

Quantifying the Effect of the GST on Inflation in Australia's Capital Cities: An Intervention Analysis

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Abstract

This article examines the magnitude and duration of the effect of the Goods and Services Tax (GST) on inflation in Australia's eight capital cities using the Box and Tiao intervention analysis and quarterly data spanning from 1948:4 to 2003:1. We found that the GST had a significant but transitory impact on inflation only in the September quarter of 2000 when this new tax system was implemented. In this quarter inflation showed an additional increase of 2.6 per cent in Sydney (minimum effect) and 2.8 per cent in Australia as a whole, and the figure for Hobart was 3.3 per cent (maximum effect). Based on Wald test results, we also found some evidence that there is no significant (or substantial) difference in the average price changes among capital cities. We could not reject the null hypothesis that the GST increased the consumer price index by 2.8 per cent across the board in various cities. These results are also consistent with previous studies and surveys.

1. Introduction

On 1 July 2000 (the beginning of the third quarter or 2000:3) A New Tax System (ANTS) was implemented, whereby 'most goods and services became subject to GST [Goods and Services Tax] equivalent to one-eleventh of the selling price, some goods and services were GST-free and some were input taxed' (Australian Competition and Consumer Commission (ACCC) 2003, p. 2). The Commonwealth Treasury (2000) of Australia believes that this major tax reform is the largest structural change to the Australian economy since World War II.

ANTS has also had very important implications for social security systems, business tax, indirect tax, income tax, and Commonwealth–State financial relations. See Dawkins and Johnson (1998) for a general discussion on the interaction between the tax and social security systems in Australia. Prior to the introduction of the GST, Johnson, Freebairn and Scutella (1999) thoroughly evaluated the revenue, efficiency and equity effects of the indirect tax changes associated with the government's tax package. They argued that in the long run both reductions in personal income tax and increases in social security rates could sufficiently attenuate the average price rises among broad groups of households. After almost three years, it is now important to examine the extent to which the GST has impacted on inflation in various parts of Australia.

As can be seen from the brief review of the relevant literature presented below, various studies and surveys have already examined the

* We wish to acknowledge Ian McDonald and an anonymous referee for their useful comments on an earlier draft of this article. The usual caveat applies.

effect of the GST on inflation. However, our contribution to such an important issue is two-fold. First, this article uses a totally different approach to examine systematically the size and duration of the GST effect on inflation not only in Australia as a whole but also in its eight capital cities, namely Adelaide, Brisbane, Canberra, Darwin, Hobart, Melbourne, Perth and Sydney. Although previous studies and surveys (undertaken by the ACCC, the Commonwealth Treasury and various State Treasuries) have already examined this issue, they use different approaches and/or different survey data. Enough aggregated quarterly time series data are now available since the introduction of the GST to enable a meaningful econometric analysis to be used to examine this issue for each capital city in Australia.

This study can therefore provide a consistency check on the impact and duration of the GST effect. The relevant review of literature indicates that the various studies and surveys have provided slightly different estimates for the GST effect. Under various assumptions and approaches, these estimates also vary through time (see various estimates of the ACCC in different surveys discussed below). It seems that with the passage of time these estimates have become more accurate and differences are now being narrowed, resulting in a consensus among analysts in relation to the effect of the GST on inflation.

Second, the article makes a contribution regarding the duration of the GST effect. Almost all previous studies have indicated that the effect of the GST on inflation was one-off and of a transitory nature, but they have not been very specific as to the duration of the GST effect. For example, the ACCC (2001, p. 2) has estimated the effect of the GST on inflation during the third and fourth quarters of the year 2000 to be around 4 per cent, with 3.7 per cent occurring in the September quarter 2000. The Commonwealth Treasury (2000, p. 11) expected that ANTS would 'add around 234 percentage points to the CPI [consumer price index] through the year to the June quarter 2001'.

The present study uses quarterly data—with inflation defined as quarter-to-quarter log changes—and clearly finds that the GST effect

on inflation in all cities was statistically significant only in the September quarter of 2000, suggesting no significant effect in any of the four prior or subsequent quarters. As seen later in this article, although the point estimates for the eight capitals varied from 2.6 per cent in Sydney to 3.3 per cent in Hobart, these differences were not found to be statistically significant from the national point estimate of 2.8 per cent. To the best of our knowledge the present study is the only independent (that is, non-government) study which quantifies the size and duration of the GST effect on inflation at an aggregate level and for various capital cities. We present below a brief review of the relevant literature prior to discussing our theoretical framework

Warren et al. (1999) within the National Centre for Social and Economic Modelling modelled the distributional impact of the implementation of the government's ANTS tax package under 10 possible scenarios. According to this comprehensive study, with different sets of assumptions and depending which scenario is considered, the effect of this tax reform on inflation was predicted to be between 0.8 per cent and 3.6 per cent. Warren et al. (1999, p. 1) also argue that according to their first scenario, which is exactly the methodology adopted by the Commonwealth Treasury in measuring the distributional impact of this reform, inflation would increase by 2.0 per cent which is quite near the Treasury's estimate.

As mentioned above, according to the Commonwealth Treasury (2000, p. 11) and the Queensland Treasury (2001, p. 1), the GST increased the CPI by 2.75 per cent through the year to the June quarter 2001. It is widely believed that apart from this one-off price-perturbation, inflationary pressures would remain low (New South Wales Treasury 2001; Queensland Treasury 2001). Examining this same issue, the New South Wales Treasury (2001, p. 14) states that:

... while the ABS [Australian Bureau of Statistics] has not been able to publish a conclusive estimate of the impact from the GST on the September quarter CPI, the Commonwealth Treasury and private sector estimates are mostly in the range of 2½–3 percentage points.

During the GST transition period the ACCC (2001, 2003) also conducted eight general surveys (December 1999; January 2000; March, May, August and October 2000; and February and May 2001), in which prices for various goods and services were collected from about 10000 retail outlets in 115 geographical locations (that is, capital cities, regional cities, towns etc. in all states and territories). The ACCC's retail price surveys do not represent an economy-wide measure of the effects of the GST and therefore one cannot compare them directly to the CPI compiled by the ABS. However, they provide a rough estimate of the impact of the GST on inflation. According to the ACCC (2001, p. 2), the effect of ANTS on inflation during the third and fourth quarters of the year 2000 was expected to be around 4 per cent, with 3.7 per cent occurring in the September quarter 2000. The ACCC (2001, p. 14) also estimated an upper estimate of the short-term effects of ANTS on prices to be around 3.0 per cent.

More recently the ACCC (2003) in its final report on the GST made 320000 price comparisons between the survey in May 2000 (the pre-GST base period) and the May 2001 survey (the post-GST period). The ACCC (2003, p. 11) found that:

The weighted average price change over the three months between the May and August 2000 surveys was +2.6 per cent. Weighted on the same basis the Commission's estimate of the effects of the ANTS by the end of 2000 was an increase of 3 per cent. The weighted average price change over 12 months between the May 2000 and May 2001 surveys, by which time non-tax factors were generally determining prices outcomes, was +5.7 per cent.

The ACCC (2003, p. 11) also argued that price changes caused by the implementation of ANTS were:

... fairly consistent across geographical locations even though price levels may have been quite different. The results also showed no substantial differences in the average price changes between the states and territories, although again prices may have been at different levels.

Table 1 A Summary of the Previous Estimates of the Inflationary Effect of the GST/ANTS

<i>Previous studies</i>	<i>Effect on inflation (per cent)</i>
Queensland Treasury (2001)	2.75
Commonwealth Treasury (2000)	2.75
ACCC (2001)	3.70–4.00
ACCC (2003)	3.00
Warren et al. (1999)	2.00
New South Wales Treasury (2001)	2.50–3.00
Present study	2.80

It should be noted that the results obtained from the present study also confirm this issue. Table 1 summarises these estimates.

The GST was an important component of the ANTS package. However, it should be noted that the ANTS package was a more comprehensive reform which encompassed the sequential adjustment and removal of the wholesale sales tax and changes to excise taxes as well as the introduction of the GST. It is important to recognise that it is very difficult to separate the GST effect from the effect associated with other components of the ANTS package through time. One should note that we have used time series data on the CPI which reflect (simultaneously) all price changes associated with the ANTS package (including the GST effect) at an aggregate level. Therefore, in this article we have used the term 'GST' as a generic term for the ANTS package. In this article both 'GST' and 'ANTS' are employed interchangeably.

The structure of this article is as follows. Section 2 presents a brief review of the theoretical framework of the Box and Tiao intervention analysis. Section 3 provides some relevant time series data on the phenomena to be explained. This section also examines the time series properties of the data. The empirical econometric results and the policy implications of the article are discussed in Section 4. Finally, some concluding remarks follow in Section 5.

2. Theoretical Framework

Since the CPI data are collected over time in regularly spaced intervals (that is, quarterly)

and the timing of the intervention (the introduction of the GST) is also known, we use the Box and Tiao (1975) intervention analysis to examine the impact of this policy change on inflation through time. This approach uses the Box-Jenkins methodology in which an autoregressive integrated moving average (ARIMA) type model is augmented by dummy variables to evaluate the effects of unusual events. Since Box and Tiao introduced this useful technique in 1975, many analysts have used it in a wide variety of applications (see Enders, Todd and Parise 1992; Enders, Sandler and Cauley 1990; Hogan 1984; Thompson and Noordewier 1992). For example, Bhattacharyya and Layton (1979) and Harvey and Durbin (1986) have applied the intervention analysis framework (augmented with a causal variable) to analyse the effects of seatbelt laws on road fatality rates in Australia and Britain, respectively. Layton (1983) and Layton and Weigh (1983) also used the approach to investigate the efficacy of introducing random breath testing and increased penalties on the incidence of drink driving in Australia.

Lloyd, Morrissey and Reed (1998) employed intervention analysis to estimate the effect of anti-dumping and anti-cartel actions in the context of the European Commission. Sharma and Khare (1999) have analysed the effectiveness of legislation to control carbon dioxide pollution in India by using the univariate ARIMA intervention analysis. More recently, Bausell, Rusco and Walls (2001) have also used this technique to examine the long-run price effects on crude oils of removing the US export ban on Alaskan North Slope crude oil.

In order to facilitate the analysis and the interpretation of the empirical results, we have used the logarithmic transformation, which allows us to (i) consider percentage changes rather than absolute shifts and (ii) stabilise the variance of the series. In this article the following general ARIMA process of the order (k, d, q) is estimated:

$$\Phi_k(L)\Delta^d\Delta_r^s p_t = \mu + \Theta_q(L)\varepsilon_t + \beta D_t \quad (1)$$

where $\Phi_k(L)$ represents a k -order polynomial lag operator; Δ^d and Δ_r^s denote the ordinary dif-

ference and seasonal difference operators, respectively; d and s are the number of times these differences are applied; r is the seasonal lag term; $p = \ln(P)$; P is the CPI; μ is a constant; $\Theta_q(L)$ denotes a q -order polynomial lag operator; ε is a white noise process; k is the number of autoregressive terms; q is the number of moving-average terms; and D_t is the intervention (or dummy) variable.

Whilst not behaviourally explaining the inflation process, the ARIMA model should nonetheless capture any underlying systematic time series patterns in the data (of which seasonality would be the most obvious). It is important that such systematic time series patterns in the fluctuations in the data be accounted for so as to accurately gauge the impact of the intervention itself. The magnitude of β will represent the effect of the introduction of the GST on the rate of inflation beyond what could have been expected on the basis of the discernible systematic pattern of fluctuation in the data.

It is also important to recognise that an intervention such as the introduction of the GST may well have only an immediate and temporary impact on the rate of inflation in the quarter in which it is introduced. Such an immediate and temporary impact could be well captured by a variable such as D_t , a dummy variable taking the value of zero everywhere except in the quarter in which the GST was introduced, namely the September quarter of 2000.

On the other hand, there is the possibility that the effect of the intervention may persist beyond the period of introduction. In the case of the GST this might occur if the initial impact on prices gave rise to some residual momentum of further price rises. This may arise from either subsequent nominal wage growth increasing cost pressures or simply a further round of price rises deriving from a belief on the part of price setters that they may be able to extract additional price rises from consumers as a result of the initial price rise impetus coming about from the introduction of the GST. In order to test this possibility we allow the GST to impact on inflation for up to five quarters by initially including a further four pulse dummies (each

with a non-zero value of 1 in only the relevant subsequent quarter: that is, December, March, June and September). In other words, it is hypothesised that the GST effect (if any) on inflation is exhausted by the September quarter of 2001.

Thus, in sum, in order to separate the immediate impact effect from any subsequent effects of the GST on inflation, the following pulse dummy variables are incorporated into the model: D_1 takes on the value of 1 in the third quarter of 2000 (when the GST was introduced) and zero otherwise; D_2 takes on the value of 1 in the fourth quarter of 2000 (2000:4) and zero otherwise; D_3 takes on the value of 1 in the first quarter of 2001 (2001:1) and zero otherwise; D_4 takes on the value of 1 in the second quarter of 2001 (2001:2) and zero otherwise; and D_5 takes on the value of 1 in the third quarter of 2001 (2001:3) and zero otherwise. The duration of the GST effect on inflation is then simply a matter of empirical investigation, which can be examined by testing for the statistical significance of these dummy variables in the intervention model.

In addition to identifying an ARIMA process, one should test seasonality of quarterly data on inflation as the headline inflation data are quite often subject to seasonal variations. Box, Jenkins and Reinsel (1994) suggest that a seasonal autoregressive term should also be incorporated into monthly or quarterly models to account for systematic seasonal movements. In order to address this possibility, equation (1)

has also been augmented by a seasonal autoregressive term.

As part of the estimation process one first needs to choose accurate values for k , d , r and q in the specification of the ARIMA model. The identification of an ARIMA model is not an 'exact science', but as a rule of thumb, spikes in the autocorrelation function and the partial autocorrelation function are used to determine q and k , respectively. The estimated model is then subjected to a range of diagnostic checks on the residuals to ensure that all systematic variation in the time series has been properly accounted for by the model.

It is also important that the series being modeled is stationary. In this analysis, as expected, the log CPI levels series proved to be non-stationary. However, their first differences—effectively quarterly rates of price change or quarterly inflation rates—satisfied the usual tests of stationarity (see Table 3). Thus, for each city we use quarterly inflation rates as the dependent variable denoted by y_t . The generic equation used to model the data on each capital city (and for Australia as a whole) is as follows:

$$(1 - \rho_1 L - \rho_2 L^2 - \dots - \rho_k L^k)(1 - \phi L^r)y_t = \mu_0 + (1 - \theta_1 L - \theta_2 L^2 - \dots - \theta_q L^q) + \sum_{i=1}^5 \beta_i D_{it} + w_t \quad (2)$$

3. The Data

The basic data employed in this study were quarterly time series data for the CPI of the

Table 2 Summary Statistics of the Data Employed: Quarterly Inflation Rate $\Delta \ln(P_t)$, 1948:4–2003:1

City	Mean	Maximum	Minimum	Standard deviation
Adelaide	0.014	0.066	-0.016	0.014
Brisbane	0.014	0.081	-0.007	0.013
Canberra	0.014	0.078	-0.008	0.014
Darwin ^a	0.011	0.058	-0.005	0.010
Hobart	0.014	0.074	-0.008	0.014
Melbourne	0.014	0.081	-0.009	0.014
Perth	0.014	0.062	-0.009	0.014
Sydney	0.014	0.068	-0.009	0.013
Australia	0.014	0.070	-0.009	0.013

Note: (a) The data on the rate of inflation in Darwin only cover the 1980:4–2003:1 period.

Source: Australian Bureau of Statistics (2003, Table 1B).

Figure 1 The Quarterly Inflation Rate in Eight Capital Cities of Australia, 1948:4–2003:1

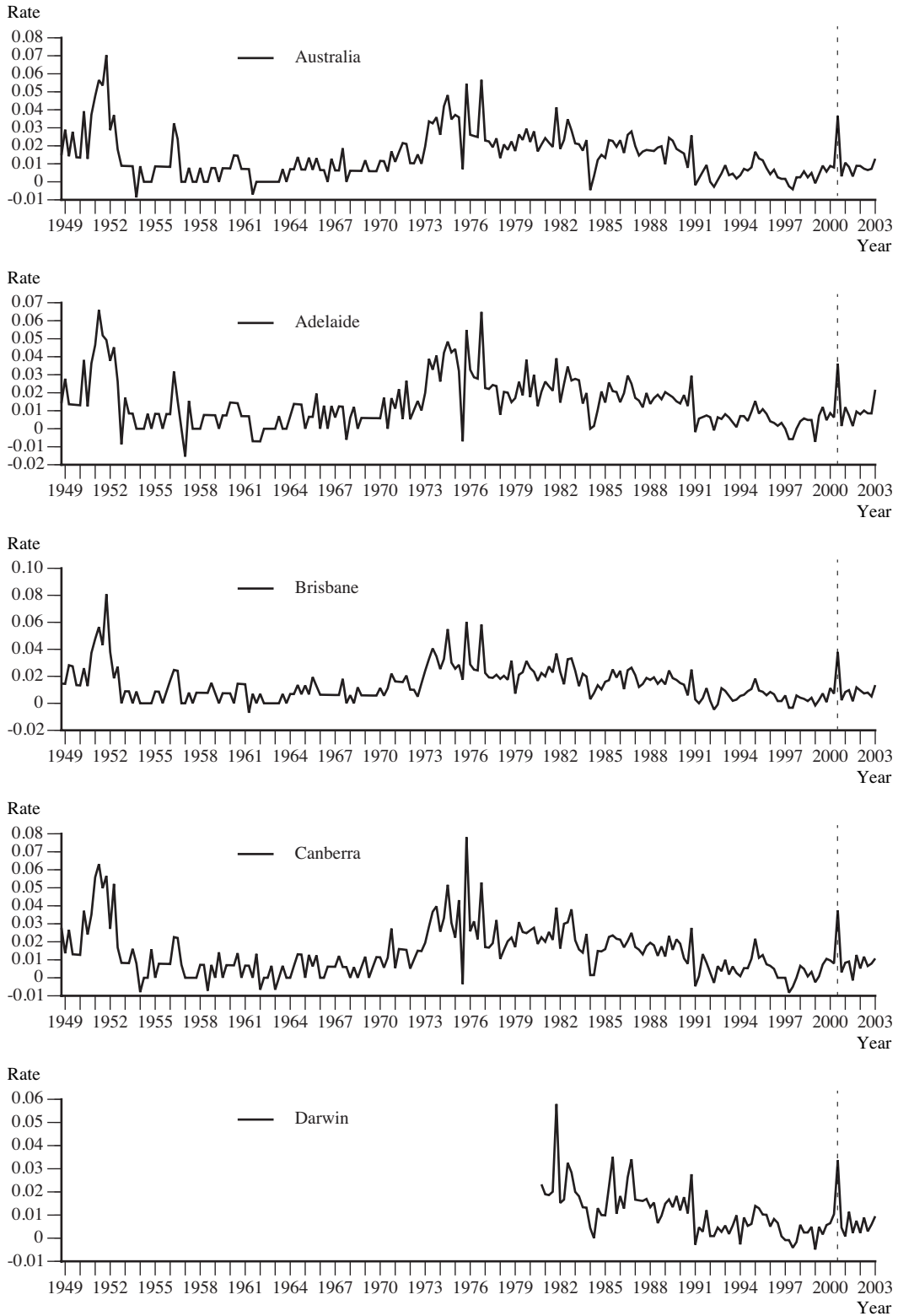
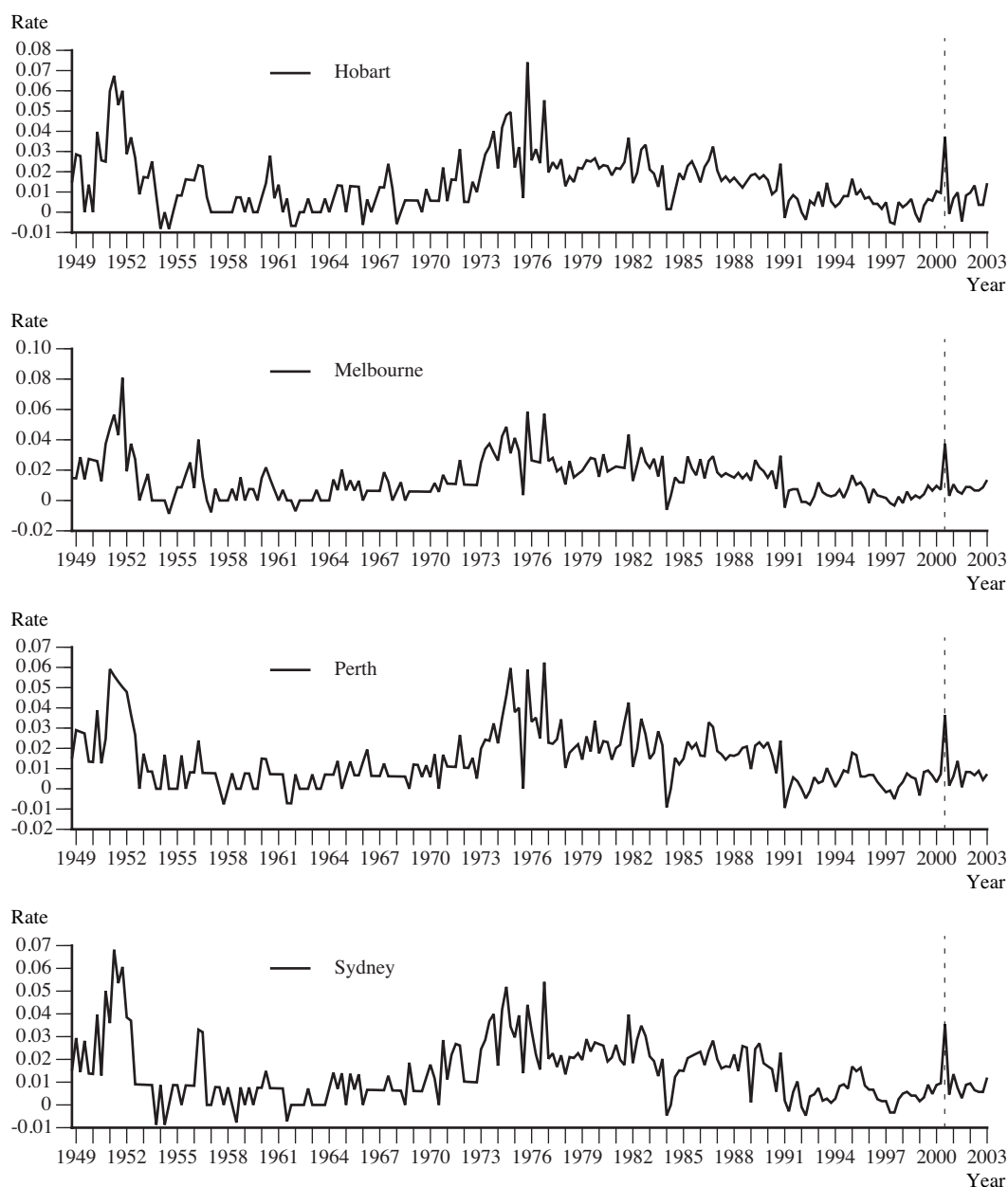


Figure 1 Continued



Notes: (a) The dashed line coincides with the third quarter of 2000 when the GST was introduced.

(b) The quarterly inflation rate has been calculated by $\Delta \ln(P_t)$.

(c) The data on the rate of inflation in Darwin only cover the 1980:4–2003:1 period.

Source: Australian Bureau of Statistics (2003, Table 1B).

eight capital cities in Australia. These cities are Adelaide, Brisbane, Canberra, Darwin, Hobart, Melbourne, Perth and Sydney. The data for all these cities (and Australia as a whole) are available from the third quarter of 1948 (that is,

1948:3) to the first quarter of 2003 (that is, 2003:1), with the only exception being Darwin for which the data are available only from 1980:4. Table 2 presents the summary statistics of the data employed on the quarterly rate of

inflation in these eight cities as well as Australia as a whole. During the 1948:4–2003:1 period both the mean and standard deviation of inflation per quarter across seven of these eight cities varied from 0.13 to 0.14, suggesting that the relative volatility of inflation is the same among these capital cities.

Using all available data, Figure 1 plots the inflation rate, defined as $\Delta \ln(P_t)$, in these eight cities plus the weighted average rate of inflation for Australia as a whole.¹ A cursory inspection of these graphs clearly shows an abnormal spike in the third quarter of 2000, which coincides with the introduction of ANTS. The dashed lines in Figure 1 also suggest that the GST effect on inflation is considerable only in 2000:3. However, one needs to use a more formal technique to properly evaluate this proposition.

The Augmented Dickey-Fuller (ADF) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS 1992) test have been used to examine the stationarity, or otherwise, of the time series data. Table 3 presents the results of applying the ADF and KPSS tests to the data. On the basis of these results, p or the log of the CPI is $I(1)$ and the rate of inflation is $I(0)$ in seven out of eight capital cities, namely Adelaide, Brisbane, Canberra, Hobart, Melbourne, Perth and Sydney and also Australia as a whole. However, in the case of Darwin the results of the ADF test and the KPSS test are contradictory. This could be due to the fact that the number of quarterly observations for Darwin is considerably less than those of the other seven cities. Given that in all the other cities (and Australia as a whole) p is $I(1)$, the authors have assumed that the CPI in Darwin is also $I(1)$.

Table 3 ADF and KPSS Test Results, 1948:3–2003:1

Variable	ADF test		KPSS statistics
	ADF statistics	Optimum lag	
$\Delta \ln(P_t)$			
Adelaide	-0.63	4	1.90*
Brisbane	-0.61	4	1.91*
Canberra	-0.74	4	1.90*
Darwin	-4.78*	1	1.17*
Hobart	-0.93	4	1.91*
Melbourne	-0.68	3	1.91*
Perth	-0.64	4	1.91*
Sydney	-0.73	3	1.91*
Australia	-0.73	3	1.91*
$\Delta \ln(P_t)$			
Adelaide	-3.47*	4	0.190
Brisbane	-3.31*	3	0.210
Canberra	-3.18*	4	0.189
Darwin	-1.34	3	0.909*
Hobart	-3.52*	4	0.205
Melbourne	-3.84*	4	0.201
Perth	-3.26*	4	0.193
Sydney	-3.68*	4	0.199
Australia	-3.68*	4	0.203

Notes: (a) P denotes the CPI.

(b) * indicates that the corresponding null hypothesis is rejected at the 5 per cent significance level.

(c) The data on the rate of inflation in Darwin only cover the 1980:3–2003:1 period.

(d) The Akaike Information Criterion has been used as a guide to determine the optimal lag length.

4. Empirical Results and Policy Implications

The aim of this section is to shed light on the following three questions. (i) As a result of the

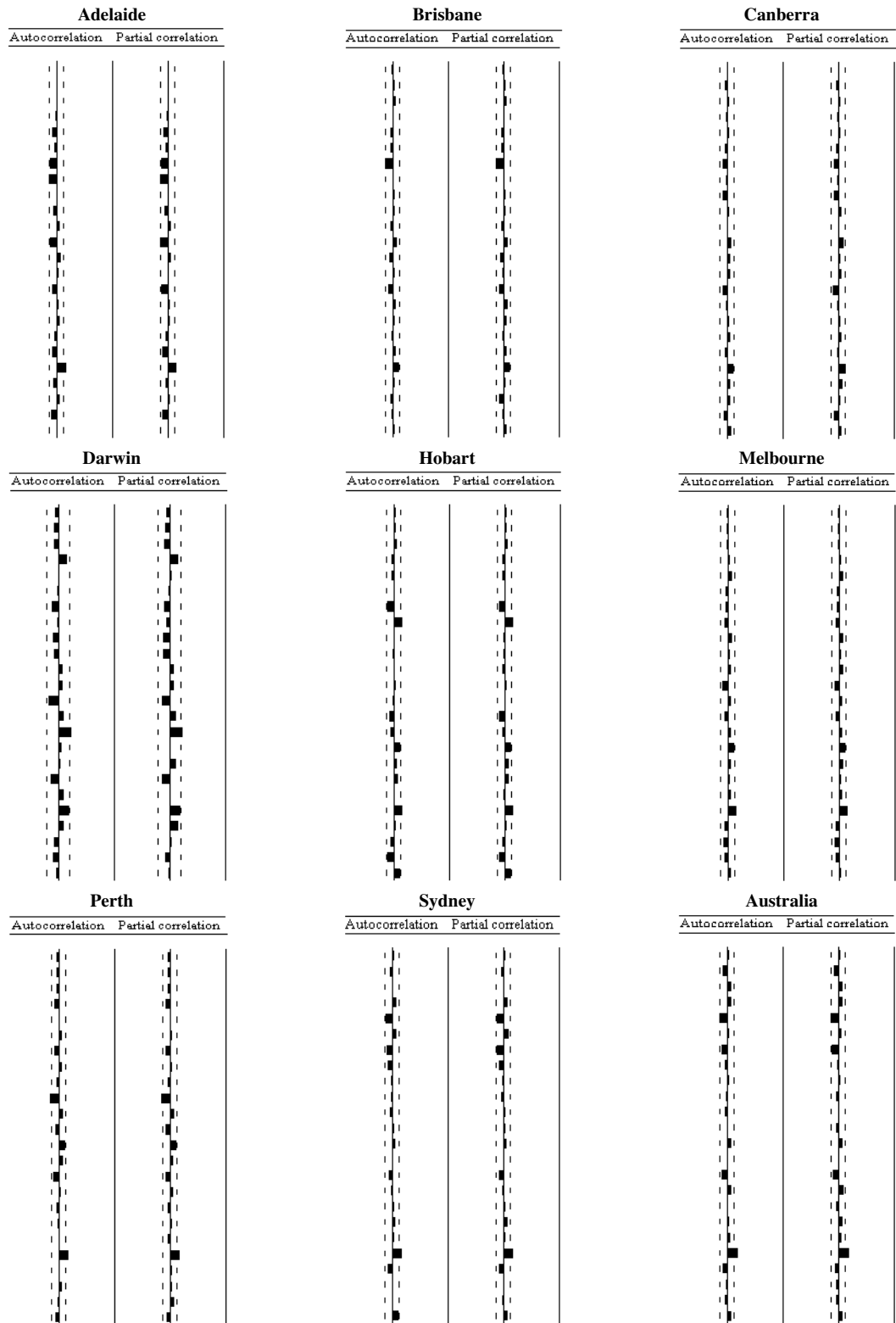
introduction of ANTS, how much did inflation rise in each city and for Australia as a whole? (ii) For how long did ANTS affect inflation? In other words, was inflation only a one-off phenomenon or did its effects persist for a number

Table 4 Estimated Coefficients for the Intervention Model, $\Delta \ln(P_{it})$

<i>Estimated coefficients</i>	<i>Adelaide</i>	<i>Brisbane</i>	<i>Canberra</i>	<i>Darwin</i>	<i>Hobart</i>	<i>Melbourne</i>	<i>Perth</i>	<i>Sydney</i>	<i>Australia</i>
μ_0	0.013 (0.13)	0.014 (0.00)	0.014 (0.00)	0.010 (0.00)	0.014 (0.00)	0.014 (0.00)	0.013 (0.00)	0.014 (0.00)	0.014 (0.00)
β_1	0.028 (0.00)	0.029 (0.00)	0.026 (0.01)	0.026 (0.00)	0.027 (0.01)	0.029 (0.00)	0.029 (0.00)	0.026 (0.00)	0.028 (0.00)
β_2	-0.007 (0.45)	-0.007 (0.48)	-0.009 (0.29)	-0.003 (0.71)	-0.010 (0.27)	-0.006 (0.53)	-0.004 (0.66)	-0.005 (0.59)	-0.006 (0.48)
β_3	0.003 (0.72)	-0.002 (0.84)	-0.002 (0.86)	-0.007 (0.36)	-0.004 (0.67)	0.001 (0.93)	0.000 (0.99)	0.004 (0.67)	0.002 (0.86)
β_4	-0.001 (0.94)	0.000 (0.99)	-0.002 (0.83)	0.005 (0.56)	-0.001 (0.88)	-0.003 (0.77)	0.005 (0.60)	-0.002 (0.82)	-0.001 (0.92)
β_5	-0.008 (0.40)	-0.009 (0.32)	-0.011 (0.25)	-0.005 (0.53)	-0.013 (0.16)	-0.005 (0.55)	-0.009 (0.30)	-0.006 (0.49)	-0.006 (0.48)
ρ_1	0.105 (0.50)	0.862 (0.00)	0.794 (0.00)	0.278 (0.01)	0.421 (0.00)	-0.338 (0.00)	-	0.873 (0.00)	0.879 (0.00)
ρ_2	-	-	-	0.201 (0.08)	0.277 (0.00)	0.543 (0.00)	-	-	-
ρ_3	-	-	-	0.252 (0.02)	-	-	-	-	-
ρ_4	-	-	-	-	-	-	0.643 (0.00)	-	-
$\phi(r=3)$	-	-	-	-	-	0.468 (0.00)	-	-	-
$\phi(r=4)$	0.863 (0.00)	0.139 (0.07)	0.259 (0.00)	-	0.248 (0.00)	-	-	-	-
θ_1	0.280 (0.04)	-0.416 (0.00)	-0.587 (0.00)	-	-	0.683 (0.00)	0.422 (0.00)	-0.543 (0.00)	-0.567 (0.00)
θ_2	0.459 (0.00)	-	0.303 (0.00)	-	-	-	0.467 (0.00)	0.195 (0.01)	0.248 (0.00)
θ_3	0.413 (0.00)	-	-	-	-	-	0.486 (0.00)	-	-
θ_4	-0.497 (0.00)	-	-	-	-	-	-	-	-
\bar{R}^2	0.529	0.499	0.515	0.351	0.510	0.509	0.562	0.512	0.557
DW	1.98	2.03	1.97	2.10	1.91	2.02	2.06	1.96	1.92
AIC	-6.43	-6.52	-6.42	-6.67	-6.39	-6.42	-6.53	-6.49	-6.64
SC	-6.24	-6.38	-6.26	-6.41	-6.25	-6.26	-6.38	-6.35	-6.50
Q-statistic (24 lags)	25.0 (0.12)	13.0 (0.91)	13.5 (0.85)	27.4 (0.16)	25.8 (0.21)	20.4 (0.43)	26.1 (0.16)	21.1 (0.45)	26.2 (0.20)
LM (4 lags)	0.17 (0.95)	0.50 (0.74)	0.56 (0.69)	0.94 (0.44)	2.0 (0.10)	0.58 (0.68)	0.84 (0.50)	0.70 (0.59)	1.44 (0.22)

Note: The figures in brackets are the corresponding p-values.

Figure 2 Correlograms of Residuals for the Estimated Intervention Models



of quarters? (iii) Was there any significant difference among these eight capital cities in terms of the magnitude of price changes? As mentioned in Section 1, many previous studies and surveys have already tried to provide convincing answers to these questions, but this article uses a totally different technique to systematically undertake a consistency check on the results obtained previously and also to shed some further light on the size and duration of the GST effect on inflation.

Equation (2) was estimated for eight capital cities and Australia and the results are presented in Table 4. As can be seen, the estimated ARIMA intervention models pass all diagnostic tests.² The estimated Ljung and Box (1979) Q-statistics (up to 24 lags) and the LM (Lagrange Multiplier test for serial autocorrelation up to 4 lags) in Table 4 and the correlograms of the resulting residuals for the estimated equations in Figure 2 clearly indicate that the ARIMA intervention models are statistically quite acceptable. All estimated coefficients for ϕ , ρ and θ are statistically significant and the inverted AR and MA roots have modulus less than one, suggesting that the estimated ARIMA models are stationary (the inverted AR and MA roots have not been reported here but they are available from the authors upon request).

Among the estimated coefficients for β_j , only β_1 is positive and statistically significant

Table 5 The Estimated Effects of the GST on Inflation (β_{1j}) in 2000:3

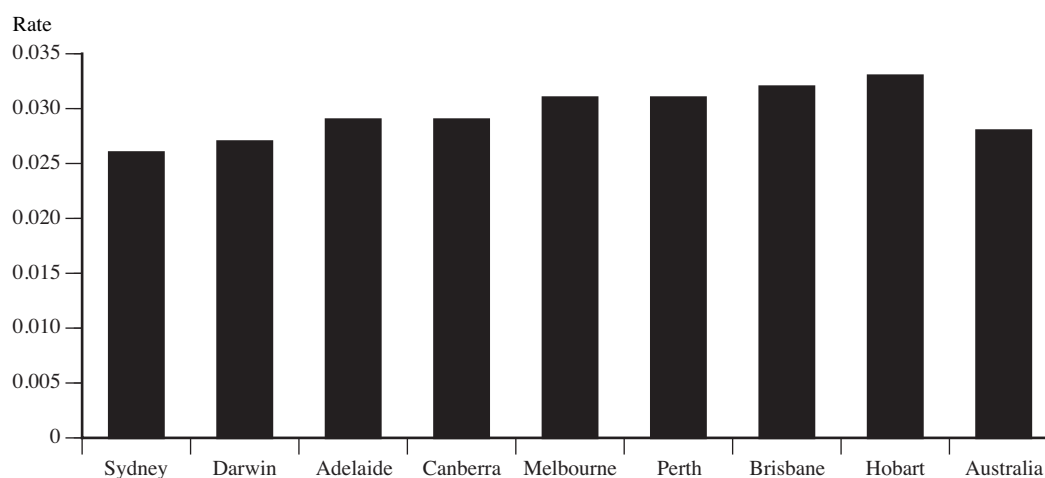
City	$\beta_j = 0$	$\beta_j \neq 0$
	($j = 2, 3, 4, 5$)	($j = 2, 3, 4, 5$)
Adelaide	0.029	0.028
Brisbane	0.032	0.029
Canberra	0.029	0.026
Darwin	0.027	0.026
Hobart	0.033	0.027
Melbourne	0.031	0.029
Perth	0.031	0.029
Sydney	0.026	0.026
Australia	0.028	0.028

Note: All the estimated coefficients are statistically significant at 1 per cent level.

in all eight capital cities. In other words, according to the empirical results in Table 4, the introduction of the GST would appear to have increased quarterly inflation only in the September quarter of 2000. Therefore, one may conclude that the duration of the GST effect was confined to 2000:3. As noted above, Figure 1 also informally confirms this finding.

Given that none of the estimated coefficients for β_2 to β_5 was statistically significant, we excluded these pulse dummy variables (that is, D_2 to D_5) from the model and re-estimated these equations. Table 5 presents the estimated coefficients for β_1 for the eight capital cities (plus Australia as a whole) when the insignificant

Figure 3 The Effect of the GST on Inflation in the September Quarter of 2000



Source: Authors' calculations extracted from the first column of Table 5.

Table 6 Testing the Equality of the Short-Run Effect of the GST on Inflation ($\beta_{i1} = 0.028$) across Eight Capital Cities

City	F-statistic	P-value
Adelaide	F(1, 205) = 0.004	0.950
Brisbane	F(1, 208) = 0.280	0.597
Canberra	F(1, 207) = 0.015	0.904
Darwin	F(1, 82) = 0.036	0.849
Hobart	F(1, 207) = 0.358	0.551
Melbourne	F(1, 207) = 0.100	0.755
Perth	F(1, 208) = 0.172	0.679
Sydney	F(1, 212) = 0.039	0.844

pulse dummy variables are excluded from the estimated model. In order to make comparison easier, we have also reported the earlier estimates of β_1 (already presented in Table 4) in the second column of Table 5. A cursory look at the estimated coefficients for β_1 across the eight capital cities shows that these estimates have not changed considerably.

Based on the first column in Table 5 one can argue that the introduction of the GST increased the rate of inflation in the September quarter of 2000 by 2.9 per cent in Adelaide, 3.2 per cent in Brisbane, 2.9 per cent in Canberra, 2.7 per cent in Darwin, 3.3 per cent in Hobart (maximum effect), 3.1 per cent in Melbourne, 3.1 per cent in Perth, 2.6 per cent in Sydney (minimum effect) and 2.8 per cent in Australia. The effect of the GST on inflation (measured by percentage changes in the headline CPI) in Australian capital cities is also shown in Figure 3. These results are consistent with previous studies and surveys outlined in Section 1.

We have also examined the sensitivity of the estimated coefficients of the pulse dummy variables (particularly the β_1 coefficient) to different sample periods as well as to various specifications by including/excluding autoregressive and moving-average error terms. We found that the estimated coefficients remain more or less fairly robust to different ARIMA specifications and/or sample changes. The sensitivity results have not been reported here but they are available from the authors upon request.

Table 7 Testing the Effect of the GST on Inflation Starting from Four Quarters before Its Introduction (1999:3–2000:2)

City	F-statistic $H_0: \beta_j = 0$ ($j = -1, -2, -3, -4$)	P-value
Adelaide	F(4, 197) = 0.218	0.928
Brisbane	F(4, 200) = 0.309	0.872
Canberra	F(4, 199) = 0.296	0.880
Darwin	F(4, 74) = 0.150	0.962
Hobart	F(4, 199) = 0.085	0.987
Melbourne	F(4, 199) = 0.173	0.952
Perth	F(4, 200) = 0.169	0.954
Sydney	F(4, 204) = 0.080	0.989
Australia	F(4, 204) = 0.104	0.981

Notes: In the estimated ARIMA models there are nine pulse dummy variables which capture the pre-GST and post-GST effect on inflation in nine quarters separately starting from 1999:3 to 2001:3. We have allowed the GST to impact on inflation for four quarters prior to its introduction by including four pulse dummies (each with a non-zero value of 1 in only the relevant previous quarter: that is, September 1999, December 1999, March 2000 and June 2000). The above Wald test statistics clearly indicate that inflation did not increase significantly from its underlying systematic pattern prior to the introduction of the GST.

Almost all previous studies indicate that ANTS equally impacted on inflation in different parts of Australia. In order to test this hypothesis, we have used the Wald test to examine if $\beta_{i1} = 0.028$ ($i = 1, 2, \dots, 8$). It should be noted that, according to Tables 4 and 5, this coefficient for Australia as a whole is 0.028. According to the Wald test results presented in Table 6, one cannot reject the null hypothesis that $\beta_1 = 0.028$ in all eight capital cities, supporting the view that there were no significant differences in the average price changes among the states and territories arising from the introduction of the GST.

One may also argue that due to affected pricing behaviour in anticipation of the introduction of the GST, measured inflation may have been impacted prior to the September quarter of 2000. In order to test this possibility we have allowed the GST to impact on inflation for four quarters before its implementation by including a further four separate pulse dummies (each with a non-zero value of 1 in only the relevant previous quarter: that is, September 1999,

December 1999, March 2000 and June 2000). It is thus hypothesised that the pre-GST effect (if any) on inflation started from the September quarter of 1999. Table 7 presents the Wald test statistics which lend some empirical support to the fact that at least at an aggregate level the GST did not significantly increase inflation prior to its introduction in the eight capital cities and Australia as a whole.

5. Conclusions

The purpose of this study was to investigate the magnitude and duration of the GST effect on inflation in Australia's eight capital cities as evidenced in available quarterly data from 1948:3 to 2003:1 using the econometric technique of intervention analysis. To our knowledge no one has estimated the impact of the GST in this way. Our analysis provides a further valuable consistency check of others' estimates of the GST inflation impact derived from alternative approaches. It has the great advantage of properly, in a statistical sense, allowing for any discernible systematic variation existing in the underlying inflation process, and distilling out from that variation the impact of the GST introduction. Our contribution also lies in determining the extent of regional differences in impact.

We find that the national effect was a one-off lift in inflation—measured quarter to quarter—of 2.8 per cent in the quarter of the introduction of the GST (namely the September quarter of 2000). There were no statistically significant effects beyond this first quarter. As far as different regions—proxied by the eight state and territory capital cities—were concerned, the estimates ranged from 2.6 per cent (Sydney) up to 3.3 per cent (Hobart). Again there was no statistically significant evidence to suggest any residual impact after the quarter of introduction.

Finally, though the point estimates for the eight capitals varied from 2.6 per cent to 3.3 per cent, these differences were not found to be statistically significant from the national point estimate of 2.8 per cent. Thus, it could be concluded that the impact was approximately uniform across the nation and limited to just the

quarter of introduction. The actual estimate of 2.8 per cent is also consistent with a number of other earlier estimates obtained from different methods.

*First version received August 2003;
final version accepted October 2003 (Eds).*

Endnotes

1. Australia's inflation rate is a weighted average of the inflation rates in these eight capitals, the weights being each region's population.
2. EViews 4.1 (2002) was used in the estimation process.

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