is outlined.

Technique 1 - Generating future values of the e-substitution variable based on long run trends 2002Q2 to 2021Q4

Other small letters

The forecasts of the Other small letter principal components from June 2022 to June 2024 are based on an AR(1) model with a time trend, see Table B.1.2.8.

Table B.1.2.8 Long-run trend model of Other small letter principal components

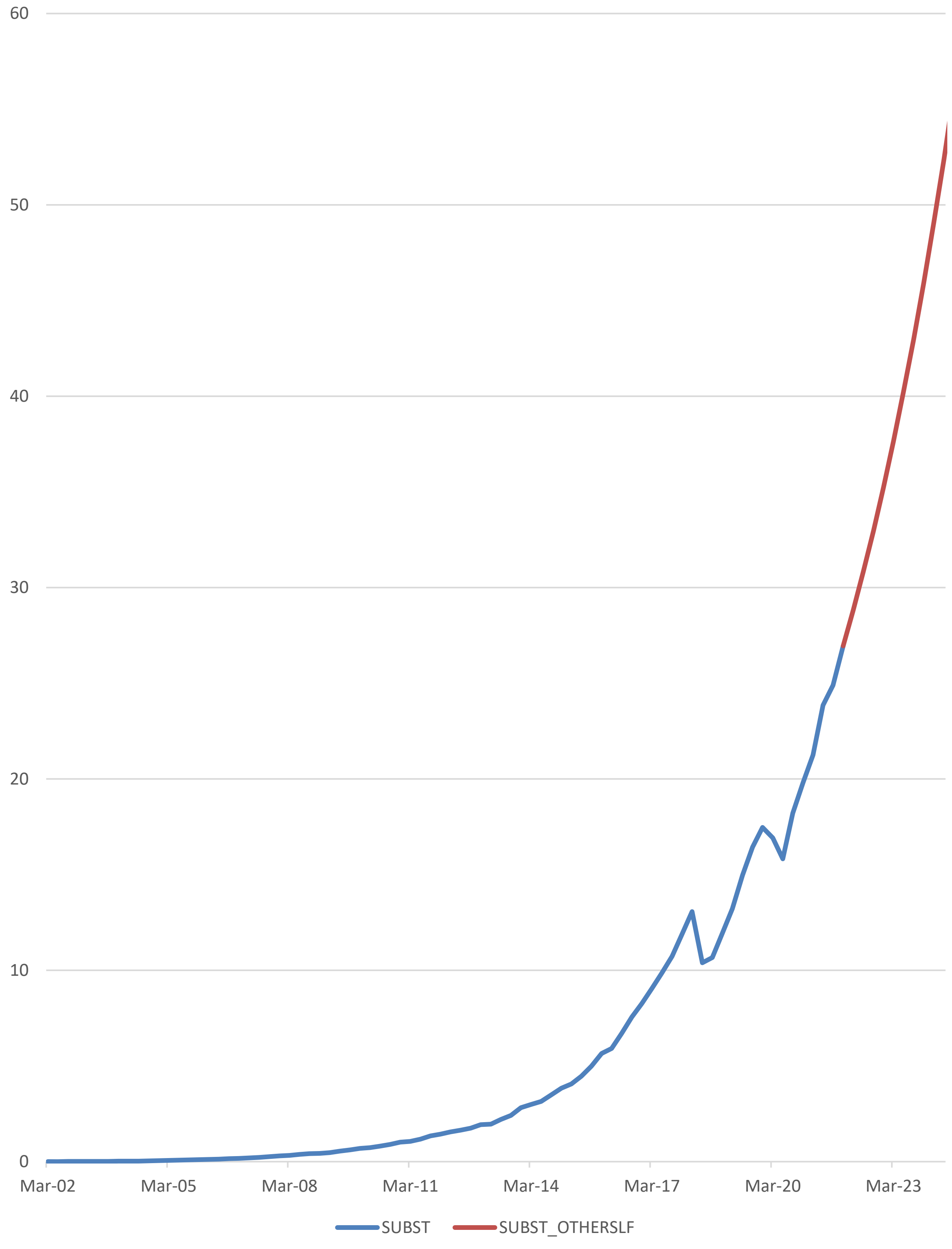
Dependent Variable: LOG(SUBST_OTHERSL)
Method: Least Squares
Date: 05/28/22   Time: 17:35
Sample (adjusted): 6/01/2002 12/01/2021
Included observations: 79 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.027212	0.054864	-0.495979	0.6213
LOG(SUBST_OTHERSL(-1))	0.948244	0.012765	74.28370	0.0000
@TREND(2002Q1)	0.003271	0.001318	2.481794	0.0153

R-squared	0.999530	Mean dependent var	0.067368
Adjusted R-squared	0.999518	S.D. dependent var	2.321277
S.E. of regression	0.050978	Akaike info criterion	-3.077612
Sum squared resid	0.197505	Schwarz criterion	-2.987633
Log likelihood	124.5657	Hannan-Quinn criter.	-3.041564
F-statistic	80825.71	Durbin-Watson stat	1.814471
Prob(F-statistic)	0.000000		

A plot of the within-sample (SUBST) and out-of-sample substitution variables (SUBST_OTHERSLF) are provided in Chart B.1.2.7.

Chart B.1.2.7 Long-run trend model of Other small letter principal components



Non-Other small letters

The forecasts of the non-Other small letter principal components from June 2022 to June 2024 are based on an AR(1) model with a time trend, see Table B.1.2.9.

Table B.1.2.9 Long-run trend model of non-Other small letter principal components

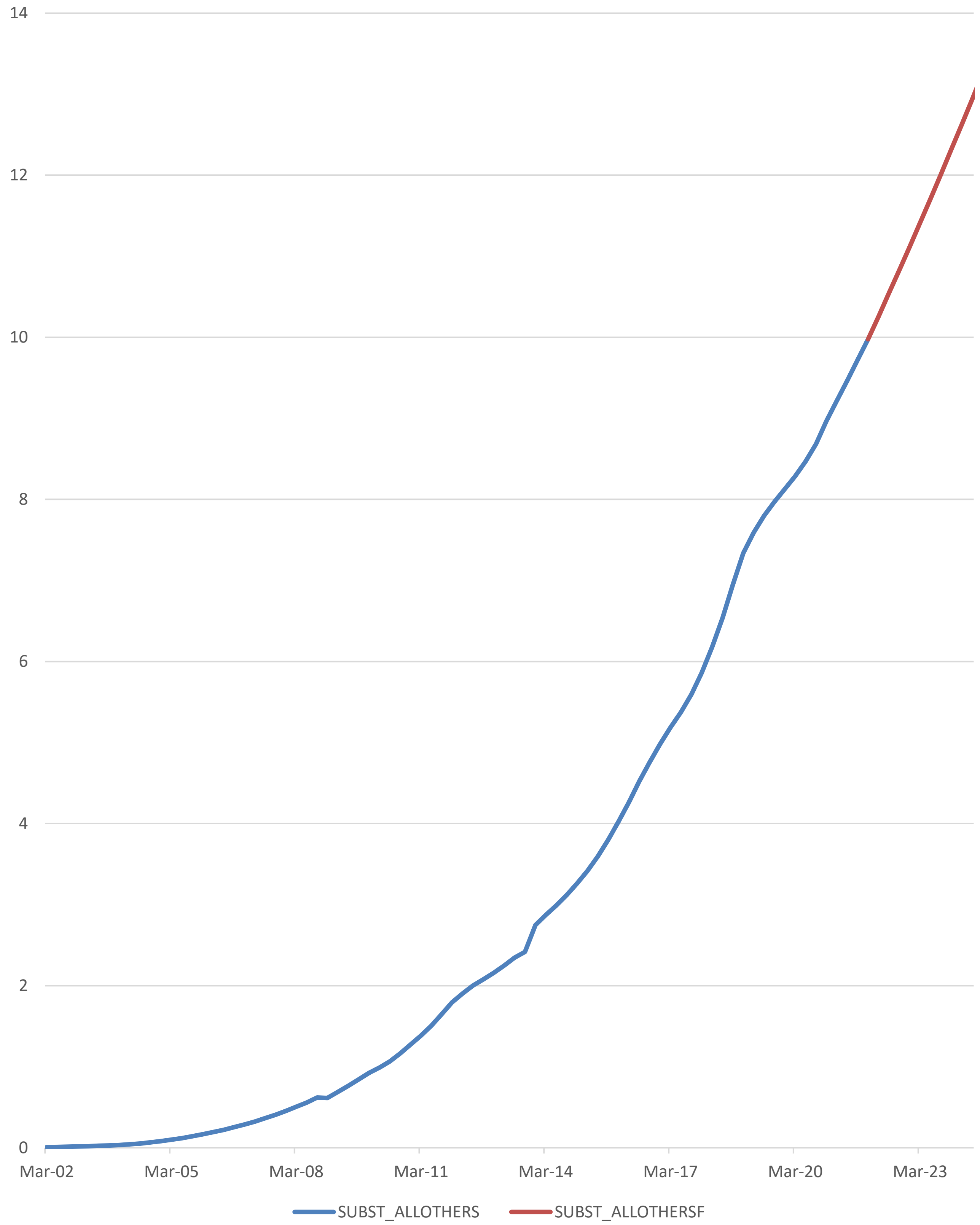
Dependent Variable: LOG(SUBST_ALLOTHERS)
Method: Least Squares
Date: 05/28/22 Time: 17:34
Sample (adjusted): 6/01/2002 12/01/2021
Included observations: 79 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.064009	0.015666	4.085910	0.0001
LOG(SUBST_ALLOTHERS(-1))	0.962917	0.004369	220.4137	0.0000
@TREND(2002Q1)	0.000605	0.000374	1.615423	0.1104

R-squared	0.999869	Mean dependent var	0.060761
Adjusted R-squared	0.999865	S.D. dependent var	1.906591
S.E. of regression	0.022123	Akaike info criterion	-4.747119
Sum squared resid	0.037198	Schwarz criterion	-4.657140
Log likelihood	190.5112	Hannan-Quinn criter.	-4.711071
F-statistic	289611.4	Durbin-Watson stat	1.401683
Prob(F-statistic)	0.000000		

A plot of the within-sample (SUBST_ALLOTHERS) and out-of-sample substitution variables (SUBST_ALLOTHERSLF) are provided in Chart B.1.2.8.

Chart B.1.2.8 Long-run trend model of non-Other small letter principal components



Technique 2 - Generating future values of the e-substitution variable based on 2019 trends

Other small letters

The Other small letter principal component forecasts for June 2022 to June 2024 are based on an exponential trend model estimated over the 2019 data only, the last full calendar year prior to the spread of the COVID-19 pandemic within Australia, see Table B.1.2.10.

Table B.1.2.10 2019 trend model of Other small letter principal components

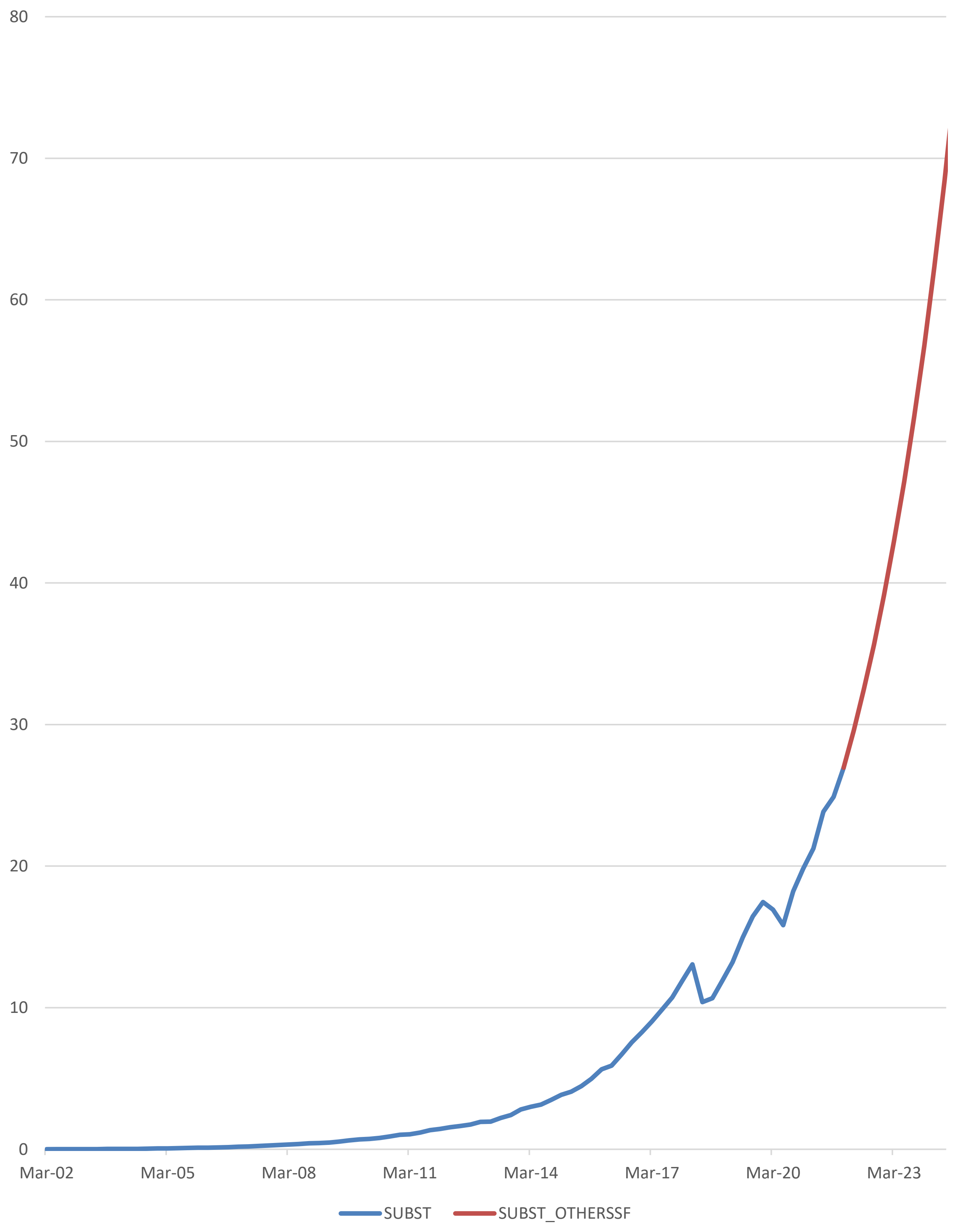
Dependent Variable: LOG(SUBST_OTHERSL)
Method: Least Squares
Date: 06/16/22 Time: 11:33
Sample: 3/01/2019 12/01/2019
Included observations: 4

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-3.831305	0.720009	-5.321192	0.0335
@TREND(2002Q1)	0.093166	0.010212	9.123588	0.0118

R-squared	0.976537	Mean dependent var	2.736933
Adjusted R-squared	0.964805	S.D. dependent var	0.121714
S.E. of regression	0.022834	Akaike info criterion	-4.414293
Sum squared resid	0.001043	Schwarz criterion	-4.721146
Log likelihood	10.82859	Hannan-Quinn criter.	-5.087658
F-statistic	83.23986	Durbin-Watson stat	2.000002
Prob(F-statistic)	0.011801		

A plot of the within-sample (SUBST) and out-of-sample substitution variables (SUBST_OTHERSSF) are provided in Chart B.1.2.9.

Chart B.1.2.9 2019 trend model of Other small letter principal components



Non-Other small letters

The forecasts of the non-Other small letter principal components from June 2022 to June 2024 are based on an exponential trend model estimated over the 2019 data only, the last year before the onset of COVID-19 in Australia, see Table B.1.2.11.

Table B.1.2.11 2019 trend model of non-Other small letter principal components

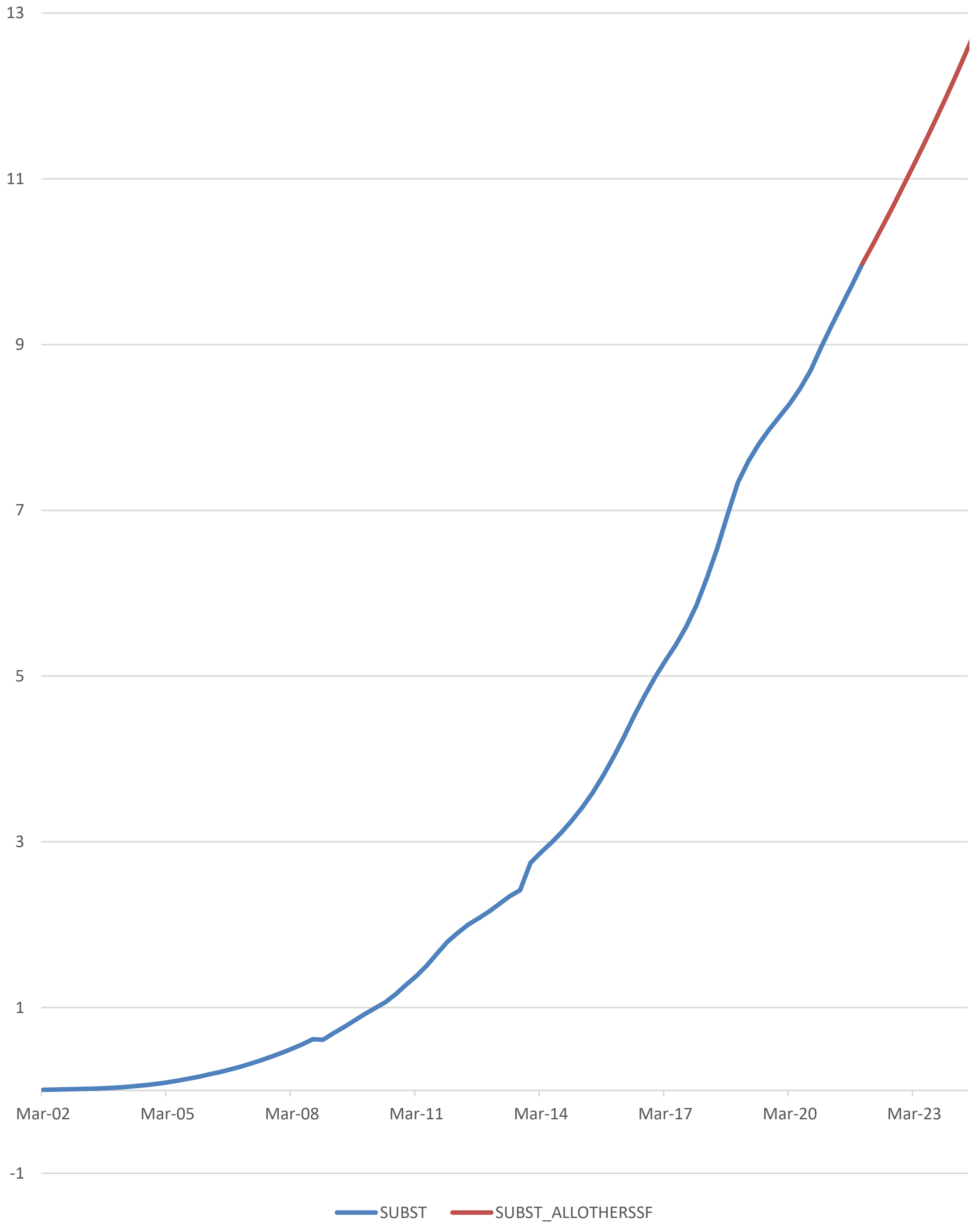
Dependent Variable: LOG(SUBST_ALLOTHERS)
Method: Least Squares
Date: 06/16/22 Time: 11:33
Sample: 3/01/2019 12/01/2019
Included observations: 4

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.459576	0.079722	5.764741	0.0288
@TREND(2002Q1)	0.022745	0.001131	20.11614	0.0025

R-squared	0.995082	Mean dependent var	2.063073
Adjusted R-squared	0.992623	S.D. dependent var	0.029436
S.E. of regression	0.002528	Akaike info criterion	-8.815729
Sum squared resid	1.28E-05	Schwarz criterion	-9.122582
Log likelihood	19.63146	Hannan-Quinn criter.	-9.489095
F-statistic	404.6590	Durbin-Watson stat	2.031151
Prob(F-statistic)	0.002462		

A plot of the within-sample (SUBST_ALLOTHERS) and out-of-sample substitution variables (SUBST_ALLOTHERSSF) are provided in Chart B.1.2.10.

Chart B.1.2.10 2019 trend model of Other small letter principal components



Volume projections based upon alternative e-substitution variables

The econometric baseline projections reported in Sections 3-6 of this document reflect the first technique for extrapolating the e-substitution variables to 2023/24. These projections are contrasted to those generated via the second technique in Table B.1.2.12. The results imply a marginally softer decline in letter volumes when excluding the longer-term e-substitution impacts. Qualitatively, the volume projections are not overly sensitive to variations on future values of the e-substitution variable, ratifying the robustness of the methodological approach to quantifying and projecting e-substitution.

Table B.1.2.12 Projected % changes in total letter volume inclusive of proposed rate rises[89]

	Technique 1: Generating future values of the e-substitution variable based on long run (2002Q2 to 2021Q4) trends[90]			**Technique 2:** Generating future values of the e-substitution variable based on 2019 trends		
	2021/22	**2022/23**	**2023/24**	**2021/22**	**2022/23**	**2023/24**
Ordinary/Other Small	-10.4	-10.1	-10.8	-10.4	-10.4	-10.9
PreSort Small	-4.6	-8.4	-9.2	-4.5	-7.7	-8.7
Ordinary/Other Large	-2.5	-10.7	-8.2	-2.5	-10.3	-8.4
PreSort Large	11.0	-13.8	-8.9	11.0	-13.5	-8.1
Print Post	-4.7	-11.6	-5.2	-4.6	-10.8	-4.7
Total letters	**-5.7**	**-9.3**	**-9.3**	**-5.6**	**-8.9**	**-9.0**

[89] The 2021/22 percentage changes reported in Table 3 is constructed by utilising nine months of actual values and 3 months of econometric projected values.

[90] Due to the VECM framework the e-substitution projections for Other (Ordinary small and large) in addition to PreSort large were derived via an endogenous process. For the remaining segments, an AR(1) with time trend technique was used to derive forward projections for e-substitution in the context of volume projections presented in Technique 1.

B.1.3 Market size

***<u>Hypotheses:</u>* Fluctuations in the size of the Australian population are positively associated with movements in letter volume.**

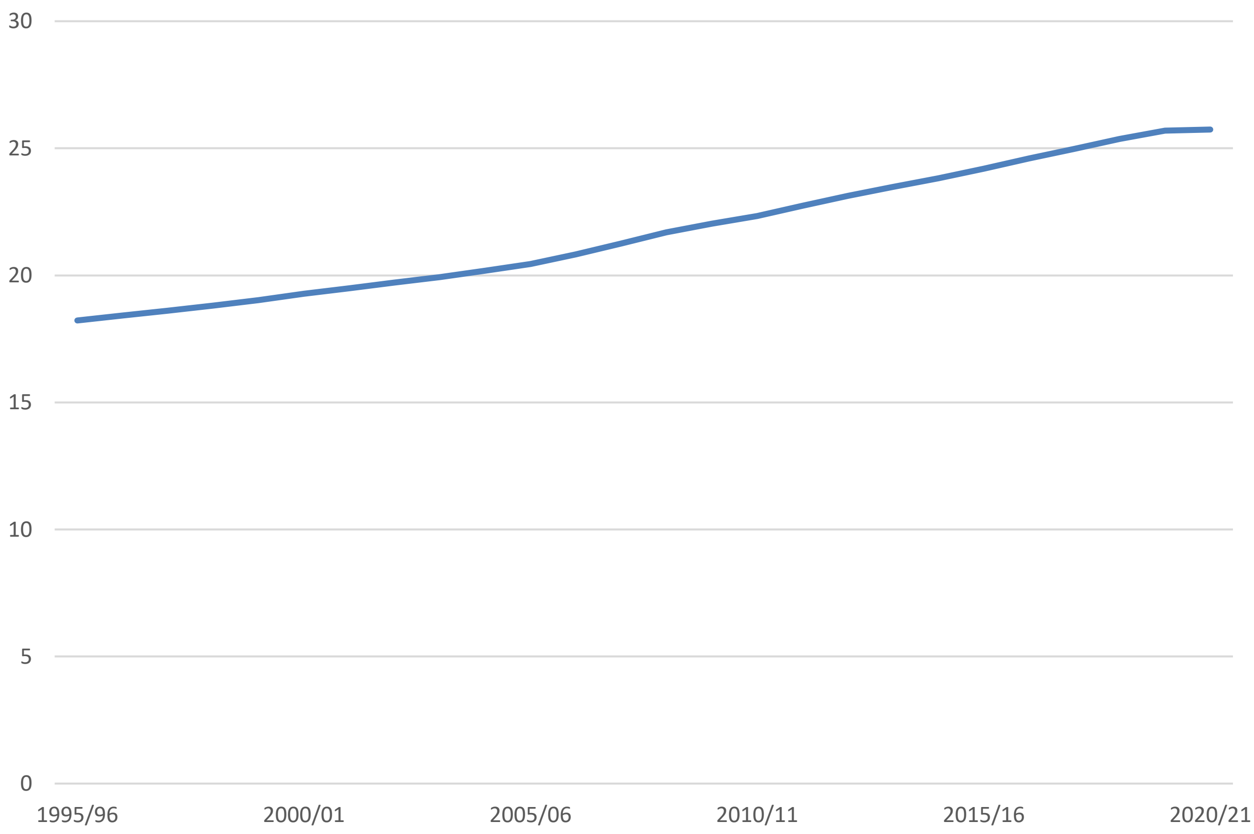
The size of the Australian population acts as a proxy for the number of delivery points across the Australia Post network. Market size factors have greater applicability as a demand driver when considering long run fluctuations in letter volumes, rather than within the models derived in this project which are focused on factors with a more immediate impact. Measures on these indicators suggest limited variation over the short run, evident in Table B.1.3.1 and Chart B.1.3.1. However, population growth did stall in 2020/21 with the onset of COVID-19 which temporarily halted the levels of inward and outward migrations.

Table B.1.3.1 Market size measures (annual, percentage change)

	2017/18	***2018/19***	***2019/20***	***2020/21***
Australian population growth	1.5	1.5	1.3	0.2

Source: ABS. Quarterly population estimates ABS Cat. No. 3101.0 Table 1.

Chart B.1.3.1 Australian resident population (annual, millions)



Source: ABS. Quarterly population estimates ABS Cat. No. 3101.0 Table 1.

B.1.4 Economic activity

Hypotheses: ***Fluctuations in the level of Australian economic activity are positively associated with movements in letter volume.***

The positive association linking Australia Post's domestic letter volume with GDP movements was accentuated in the presence of the pandemic. During this period non-essential retail shutdowns and social mobility restrictions resulted in an increased propensity for Australian firms to focus on cost containment given they could not realise their profit aspirations through sales. This meant as the economy and the retail trade sector contracted, as evident in the 2020 figures contained within Table B.1.4.1 and Table B.1.4.2, Australia Post's letter volume declines intensified.

Table B.1.4.1 Australian Non-farm GDP (annual, percentage change)

	2017/18	2018/19	2019/20	2020/21
Non-farm GDP	3.0	2.4	0.2	1.1

Source (1): Real non-farm GDP, ABS

Table B.1.4.2 Australian retail trade sales (annual, percentage change)

	2017/18	2018/19	2019/20	2020/21
Retail trade sales	2.7	0.8	-0.3	5.5

Source (2): Retail trade, ABS

As an alternative, to proxy these dynamics a structural break test revealed March 2020 as the month where the association between income and Australia Post's letter volumes altered. A series of dichotomous variables, constructed by Diversified Specifics, was therefore deployed to monitor this change in pre vs post COVID-19 income effects.

B.1.5 Events

***<u>Hypotheses:</u>* Certain events may either increase or decrease letter volume demand depending upon the nature of that occurrence.**

Time specific dichotomous variables and volume observations are used to capture a wide variety of events that have historically impacted Australia Post's domestic letter volumes.[91] Events included within testing consist of:

- COVID-19[92]
- Federal elections[93]
- State elections
- Referendums
- The Australian Census
- The global financial crisis (GFC)
- Closure of the Medium PreSort service[94]

In some cases, the historical letter volumes associated with each event may be unobservable or unavailable. When confronted with such instances, dichotomous variable techniques are be utilised to quantify and incorporate the magnitudes of the volume impact into the baseline estimates. The repetition of an event can result in differing behaviours regarding the accompanying use of letter based communications. For instance, political parties may sometimes adopt a preference against using the addressed letter for most of their election related communications with their constituents. As these preference sets change there may be a movement away from the traditional addressed letter item entirely towards a campaign that consists largely of unaddressed mailings or towards exploiting the popularity of social media channels. This then alters the degree to which each election can be treated homogeneously across a time series underlining the econometric process.

[91] Time-specific dichotomous variables were constructed by Diversified Specifics for the events based upon historical dates of occurrence.

[92] For a discussion about the impact of the pandemic on letter volume demand and the measurement techniques designed to capture these effects within the econometric process of this project, see Section 2.3.

[93] As the econometric models were generated based upon a sample concluding December 2021, letter volume associated with the 2022 Australian Federal election is not tested within this project and must be considered an overlay onto any projected baseline.

[94] Includes the closure of PreSort Medium Regular in June 2015 and PreSort Medium Priority in June 2014. For an extended discussion about the consequences of the closure of this service consult page 28 of Diversified Specifics (2019), see bibliography.

Government mandated legislative changes to the use of paper-based communication can also have severe consequences on the erosion rates of letter volumes. For example, the Australian Tax Office instituted a staged roll-out from July 2014 of mandatory requirements for employers to pay superannuation contributions electronically, eliminating the use of cheque payments from this process.[95] These changes directly accelerated Other (Ordinary) small letter volume declines. Such initiatives may place public sector letter volumes at risk to greater rates of substitutive pressures than other industry segments. Initiatives, such as these should be monitored so any announced targets can be incorporated within the set of off model augmentations. These impacts might extend to mandates on the proliferation of an eCensus or the development of an online platform for government department communications with the Australian population that represent a shift away from documentation that was once posted via the mail.

Historical changes in Australia Post's product definitions can result in artificial data spikes unrelated to the demand effects emanating from the market. These changes can include adjustments to minimum lodgement quantity requirements, or a change in the definitions, options, and features of lodging a letter, such as the introduction of the dual speed letter. Additionally, closures of a letter product stream, such as occurred with the Medium PreSort service, can be potentially distortive if not incorporated into the variables for testing. When this occurs, volumes in subsequent periods are redirected towards alternate segments providing a misleading indication on demand implications if not adequately accounted for. Diversified Specifics constructs dichotomous variables to assist in the capture of intercept shifts resulting from these events where possible.

[95] Source: The Australian Taxation Office website, www.ato.gov.au

B.1.6 Market expectations

Hypotheses: ***Fluctuations in the level of Australian business confidence are positively associated with movements in letter volume.***

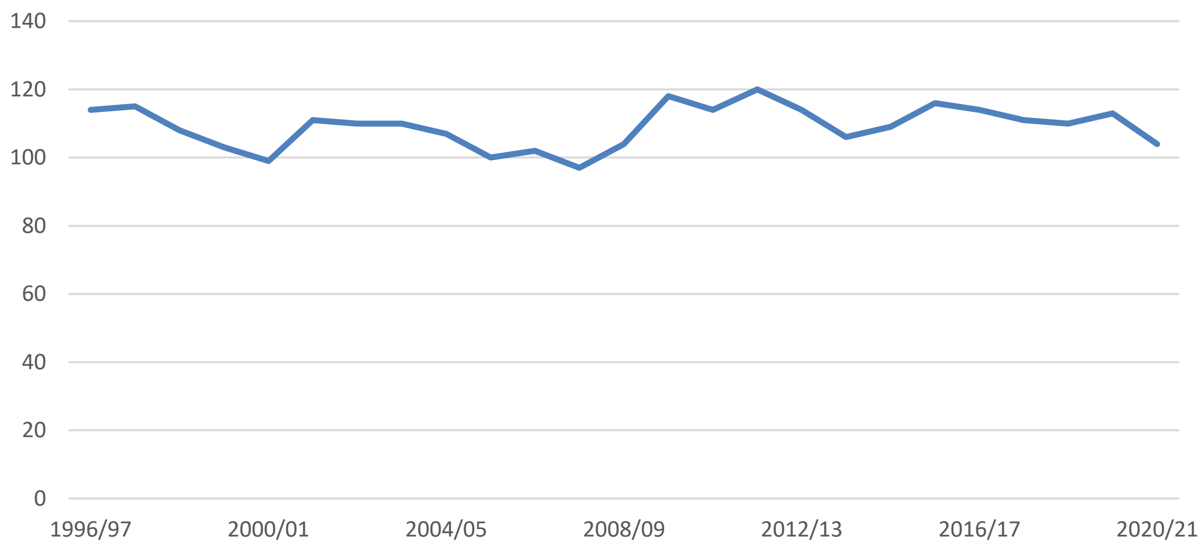
Expectations of a more prosperous economy inspire greater business confidence levels and can result in increased economic growth within the Australian economy. A positive outlook can lead to a larger quantity of transactional and promotional activity that will eventually translate into an increased need for all types of communication, stimulating letter volume demand. Recognised institutional projections on expectation variables however tend to be scarce. The consequence for econometric estimation is, on many occasions these variables are supplanted by alternative measures of macro growth, such as GDP or e-substitution, when forecasting is a key objective of the estimated models.[96] Table B.1.6.1 and Chart B.1.6.1 highlight the largely pessimistic outlook from the Australian business community in recent times, exacerbated by the perceived and actual impact of the pandemic in 2020/21.

Table B.1.6.1 Australian business confidence (annual, percentage change)

	2017/18	2018/19	2019/20	2020/21
Australian business confidence	-2.6%	-0.9%	2.7%	-8.0%

Source: NAB business confidence index – Australia, www.business.nab.com.au

Chart B.1.6.1 Australian business confidence (annual, indexed)



Source: NAB business confidence index – Australia, www.business.nab.com.au

[96] A similar rationale applies for measures of consumer sentiment. It is therefore rare that expectations variables play an important role in the estimation process of Australia Post's preferred set of letter volume demand models despite the economic significance.

B.1.7 Seasonality

An important demand characteristic common to many letter volume segments is the inherent seasonality. Seasonal factors highlight regular demand tendencies throughout any given year and to obtain a clearer understanding of the underlying drivers of demand, Diversified Specifics typically seasonally adjust all letter volume variables prior to econometric modeling. These seasonal factors can also convey important information regarding volume fluctuations during a year and for that reason they are reported within this section. The quarterly seasonal factors for each letter volume segment are summarised in Table B.1.7.1.

Table B.1.7.1: Quarterly seasonal factors by letter segment.[97]

	Other (Ordinary)		PreSort		
	Small	Large	Small	Large	Print Post
March	92.8	92.3	96.3	85.4	92.6
June	96.9	96.6	98.8	87.4	97.9
September	101.3	104.9	104.1	111.4	103.7
December	109.6	106.2	100.8	115.7	105.8

For practical interpretation, the quarterly seasonal factors can be contrasted to an average of 100% and contribute insights such as:

- PreSort large letter volumes in the December quarter are typically 15.7% higher than the quarterly average due to the proliferation of annual report-type mail.

- The Christmas-related peak is evident in Other (Ordinary) small letter volumes in the December quarter which are typically 9.6% greater than the quarterly average.

- Volume traffic across all segments tends to be higher in the latter half of each calendar year.

The dynamic evolution of seasonal factors across each key letter segments is provided in Tables B.1.7.2 to B.1.7.6. These tables highlight the shift in seasonality over time and therefore provide the basis for seasonal adjustment within this research project.

[97] Seasonal factors are derived over the 2002Q1 to 2021Q4 time frame excluding Print Post where limitations on the available observations restrict the feasible data set to commence at 2006Q3.

Table B.1.7.2 Other small letter dynamic seasonal factors

Final seasonal factors
From 2002.1 to 2021.4
Observations 80
Seasonal filter 3 x 3 moving average

	1st	2nd	3rd	4th	AVGE
2002	90.7	93.6	101.5	116.0	100.4
2003	90.8	93.7	101.3	115.7	100.4
2004	91.0	94.0	101.0	115.5	100.4
2005	91.0	94.6	100.8	115.1	100.4
2006	90.8	95.2	100.7	114.9	100.4
2007	90.4	96.0	100.5	114.7	100.4
2008	90.2	96.4	100.5	114.2	100.3
2009	90.3	96.6	100.6	113.5	100.2
2010	90.8	96.4	101.1	112.4	100.2
2011	91.4	96.4	101.6	111.1	100.1
2012	91.9	96.7	102.1	109.2	100.0
2013	92.4	97.5	102.8	106.7	99.8
2014	92.9	98.9	103.1	103.9	99.7
2015	94.1	99.9	103.3	101.8	99.8
2016	95.0	100.7	102.7	101.4	99.9
2017	95.9	100.3	102.1	102.1	100.1
2018	96.3	99.6	100.8	104.1	100.2
2019	96.5	98.3	100.3	105.6	100.2
2020	96.8	97.1	99.9	107.0	100.2
2021	96.8	96.2	100.2	107.4	100.2
AVGE	92.8	96.9	101.3	109.6	

Table B.1.7.3 Other large letter dynamic seasonal factors

Final seasonal factors
From 2002.1 to 2021.4
Observations 80
Seasonal filter 3 x 5 moving average

	1st	2nd	3rd	4th	AVGE
2002	90.7	95.0	107.3	106.9	100.0
2003	90.7	95.3	107.2	106.5	99.9
2004	91.0	95.9	106.9	105.9	99.9
2005	91.3	96.5	106.5	105.2	99.9
2006	91.6	97.3	105.9	104.8	99.9
2007	92.0	97.8	105.4	104.5	99.9
2008	92.2	98.0	105.0	104.6	100.0
2009	92.5	97.9	104.8	104.8	100.0
2010	92.6	97.9	104.5	105.0	100.0
2011	92.9	97.5	104.3	105.4	100.0
2012	93.0	97.2	104.0	106.0	100.1
2013	93.0	96.8	104.0	106.5	100.1
2014	92.7	96.8	103.9	106.7	100.0
2015	92.6	96.8	103.8	106.7	100.0
2016	92.7	96.8	103.7	106.7	100.0
2017	92.9	96.6	103.7	106.9	100.0
2018	92.9	96.2	103.8	107.3	100.1
2019	92.9	95.7	104.0	107.7	100.1
2020	92.7	95.3	104.3	108.0	100.1
2021	92.5	95.0	104.5	108.2	100.0
AVGE	92.3	96.6	104.9	106.2	

Table B.1.7.4 PreSort small letter dynamic seasonal factors

Final seasonal factors
From 2002.1 to 2021.4
Observations 80
Seasonal filter 3 x 5 moving average

	1st	2nd	3rd	4th	AVGE
2002	96.1	99.3	102.8	101.8	100.0
2003	96.0	99.4	102.9	101.7	100.0
2004	96.1	99.3	102.9	101.7	100.0
2005	96.0	99.3	102.9	101.8	100.0
2006	95.9	99.3	102.9	102.0	100.0
2007	95.8	99.2	103.1	102.0	100.0
2008	95.8	98.9	103.5	101.8	100.0
2009	95.8	98.6	104.1	101.4	100.0
2010	95.9	98.4	104.8	100.8	99.9
2011	96.1	98.1	105.4	100.0	99.9
2012	96.5	98.0	105.8	99.5	99.9
2013	96.8	98.1	105.8	99.1	99.9
2014	97.0	98.2	105.7	99.0	100.0
2015	97.1	98.5	105.3	99.2	100.0
2016	96.8	98.9	104.9	99.5	100.0
2017	96.6	99.2	104.2	100.2	100.1
2018	96.5	99.1	103.9	100.7	100.1
2019	96.5	98.7	103.7	101.3	100.1
2020	96.4	98.4	103.8	101.5	100.0
2021	96.4	98.3	103.8	101.6	100.0
AVGE	96.3	98.8	104.1	100.8	

Table B.1.7.5 PreSort large letter dynamic seasonal factors

Final seasonal factors
From 2002.1 to 2021.4
Observations 80
Seasonal filter 3 x 5 moving average

	1st	2nd	3rd	4th	AVGE
2002	84.6	90.2	101.4	123.7	100.0
2003	84.6	90.4	101.3	123.8	100.0
2004	84.4	90.6	101.4	123.6	100.0
2005	84.2	90.5	102.5	122.6	100.0
2006	84.1	90.2	104.6	120.8	99.9
2007	84.3	89.3	107.4	118.4	99.9
2008	84.7	88.5	110.2	115.9	99.8
2009	85.5	87.5	112.8	113.4	99.8
2010	86.5	86.8	114.3	111.8	99.8
2011	87.2	86.4	115.1	111.1	99.9
2012	87.5	86.2	115.0	111.7	100.1
2013	87.1	85.7	115.5	112.1	100.1
2014	86.6	85.3	115.8	113.1	100.2
2015	85.8	84.7	116.3	113.7	100.1
2016	85.2	84.7	115.9	114.7	100.1
2017	84.6	84.9	115.8	114.4	99.9
2018	84.7	85.6	115.3	113.8	99.9
2019	85.1	86.1	115.5	112.5	99.8
2020	85.7	86.8	115.5	111.6	99.9
2021	86.0	87.1	115.5	111.0	99.9
AVGE	85.4	87.4	111.4	115.7	

Table B.1.7.6 Print Post letter dynamic seasonal factors

Final seasonal factors
From 2006.3 to 2021.4
Observations 62
Seasonal filter 3 x 5 moving average

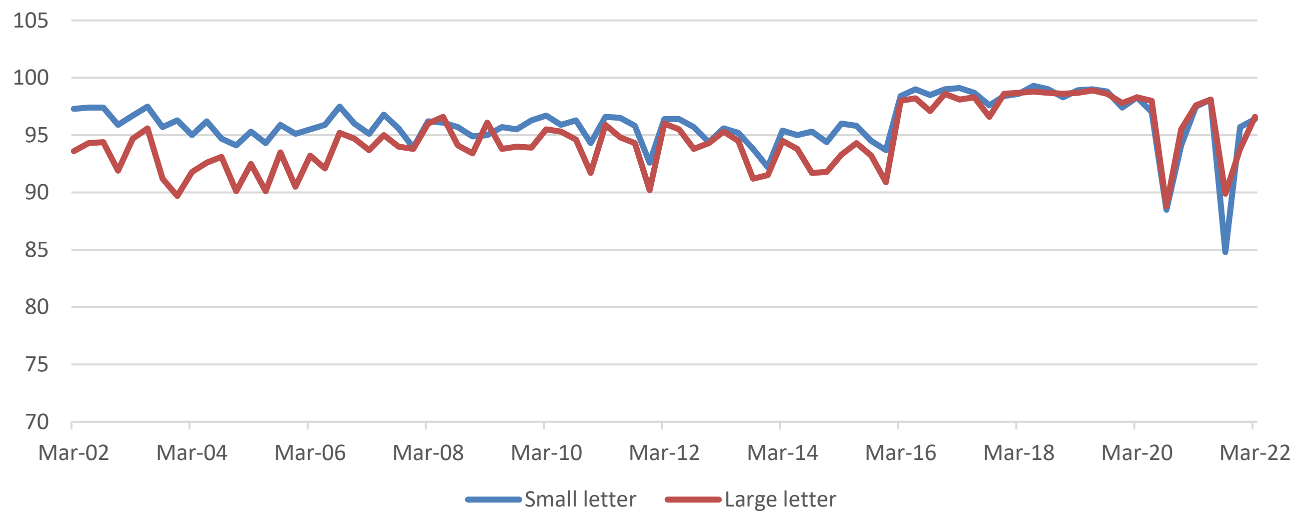
	1st	2nd	3rd	4th	AVGE
2006			103.0	108.1	105.5
2007	91.9	97.1	103.1	107.9	100.0
2008	91.8	97.3	102.9	107.8	100.0
2009	91.8	97.8	102.7	107.6	100.0
2010	91.8	98.3	102.4	107.3	99.9
2011	92.1	98.5	102.3	106.8	99.9
2012	92.6	98.5	102.3	106.1	99.9
2013	93.3	98.2	102.8	105.4	99.9
2014	93.8	97.8	103.5	104.7	99.9
2015	94.0	97.5	104.4	104.1	100.0
2016	93.9	97.6	104.9	103.8	100.0
2017	93.5	97.7	105.1	103.9	100.1
2018	92.9	98.0	105.1	104.3	100.1
2019	92.4	98.1	105.1	104.7	100.1
2020	92.0	98.3	105.0	104.9	100.0
2021	91.7	98.4	105.0	105.0	100.0
AVGE	92.6	97.9	103.7	105.8	

B.1.8 Delivery service performance

<u>Hypotheses:</u> Fluctuations in the level of Australia Post's delivery service performance are positively associated with movements in parcel volume.

Australia Post collect service performance information on the percentage of items delivered on-time based upon broad small and large letter classifications.[98] During the pandemic the occurrence of lockdowns, quarantining, and inter-State border restrictions limited Australia Posts capacity to reach all nodes within its extensive delivery network. As a result, temporary regulatory relief (TRR) initiatives were granted widening the acceptable window for delivery. Additionally, the 'Priority' service was halted temporarily. Australia Post supplied Diversified Specifics with the complete set of delivery service performance data aligning with the changes and this is illustrated in Chart B.1.8.1.

Chart B.1.8.1: Australia Post delivery service performance by letter size (Quarterly, percentage)



Source: Australia Post

Since March 2014, the introduction of the dual speed letter service raises the possibility for cross product migration between the Priority and Regular segments.[99] Preliminary investigations had suggested little difference in the long run price elasticity across the two services.[100] Attempts to replicate testing on this occasion was limited given the suspension of the Priority service as part of the TRR initiatives imposed following the onset of the pandemic.

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[98] Due to the unavailability of a service performance measure for the Print Post segment this hypothesis is only tested for Australia Post's small and large letter segments.

[99] Letters sent at the Regular speed can take up to 1-2 business days longer than the estimated delivery times for the Priority service, dependent upon the sender's posting origin and the recipient's destination.

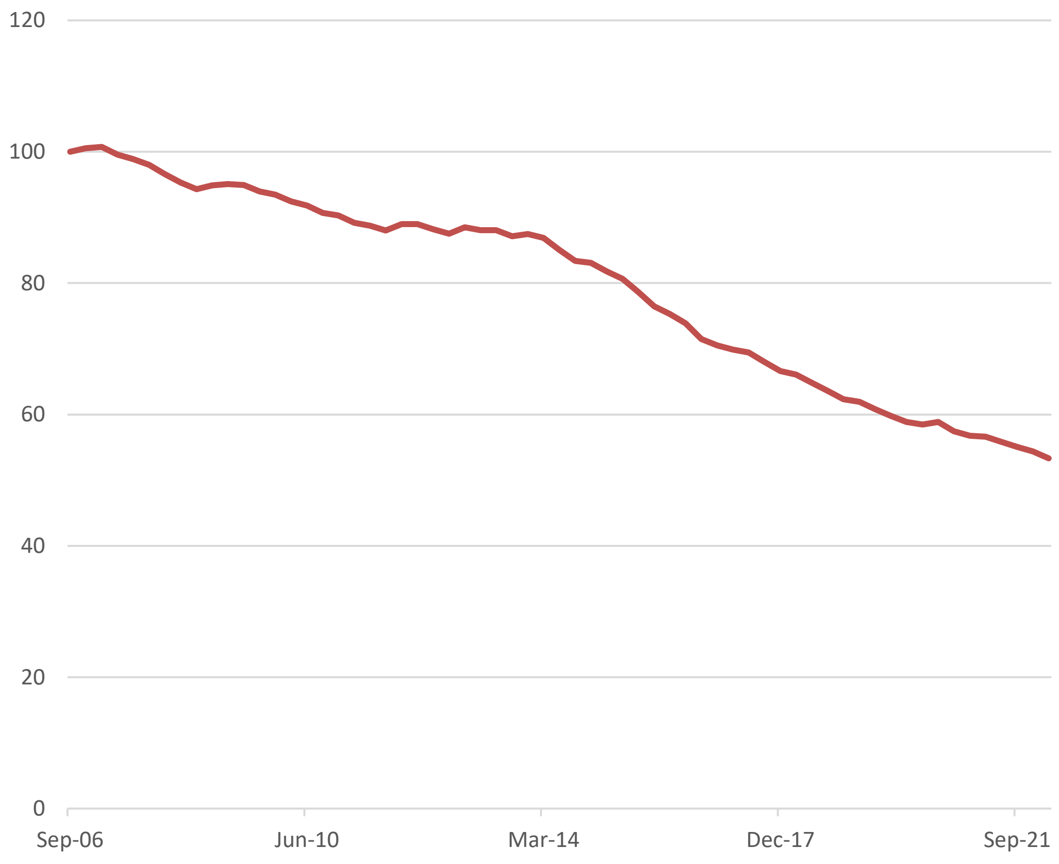
[100] Diversified Specifics (2019), see bibliography.

B.1.9 Cross price

<u>Hypotheses:</u> Fluctuations in the price of technologies that are regarded as a substitute to mail are positively associated with movements in letter volume.

Although an own price elasticity inherently incorporates the competitive landscape into its magnitude, the derivation of a unique cross price elasticity can provide more detailed information on e-substitution pressures. Diversified Specifics extensions to the models developed in previous research undertakings now incorporate a more direct quantification of the competitive landscape. This is achieved by utilising a variable that captures a typical basket of prices associated with the technology services provided within the telecommunications industry.[101] Fluctuations in this Australian Telecommunications CPI, as measured by the ABS, is illustrated in Chart B.1.9.1.

Chart B.1.9.1 Real competitor price for domestic letters at Australia Post (Quarterly, indexed)



Indexed: September Quarter 2006 = 100; Australian telecommunications industry CPI Source: ABS 6401.0 Consumer Price Index, Australia, TABLE 7. Deflated by headline Australian CPI, ABS, 6401.0 Consumer Price Index, Australia, TABLES 1 and 2. CPI: All Groups, Index Numbers and Percentage Changes, www.abs.gov.au

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[101] As the telecommunications CPI is estimated by the ABS in nominal terms, the variable is deflated by the Australian headline CPI data to generate a real equivalent to facilitate econometric testing.

In recent years the price of technologies competing with the letter have been in decline, see Table B.1.9.2.

Table B.1.9.2 Australian headline CPI vs The CPI of the Australian telecommunications industry (annual, percentage change)

	2017/18	2018/19	2019/20	2020/21
Australian CPI	2.1	1.6	-0.3	3.8
Australian telecommunications industry CPI	-4.7	-4.7	-3.6	-1.4

Source: ABS (2022) 6401.0 Consumer Price Index, Australia,
TABLE 7. CPI: Group, Sub-group and Expenditure Class, Weighted Average of Eight Capital Cities

Future values of the Telecommunications CPI variable deployed for the various volume projection scenarios are generated by estimating an AR(1) model with a time trend. The estimated model is based on the sample period March 2002 to March 2022, with the results given in Table B.1.9.3.

Table B.1.9.3 Long-run trend model of the Telecommunications CPI data series

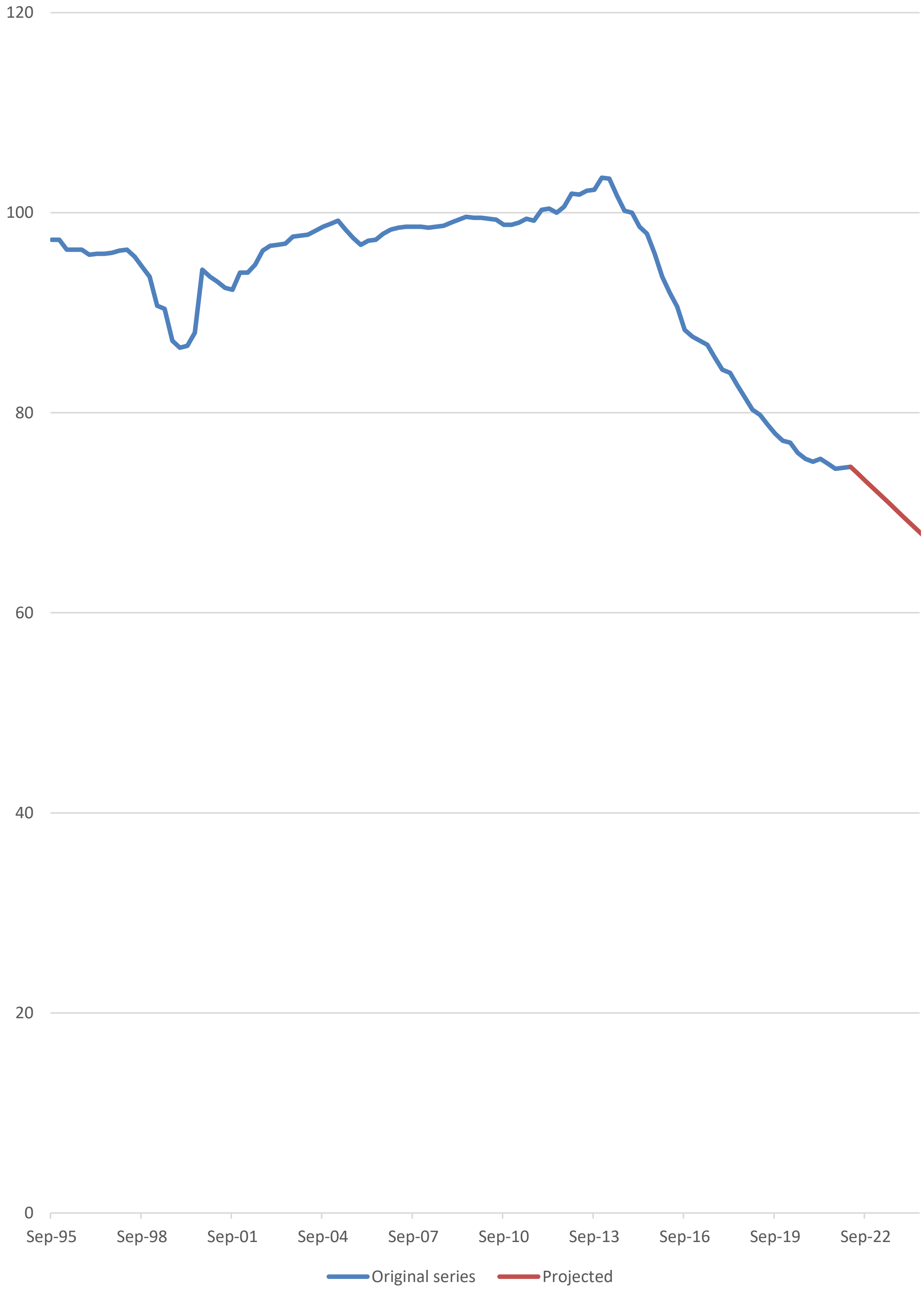
Dependent Variable: LOG(TELECOMCPI)
Method: Least Squares
Date: 05/29/22 Time: 03:27
Sample: 3/01/2002 3/01/2022
Included observations: 81

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.040379	0.050568	0.798497	0.4270
LOG(TELECOMCPI(-1))	0.988525	0.011450	86.33471	0.0000
@TREND(2022Q1)	-0.000225	4.85E-05	-4.646540	0.0000

R-squared	0.995344	Mean dependent var	4.530342
Adjusted R-squared	0.995225	S.D. dependent var	0.102594
S.E. of regression	0.007089	Akaike info criterion	-7.024081
Sum squared resid	0.003920	Schwarz criterion	-6.935397
Log likelihood	287.4753	Hannan-Quinn criter.	-6.988500
F-statistic	8337.743	Durbin-Watson stat	0.983547
Prob(F-statistic)	0.000000		

Plots of the original series spanning March 2002 to March 2022 combined with the projected series, June 2022 to June 2024, are provided in Chart B.1.9.2.

Chart B.1.9.2 Long-run trend model of the Telecommunications CPI data series (Quarterly)

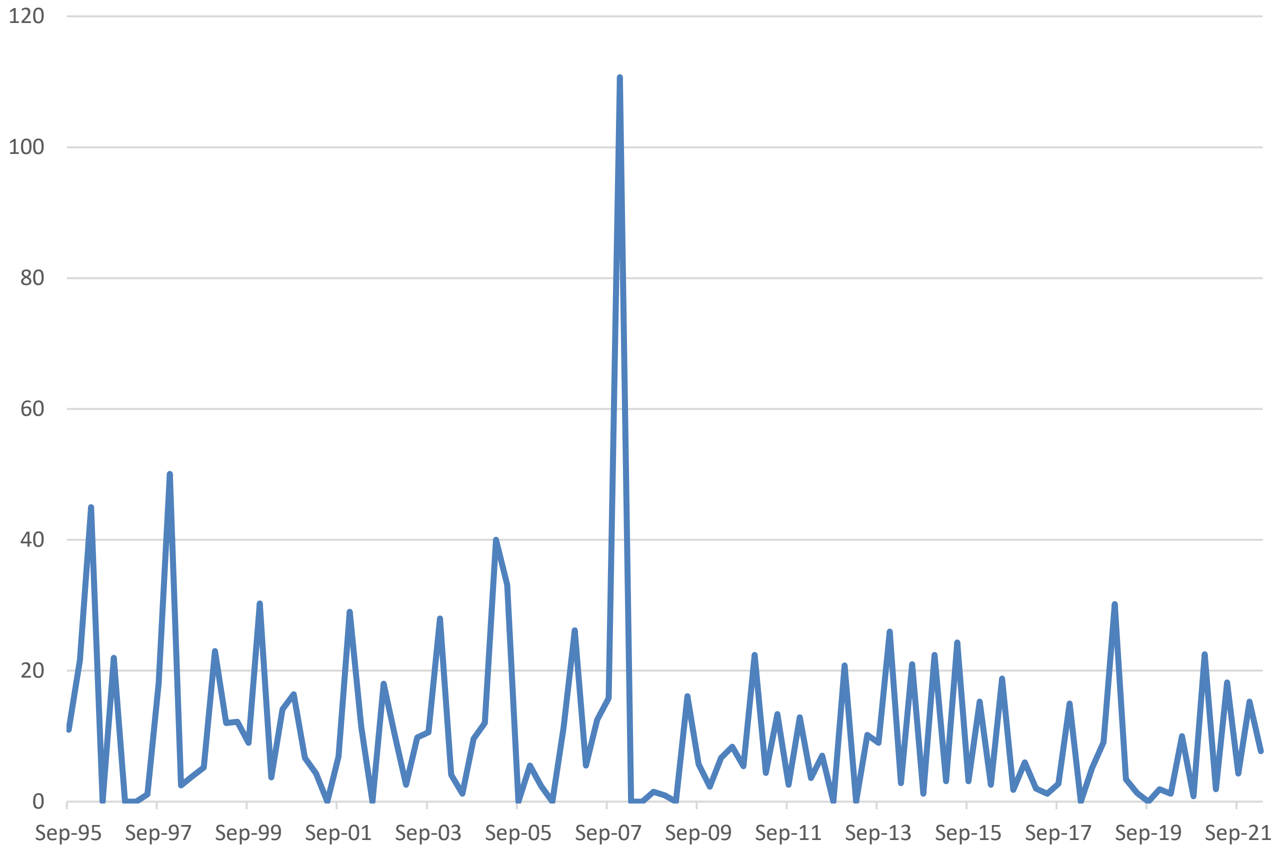


B.1.10 Initial public offerings

<u>Hypotheses:</u> Increases in the number of initial public offerings on the Australian share market are positively associated with movements in letter volume.

The sending of prospectuses relating to large share floats or initial public offerings (IPO's) are generally expected to have an impact upon PreSort large letter volumes. As there is no direct measure of the letter volumes associated with these IPO's, Diversified Specifics develop a proxy using data from the S&P/ASX 300 companies listed on the Australian Stock Exchange (ASX).[102] From this data a set of suitably large IPOs are identified and a variable is constructed based on current value market capitalisations. The IPO variable was defined by an estimated 'mail-out' date rather than the 'listing' date. This allows a 3-4 week lead time into the public offering date for prospectus dissemination via mail.[103] In total, there were 1,530 IPO's that occurred over the 2002 to 2021 period with 188 of these relating to ASX Top 300 companies. The corresponding market capitalisations are illustrated in Chart B.1.10.1

Chart B.1.10.1 Large Initial Public Offerings - Australia
Sum of Market Capitalisation (Quarterly, Billions of dollars)



Source: S&P/ASX 300, www2.asx.com.au.[104]

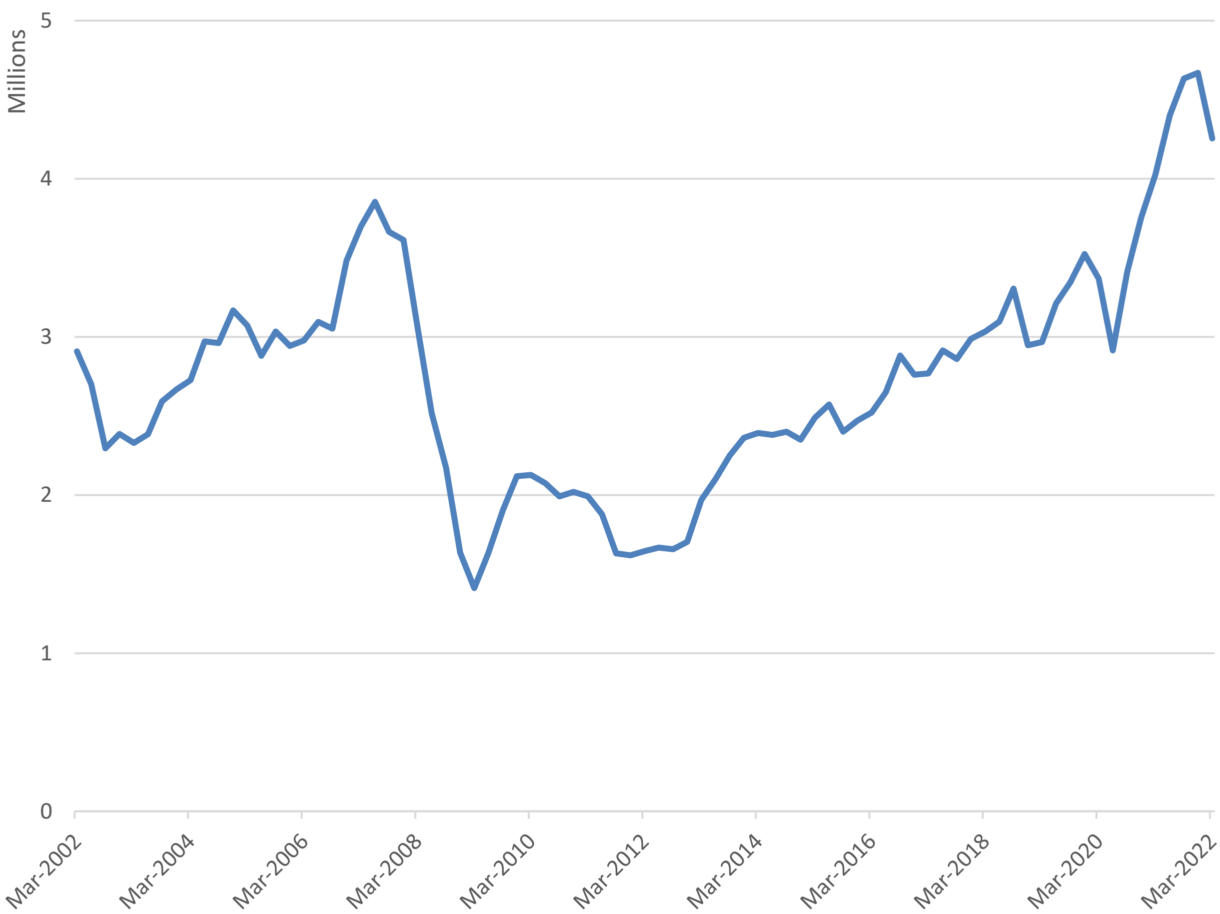
[102] ASX listed companies are obtained from the ASX, see *www2.asx.com.au.*
[103] A caveat on this variable is the limited focus on larger companies. Substantial numbers of smaller IPO's occurring simultaneously could represent a potential explainer of PreSort large letter volume fluctuations, although empirical data suggests this is unlikely.
[104] Variable constructed by Diversified Specifics using Australian Stock Exchange data on S&P/ASX 300, see *www2.asx.com.au.*

B.1.11 Health of the Australian advertising industry

<u>Hypotheses:</u> Fluctuations in the health of the Australian advertising industry are positively associated with movements in letter volume.

In the absence of a direct measurement reflecting the health of the advertising industry, an index is constructed based on fluctuations in the S&P/ASX Top 200 Consumer Discretionary Index. The underlying rationale in using this variable is the greater the level of investment in these firms, the larger the discretionary expenditure, leading to an environment more conducive towards promotional activities via Australia Post's Promo Post component of its PreSort letter services. As a proxy variable, this measure reflects the health of the Australian advertising industry rather than directly tracking promotional activity. In particular, the S&P/ASX 200 Consumer Discretionary Index reflects a range of industries, including the media, that tend to be the most sensitive to economic cycles. The manufacturing segment includes automotive, household durable goods, textiles and apparel and leisure equipment. The services segment includes hotels, restaurants and other leisure facilities, media production and services, and consumer retailing and services.

Chart B.1.11.1 Health of the Australian Advertising Industry (Quarterly, Indexed)



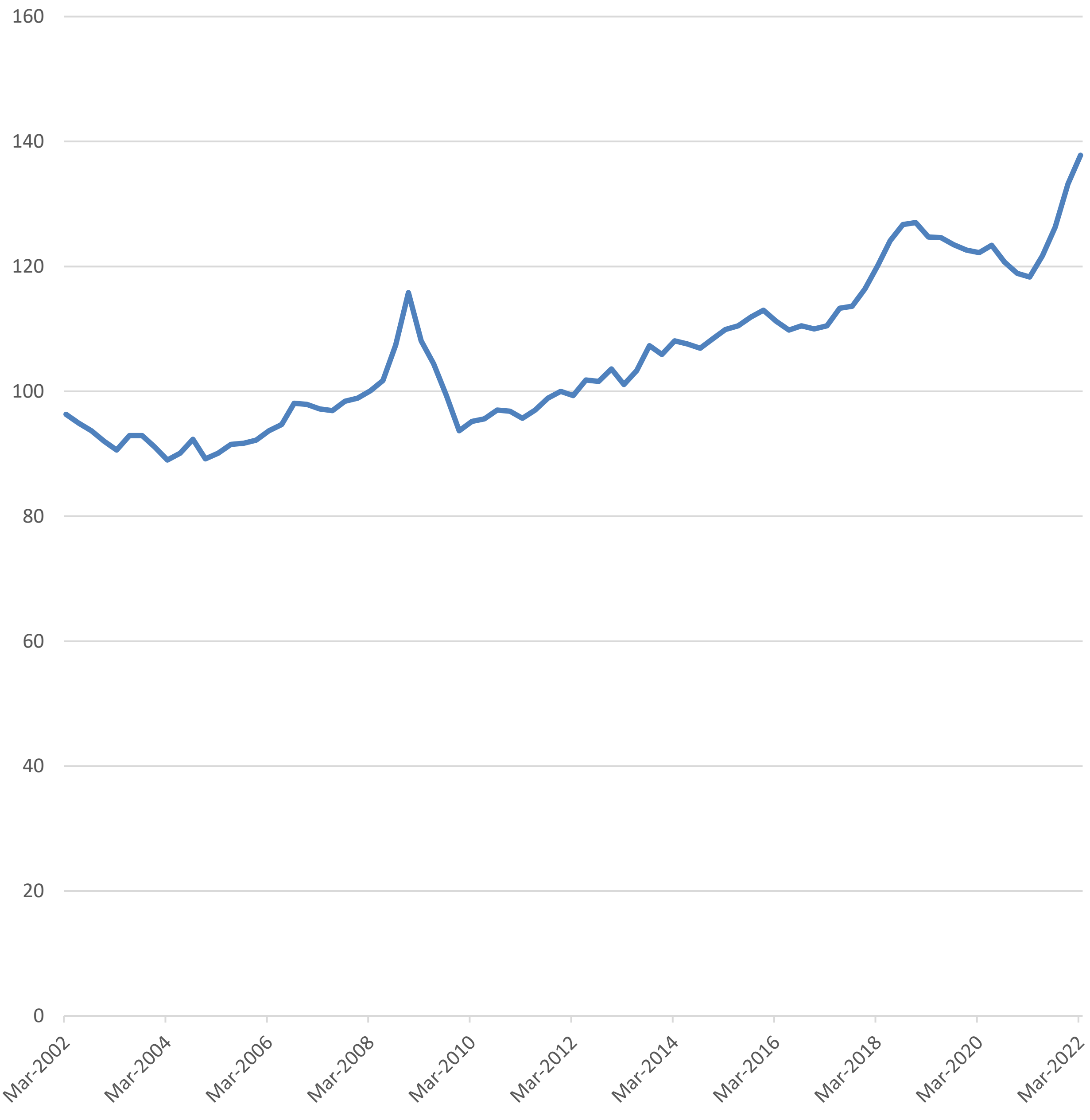
Source: S&P/ASX 200 Consumer Discretionary Index, see www2.asx.com.au.

B.1.12 Paper costs as an input

<u>Hypotheses:</u> Fluctuations in the cost of paper are negatively associated with movements in letter volume.

It is hypothesised that increases in the additional costs (beyond postage) of sending a bulk produced, PreSort large or Print Post, letter item are negatively associated with volume growth. Examples of these outlays that contribute to the real input costs of producing the content of a mail item include those associated with the health of the paper and printing industries. Paper costs in Australia have exhibited an upward trend over the past twenty years as illustrated in Chart B.1.12.1.

Chart B.1.12.1 Paper as an input cost (Monthly, Indexed)



Source: ABS Producer Price Index; 15 Pulp, paper and converted paper product manufacturing

APPENDIX C QUALIFICATIONS

C.1 Econometric caveats

The interpretation of the projections relating to segmented letter volumes via empirical modelling techniques must be conducted with all due caution. The *ex-ante* projections generated in this research undertaking are econometric in nature and they therefore depend heavily upon:

- Accurately projecting future growth rates for each of the exogenous drivers;
- An assumption that prior statistical associations detected by the modelling continues to hold over the projection period which may not always be the case as there is no guarantee the future will replicate the past;
- An assumption of comprehensiveness governing the statistically significant segmented letter volume drivers. That is, there are other variables logically associated with volume movements in each segment however significant variation over the sampled timeframe may not have been evident. Therefore, these drivers tend to be excluded from the econometric models. Such variables still retain economic, if not statistical, significance and should continue to be monitored by Australia Post and interested stakeholders; &
- The global/national economy remaining similar to that observed over the sampled timeframe.

The methodology employed acknowledges these limitations and the impossibility of embedding all possible contingencies within the *ex-ante* projection estimates. It is therefore recommended that any interpretation of the projection results generated by these models be augmented by further internal and market intelligence. That is, the generation of baseline *ex-ante* projections provided in this document should necessarily represent an initial step in the volume forecasting process at Australia Post. Ultimately the baseline must be augmented via further market intelligence on emerging trends and known future events that are not directly observable empirically.

The nature of developing econometric models based on historical data also suggests a need for on-going refinements and research to ensure an adequate currency of both the statistical associations and projections produced via the models. In developing the econometric projections an ideal scenario would involve a longer timeframe, an increased number of observations and greater degrees of freedom. These considerations were evaluated against the desire to estimate a set of parameters that more accurately reflect the status quo rather than examining a lengthier timeframe where the current forces of substitution, pricing and economic growth do not apply. In this regard, a series of structural break tests have, in some cases, impacted the selection of commencement dates for statistical evaluation and the results of these tests are summarised in Section D.2 of Appendix D.

APPENDIX D ECONOMETRIC PROCESS

D.1 Methodological approach

This appendix summarises the econometric process deployed and reflects Diversified Specifics extensive experience modelling demand functions within the global postal industry.

Representing the cornerstone of this analysis is the selection of key letter volume drivers which are used to construct various scenarios regarding potential changes in real price, e-substitution, and significant macroeconomic events such as the GFC and COVID-19.

The core econometric methodology is premised on a structured approach for specifying a set of dynamic models that allow for both long-run and short-run movements combined with their interaction effects on letter volumes.

Formally this modelling framework is underlined by a vector error correction model (VECM) which explicitly models the dynamic trends contained within letter volume movements and their key drivers. Additionally, the long-run and short-run interactive effects are captured by error-correction components.

The VECM consists of two components:

1) the cointegrating equation which captures the long-run dynamical relationship between letter volumes and its determinants, and

2) the vector error equations which capture the short-run dynamics.

In the case of a bivariate model consisting of the variables y_t and x_t, the first component of the VECM is the cointegrating equation given by

$$y_t = \beta x_t + u_t$$

The short-run dynamical equations for y_t and x_t for the special case of no lags in the VECM are

$$\begin{aligned} y_t - y_{t-1} &= \gamma_1 u_{t-1} + v_{1t} \\ x_t - x_{t-1} &= \gamma_2 u_{t-1} + v_{2t} \end{aligned}$$

where v_{1t} and v_{2t} are disturbance terms, and γ_1 and γ_2 are known as the error-correction parameters which control how y_t and x_t adjust when the system is not at the long-run equilibrium at a point in time t, i.e., when $u_t \neq 0$.

The estimation of the VECM is performed using the Johansen estimator, which is a maximum likelihood procedure where the computations are performed using an eigen decomposition. Alternatively, an iterative procedure can be employed which imposes the cross-equation restriction on the VECM arising from the presence of cointegration.[105]

For letter segments where the sample size is restricted because of either data availability or the effects of structural change, a single equation approach based on dynamic ordinary least squares (DOLS) is also investigated.

The DOLS of Stock and Watson is a single equation cointegrating estimator based on augmenting the cointegrating equations with lags and leads of the change in the explanatory variables to purge the disturbance term of any autocorrelation.[106] In the case where y_t and x_t are single variables, the DOLS estimator is based on the estimating the following equation by ordinary least squares (OLS)

$$y_t = \beta x_t + \sum_{j=-q}^{r} \Delta x_{t+j}\delta_j + u_t$$

where u_t is the disturbance term which by assumption is independent of y_t and x_t . It is also necessary to replace the OLS estimator of the disturbance variance by the corresponding long-run estimator to ensure valid inferences.[107]

The VECM is a special case of a slightly more general dynamic model known as a vector autoregression, or VAR, as it imposes a set of cross-equation restrictions on the parameters of the VAR caused by the long-run component of the model impacting upon all variables within the dynamic system.

In a similar manner to previous letter volume demand updates in this series, the implementation of a dynamic VECM/DOLS framework for each letter segment follows a set of steps which constitute the defining methodological approach:

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[105] Martin, Hurn, Harris (2013), see bibliography.

[106] Stock and Watson (1993), see bibliography.

[107] In the simulations, the statistical software package deployed in this research, EViews, uses the cointegrating equation component from the DOLS procedure to generate the projections of letter volumes.

Step 1

The base model of each letter volume segment consists of a dynamic multivariate framework which has been developed and refined over successive letter volume demand updates. In recent times, for all segments the statistically significant letter volume drivers have traditionally consisted of real own price and e-substitution, lagged dynamic variables as well as significant economic events within Australia, such as the GFC and COVID-19. Beyond these core drivers, tests for statistical relevance are conducted across a broader array of potential letter volume drivers such as cross-price considerations, additional macroeconomic variables, delivery service performance measurements, population size characteristics and other events that might result in letter volume fluctuations. Discriminatory statistical tests result in a revised set of narrowly defined demand drivers within a parsimonious framework for each letter volume segment.

An important set of variables investigated relate to those attempting to quantify the effects of e-substitution. This phenomenon is inherently difficult to measure as a broad set of factors affect the migration of letter-based communication towards the digital alternatives. Indeed, time series quantitative measurements on emerging technologies are often unavailable. There is also the added dimension of complexity as the technological landscape, penetration rates and the way technological change impacts letter volumes is continually evolving. For these reasons identifying variables and constructing a consistent series to measure substitution provides additional challenges. Following the suggestions of the ACCC, this update utilises a refined set of variables to capture these e-substitution impacts by (i) recognising the different demand characteristics of each letter segment, and (ii) solely focusing on Australian, rather than worldwide, quantitative measures.

Step 2

In determining the long-run drivers of letter volumes, an exhaustive set of unit root tests are conducted to classify variables in terms of their stochastic trend behaviour.

Step 3

Related to the determination of the stochastic trend properties of the key variables in each model, tests for structural breaks are performed. This permits an identification of the dramatic changes in segmented letter volumes since the turn of the century caused by external shocks to the Australian economy including the GFC and from policy responses aimed at limiting the spread of COVID-19. This is in addition to the continual e-substitutive effects on letter volumes arising from the emergence and penetration of new technologies.

To capture and reflect the effects of demand shocks on letter volumes, structural break tests allow for a combination of shifts in the intercept and changes in the trend of the cointegrating systems. The outcomes of these tests when applied to each letter segment are used to determine whether the VECM's require augmentation directly to account for structural change effects not captured directly by the drivers of the specified models, and to identify the choice of estimation periods.

Step 4

The initial specification of the VECM dynamics is identified using various information criteria based on methods given by Akaike, Hannan-Quinn and Schwarz. In implementing these procedures, the lag length criteria are based on the VAR which is appropriate as it represents the unrestricted dynamical model of a VECM. For some letter segments, a potential range of lags are considered to determine optimality. In these cases, sensitivity analysis is performed by estimating the cointegrating system over a range of lags.

Step 5

The next phase of the econometric analysis involves establishing the presence of a long-run relationship amongst the drivers. As the drivers are identified to be integrated processes based on the unit root tests, the establishment of a long-run relationship is equivalent to testing for cointegration amongst all the drivers within each segment. The cointegration tests are based on the tests proposed by Johansen[108] which is appropriate for the VECM framework adopted in this project due to the multivariate tests of cointegration that are applied to a sequence of VECM specifications beginning with the unrestricted VAR model. In choosing these subset specifications, an allowance for intercepts in both long-run and short-run specifications is adopted for maximum flexibility.

Step 6

An important component of the modelling process is the treatment of the demand effects resulting from macroeconomic policies implemented to limit the spread of COVID-19. Inspection of recent trends and movements in letter volumes suggest these pandemic related impacts varied widely across the differing letter volume segments. To capture these variations a range of indicator variables are employed in specifying the segmented VECMs.

Step 7

Having established the presence of a long-run cointegrating equation, the VECM is then estimated to derive point estimates of the long-run and short-run parameters. This includes estimates of the error-correction parameters which control the dynamic equilibrium properties of the model.

[108] Johansen, S. (1995), see bibliography.

Step 8

For each letter segment the model is refined in terms of sample and variable selection because of the economic/statistical significance of the parameter estimates. The drivers must initially conform with conventional associations bound by the principles of economics and logical linkages governing how a potential driver relates to segmented letter volume movements. For example, all price elasticities should be inversely related to demand, and all income effects must be positive. For some of the segments, there might be dramatic changes in the time series properties of letter volumes resulting in changes in the choice of the starting date to estimate the parameters of the models. Following the methodological approach adopted in previous price notifications these choices are based on the results of structural break tests which are discussed in detail in Section D.2. For some segments this restriction in sample size results in the adoption of a single cointegrating approach based on a DOLS estimator.

Step 9

Diagnostic tests are applied to each estimated model including within sample goodness of fit tests in addition to tests for weak and strong exogeneity.

Step 10

The final stage of the econometric analysis involves undertaking various scenario tests to project future trends in letter volumes for each segment. The scenarios are based on a combination of the historical trends identified in the variables of the model together with assumed future patterns that the drivers may follow. These future patterns are based on proposed future price changes as provided by Australia Post and projections on consumer price movements as obtained from recognised forecasting institutions such as the IMF and the ABS. Some of the driver sensitivity analyses are also performed upon the e-substitution variables as well as other variables that are included in the final specification of the models.

Whilst the econometric methodology is common across all letter volume segments investigated by Diversified Specifics, nonetheless there are some specific features that are idiosyncratic to modelling each letter volume segment which require additional refinements.

These may include the choice of variables, final model specifications, sample periods, construction of COVID-19 indicators, etc. Some of these issues are elaborated on in these appendices with details of the estimated specifications governing all preferred econometric models and test statistics contained within Appendix E of this document.

D.2 Structural break testing

Each of the letter volume segments were tested individually for a structural break in the presence of a unit root. An allowance for structural breaks in intercepts and time trends are entertained to reflect the major shocks encountered by the Australian economy. These tests serve two purposes. Firstly, to identify the need for structural break dichotomous variables as additional variables in the econometric models. Secondly, to account for those letter segments where there are dramatic changes in their time series properties, which may result in parameter estimates that do not conform to economic theory. The structural break tests are also used as a basis to determine the timeframe that would best reflect recent movements in letter volumes. For those cases where there is a range of potential break dates, the optimal interval is chosen based on sensitivity analysis.

For each segment, outliers in letter volumes have previously occurred in 1998/99 and 2001/02. These outliers arose due to Australia Post altering the rules governing lodgement minimums for PreSort bulk mail. As these periods now fall out-of-sample the econometric models no longer require further correction for these instances. Those volume spikes and troughs reflected cross-segment letter volume migration, not an underlying market trend or a genuine structural break in any of the series.

D.2.1 Other (Ordinary) small

Structural break tests applied to Other small letter volumes suggest three potential structural breaks: March 2011, June 2014, and September 2015. The March 2011 structural break date is selected based on sensitivity analysis from estimating the VECM where the sample period started at each of the three structural break dates. This structural break date of March 2011 coincides with an acceleration in the decline of Other small letter volumes following the GFC.

The first structural break test, outlined in Table D.2.1.1, is based on a break in the intercept only.

Table D.2.1.1 Other small letter volume structural break test 1

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 6/01/2014
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 2 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.871703	> 0.99
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: LVOLUME_SA
Method: Least Squares
Date: 06/14/22 Time: 17:49
Sample (adjusted): 12/01/2002 12/01/2021
Included observations: 77 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVOLUME_SA(-1)	0.985704	0.016400	60.10500	0.0000
D(LVOLUME_SA(-1))	-0.452847	0.104570	-4.330566	0.0000
D(LVOLUME_SA(-2))	-0.258412	0.104598	-2.470529	0.0159
C	0.063807	0.098873	0.645338	0.5208
INCPTBREAK	-0.050426	0.017283	-2.917720	0.0047
BREAKDUM	0.027652	0.034605	0.799089	0.4269

R-squared	0.996379	Mean dependent var	5.617243
Adjusted R-squared	0.996124	S.D. dependent var	0.519599
S.E. of regression	0.032349	Akaike info criterion	-3.949726
Sum squared resid	0.074300	Schwarz criterion	-3.767092
Log likelihood	158.0645	Hannan-Quinn criter.	-3.876674
F-statistic	3907.268	Durbin-Watson stat	2.066160
Prob(F-statistic)	0.000000		

The second structural break test presented in Table D.2.1.2 allows for a constant and a time trend, however, is based on a break in the intercept only.

Table D.2.1.2 Other small letter volume structural break test 2

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Trend and intercept
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 9/01/2015
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 2 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.752225	0.9608
Test critical values:	1% level	-5.347598	
	5% level	-4.859812	
	10% level	-4.607324	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: LVOLUME_SA
Method: Least Squares
Date: 06/14/22 Time: 17:51
Sample (adjusted): 12/01/2002 12/01/2021
Included observations: 77 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVOLUME_SA(-1)	0.884511	0.041962	21.07879	0.0000
D(LVOLUME_SA(-1))	-0.417746	0.102120	-4.090713	0.0001
D(LVOLUME_SA(-2))	-0.247314	0.103062	-2.399660	0.0191
C	0.722422	0.267441	2.701244	0.0087
TREND	-0.002251	0.000714	-3.151864	0.0024
INCPTBREAK	-0.058227	0.020995	-2.773340	0.0071
BREAKDUM	0.038917	0.035328	1.101582	0.2744

R-squared	0.996540	Mean dependent var	5.617243
Adjusted R-squared	0.996244	S.D. dependent var	0.519599
S.E. of regression	0.031846	Akaike info criterion	-3.969310
Sum squared resid	0.070991	Schwarz criterion	-3.756237
Log likelihood	159.8184	Hannan-Quinn criter.	-3.884083
F-statistic	3360.374	Durbin-Watson stat	1.990672
Prob(F-statistic)	0.000000		

The third structural break test, outlined in Table D.2.1.3, allows for a constant and a time trend. This test is based on both a break in the intercept and time trend.

Table D.2.1.3 Other small letter volume structural break test 3

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Trend and intercept
Break Specification: Trend and intercept
Break Type: Innovational outlier

Break Date: 3/01/2011
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.368356	0.0295
Test critical values:	1% level	-5.719131	
	5% level	-5.175710	
	10% level	-4.893950	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: LVOLUME_SA
Method: Least Squares
Date: 05/30/22 Time: 23:45
Sample (adjusted): 6/01/2002 12/01/2021
Included observations: 79 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVOLUME_SA(-1)	0.494154	0.094227	5.244275	0.0000
C	3.169325	0.589814	5.373427	0.0000
TREND	-0.005008	0.000983	-5.092252	0.0000
INCPTBREAK	0.032176	0.016790	1.916380	0.0592
TRENDBREAK	-0.011698	0.002359	-4.958614	0.0000
BREAKDUM	-0.048567	0.035851	-1.354699	0.1797

R-squared	0.996280	Mean dependent var	5.633352
Adjusted R-squared	0.996025	S.D. dependent var	0.522726
S.E. of regression	0.032956	Akaike info criterion	-3.914391
Sum squared resid	0.079284	Schwarz criterion	-3.734433
Log likelihood	160.6185	Hannan-Quinn criter.	-3.842295
F-statistic	3910.141	Durbin-Watson stat	2.172079
Prob(F-statistic)	0.000000		

D.2.2 PreSort small

Structural break tests applied to PreSort small letter volumes suggest three potential structural breaks: December 2002, June 2007, and September 2016. The September 2016 structural break date is selected based on sensitivity analysis from estimating the cointegrating model where the sample period started at each of the three structural break dates. However, given the reduced sample size, the adoption of the multivariate dynamic model with a shorter timeframe resulted in less precise parameter estimates of the long run cointegrating equation which was resolved by adopting a single equation approach based on DOLS. This choice of the structural break coincides with a downside acceleration of PreSort letter volumes following the GFC.

The first PreSort small letter volume structural break test results based on a break in the intercept only, see Table D.2.2.1.

Table D.2.2.1 PreSort small letter volume structural break test 1

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 9/01/2016
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 1 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.920404	> 0.99
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

The second PreSort small letter volume structural break test allows for a constant and a time trend, based on a break in the intercept only, see Table D.2.2.2.

Table D.2.2.2 PreSort small letter volume structural break test 2

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Trend and intercept
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 12/01/2002
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 1 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.868411	> 0.99
Test critical values:	1% level	-5.347598	
	5% level	-4.859812	
	10% level	-4.607324	

The third PreSort small letter volume structural break test allows for a constant and a time trend. This test is based on a break in both the intercept and time trend, see Table D.2.2.3.

Table D.2.2.3 PreSort small letter volume structural break test 3

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Trend and intercept
Break Specification: Trend and intercept
Break Type: Innovational outlier

Break Date: 6/01/2007
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 1 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.879061	0.9758
Test critical values:	1% level	-5.719131	
	5% level	-5.175710	
	10% level	-4.893950	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: LVOLUME_SA
Method: Least Squares
Date: 05/26/22 Time: 08:03
Sample: 3/01/2002 12/01/2021
Included observations: 80

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVOLUME_SA(-1)	0.816344	0.063790	12.79736	0.0000
D(LVOLUME_SA(-1))	-0.339160	0.103702	-3.270508	0.0016
C	1.107412	0.387519	2.857695	0.0056
TREND	0.002463	0.001303	1.889401	0.0628
INCPTBREAK	0.023688	0.021855	1.083861	0.2820
TRENDBREAK	-0.005832	0.001859	-3.136817	0.0025
BREAKDUM	-0.028478	0.037468	-0.760071	0.4497

R-squared	0.981961	Mean dependent var	6.017598
Adjusted R-squared	0.980478	S.D. dependent var	0.243616
S.E. of regression	0.034038	Akaike info criterion	-3.839256
Sum squared resid	0.084576	Schwarz criterion	-3.630828
Log likelihood	160.5702	Hannan-Quinn criter.	-3.755691
F-statistic	662.3025	Durbin-Watson stat	2.079722
Prob(F-statistic)	0.000000		

D.2.3 Other (Ordinary) large

Structural break tests applied to Other large letter volumes suggest two potential structural breaks: December 2011, and March 2014. The December 2011 structural break date is chosen based on sensitivity analysis from estimating the VECM where the sample period commenced at each of the two structural break dates. The timing of the break coincides of the break corresponds to the period where Other large letter volumes began to trend downwards.

The first Other large letter volume structural break test, presented in Table D.2.3.1, is based on a break in the intercept only.

Table D.2.3.1 Other large letter volume structural break test 1

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 3/01/2014
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 2 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.770673	> 0.99
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: LVOLUME_SA
Method: Least Squares
Date: 06/14/22 Time: 17:43
Sample (adjusted): 12/01/2002 12/01/2021
Included observations: 77 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVOLUME_SA(-1)	0.956672	0.024470	39.09597	0.0000
D(LVOLUME_SA(-1))	-0.467931	0.109072	-4.290096	0.0001
D(LVOLUME_SA(-2))	-0.377088	0.126224	-2.987459	0.0039
C	0.159901	0.096874	1.650611	0.1032
INCPTBREAK	-0.084160	0.023098	-3.643520	0.0005
BREAKDUM	0.066570	0.047664	1.396645	0.1669

R-squared	0.991553	Mean dependent var	3.594380
Adjusted R-squared	0.990958	S.D. dependent var	0.467541
S.E. of regression	0.044457	Akaike info criterion	-3.313850
Sum squared resid	0.140329	Schwarz criterion	-3.131216
Log likelihood	133.5832	Hannan-Quinn criter.	-3.240798
F-statistic	1666.902	Durbin-Watson stat	1.913803
Prob(F-statistic)	0.000000		

The second Other large letter volume structural break test, outlined in Table D.2.3.2, allows for a constant and a time trend, however, is based on a break in the intercept only.

Table D.2.3.2 Other large letter volume structural break test 2

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Trend and intercept
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 3/01/2014
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 2 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.917035	0.4249
Test critical values:	1% level	-5.347598	
	5% level	-4.859812	
	10% level	-4.607324	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: LVOLUME_SA
Method: Least Squares
Date: 06/14/22 Time: 17:44
Sample (adjusted): 12/01/2002 12/01/2021
Included observations: 77 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVOLUME_SA(-1)	0.861806	0.035280	24.42742	0.0000
D(LVOLUME_SA(-1))	-0.499879	0.101682	-4.916103	0.0000
D(LVOLUME_SA(-2))	-0.449761	0.119010	-3.779192	0.0003
C	0.586288	0.151020	3.882181	0.0002
TREND	-0.002272	0.000646	-3.514818	0.0008
INCPTBREAK	-0.076882	0.021547	-3.568134	0.0007
BREAKDUM	0.088461	0.044693	1.979315	0.0517

R-squared	0.992820	Mean dependent var	3.594380
Adjusted R-squared	0.992205	S.D. dependent var	0.467541
S.E. of regression	0.041279	Akaike info criterion	-3.450407
Sum squared resid	0.119278	Schwarz criterion	-3.237334
Log likelihood	139.8407	Hannan-Quinn criter.	-3.365180
F-statistic	1613.280	Durbin-Watson stat	1.952394
Prob(F-statistic)	0.000000		

The third structural break test, presented in Table D.2.3.3, allows for a constant and a time trend. This test is based on a break in both the intercept and time trend.

Table D.2.3.3 Other large letter volume structural break test 3

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Trend and intercept
Break Specification: Trend and intercept
Break Type: Innovational outlier

Break Date: 12/01/2011
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.491572	0.2405
Test critical values:	1% level	-5.719131	
	5% level	-5.175710	
	10% level	-4.893950	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: LVOLUME_SA
Method: Least Squares
Date: 06/14/22 Time: 17:45
Sample (adjusted): 6/01/2002 12/01/2021
Included observations: 79 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVOLUME_SA(-1)	0.618697	0.084893	7.287965	0.0000
C	1.566514	0.345194	4.538074	0.0000
TREND	-0.002312	0.000745	-3.102636	0.0027
INCPTBREAK	-0.003712	0.021420	-0.173317	0.8629
TRENDBREAK	-0.009791	0.002519	-3.887356	0.0002
BREAKDUM	-0.072139	0.049012	-1.471879	0.1454

R-squared	0.990716	Mean dependent var	3.604450
Adjusted R-squared	0.990080	S.D. dependent var	0.465833
S.E. of regression	0.046397	Akaike info criterion	-3.230266
Sum squared resid	0.157144	Schwarz criterion	-3.050308
Log likelihood	133.5955	Hannan-Quinn criter.	-3.158170
F-statistic	1557.975	Durbin-Watson stat	2.169124
Prob(F-statistic)	0.000000		

D.2.4 PreSort large

Structural break tests applied to PreSort large letter volumes suggest three potential structural breaks: June 2010, March 2015, and December 2015. However, estimation of the VECM for PreSort large letter volumes based on the full sample period nonetheless yielded economically and statistically significant parameter estimates, in which case it was not necessary to estimate the cointegrating model over a shorter sample based on the structural break tests. This result implies the critical fluctuations in PreSort large letter volumes are captured by the key drivers in the model.

The first PreSort large letter volume structural break test is based on a break in the intercept only, see Table D.2.4.1.

Table D.2.4.1 PreSort large letter volume structural break test 1

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 3/01/2015
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.864652	0.7554
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

The second PreSort large letter volume structural break test allows for a constant and a time trend however is based on a break in the intercept only, see Table D.2.4.2.

Table D.2.4.2 PreSort large letter volume structural break test 2

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Trend and intercept
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 12/01/2015
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.260902	0.8203
Test critical values:	1% level	-5.347598	
	5% level	-4.859812	
	10% level	-4.607324	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: LVOLUME_SA
Method: Least Squares
Date: 06/15/22 Time: 10:18
Sample (adjusted): 6/01/2002 12/01/2021
Included observations: 79 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVOLUME_SA(-1)	0.820388	0.055080	14.89436	0.0000
C	0.683564	0.210928	3.240744	0.0018
TREND	-0.001454	0.000735	-1.978777	0.0516
INCPTBREAK	-0.149262	0.052664	-2.834230	0.0059
BREAKDUM	0.081033	0.083987	0.964825	0.3378

R-squared	0.978800	Mean dependent var	3.301236
Adjusted R-squared	0.977654	S.D. dependent var	0.513190
S.E. of regression	0.076714	Akaike info criterion	-2.236259
Sum squared resid	0.435496	Schwarz criterion	-2.086294
Log likelihood	93.33221	Hannan-Quinn criter.	-2.176178
F-statistic	854.1485	Durbin-Watson stat	1.871307
Prob(F-statistic)	0.000000		

The third PreSort large letter volume structural break test allows for a constant and a time trend. This test is based on both a break in the intercept and time trend, see Table D.2.4.3.

Table D.2.4.3 PreSort large letter volume structural break test 3

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Trend and intercept
Break Specification: Trend and intercept
Break Type: Innovational outlier

Break Date: 6/01/2010
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.949324	0.9682
Test critical values:	1% level	-5.719131	
	5% level	-5.175710	
	10% level	-4.893950	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: LVOLUME_SA
Method: Least Squares
Date: 05/26/22 Time: 07:58
Sample (adjusted): 6/01/2002 12/01/2021
Included observations: 79 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVOLUME_SA(-1)	0.798806	0.068217	11.70978	0.0000
C	0.730258	0.248120	2.943167	0.0044
TREND	0.000744	0.001537	0.483664	0.6301
INCPTBREAK	0.013783	0.037164	0.370882	0.7118
TRENDBREAK	-0.008145	0.003276	-2.486523	0.0152
BREAKDUM	-0.086254	0.083060	-1.038452	0.3025

R-squared	0.978394	Mean dependent var	3.301236
Adjusted R-squared	0.976914	S.D. dependent var	0.513190
S.E. of regression	0.077975	Akaike info criterion	-2.191959
Sum squared resid	0.443842	Schwarz criterion	-2.012001
Log likelihood	92.58239	Hannan-Quinn criter.	-2.119862
F-statistic	661.1348	Durbin-Watson stat	1.793076
Prob(F-statistic)	0.000000		

D.2.5 Print Post

The data provided by Australia Post on Print Post volumes commence in 2006, a date later than the previous letter segments considered. Structural break tests applied to the remaining segments identify a break at the time of the GFC. It is not feasible to include the possibility of a structural break at the time of the GFC in the case of Print Post as the data for this segment commences just prior to its occurrence. Nonetheless, structural break tests are still performed for this segment to identify the timing of the dramatic changes in the effects of e-substitution on Print Post in the post GFC period.

Structural break tests applied to Print Post letter volumes suggest three potential structural breaks: March 2015, September 2015, and June 2019. Sensitivity analysis from estimating the cointegrating equation with the starting period based on the three break dates, resulted in an optimal break date of March 2015. As a result of the relatively short time frame, the final parameter estimates of Print Post are based on the DOLS estimator. The timing of the selected structural break is consistent with the recent behavioural change associated with consumers demanding less of published content that requires postal delivery due to the popularity of digital alternatives.

The first Print Post letter volume structural break test results based on a break in the intercept only, see Table D.2.5.1.

Table D.2.5.1 Print Post letter volume structural break test 1

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 9/01/2015
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 1 (Automatic - based on Schwarz information criterion, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.864588	> 0.99
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

The second Print Post letter volume structural break test allows for a constant and a time trend, however, is based on a break in the intercept only, see Table D.2.5.2.

Table D.2.5.2 Print Post letter volume structural break test 2

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Trend and intercept
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 6/01/2019
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.394156	0.7526
Test critical values:	1% level	-5.347598	
	5% level	-4.859812	
	10% level	-4.607324	

The third Print Post letter volume structural break test allows for a constant and a time trend. This test is based on a break in both the intercept and time trend, see Table D.2.5.3.

Table D.2.5.3 Print Post letter volume structural break test 3

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Trend and intercept
Break Specification: Trend and intercept
Break Type: Innovational outlier

Break Date: 3/01/2015
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.757921	0.1373
Test critical values:	1% level	-5.719131	
	5% level	-5.175710	
	10% level	-4.893950	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: LVOLUME_SA
Method: Least Squares
Date: 05/26/22 Time: 07:56
Sample (adjusted): 12/01/2006 12/01/2021
Included observations: 61 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVOLUME_SA(-1)	0.449463	0.115710	3.884412	0.0003
C	2.335665	0.491466	4.752446	0.0000
TREND	-0.004906	0.001218	-4.027692	0.0002
INCPTBREAK	0.029645	0.023726	1.249486	0.2168
TRENDBREAK	-0.013969	0.003195	-4.372281	0.0001
BREAKDUM	-0.065965	0.045122	-1.461921	0.1495

R-squared	0.987214	Mean dependent var	3.834587
Adjusted R-squared	0.986052	S.D. dependent var	0.349617
S.E. of regression	0.041291	Akaike info criterion	-3.443181
Sum squared resid	0.093770	Schwarz criterion	-3.235554
Log likelihood	111.0170	Hannan-Quinn criter.	-3.361810
F-statistic	849.3253	Durbin-Watson stat	2.003091
Prob(F-statistic)	0.000000		

APPENDIX E ECONOMETRIC MODELS

E.1 Other small letters

E.1.1. Structural break tests

Structural break tests on the Other small letter segment results suggest three breaks:

1. The first break occurs in March 2011, see Table E.1.1.1.

Table E.1.1.1 Other small letter structural break test 1

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Trend and intercept
Break Specification: Trend and intercept
Break Type: Innovational outlier

Break Date: 3/01/2011
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.368356	0.0295
Test critical values:	1% level	-5.719131	
	5% level	-5.175710	
	10% level	-4.893950	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: LVOLUME_SA
Method: Least Squares
Date: 05/30/22 Time: 23:45
Sample (adjusted): 6/01/2002 12/01/2021
Included observations: 79 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVOLUME_SA(-1)	0.494154	0.094227	5.244275	0.0000
C	3.169325	0.589814	5.373427	0.0000
TREND	-0.005008	0.000983	-5.092252	0.0000
INCPTBREAK	0.032176	0.016790	1.916380	0.0592
TRENDBREAK	-0.011698	0.002359	-4.958614	0.0000
BREAKDUM	-0.048567	0.035851	-1.354699	0.1797

R-squared	0.996280	Mean dependent var	5.633352
Adjusted R-squared	0.996025	S.D. dependent var	0.522726
S.E. of regression	0.032956	Akaike info criterion	-3.914391
Sum squared resid	0.079284	Schwarz criterion	-3.734433
Log likelihood	160.6185	Hannan-Quinn criter.	-3.842295
F-statistic	3910.141	Durbin-Watson stat	2.172079
Prob(F-statistic)	0.000000		

2. The second break occurs in June 2014, see Table E.1.1.2.

Table E.1.1.2 Other small letter structural break test 2

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 6/01/2014
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 2 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.871703	> 0.99
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: LVOLUME_SA
Method: Least Squares
Date: 06/14/22 Time: 17:49
Sample (adjusted): 12/01/2002 12/01/2021
Included observations: 77 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVOLUME_SA(-1)	0.985704	0.016400	60.10500	0.0000
D(LVOLUME_SA(-1))	-0.452847	0.104570	-4.330566	0.0000
D(LVOLUME_SA(-2))	-0.258412	0.104598	-2.470529	0.0159
C	0.063807	0.098873	0.645338	0.5208
INCPTBREAK	-0.050426	0.017283	-2.917720	0.0047
BREAKDUM	0.027652	0.034605	0.799089	0.4269

R-squared	0.996379	Mean dependent var	5.617243
Adjusted R-squared	0.996124	S.D. dependent var	0.519599
S.E. of regression	0.032349	Akaike info criterion	-3.949726
Sum squared resid	0.074300	Schwarz criterion	-3.767092
Log likelihood	158.0645	Hannan-Quinn criter.	-3.876674
F-statistic	3907.268	Durbin-Watson stat	2.066160
Prob(F-statistic)	0.000000		

3. The third break occurs in September 2015, see Table E.1.1.3.

Table E.1.1.3 Other small letter structural break test 3

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Trend and intercept
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 9/01/2015
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 2 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.752225	0.9608
Test critical values:	1% level	-5.347598	
	5% level	-4.859812	
	10% level	-4.607324	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: LVOLUME_SA
Method: Least Squares
Date: 06/14/22 Time: 17:51
Sample (adjusted): 12/01/2002 12/01/2021
Included observations: 77 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVOLUME_SA(-1)	0.884511	0.041962	21.07879	0.0000
D(LVOLUME_SA(-1))	-0.417746	0.102120	-4.090713	0.0001
D(LVOLUME_SA(-2))	-0.247314	0.103062	-2.399660	0.0191
C	0.722422	0.267441	2.701244	0.0087
TREND	-0.002251	0.000714	-3.151864	0.0024
INCPTBREAK	-0.058227	0.020995	-2.773340	0.0071
BREAKDUM	0.038917	0.035328	1.101582	0.2744

R-squared	0.996540	Mean dependent var	5.617243
Adjusted R-squared	0.996244	S.D. dependent var	0.519599
S.E. of regression	0.031846	Akaike info criterion	-3.969310
Sum squared resid	0.070991	Schwarz criterion	-3.756237
Log likelihood	159.8184	Hannan-Quinn criter.	-3.884083
F-statistic	3360.374	Durbin-Watson stat	1.990672
Prob(F-statistic)	0.000000		

E.1.2. Lag specification tests

The lag structure tests suggest a VAR with 1 or 3 lags, hence a VECM with either no lags or 2 lags, see Table E.1.2.1.

Table E.1.2.1 Other small letters lag structure test

VAR Lag Order Selection Criteria
Endogenous variables: LOG(VOLUME_SA) LOG(REALPR) LOG(SUBST)
Exogenous variables: C ECONDOWN DUM_PRICE DUM_COVID_TOTAL
Date: 05/30/22 Time: 23:50
Sample: 3/01/2002 12/01/2021
Included observations: 77

Lag	LogL	LR	FPE	AIC	SC	HQ
0	19.94439	NA	0.000163	-0.206348	0.158920	-0.060244
1	442.3996	768.1004	3.55e-09	-10.94544	-10.30622*	-10.68976*
2	454.7033	21.41161	3.26e-09	-11.03125	-10.11808	-10.66599
3	467.6479	21.51828*	2.96e-09*	-11.13371*	-9.946589	-10.65887

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

E.1.3. Preferred Other (Ordinary) small letter econometric model

The VECM parameter estimates for the full sample results in an e-substitution variable with an incorrect sign based on 0 lags. Extending the VECM to 1 or 2 lags does not solve the problem.[109] This necessitates a VECM based on a restricted sample using the information contained within the structural break tests. To rectify the full sample issues, the commencement date of the sample is selected based on the first structural break test. This results in a preferred model, presented in Table E.1.3.1, that contains correctly signed and statistically significant price and e-substitution variable.

Table E.1.3.1 Preferred Other (Ordinary) small letter econometric model

Vector Error Correction Estimates
Date: 05/30/22 Time: 23:49
Sample: 3/01/2011 12/01/2021
Included observations: 44
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1			
LOG(VOLUME_SA(-1))	1.000000			
LOG(REALPR(-1))	0.152465 (0.07037) [2.16670]			
LOG(SUBST(-1))	0.241706 (0.01757) [13.7543]			
LOG(TELECOMCPI(-1)/CPI(-1))	-0.699663 (0.15130) [-4.62427]			
C	-5.084353			
Error Correction:	**D(LOG(VOLUME_SA))**	**D(LOG(REALPR))**	**D(LOG(SUBST))**	**D(LOG(TELECOMCPI/CPI))**
CointEq1	-0.629077 (0.23949) [-2.62675]	0.396461 (0.17226) [2.30159]	-0.599167 (0.43935) [-1.36377]	0.117427 (0.06227) [1.88576]
D(LOG(VOLUME_SA(-1)))	-0.139147 (0.24627) [-0.56501]	-0.164946 (0.17713) [-0.93119]	-0.045867 (0.45179) [-0.10152]	-0.056648 (0.06403) [-0.88464]
D(LOG(VOLUME_SA(-2)))	-0.202442 (0.20209) [-1.00172]	0.096201 (0.14536) [0.66181]	0.355559 (0.37075) [0.95904]	-0.071957 (0.05255) [-1.36937]
D(LOG(VOLUME_SA(-3)))	-0.001407 (0.17706) [-0.00795]	0.226731 (0.12735) [1.78039]	-0.190414 (0.32481) [-0.58623]	-0.066137 (0.04604) [-1.43659]
D(LOG(REALPR(-1)))	-0.008235 (0.08697) [-0.09468]	-0.207919 (0.06256) [-3.32375]	0.289663 (0.15955) [1.81549]	-0.026466 (0.02261) [-1.17032]
D(LOG(REALPR(-2)))	-0.126146	-0.062920	0.157720	-0.057809

[109] Intermediate statistical results are not presented however are available from Diversified Specifics upon request.

	(0.09102)	(0.06547)	(0.16698)	(0.02367)
	[-1.38586]	[-0.96106]	[0.94453]	[-2.44256]
D(LOG(REALPR(-3)))	0.004601	-0.121086	-0.101055	-0.009382
	(0.09036)	(0.06499)	(0.16576)	(0.02349)
	[0.05092]	[-1.86312]	[-0.60964]	[-0.39931]
D(LOG(SUBST(-1)))	0.112087	-0.082707	0.219298	-0.002766
	(0.09709)	(0.06984)	(0.17812)	(0.02525)
	[1.15441]	[-1.18429]	[1.23117]	[-0.10957]
D(LOG(SUBST(-2)))	-0.081117	0.154114	-0.057589	0.003931
	(0.09552)	(0.06871)	(0.17524)	(0.02484)
	[-0.84919]	[2.24309]	[-0.32863]	[0.15827]
D(LOG(SUBST(-3)))	0.197948	-0.074578	-0.119330	-0.037264
	(0.09408)	(0.06767)	(0.17259)	(0.02446)
	[2.10399]	[-1.10209]	[-0.69139]	[-1.52331]
D(LOG(TELECOMCPI(-1)/CPI(-1)))	0.723140	-0.209808	-1.885752	0.320543
	(0.67642)	(0.48652)	(1.24090)	(0.17588)
	[1.06907]	[-0.43124]	[-1.51966]	[1.82252]
D(LOG(TELECOMCPI(-2)/CPI(-2)))	-0.183909	-0.208612	1.813752	0.109640
	(0.68529)	(0.49291)	(1.25718)	(0.17819)
	[-0.26836]	[-0.42323]	[1.44271]	[0.61531]
D(LOG(TELECOMCPI(-3)/CPI(-3)))	0.303228	-0.310410	0.504458	0.182683
	(0.61768)	(0.44427)	(1.13313)	(0.16060)
	[0.49092]	[-0.69869]	[0.44519]	[1.13747]
C	-0.034239	-0.008479	0.091603	-0.008683
	(0.01905)	(0.01370)	(0.03494)	(0.00495)
	[-1.79760]	[-0.61891]	[2.62155]	[-1.75320]
DUM_PRICE	-0.022351	0.438826	-0.053886	0.001701
	(0.03910)	(0.02812)	(0.07172)	(0.01017)
	[-0.57168]	[15.6047]	[-0.75129]	[0.16728]
DUM_COVID_TOTAL	-0.063396	0.041601	-0.077585	0.010861
	(0.02445)	(0.01758)	(0.04485)	(0.00636)
	[-2.59327]	[2.36589]	[-1.72998]	[1.70862]
R-squared	0.587959	0.927690	0.359146	0.445873
Adj. R-squared	0.367223	0.888952	0.015831	0.149019
Sum sq. resids	0.032981	0.017062	0.110996	0.002230
S.E. equation	0.034321	0.024686	0.062962	0.008924
F-statistic	2.663627	23.94809	1.046113	1.501995
Log likelihood	95.87879	110.3781	69.18056	155.1476
Akaike AIC	-3.630854	-4.289913	-2.417298	-6.324890
Schwarz SC	-2.982058	-3.641116	-1.768502	-5.676094
Mean dependent	-0.029681	0.008435	0.074420	-0.011520
S.D. dependent	0.043145	0.074078	0.063466	0.009674

Determinant resid covariance (dof adj.)	1.77E-13
Determinant resid covariance	2.91E-14
Log likelihood	435.9828
Akaike information criterion	-16.72649
Schwarz criterion	-13.96911
Number of coefficients	68

E.1.4. Cointegration tests

The cointegration test implies the null hypothesis of one cointegrating equation is not rejected at the 5% level of significance, see Table E.1.4.1.

Table E.1.4.1 Other small letter cointegration test

Date: 07/15/22 Time: 12:18
Sample: 3/01/2011 12/01/2021
Included observations: 44
Trend assumption: Linear deterministic trend
Series: LOG(VOLUME_SA) LOG(REALPR) LOG(SUBST) LOG(TELECOMCPI/CPI)
Exogenous series: DUM_PRICE DUM_COVID_TOTAL
Warning: Critical values assume no exogenous series
Lags interval (in first differences): 1 to 3

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.557173	64.53585	47.85613	0.0007
At most 1	0.393862	28.69452	29.79707	0.0666
At most 2	0.138559	6.666027	15.49471	0.6168
At most 3	0.002349	0.103492	3.841465	0.7477

E.2 Other large letters

E.2.1. Structural break tests

Structural break test results suggest a break in December 2011, see Table E.2.1.1.

Table E.2.1.1 Other large letter structural break test

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Trend and intercept
Break Specification: Trend and intercept
Break Type: Innovational outlier

Break Date: 12/01/2011
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.517647	0.2299
Test critical values:	1% level	-5.719131	
	5% level	-5.175710	
	10% level	-4.893950	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: LVOLUME_SA
Method: Least Squares
Date: 05/26/22 Time: 08:00
Sample (adjusted): 6/01/2002 12/01/2021
Included observations: 79 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVOLUME_SA(-1)	0.614512	0.085329	7.201656	0.0000
C	1.583513	0.346972	4.563812	0.0000
TREND	-0.002326	0.000752	-3.091712	0.0028
INCPTBREAK	-0.003584	0.021647	-0.165562	0.8690
TRENDBREAK	-0.009917	0.002532	-3.917322	0.0002
BREAKDUM	-0.072545	0.049523	-1.464876	0.1472

R-squared	0.990520	Mean dependent var	3.604461
Adjusted R-squared	0.989870	S.D. dependent var	0.465848
S.E. of regression	0.046886	Akaike info criterion	-3.209279
Sum squared resid	0.160477	Schwarz criterion	-3.029321
Log likelihood	132.7665	Hannan-Quinn criter.	-3.137183
F-statistic	1525.415	Durbin-Watson stat	2.137411
Prob(F-statistic)	0.000000		

E.2.2. Lag specification tests

Optimal lag specification tests suggest a VAR with lags between 1 and 3, resulting in a VECM with between 0 and 2 lags, see Table E.2.2.1.

Table E.2.2.1 Other large letter lag specification test

VAR Lag Order Selection Criteria
Endogenous variables: LOG(VOLUME_SA) LOG(REALPR) LOG(SUBST)
Exogenous variables: C DUM_PRICE DUM_COVID7 DUM_COVID8 DUM_COVID_TOTAL C
Date: 06/01/22 Time: 21:43
Sample: 3/01/2002 12/01/2021
Included observations: 77

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-30.68735	NA	0.000658	1.186684	1.643270	1.369315
1	499.4720	950.1557	8.71e-10	-12.34992	-11.61938*	-12.05771*
2	509.7767	17.66519	8.45e-10	-12.38381	-11.37932	-11.98202
3	520.3640	17.32466*	8.16e-10*	-12.42504*	-11.14660	-11.91367

E.2.3. Cointegration tests

The results of the cointegration test suggest a single cointegrating equation at the 5% level of significance, see Table E.2.3.1.

Table E.2.3.1 Other large letter cointegration test

Date: 06/01/22 Time: 21:52
Sample (adjusted): 6/01/2002 12/01/2021
Included observations: 79 after adjustments
Trend assumption: Linear deterministic trend
Series: LOG(VOLUME_SA) LOG(REALPR) LOG(SUBST)
Exogenous series: DUM_PRICE DUM_COVID7 DUM_COVID8 DUM_COVID_TOTAL
Warning: Critical values assume no exogenous series
Lags interval (in first differences): No lags

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.883778	181.5146	29.79707	0.0000
At most 1	0.127416	11.48657	15.49471	0.1833
At most 2	0.009062	0.719183	3.841465	0.3964

The parameter estimates based on zero lags in the VECM yield a positive price elasticity suggesting model misspecification. Further testing suggested this may be the result of the lag structure choice.[110]

[110] Extending the lag structure to 1 or 2 lags fails to result in a negative price elasticity. Intermediate statistical results are not presented however are available from Diversified Specifics upon request.

By truncating the data series to commence in March 2011, the date of the structural break, the cointegration test result is satisfied, characterised by a single cointegrating vector, see Table E.2.3.2.

Table E.2.3.2 Other large letter cointegration test (Truncated)

Date: 06/01/22   Time: 21:55
Sample: 12/01/2011 12/01/2021
Included observations: 41
Trend assumption: Linear deterministic trend
Series: LOG(VOLUME_SA) LOG(REALPR) LOG(SUBST)
Exogenous series: DUM_PRICE DUM_COVID7 DUM_COVID8 DUM_COVID_TOTAL
Warning: Critical values assume no exogenous series
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.541741	40.68519	29.79707	0.0019
At most 1	0.171202	8.692022	15.49471	0.3946
At most 2	0.023930	0.993076	3.841465	0.3190

E.2.3 Preferred Other (Ordinary) large letter econometric model

This necessitates a VECM based on a restricted sample with a commencement date selected via the structural break testing procedure outlined in Section E.2.1. This results in a preferred model, presented in Table E.2.3.1, that contains correctly signed price and e-substitution variables in the long run component of the model.[111]

Table E.2.3.1 Preferred Other (Ordinary) large letter econometric model

Vector Error Correction Estimates
Date: 06/01/22 Time: 17:51
Sample: 12/01/2011 12/01/2021
Included observations: 41
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(VOLUME_SA(-1))	1.000000		
LOG(REALPR(-1))	0.179910 (0.10792) [1.66705]		
LOG(SUBST(-1))	0.598066 (0.04706) [12.7092]		
C	-3.431430		
Error Correction:	**D(LOG(VOLUME_SA))**	**D(LOG(REALPR))**	**D(LOG(SUBST))**
CointEq1	-0.480285 (0.10017) [-4.79485]	0.384706 (0.10956) [3.51134]	-0.066547 (0.06263) [-1.06246]
D(LOG(VOLUME_SA(-1)))	-0.271300 (0.14027) [-1.93414]	0.073899 (0.15342) [0.48166]	0.120913 (0.08771) [1.37854]
D(LOG(VOLUME_SA(-2)))	0.020498 (0.13448) [0.15243]	-0.017593 (0.14709) [-0.11961]	0.157515 (0.08409) [1.87321]
D(LOG(REALPR(-1)))	0.068809 (0.08011) [0.85897]	-0.196741 (0.08762) [-2.24542]	0.056057 (0.05009) [1.11911]
D(LOG(REALPR(-2)))	0.251525 (0.07975) [3.15405]	-0.166761 (0.08723) [-1.91183]	0.067051 (0.04987) [1.34462]
D(LOG(SUBST(-1)))	0.479528 (0.27178) [1.76441]	-0.427400 (0.29727) [-1.43776]	0.158447 (0.16994) [0.93234]
D(LOG(SUBST(-2)))	-1.241454 (0.26987) [-4.60023]	1.556982 (0.29518) [5.27473]	0.029609 (0.16875) [0.17546]
C	0.008954	-0.057655	0.045629

[111] Although e-substitution is significant at a 5% level of confidence, own price is significant at 10%.

	(0.02039)	(0.02230)	(0.01275)
	[0.43916]	[-2.58532]	[3.57899]
DUM_PRICE	-0.051792	0.358598	0.011525
	(0.02946)	(0.03222)	(0.01842)
	[-1.75819]	[11.1295]	[0.62566]
DUM_COVID7	0.219245	0.023166	0.001211
	(0.03249)	(0.03553)	(0.02031)
	[6.74895]	[0.65197]	[0.05960]
DUM_COVID8	-0.034801	-0.082470	-0.023041
	(0.04417)	(0.04831)	(0.02762)
	[-0.78796]	[-1.70715]	[-0.83430]
DUM_COVID_TOTAL	-0.070574	0.068766	-0.021500
	(0.01770)	(0.01935)	(0.01106)
	[-3.98831]	[3.55295]	[-1.94311]
R-squared	0.860794	0.870469	0.377786
Adj. R-squared	0.807991	0.821336	0.141774
Sum sq. resids	0.023748	0.028411	0.009285
S.E. equation	0.028616	0.031300	0.017894
F-statistic	16.30218	17.71674	1.600706
Log likelihood	94.62723	90.95182	113.8775
Akaike AIC	-4.030597	-3.851308	-4.969633
Schwarz SC	-3.529063	-3.349775	-4.468100
Mean dependent	-0.028910	0.011503	0.043864
S.D. dependent	0.065306	0.074050	0.019315
Determinant resid covariance (dof adj.)		2.34E-10	
Determinant resid covariance		8.27E-11	
Log likelihood		301.3851	
Akaike information criterion		-12.79927	
Schwarz criterion		-11.16929	
Number of coefficients		39	

E.3 PreSort small letters

E.3.1. Structural break tests

Three structural breaks characterised the PreSort small letter volume series:

1. Structural break test results suggest a break in September 2016, see Table E.3.1.1.

Table E.3.1.1 PreSort small letter structural break test 1

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 9/01/2016
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 1 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.920404	> 0.99
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

2. Results of the second structural break test identify December 2002 as the break, see Table E.3.1.2.

Table E.3.1.2 PreSort small letter structural break test 2

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Trend and intercept
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 12/01/2002
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 1 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.868411	> 0.99
Test critical values:	1% level	-5.347598	
	5% level	-4.859812	
	10% level	-4.607324	

3. Results of the third structural break test suggest a break in the series in June 2007, see Table E.3.1.3.

Table E.3.1.3 PreSort small letter structural break test 3

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Trend and intercept
Break Specification: Trend and intercept
Break Type: Innovational outlier

Break Date: 6/01/2007
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 1 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.879061	0.9758
Test critical values:	1% level	-5.719131	
	5% level	-5.175710	
	10% level	-4.893950	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: LVOLUME_SA
Method: Least Squares
Date: 05/26/22 Time: 08:03
Sample: 3/01/2002 12/01/2021
Included observations: 80

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVOLUME_SA(-1)	0.816344	0.063790	12.79736	0.0000
D(LVOLUME_SA(-1))	-0.339160	0.103702	-3.270508	0.0016
C	1.107412	0.387519	2.857695	0.0056
TREND	0.002463	0.001303	1.889401	0.0628
INCPTBREAK	0.023688	0.021855	1.083861	0.2820
TRENDBREAK	-0.005832	0.001859	-3.136817	0.0025
BREAKDUM	-0.028478	0.037468	-0.760071	0.4497

R-squared	0.981961	Mean dependent var	6.017598
Adjusted R-squared	0.980478	S.D. dependent var	0.243616
S.E. of regression	0.034038	Akaike info criterion	-3.839256
Sum squared resid	0.084576	Schwarz criterion	-3.630828
Log likelihood	160.5702	Hannan-Quinn criter.	-3.755691
F-statistic	662.3025	Durbin-Watson stat	2.079722
Prob(F-statistic)	0.000000		

E.3.2. Lag specification tests

The lag specification tests point towards an optimal lag structure of the VAR at either 1 or 2 lags, which suggests an initial estimate of the VECM lag structure to have either zero lags or 1 lag, see Table E.3.2.1.

Table E.3.2.1 PreSort small letter lag specification test

VAR Lag Order Selection Criteria
Endogenous variables: LOG(VOLUME_SA) LOG(REALPR) LOG(SUBST) LOG(TELECOMCPI/CPI)
Exogenous variables: @TREND(2020Q1)*DUM_COVID_TOTAL DUM_COVID2 DUM_COVID3 DUM_COVID6 C
Date: 06/14/22 Time: 17:21
Sample: 3/01/2002 12/01/2021
Included observations: 77

Lag	LogL	LR	FPE	AIC	SC	HQ
0	163.2850	NA	2.85e-07	-3.721687	-3.112907	-3.478180
1	768.3221	1068.637	6.47e-14	-19.02135	-17.92555*	-18.58304*
2	784.9304	27.60857*	6.43e-14*	-19.03715*	-17.45432	-18.40403
3	792.7485	12.18410	8.08e-14	-18.82464	-16.75478	-17.99671

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

E.3.3. DOLS with sample based upon structural break tests

When constructing a VECM based upon zero and one lags, the parameter estimates fail the test of common sense given real price is incorrectly signed.[112] Given the difficulties associated with the VECM specifications, a DOLS functional form is constructed based on the results of the first structural break test. The results contained in Table E.3.3.1. represent the preferred model for PreSort small letters.

Table E.3.3.1 Preferred PreSort small letter econometric model

Dependent Variable: LOG(VOLUME_SA)
Method: Dynamic Least Squares (DOLS)
Date: 06/05/22 Time: 08:00
Sample: 9/01/2016 12/01/2021
Included observations: 22
Cointegrating equation deterministics: C @TREND(2020Q1)
*DUM_COVID_TOTAL DUM_COVID2 DUM_COVID3
DUM_COVID6
Fixed leads and lags specification (lead=0, lag=0)
Long-run variance estimate (Bartlett kernel, Newey-West fixed bandwidth
= 3.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(REALPR)	-0.547228	0.462431	-1.183372	0.2579
LOG(SUBST)	-0.486018	0.081756	-5.944777	0.0000
C	3.947283	2.431261	1.623554	0.1285
@TREND(2020Q1)*DUM_COVID_TOTAL	-0.010128	0.003921	-2.582845	0.0227
DUM_COVID2	-0.094373	0.041495	-2.274321	0.0405
DUM_COVID3	-0.093028	0.041316	-2.251614	0.0423
DUM_COVID6	-0.036977	0.036214	-1.021079	0.3258

R-squared	0.974654	Mean dependent var	5.669376
Adjusted R-squared	0.959056	S.D. dependent var	0.160421
S.E. of regression	0.032461	Sum squared resid	0.013698
Long-run variance	0.001016		

112 Intermediate VECM outputs are not presented however are available from Diversified Specifics upon request.

E.3.4 Cointegration test

The cointegration test is satisfied at the 5% level of significance, see Table 3.4.1.

Table E.3.4.1 PreSort small letter cointegration test

Cointegration Test - Phillips-Ouliaris
Date: 06/04/22 Time: 17:14
Equation: OLS_DYNAMIC
Specification: LOG(VOLUME_SA) LOG(REALPR) LOG(SUBST_OLD) C @TREND(2020Q1)*COVID DUM_COVID2 DUM_COVID3 DUM_COVID6
Cointegrating equation deterministics: C @TREND(2020Q1)*COVID DUM_COVID2 DUM_COVID3 DUM_COVID6
Null hypothesis: Series are not cointegrated
Long-run variance estimate (Bartlett kernel, Newey-West fixed bandwidth = 3.0000)
No d.f. adjustment for variances

	Value	Prob.*
Phillips-Ouliaris tau-statistic	-4.193870	0.0479
Phillips-Ouliaris z-statistic	-17.97856	0.0682

E.4 PreSort large letters

E.4.1. Structural break tests

A structural break test in the PreSort large letter volume series reveals:

1. A break in September 2015, see Table E.4.1.1.

Table E.4.1.1 PreSort large letter structural break test 1

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 3/01/2015
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.864652	0.7554
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

2. A second break identified in December 2015, see Table E.4.1.2.

Table E.4.1.2 PreSort large letter structural break test 2

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Trend and intercept
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 12/01/2015
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.260902	0.8203
Test critical values:	1% level	-5.347598	
	5% level	-4.859812	
	10% level	-4.607324	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: LVOLUME_SA
Method: Least Squares
Date: 06/15/22 Time: 10:18
Sample (adjusted): 6/01/2002 12/01/2021
Included observations: 79 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVOLUME_SA(-1)	0.820388	0.055080	14.89436	0.0000
C	0.683564	0.210928	3.240744	0.0018
TREND	-0.001454	0.000735	-1.978777	0.0516
INCPTBREAK	-0.149262	0.052664	-2.834230	0.0059
BREAKDUM	0.081033	0.083987	0.964825	0.3378

R-squared	0.978800	Mean dependent var	3.301236
Adjusted R-squared	0.977654	S.D. dependent var	0.513190
S.E. of regression	0.076714	Akaike info criterion	-2.236259
Sum squared resid	0.435496	Schwarz criterion	-2.086294
Log likelihood	93.33221	Hannan-Quinn criter.	-2.176178
F-statistic	854.1485	Durbin-Watson stat	1.871307
Prob(F-statistic)	0.000000		

3. A third break in June 2010, see Table E.4.1.3

Table E.4.1.3 PreSort large letter structural break test 3

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Trend and intercept
Break Specification: Trend and intercept
Break Type: Innovational outlier

Break Date: 6/01/2010
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.949324	0.9682
Test critical values:	1% level	-5.719131	
	5% level	-5.175710	
	10% level	-4.893950	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: LVOLUME_SA
Method: Least Squares
Date: 05/26/22 Time: 07:58
Sample (adjusted): 6/01/2002 12/01/2021
Included observations: 79 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVOLUME_SA(-1)	0.798806	0.068217	11.70978	0.0000
C	0.730258	0.248120	2.943167	0.0044
TREND	0.000744	0.001537	0.483664	0.6301
INCPTBREAK	0.013783	0.037164	0.370882	0.7118
TRENDBREAK	-0.008145	0.003276	-2.486523	0.0152
BREAKDUM	-0.086254	0.083060	-1.038452	0.3025

R-squared	0.978394	Mean dependent var	3.301236
Adjusted R-squared	0.976914	S.D. dependent var	0.513190
S.E. of regression	0.077975	Akaike info criterion	-2.191959
Sum squared resid	0.443842	Schwarz criterion	-2.012001
Log likelihood	92.58239	Hannan-Quinn criter.	-2.119862
F-statistic	661.1348	Durbin-Watson stat	1.793076
Prob(F-statistic)	0.000000		

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E.4.2. Lag specification tests

The lag specification tests imply an optimal lag structure of the VAR between 1 and 2 lags. This suggests the estimated PreSort large letter VECM lag structure will contain either zero or 1 lag, see Table E.4.2.1.

Table E.4.2.1 PreSort large letter lag specification test

VAR Lag Order Selection Criteria
Endogenous variables: LOG(VOLUME_SA) LOG(REALPR) LOG(SUBST) LOG(TELECOMCPI/CPI)
Exogenous variables: DUM_PRICE DUM_COVID2 DUM_COVID3 DUM_COVID4 DUM_COVID5 DUM_COVID8 C
Date: 06/15/22 Time: 10:54
Sample: 3/01/2003 12/01/2021
Included observations: 76

Lag	LogL	LR	FPE	AIC	SC	HQ
0	97.64404	NA	1.88e-06	-1.832738	-0.974047	-1.489563
1	690.3220	1013.791	4.86e-13	-17.00847	-15.65910*	-16.46920*
2	707.7379	27.95705*	4.75e-13*	-17.04573*	-15.20568	-16.31036
3	717.2780	14.31024	5.75e-13	-16.87574	-14.54500	-15.94426

E.4.3. VECM with sample based upon a lag structure of three

When constructing a VECM based upon zero, one and two lags, the estimated coefficients fail the test of common sense since e-substitution is incorrectly signed on all occasions.[113] Increasing the lag structure to 3 lags results in a model where price and substitution are correctly signed. For this reason, the preferred VECM is provided in Table E.4.3.1.

Table E.4.3.1 Preferred PreSort large letter econometric model

Vector Error Correction Estimates
Date: 06/03/22 Time: 07:37
Sample (adjusted): 3/01/2003 12/01/2021
Included observations: 76 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1			
LOG(VOLUME_SA(-1))	1.000000			
LOG(REALPR(-1))	0.474571 (0.39467) [1.20244]			
LOG(SUBST(-1))	0.159824 (0.06646) [2.40471]			
LOG(TELECOMCPI(-1)/CPI(-1))	-2.045207 (0.86064) [-2.37638]			
C	-1.233143			
Error Correction:	D(LOG(VOLUME_SA))	D(LOG(REALPR))	D(LOG(SUBST))	D(LOG(TELECOMCPI/CPI))
CointEq1	-0.164359 (0.07704) [-2.13333]	-0.003306 (0.04842) [-0.06828]	-0.108552 (0.02160) [-5.02655]	-0.009379 (0.00844) [-1.11094]
D(LOG(VOLUME_SA(-1)))	0.040102 (0.13849) [0.28956]	-0.091297 (0.08705) [-1.04883]	0.036303 (0.03882) [0.93516]	0.010472 (0.01518) [0.69006]
D(LOG(VOLUME_SA(-2)))	0.275179 (0.15132) [1.81854]	-0.070214 (0.09511) [-0.73826]	0.099975 (0.04242) [2.35704]	0.007993 (0.01658) [0.48207]
D(LOG(VOLUME_SA(-3)))	0.165772 (0.15274) [1.08534]	-0.186388 (0.09600) [-1.94154]	0.116513 (0.04281) [2.72142]	0.014712 (0.01674) [0.87907]
D(LOG(REALPR(-1)))	0.049288 (0.17083) [0.28851]	-0.467850 (0.10737) [-4.35717]	0.045629 (0.04789) [0.95288]	-0.003617 (0.01872) [-0.19321]
D(LOG(REALPR(-2)))	0.105554 (0.18805) [0.56130]	-0.123902 (0.11820) [-1.04827]	0.086299 (0.05271) [1.63717]	-0.012855 (0.02061) [-0.62383]
D(LOG(REALPR(-3)))	-0.045096	-0.283525	0.075702	-0.027324

[113] Intermediate VECM outputs are not presented however are available from Diversified Specifics upon request.

	(0.16295)	(0.10242)	(0.04567)	(0.01785)
	[-0.27676]	[-2.76837]	[1.65741]	[-1.53032]
D(LOG(SUBST(-1)))	0.129125	0.065183	0.133711	-0.012637
	(0.43207)	(0.27157)	(0.12111)	(0.04734)
	[0.29885]	[0.24002]	[1.10402]	[-0.26692]
D(LOG(SUBST(-2)))	-0.032821	-0.005293	0.134616	-0.034747
	(0.41986)	(0.26390)	(0.11769)	(0.04601)
	[-0.07817]	[-0.02006]	[1.14382]	[-0.75526]
D(LOG(SUBST(-3)))	-0.843811	-0.233271	0.014925	0.002304
	(0.39281)	(0.24689)	(0.11011)	(0.04304)
	[-2.14815]	[-0.94483]	[0.13555]	[0.05353]
D(LOG(TELECOMCPI(-1)/CPI(-1)))	0.716230	-0.298431	-0.371410	0.302623
	(1.23275)	(0.77482)	(0.34555)	(0.13508)
	[0.58100]	[-0.38516]	[-1.07485]	[2.24034]
D(LOG(TELECOMCPI(-2)/CPI(-2)))	-0.867229	-0.051759	0.156800	-0.051658
	(1.28409)	(0.80709)	(0.35994)	(0.14071)
	[-0.67536]	[-0.06413]	[0.43563]	[-0.36713]
D(LOG(TELECOMCPI(-3)/CPI(-3)))	-0.268394	-0.354511	-0.179615	0.107325
	(1.20929)	(0.76007)	(0.33897)	(0.13251)
	[-0.22194]	[-0.46642]	[-0.52988]	[0.80995]
C	0.062321	0.012776	0.059453	-0.001457
	(0.04525)	(0.02844)	(0.01268)	(0.00496)
	[1.37718]	[0.44920]	[4.68709]	[-0.29382]
DUM_PRICE	-0.123473	0.255112	0.014277	0.003318
	(0.08086)	(0.05082)	(0.02267)	(0.00886)
	[-1.52701]	[5.01968]	[0.62990]	[0.37447]
DUM_COVID2	-0.159260	0.072991	0.005105	0.015699
	(0.07766)	(0.04881)	(0.02177)	(0.00851)
	[-2.05073]	[1.49536]	[0.23450]	[1.84482]
DUM_COVID3	-0.082392	-0.048813	-0.009007	-0.016457
	(0.08158)	(0.05128)	(0.02287)	(0.00894)
	[-1.00993]	[-0.95195]	[-0.39387]	[-1.84092]
DUM_COVID4	0.003739	-0.071174	-0.002313	0.004233
	(0.08494)	(0.05339)	(0.02381)	(0.00931)
	[0.04401]	[-1.33309]	[-0.09715]	[0.45477]
DUM_COVID5	0.184145	-0.069600	0.005921	0.010102
	(0.08587)	(0.05397)	(0.02407)	(0.00941)
	[2.14441]	[-1.28953]	[0.24601]	[1.07355]
DUM_COVID8	-0.116421	-0.017586	-0.021971	-0.003944
	(0.09052)	(0.05689)	(0.02537)	(0.00992)
	[-1.28619]	[-0.30911]	[-0.86593]	[-0.39762]
R-squared	0.353060	0.579454	0.909461	0.360610
Adj. R-squared	0.133563	0.436769	0.878743	0.143674
Sum sq. resids	0.309066	0.122097	0.024284	0.003711
S.E. equation	0.074290	0.046694	0.020824	0.008140
F-statistic	1.608493	4.061070	29.60638	1.662285
Log likelihood	101.3481	136.6404	198.0105	269.3949
Mean dependent	-0.014750	0.004446	0.085097	-0.009309
S.D. dependent	0.079811	0.062218	0.059801	0.008797

Determinant resid covariance (dof adj.)	2.78E-13
Akaike information criterion	-16.57189
Schwarz criterion	-13.99582
Number of coefficients	84

E.4.4 Cointegration test

The cointegration test suggests 1 cointegrating equation at the 1% level of significance and potentially another at 5%, see Table E.4.4.1.

Table E.4.4.1 PreSort large letter cointegration test

Date: 07/15/22 Time: 12:23
Sample: 3/01/2003 12/01/2021
Included observations: 76
Trend assumption: Linear deterministic trend
Series: LOG(VOLUME_SA) LOG(REALPR) LOG(SUBST) LOG(TELECOMCPI/CPI)
Exogenous series: DUM_PRICE DUM_COVID2 DUM_COVID3 DUM_COVID4 DUM_COVID5 DUM_COVID8
Warning: Critical values assume no exogenous series
Lags interval (in first differences): 1 to 3

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.351581	65.19130	47.85613	0.0005
At most 1 *	0.276432	32.26678	29.79707	0.0255
At most 2	0.089887	7.676130	15.49471	0.5007
At most 3	0.006792	0.517939	3.841465	0.4717

E.5 Print Post

E.5.1. Structural break tests

Three structural breaks are evident within the Print Post volume series:

1. Structural break test results suggest a break in September 2015, see Table E.5.1.1.

Table E.5.1.1 Print Post structural break test 1

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 9/01/2015
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 1 (Automatic - based on Schwarz information criterion, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.864588	> 0.99
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

2. Results of the second structural break test identify a break in June 2019, see Table E.5.1.2.

Table E.5.1.2 Print Post structural break test 2

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Trend and intercept
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 6/01/2019
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.394156	0.7526
Test critical values:	1% level	-5.347598	
	5% level	-4.859812	
	10% level	-4.607324	

3. Results of the third structural break test suggest a break in March 2015, see Table E.5.1.3.

Table E.5.1.3 Print Post structural break test 3

Null Hypothesis: LVOLUME_SA has a unit root
Trend Specification: Trend and intercept
Break Specification: Trend and intercept
Break Type: Innovational outlier

Break Date: 3/01/2015
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.757921	0.1373
Test critical values:	1% level	-5.719131	
	5% level	-5.175710	
	10% level	-4.893950	

*Vogelsang (1993) asymptotic one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: LVOLUME_SA
Method: Least Squares
Date: 05/26/22 Time: 07:56
Sample (adjusted): 12/01/2006 12/01/2021
Included observations: 61 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVOLUME_SA(-1)	0.449463	0.115710	3.884412	0.0003
C	2.335665	0.491466	4.752446	0.0000
TREND	-0.004906	0.001218	-4.027692	0.0002
INCPTBREAK	0.029645	0.023726	1.249486	0.2168
TRENDBREAK	-0.013969	0.003195	-4.372281	0.0001
BREAKDUM	-0.065965	0.045122	-1.461921	0.1495

R-squared	0.987214	Mean dependent var	3.834587
Adjusted R-squared	0.986052	S.D. dependent var	0.349617
S.E. of regression	0.041291	Akaike info criterion	-3.443181
Sum squared resid	0.093770	Schwarz criterion	-3.235554
Log likelihood	111.0170	Hannan-Quinn criter.	-3.361810
F-statistic	849.3253	Durbin-Watson stat	2.003091
Prob(F-statistic)	0.000000		

E.5.2. Lag specification test

The lag specification tests imply a VAR with an optimal lag structure of 1, which suggests a VECM lag structure with zero lags, see Table E.5.2.1.

Table E.5.2.1 Print Post lag specification test

VAR Lag Order Selection Criteria
Endogenous variables: LOG(VOLUME_SA) LOG(REALPR) LOG(SUBST)
Exogenous variables: DUM_COVID_TOTAL DUM_COVID1 DUM_COVID2 C
Date: 07/15/22 Time: 12:58
Sample: 9/01/2006 12/01/2021
Included observations: 59

Lag	LogL	LR	FPE	AIC	SC	HQ
0	103.7035	NA	8.97e-06	-3.108594	-2.686044	-2.943648
1	387.2296	499.7747*	8.17e-10*	-12.41456*	-11.67510*	-12.12591*
2	395.8692	14.35057	8.33e-10	-12.40235	-11.34597	-11.98998
3	402.1179	9.743788	9.26e-10	-12.30908	-10.93579	-11.77301

E.5.3. DOLS with sample based upon structural break tests

An estimated VECM based upon zero lags contains a e-substitution elasticity that is incorrectly signed combined with a nonsensical value of -3.3 for the long run price elasticity. This parameter check fails the initial test of common sense according to rational economic theory suggesting movements in e-substitution should be negatively associated with volume fluctuations.[114] Moreover, a cointegration tests suggests a possibility of three cointegrating vectors at the 5% level of significance. Increasing the lag structure only marginally improves the results as the price elasticity remains unrealistic. The VECM misspecifications result in a decision to move towards a DOLS functional form as the preferred model based on the results of the third structural break test. The results contained in Table E.5.3.1. represent the preferred Print Post model.

Table E.5.3.1 Preferred Print Post letter econometric model

Dependent Variable: LOG(VOLUME_SA)
Method: Dynamic Least Squares (DOLS)
Date: 06/03/22 Time: 08:03
Sample: 3/01/2015 12/01/2021
Included observations: 28
Cointegrating equation deterministics: C DUM_COVID_TOTAL DUM_COVID1 DUM_COVID2
Fixed leads and lags specification (lead=0, lag=0)
Long-run variance estimate (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(REALPR)	-0.059187	0.273524	-0.216388	0.8309
LOG(SUBST)	-0.517626	0.065296	-7.927326	0.0000
C	4.155497	1.388800	2.992149	0.0072
DUM_COVID_TOTAL	-0.199509	0.022851	-8.730928	0.0000
DUM_COVID1	0.120257	0.038834	3.096673	0.0057
DUM_COVID2	-0.114336	0.038139	-2.997909	0.0071

R-squared	0.988405	Mean dependent var	3.525011
Adjusted R-squared	0.984346	S.D. dependent var	0.280413
S.E. of regression	0.035084	Sum squared resid	0.024618
Long-run variance	0.001078		

[114] Intermediate VECM outputs are not presented however are available from Diversified Specifics upon request.

E.5.4 Cointegration test

The cointegration test is satisfied at the 5% level of significance, see Table 3.5.4.1.

Table E.5.4.1 Print Post cointegration test

Cointegration Test - Phillips-Ouliaris
Date: 07/15/22 Time: 12:31
Equation: OLS_DYNAMIC
Specification: LOG(VOLUME_SA) LOG(REALPR) LOG(SUBST) C DUM_COVID_TOTAL DUM_COVID1 DUM_COVID2
Cointegrating equation deterministics: C DUM_COVID_TOTAL DUM_COVID1 DUM_COVID2
Null hypothesis: Series are not cointegrated
Long-run variance estimate (Bartlett kernel, Newey-West fixed bandwidth = 3.0000)
No d.f. adjustment for variances

	Value	Prob.*
Phillips-Ouliaris tau-statistic	-4.861577	0.0102
Phillips-Ouliaris z-statistic	-25.17820	0.0092