CHAPTER 4

CIGARETTE TAXES, PRICES AND CONSUMPTION

4.1 Introduction

This chapter has two aims: firstly, to analyse the mainstay of South Africa's tobacco control policy, namely increased excise taxes, and secondly, to investigate econometrically the demand for cigarettes.

As was pointed out in the previous chapter, control measures such as restrictions on smoking in public places and advertising restrictions have played an important role in de-glamorising smoking, but their direct impact on reducing tobacco consumption is less clear. According to the international literature (see chapter 3), the potentially most potent deterrent to smoking is a large rise in the price of cigarettes. With the excise tax comprising a substantial proportion of the retail price of cigarettes in South Africa, as in most countries, the government can have a significant impact on the price of cigarettes, by changing the level of the excise tax.[1]

Of course, the effectiveness of excise tax increases is determined largely by cigarette manufacturers' reactions thereto. Conventional microeconomic theory suggests that the proportion of the increase in the excise tax passed on to consumers varies inversely with the price elasticity of supply of the product concerned. Unless the tobacco industry is faced with a perfectly elastic supply curve, the industry is hypothesised to carry a portion of the excise tax increase (i.e. by increasing retail cigarette prices by less than the increase in the cigarette excise tax). Average-cost pricing theory, in contrast, suggests that producers will pass on the full amount of the increase in the excise tax to consumers.

The effectiveness of the excise tax increase, as a tobacco control measure, would be undermined by the extent to which cigarette manufacturers do not pass on the increase in the cigarette excise tax. On the other hand, should the industry decide to increase the retail price of cigarettes by more than the increase in the excise tax, the impact of the tax increase on cigarette consumption would be amplified. From a tobacco control perspective the latter development would be advantageous. The tobacco industry's pricing strategy in reaction to excise tax increases in South Africa is investigated more fully in chapter 5.

1. In most high-income countries more than 70 per cent of the retail price of cigarettes consists of taxes (Chaloupka, et al., 2000a). For middle and low-income countries the percentage is generally lower, but in nearly all countries taxes comprise more than 30 per cent of the retail price of cigarettes.

The structure of the chapter is as follows: in Section 4.2 a brief overview of South Africa's cigarette excise tax policy is provided. This is followed in Section 4.3 by a review of the main trends in some of the most important tobacco control variables: excise tax, retail price, and consumption. In Section 4.4 the demand for cigarettes in South Africa is specified and estimated using cointegration techniques. Some of the results obtained in this chapter are used as inputs to the analysis on the industry's reaction to the excise tax increases, which is presented in chapter 5.

4.2 Overview of South Africa's cigarette excise tax policy

South Africa's tobacco control strategy rests on two main pillars: (1) increases in the excise tax on tobacco products, and (2) tobacco control legislation. As was shown in chapter 1, the passing of South Africa's tobacco control legislation generated much public and media debate. In contrast, the annual increases in the excise tax on cigarettes in the second half of the 1990s did not spark nearly as much media attention, other than the expression of shock by the tobacco industry. This is somewhat ironic, because the international evidence (discussed in chapter 3), and the South African experience, presented in this chapter, clearly indicate that consistent and large tax increases have had a more pronounced impact on cigarette consumption than legislative interventions.

Throughout the twentieth century tobacco excise taxes have been an important source of government revenue. As a percentage of total government revenue, tobacco excise taxes increased from 1.0 per cent in 1911/12, to 3.8 per cent in 1930/31, and to 6.9 per cent in 1950/51 (Van Walbeek, 1996: 22). It peaked at 7.6 per cent of total government revenue in 1960/61, decreasing to 4.4 per cent in 1970/71, 2.4 per cent in 1980 and 1.1 per cent in 1990.

Between 1961 and 1990 the nominal excise tax on cigarettes, which is levied as a specific tax, increased from 9.1 cents per pack to 36.1 cents per pack (Tobacco Board, various years). However, given South Africa's rapid inflation during the 1970s and 1980s, this meant that the *real* excise tax per pack decreased by more than 70 per cent over the 1961-1990 period. The fact that the real excise tax decreased so sharply during the 1970s and 1980s can in all likelihood be attributed to the unhealthily close relationship that existed between the tobacco industry and the National Party government during this period. Two published quotes should illustrate this. In the 1983 Budget Speech, the then Minister of Finance, Owen Horwood, said: "The Tobacco Board has presented justified arguments for the maintenance of the status quo regarding the excise taxes on tobacco, and I do not intend to wake sleeping dogs" (Republic of South Africa, 1983). In the 1986 Budget Speech the level of excise tax on cigarettes was not increased on the grounds that "any increases in excise duties at present could be counter-productive, since it could in fact – on account of the potentially adverse effect on consumption – lead to a reduction of revenue from this source" (Republic of South Africa, 1986: 12). Considering that in 1986 excise taxes comprised less than 30 per cent of the retail price of cigarettes, that the real level of excise tax on tobacco had been decreasing steadily for the previous 15 years, and that numerous econometric studies from around the world indicated that the demand for cigarettes is relatively price inelastic, the industry must have marshalled very strong arguments to persuade the Minister to believe this.

Things changed significantly after South Africa's first democratic elections in April 1994, when the African National Congress became the senior partner in the Government of National Unity. In the 1994 Budget Speech the then Minister of Finance, Derek Keys, announced that the government intended to increase the level of excise tax to 50 per cent of the retail price, a rate similar to that in many other countries (Republic of South Africa, 1994: 5.7). Importantly, the Minister pointed out that the primary aim of the increase was the promotion of public health, rather than extra revenue. In the 1994, 1995 and 1996 Budget Speeches, the tax increases of between 18 and 25 per cent were comparatively modest, but in 1997 and 1998 increases of 52 per cent and 29 per cent, respectively, were announced. Since 1997 the Department of Finance has claimed that the target excise tax rate of 50 per cent of retail price has been achieved. As will be pointed out in Section 4.3.2, this is more illusory than real. However, this does not detract from the fact that the government has made much progress in raising cigarette excise taxes to levels where they serve as an effective deterrent to smoking.

Not surprisingly, the tobacco industry berated the increases as unfair, arguing that cigarettes were already the most heavily taxed consumer product, and that it would increase the incidence of smuggling. In their corporate video and presentation on tax and smuggling issues, BAT South Africa draws a very clear link between the two (Simon Millson, Director, Corporate and Regulatory Affairs, BAT South Africa, personal communication: 2004). Illegal (i.e. counterfeit and smuggled) cigarettes are presented as the bane of legitimate cigarette manufacturers, which undermine their brands, and cause consumer resistance and confusion. The fact that excise taxes in South Africa are generally higher than in the neighbouring countries, and have increased seven-fold in nominal terms between 1993 and 2003, is held to be the main cause of the alleged increase in cigarette smuggling.

The link between cigarette taxes and cigarette smuggling seems to be held as an article of faith among multinational tobacco companies.[2] In October 1996 Johann Rupert, the chairman of Rembrandt, wrote a full-page open letter to the Minister of Health in which he argued that

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2. The following quotes are taken from BAT's website (www.bat.com): "Smuggling is caused by tax differentials, weak border controls, and import restrictions and bans…In the UK, where tobacco duties are far higher than in many neighbouring European countries, Her Majesty's Customs & Excise estimates for the year 2001-2002 put smuggled tobacco goods at some 21 per cent of the market, causing losses of tax revenue to the UK Government of more than £3.5 billion a year." The best way to reduce smuggling is to reduce, or at least not increase, the tax rate. According to BAT "when the Hong Kong Government used dramatic increases in cigarette tax to try to deter smoking, smoking did not reduce, but smuggling soared. The tobacco industry worked with Government to try to solve the problem, and one outcome was a freeze on further tax increases".
These sentiments are echoed in the websites of Philip Morris (www.philipmorrisinternational.com) and Japan Tobacco (www.jti.com) and the report of the International Tax and Investment Centre (2003).

"cheap smuggled cigarettes" had entered South Africa illegally as a result of the high tobacco taxes (Rembrandt Group, 1996). In his letter he warned the Minister that this trend would continue if she increased taxes further. The rationale for highlighting the tax-smuggling relationship is obvious: if tax increases result in more smuggling, the government would curb smuggling by not increasing the excise tax on cigarettes. The fact of the matter is that since 1996 the real excise tax on cigarettes has nearly tripled. Other than some well-publicised apprehensions of cigarette smuggling syndicates, there is no strong evidence that cigarette smuggling in South Africa is out of control.[3] From this experience it seems that the industry's comments on the threat of smuggling in reaction to tax increases seem exaggerated.

In 2004 the Minister of Finance, Trevor Manuel, announced that the excise tax on cigarettes would be adjusted so that the sum of excise tax and VAT would equal 52 per cent of the retail price of cigarettes (Republic of South Africa, 2004). In order to allow proper planning in the tobacco industry, the tax incidence would remain at this level for the following three years. In the 2005 Budget speech the Minister of Finance increased the level of the excise tax by 52 cents per pack in order to maintain the 52 per cent tax incidence.

4.3 Trends in cigarette consumption, prices, excise tax and excise revenue

The ultimate aim of a tobacco control policy is to decrease mortality and morbidity associated with tobacco consumption. In the short term the aim is to reduce tobacco consumption. If one accepts this as justification for intervention, the success of a tobacco control policy would be measured by the extent to which it has reduced consumption. Other issues, such as increases in retail prices or government revenue, while not unimportant, would be secondary. Nevertheless, given the fiscal demands on the South African government, an increase in excise revenues would certainly relieve the pressure on other revenue sources. Trends in some tobacco-related variables, namely cigarette consumption, prices, excise tax and excise revenue, are shown in Table 4.1.

3. Such evidence would presumably consist of at least the following: (1) regular reports of the existence of smuggling syndicates and the arrest of smugglers, (2) a strong awareness among the public of the existence of cigarette smuggling; (3) a rapid decrease in legal cigarette sales, not explained by an increase in cigarette prices and/or other tobacco control interventions. In South Africa these three conditions apparently do not hold. In contrast, Cunningham (1996) investigated cigarette smuggling into Canada in the early 1990s, and it was quite obvious that, despite the fact that smuggling is difficult to monitor and quantify, the evidence clearly pointed to large-scale cigarette smuggling.

Table 4.1: Trends in cigarette consumption, prices and excise taxes

Year	Con-sumption Millions of packs	Price (Nominal) Cents per pack	Price (Real, 2000 base) Cents per pack	Excise tax (Nominal) Cents per pack	Excise tax (Real, 2000 base) Cents per pack	Excise tax as perc. of price	Industry price (Real, 2000 base) Cents per pack	Excise revenue (Real, 2000 base) R mill.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1961	517	19.1	616	9.1	294	47.6%	323	1517
1965	608	19.4	571	9.1	268	46.9%	303	1626
1970	783	22.1	553	11.1	278	50.2%	275	2173
1975	1048	31.8	521	14.6	239	45.9%	282	2508
1980	1283	49	454	20.1	186	41.0%	250	2388
1981	1443	53	424	20.1	161	37.9%	247	2320
1982	1632	62	434	21.1	148	34.0%	264	2408
1983	1551	66	413	24.1	151	36.5%	239	2336
1984	1570	74	413	24.6	137	33.2%	244	2158
1985	1571	84	404	26.1	125	31.1%	237	1972
1986	1591	94	381	26.1	106	27.8%	234	1681
1987	1671	109	380	26.1	91	23.9%	248	1520
1988	1795	122	377	27.1	84	22.2%	253	1502
1989	1809	138	372	30.6	82	22.2%	247	1492
1990	1868	165	389	33.1	78	20.1%	266	1459
1991	1927	171	350	37.6	77	22.0%	235	1482
1992	1900	222	399	44.6	80	20.1%	282	1520
1993	1802	255	417	53.2	87	20.9%	282	1567
1994	1769	284	426	60.5	91	21.3%	283	1605
1995	1708	348	481	75.3	104	21.6%	318	1777
1996	1690	387	498	92.0	118	23.8%	318	2001
1997	1577	497	589	117.5	139	23.6%	377	2195
1998	1495	608	674	169.5	188	27.9%	403	2810
1999	1422	730	769	214.3	226	29.3%	449	3210
2000	1334	803	803	254.5	255	31.7%	450	3396
2001	1276	889	841	291.5	276	32.8%	462	3518
2002	1234	987	855	325.3	282	33.0%	468	3480
2003	1210	1098	899	360.2	295	32.8%	494	3571
2004*	1208	1213	970	404.6	324	33.4%	528	3909

Note: * Preliminary figures (consumption, excise taxes and government revenue based on budgeted figures, prices based on an extrapolation of the first seven months of 2004).

All data were converted to calendar years using a weighted average of the financial year, if the source data were in financial year format.

Source: Auditor-General (selected years), Statistics South Africa (1998), Republic of South Africa (selected years), Tobacco Board (selected years).

4.3.1 Consumption

Between 1961 and 1991 recorded consumption of cigarettes grew at an average annual rate of 4.1 per cent. During this period annual per capita consumption increased from 50 packs to more than 80 packs.[4]

Aggregate cigarette consumption peaked in 1991 at nearly two billion packs, after which it decreased steadily. Between 1991 and 2003 aggregate consumption decreased by 37 per cent. This was the result of decreases in both smoking prevalence and smoking intensity, as was pointed out in chapter 2. During the mid- and late-1990s the rate of decrease in cigarette consumption was very sharp, with annual decreases of around 5 per cent per year. However, in the period 2001-2004 the average rate of decrease moderated to about 2-3 per cent per year.

Given that tough anti-smoking legislation was introduced in 2001, the rather modest decrease in tobacco consumption since then may come as a disappointment to champions of such legislation. However, one cannot judge the success, or otherwise, of the legislation without considering other factors that determine the demand for cigarettes. Specifically, the growth in the country's GDP and average real personal disposable incomes in the period since 2000 could have stimulated the demand for cigarettes, ceteris paribus. For this reason a multiple regression framework is crucial to disentangle the impact of the various demand determinants.

4.3.2 Excise duties

As in many countries (Sunley et al., 2000), cigarette excise taxes in South Africa are levied as a specific tax. While a specific tax is relatively easy to administer, it can be rapidly eroded in times of inflation. This is exactly what happened in South Africa during the 1970s and 1980s. Buckling under the pressure exercised by the cigarette manufacturing industry and the Tobacco Board (representing the tobacco-growing subsector), the government allowed inflation to reduce the excise tax rate from 50 per cent of the retail price of cigarettes in 1970 to only 20 per cent in 1990. Between 1970 and 1990 the real level of excise tax fell by 72 per cent, from 278 cents per pack to 78 cents per pack (in 2000 prices).

However, as mentioned earlier, the Minister of Finance announced in June 1994 that the government would increase the excise tax on cigarettes to 50 per cent of the retail price, to be phased in over a number of years (Republic of South Africa, 1994). The result was that the nominal excise tax increased by 660 per cent between 1993 and 2004. In real terms, the excise tax increased by 272 per cent between 1993 and 2004.

Subsequently, the target of an effective 50 per cent *excise* tax on cigarettes was changed to a 50 per cent *total* tax (i.e. the sum of excise tax and VAT) on cigarettes. With a VAT rate of 14 per cent, a 50 per cent total tax burden would imply that the excise tax would equal 37.7 per

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4. Unless otherwise stated, per capita figures are calculated using a population aged 15 and older.

cent of the VAT-inclusive retail price.[5] Despite large increases in the level of excise tax, especially since 1997, the target tax rate of 50 per cent of the retail price has not yet been achieved. In 2004, excise taxes comprised only 33.4 per cent of the retail price, yielding a VAT-inclusive tax percentage of 45.7 per cent.

In each of the years between 1997 and 2003 the Ministry of Finance has claimed that the recommended increase in the level of excise tax would allow it to achieve the target excise tax rate of 50 per cent of the retail price. However, this is more illusory than real. The data suggest that the Ministry of Finance increases the level of excise tax to achieve a 50 per cent excise tax component, based on retail prices that do not take account of the tax increase. Thus, when the Minister of Finance announces the excise tax increase, total taxes as percentage of the retail price prevailing at the time of the announcement do indeed equal 50 per cent. However, the tax increase causes the retail price to increase, with the result that the denominator increases. So, *ex post*, the total tax percentage is lower than the claimed 50 per cent.

To solve this situation is quite simple. The Ministry of Finance should increase the excise tax to a level where total taxes equal 50 per cent of the retail price, taking the impact of the tax increase on the retail price into account. Of course this presupposes knowledge of the impact of tax increases on the retail price. The most plausible assumption is that the increased tax is fully passed on to consumers, and that the Ministry of Finance would calculate the required tax increase based on this assumption. Obviously, increasing the targeted tax percentage from 50 to 52 per cent of the retail price will increase the effective tax percentage, but unless the nominal cigarette price increases are very small, the ex post tax percentage is unlikely to ever exceed 50 per cent under the current formula.

As mentioned in the introduction to this chapter, the industry's pricing strategy and how they pass the excise tax increase to consumers has an important bearing on the effectiveness of the tax as (1) a tobacco control tool, and (2) a revenue generating mechanism. From Table 4.1 it is evident that the industry price of cigarettes (defined as the retail price less excise taxes and VAT) has more than doubled in real terms since the early 1990s. The impact of this is to decrease the ex post effective tax rate on cigarettes. As will be pointed out in chapter 5, the industry's pricing strategy in reaction to the excise increases has increased their profitability at the expense of the consumer, but has certainly had good tobacco control consequences.

4.3.3 Excise revenue

Before the rapid increases in the cigarette excise tax after 1994, total real excise revenue decreased rapidly, despite the fact that cigarette consumption was increasing. Due to the

5. At a nominal rate of 14 per cent, VAT comprises 12.3 per cent (=0.14/1.14) of the VAT-inclusive retail price.

decrease in the real excise tax, real (in constant 2000 prices) cigarette excise revenue decreased from a high of around R2.5 billion in the mid-1970s to less than R1.5 billion in 1990.

The large increases in the real excise tax since 1994 have resulted in large increases in real excise revenue; in fact, real cigarette excise revenues have more than doubled since 1993, despite the fact that consumption has decreased by a third. Cigarette excise revenues currently comprise about 1.5 per cent of total government revenue (Republic of South Africa, 2004), compared to about 1 per cent in the early 1990s.

4.3.4 Cigarette prices

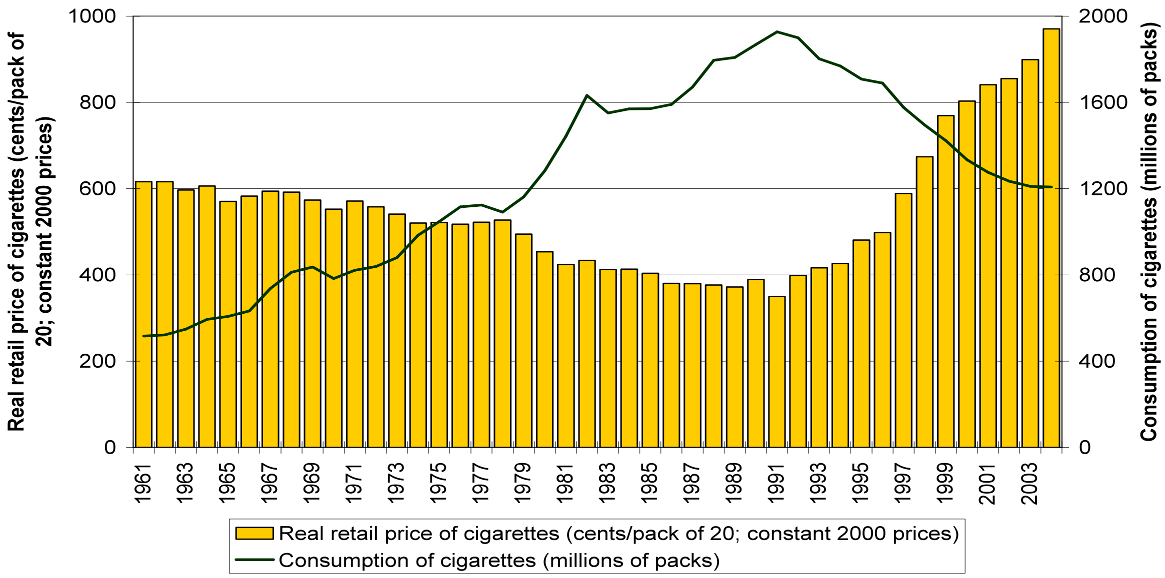
As could be expected, the real retail price of cigarettes closely follows the real excise level given that excise taxes comprise a sizeable share of the retail price. The real retail price decreased by 43 per cent between 1961 and 1991, as a result of a 74 per cent decrease in the real excise tax, and a 27 per cent decrease in the real industry price of cigarettes.

The real price of cigarettes started to increase very rapidly from 1992. In nominal terms the price of cigarettes increased at an average annual rate of 15.2 per cent between 1992 and 2004. During the same period, the real price of cigarettes rose by 143 per cent, an average annual increase of nearly 8 per cent.

The relationship between cigarette consumption and real cigarette prices is shown in Figure 4.1. This simple diagram clearly illustrates the strongly negative relationship between these two variables, although the growth in consumption up to 1983 is much faster than the fall in the real price.[6] A more rigorous treatment of the determinants of the demand for cigarettes is provided in the following section.

6. Yussuf Saloojee (Director, National Council Against Smoking, personal communication, 2004) explains that an earlier version of this graph was used by the National Council Against Smoking to persuade the then Deputy President, FW de Klerk, that an increase in excise taxes was an effective tool to curb cigarette consumption. According to Saloojee, the chain-smoking Deputy President was impressed by the strong negative relationship between cigarette prices and consumption, and subsequently supported the notion that tax increases could act as an effective tobacco control mechanism. What this anecdote suggests is that simple, yet well-presented, data can have much policy impact.

Figure 4.1: Cigarette real retail price and cigarette consumption, 1961-2004



Source: Auditor-General (selected years), Statistics South Africa (1998), Republic of South Africa (selected years).

4.4 Estimating the demand for cigarettes in South Africa[7]

Chapter 3 clearly illustrated that the single most important determinant of cigarette consumption is the price of cigarettes. From a tobacco control perspective, the recommended policy would be to increase the level of the excise tax, since this would result in a reduction in cigarette consumption. However, the effectiveness of a policy of raising the excise tax depends crucially on the magnitude of the price elasticity of demand. The greater the absolute value of the price elasticity of demand, the larger the impact of a given tax increase is likely to be on the cigarette consumption, and vice versa.[8]

Previous South African studies have found that the demand for cigarettes in South Africa is relatively price inelastic, with most price elasticity estimates clustered between -0.5 and -0.9 (Reekie, 1994, Van Walbeek, 1996 and ETCSA, 1998). Reekie (1994) and Van Walbeek (1996) used single equation techniques to estimate the demand equations, while ETCSA (1998) used a system of equations.

In the past two decades there have been major advances in econometric theory and practice, particularly in time-series analysis, as will be indicated below. Whereas previously applied econometricians largely ignored the dangers of performing analyses with non-stationary data, this issue is central to current econometric practice. Also, there is increased awareness of the

7. This section has benefited much from the input of Johannes Fedderke and Stan du Plessis. Their practical insights are gratefully acknowledged.
8. In chapter 5 this aspect, together with the impact that excise tax increases are likely to have on government revenue, is investigated in substantial detail.

fact that single equation models place unrealistic restrictions on the data, and that a more general and encompassing approach to econometric modelling is required (Enders, 2004: 262-264).

In the following sections a multi-equation system is specified and estimated using the Johansen technique. While this technique is generally regarded as state of the art in time-series analysis, its major drawback is that it is very data intensive. As will be pointed out, results of the present study are sensitive to small changes in the specification of the model, which can be attributed primarily to the fact that the model employs fewer than 40 annual observations. Unfortunately it was impossible to find longer time-series and/or higher frequency data. One could argue that it does not make sense to use such an advanced and data-intensive estimation technique given the relative paucity (and in some instances the poor quality) of the data. According to this view, the data simply cannot bear the demands that the technique places on the data. Despite all the practical drawbacks associated with this technique, it is presented here, on the grounds that it may help to understand the intricacies of the cigarette market.

Rather than presenting a systems model in which both supply and demand equations are estimated, one could make certain assumptions about industry behaviour and focus exclusively on the demand for cigarettes. This alternative approach would entail the estimation of a single equation, which places fewer demands on the data. The drawback is that such an approach is theoretically less sound than a systems approach, and thus the accusation of model misspecification could be levelled against it. As will be pointed out, the results obtained by employing this approach are less sensitive to small specification changes than the results obtained from the systems approach.

While it is unfortunate that one is caught between two imperfect approaches, the practical reality is that there is no "golden key" that employs the best possible techniques and provides robust econometric results. In the ensuing discussion, the results of the systems approach are presented first, followed by the single equation approach.

4.4.1 The modern econometric approach

The main focus of the modern approach to econometrics is on the stationarity, or otherwise, of the data. If two or more time-series are non-stationary, it is quite possible that a statistically significant, but entirely meaningless relationship exists between them. This is the problem of spurious regression. A number of tests have been developed to determine whether time-series are stationary or not, of which the augmented Dickey-Fuller and the Phillips-Perron tests are the most widely used (see Harris, 1995 and Patterson, 2000). In a stationary time-series the mean, variances, and autocovariances are independent of time. Such time-series are said to be integrated of order zero, denoted as I(0). Non-stationary time-series can always be made stationary by differencing. A time-series which needs to be differenced b times in order to yield it stationary is said to be integrated of order *b*, denoted as I(*b*). As a general principle, a linear combination of I(*b*) variables will also be I(*b*). However, where a linear combination of I(*b*) variables is I(*b*-*d*), *d*>0, these variables are said to be cointegrated, denoted as CI(*b*,*d*). If there is a long-run equilibrium relationship between a set of variables, then this would be represented as a cointegrating relationship, also known as a cointegrating vector (CV). A cointegrating relationship implies that, even though the individual time-series are non-stationary, the relationship is not spurious. Also, any deviations from the equilibrium will tend to be (partially) corrected for in the following period. In fact, according to the Granger Representation Theorem one can derive an error-correction model, also known as an equilibrium-correction model (ECM), if there is a cointegrating long-run relationship (Engle and Granger, 1987).

Given the complexity of the real world, a single-equation approach is unlikely to capture adequately all the intricacies. By employing a single-equation approach, a researcher would impose zero restrictions on many relationships without actually having tested whether such restrictions are statistically justified. A more prudent and less prescriptive approach would be to place fewer restrictions on the data and the nature of the relationships. By setting up the data in the form of a vector autoregressive relationship (VAR), all variables are endogenous, and each variable is specified to be determined by its own lagged values and the lagged values of all other variables in the system. Within such a VAR system, one can then determine one or more cointegrating relationships.

The Johansen technique, first developed by Johansen and his colleagues (see Patterson, 2000: 616) has become the standard way of establishing cointegration in a multivariate system. It is well described in numerous textbooks (e.g. Patterson, 2000, Harris, 1995 and Enders, 2004) and is a standard feature of most econometric software packages.

Two major advantages of the Johansen approach are that it does not impose *a priori* restrictions on the exogeneity of the variables in the system (although it does allow for them if desired) and allows for the possibility of more than one cointegrating relationship between the variables. Rather than estimating the long-run cointegrating equation and ECM sequentially, they are estimated simultaneously.[9] While the estimation techniques are driven by the *statistical* features of the data, the important aspect of the Johansen approach is the *economic* interpretation of the results.

9. An alternative, but limited approach to cointegration is the Engle-Granger two-step approach. It requires the researcher to first estimate the long-run equation using OLS. Cointegration is deemed to exist if the residuals are stationary. Once cointegration is established, the second step is to estimate an ECM, which includes the lagged errors from the long-run equation. While this sequential approach is easy to apply, the Engle-Granger approach suffers from a number of drawbacks. These drawbacks include the imposition of zero restrictions on potentially important relationships, and the assumption that there is only one CV, when there might be more than one (Fedderke, 2003: 198-199). Given these drawbacks, the Engle-Granger approach is not recommended.

The Johansen approach consists of the following steps:

1. Test for the order of integration of each variable entering the multivariate model. Most economic time-series (with the possible exception of nominal variables such as money supply, the CPI and nominal national accounting magnitudes) are I(1). Fedderke (2003: 211) points out that the standard Johansen technique applies only to systems of variables that are strictly I(1), although an estimation method for variables that are I(2) has been developed by Johansen (Patterson, 2000: 767).

2. Select the appropriate lag length for each of the endogenous variables included in the vector autoregressive (VAR) model. As a general rule it is better to include more, rather than fewer lags in the VAR, since an underparameterised model will give biased results (Fedderke, 2003: 198). On the other hand, an overparameterised model is very data intensive and less efficient, particularly when the sample size is small.

3. Determine the number of CVs in the VAR.

4. Based on the number of CVs found and economic theory, identify the system by imposing just-identifying restrictions on the long-run regression equations. The just-identifying restrictions are necessary to ensure that multiple CVs are empirically distinguishable from each other (Patterson, 2000: 637).

5. Using over-identifying restrictions, test whether the individual coefficients in the long-run equations are statistically significant. Some coefficients in the CVs are expected to be insignificant, if they are presumed to be irrelevant to the relationship under scrutiny. A test of over-identifying restrictions is a joint test to determine whether a set of restrictions are statistically justified or not. Furthermore, if over-identifying restrictions indicate that superfluous variables can be safely removed from the CVs, the statistical significance of the remaining variables can be tested, again using over-identifying restrictions.

6. Estimate the ECM to determine the short-run dynamics of the system. The ECM includes the lagged residuals from the long-run equation. If there are deviations from equilibrium in the long-run equations, the residuals in the long-run equation will (partially) compensate for these deviations in the following period.

4.4.2 Specifying the supply and demand system

Because the price of cigarettes and cigarette consumption are simultaneously determined, a systems approach is required to ensure unbiased parameter estimates. Provided the system is adequately identified, one can then distil the supply and demand equations from this system.

Standard demand theory indicates that the quantity demanded of a product depends on a number of factors, such as its own price, the income of consumers, the extent of the market (population size), the price of related products, tastes and product-specific factors. In the case of cigarettes, the product-specific factors would presumably include legislative and social aspects related to smoking.

Formally, the demand equation for cigarettes can be expressed as

$$Q_{DEMAND} = f(P_{2000}, PDI_{2000}, P_s, P_c, ADV_{2000}, TC), \qquad (4.1)$$

where the explanations of these variables are provided in Table 4.2 and are shown graphically in Figure 4.2.[10]

Similarly, the quantity supplied can be derived as a function of price (i.e. the industry's income) and cost factors. The following specification was used as the basis for identifying and estimating the cigarette supply equation:

$$Q_{SUPPLY} = f(P_{2000}, TOBPP_{2000}, PAPER_{2000}, EXCISE_{2000}, CR4), \qquad (4.2)$$

where the explanations are also given in Table 4.2 and shown graphically in Figure 4.2.

Raw tobacco leaf ($TOBPP_{2000}$) and paper products ($PAPER_{2000}$), together with the excise tax ($EXCISE_{2000}$) represent the major cost factors for the cigarette manufacturing industry, and should be negatively related to the quantity of cigarettes supplied. Given the high degree of concentration in the cigarette manufacturing industry, one would expect producers to be able to influence prices by limiting the quantity supplied. The four-firm concentration ratio (CR4) aims to capture the degree of market power in the tobacco industry. However, readers should note that the quality of these data is poor.[11] In principle, one would expect a negative relationship between CR4 and Q_{SUPPLY}, given that more concentrated industries would be tempted to use their monopoly power to raise prices by reducing the quantity supplied.

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10. One could argue that, other than PDI_{2000}, population size should be included in the regression equation as a proxy for market size. In the empirical application this strategy was followed, but was abandoned because of the high degree of correlation (r = 0.993) between population and PDI_{2000}.
11. The following data were derived from the censuses of manufacturing, with the tobacco industry being defined as the cigarette, cigar, snuff and tobacco industries:

Year	CR4	Year	CR4	Year	CR4
1967	0.927	1979	0.972	1988	0.858
1972	0.954	1982	0.862	1991	0.910
1976	0.982	1985	0.879	1993	0.890

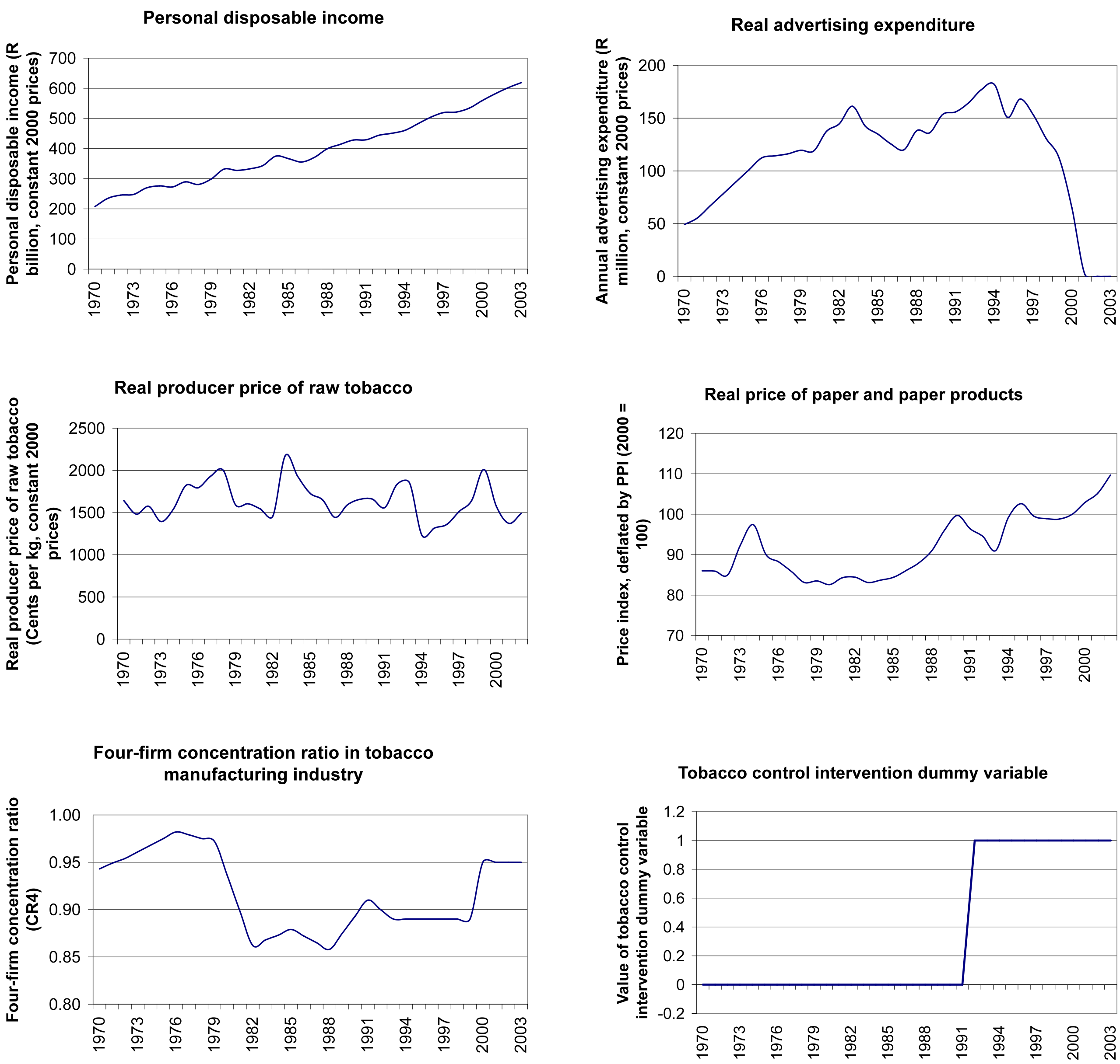
Sources: Censuses of manufacturing, various years

For non-census years before 1993 the data were interpolated. For manufacturing censuses after 1993, the tobacco industry was included in the category of miscellaneous industries, and could thus not be identified separately. Thus for the period 1993 to 1999 the CR4 was held constant at 0.890. In light of the Rothmans-BAT merger in 1999, the CR4 ratio was increased to 0.950 in 2000.

Table 4.2: Definition and units of measurement of relevant variables

Variable	*Description*	*Comments*	*Unit of measurement*
Q_{DEMAND}	Cigarettes demanded		Millions of packs per annum
PDI_{2000}	Real personal disposable income	Deflated by CPI (2000 = 100)	R millions, constant 2000 prices
P_{2000}	Real price of cigarettes	Deflated by CPI (2000 = 100)	Cents per pack of 20, constant 2000 prices
P_s	Price of substitutes	This would include price of roll-your-own and pipe tobacco. Reason for non-inclusion is because time-series data for these products do not exist and are highly correlated with P_{2000}. Also, the demand for these substitutes is small.	Not applicable
P_c	Price of complements	Possibly alcoholic beverages (see Jimenez and Labeaga, 1994) and marijuana (see Chaloupka et al., 1999). Reason for non-inclusion is because of data unavailability.	Not applicable
ADV_{2000}	Impact of advertising	Advertising expenditure, deflated by the PPI (2000 = 100).	R millions, constant 2000 prices
TC	Tobacco control interventions	The impact of the anti-smoking legislation (first passed in 1993) and changing societal norms was captured by means of dummy variable (1970-1992 = 0; 1993-2003 = 1). Alternative specification: 1970-1992 = 0; 1993-2003 = t-1992. Unfortunately, slowly changing, but difficult to measure factors like society's attitude towards smoking can not be measured directly.	0-1 dummy variable and trend variable, starting in 1993
Q_{SUPPLY}	Cigarettes supplied		Millions of packs per annum
$TOBPP_{2000}$	Real producer price of raw tobacco	Gross value of tobacco leaf produced, divided by total tobacco production, and deflated by the PPI (2000 = 100). Source: Department of Labour.	Cents per kg; constant 2000 prices
$PAPER_{2000}$	Real price of paper and paper products	Price index of paper and paper products (as published in the PPI statistics), deflated by the PPI (2000 = 100).	Index value; 2000 = 100
$EXCISE_{2000}$	Real excise tax on cigarettes	Deflated by CPI (2000 = 100).	Cents per pack of 20, constant 2000 prices
CR4	Four-firm concentration ratio	Percentage of gross output produced by the four largest establishments in the cigarette, cigar, snuff and tobacco industries. Derived from the manufacturing censuses of various years. Given interpolation, extrapolation and the generally poor quality of data, this variable must be treated with great caution.	Ratio, between zero and one

***Figure 4.2: Graphical representations of variables included in the VAR*[12]**



4.4.3 Testing for stationarity

As was mentioned in Section 4.4.1, time-series data are characterised in terms of the stationarity of their underlying data-generation processes. While the theoretical literature distinguishes between trend and difference stationarity (Patterson, 2000: 225-227, Harris, 1995 and Enders, 2004: 164-170), in practice trend stationary time-series are rare. However, for small samples, stationarity tests often cannot distinguish between these two types of stationarity. A visual inspection of the data did not suggest trend stationarity, and it was thus not investigated further in this study.

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12. Graphical representations of Q and P_{2000} were given in Figure 4.1, while $EXCISE_{2000}$ is presented in Figure 5.1.

The standard way to test for stationarity is by means of the augmented Dickey-Fuller (ADF) test. The null hypothesis is that the time-series is non-stationary. Rejection of the null implies that the series is stationary. To ensure that the error terms in the Dickey-Fuller test equation are white noise, a number of lags of the dependent variable are included in the test equation. In this study the lag length was determined by the Schwartz Information Criterion (SIC) (Patterson, 2000: 238-241). Where a time-series was found to be non-stationary, the first difference of that series was tested for stationarity, to establish whether the original series was I(1). As mentioned previously one expects most time-series to be I(1). Unfortunately, the ADF test has the drawback that it has low power, in that it may reject the hypothesis that the time-series is non-stationary, when in fact it is non-stationary (Patterson, 2000: 258, Enders, 2004: 156 and Fedderke, 2003: 109).

In practice, especially where the ADF test gives inconclusive or counterintuitive results, it is more prudent to base the decision on a number of tests, such as the Phillips-Perron test,[13] the correlogram and the spectrum (Fedderke, 2003: 112). In addition, there may be structural breaks in the data, which could "mislead" the other tests to conclude non-stationarity (or integration of a higher order), where in fact the data are stationary (or integrated of a lower order than indicated by the standard tests), but subject to a structural break. Perron's innovational outlier model specifically aims at testing for structural breaks in the data.[14] As was pointed out above, there have been significant changes in cigarette taxes, prices and consumption in the past 30 years, and one would want to test whether these constitute a structural break. In Table 4.3 the ADF tests are shown for all relevant variables, and Perron's structural break tests are shown for P_{2000} and $EXCISE_{2000}$.

Both the ADF and Perron tests are sensitive to the number of augmented terms included in the test equation. For the ADF test a trend was not included in the test equation. For the Perron test a trend variable (i.e. coefficient β in footnote 14) was initially included in the specification, but was removed if it did not add significantly to the model. The "best" test equation was chosen on the basis of the SIC.

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13. The Phillips-Perron test is similar to the augmented Dickey-Fuller test, with the exception that, rather than augmenting the test equation with lagged values of the dependent variable, a Newey-West transformation is applied to correct for autocorrelation in the residuals in the test equation.
14. The Perron test for structural breaks has the following structure:
$y_t = \mu + \beta t + \theta DU_t + \gamma DT_t + \delta DTB_t + \alpha y_{t-1} + \Sigma\alpha_i \Delta y_{t-i} + e_t$,
with $DU_t = 1$ if $t > T_b$, zero otherwise; $DT_t = t - T_b$ if $t > T_b$, zero otherwise; $DTB_t = 1$ if $t = T_b + 1$, where T_b is the time point where the structural break is held to have occurred (Fedderke, 2003: 127). The Phillips-Perron test involves testing whether α is significantly different from one. The associated t-value has a non-standard distribution, but the critical values have been recorded by Perron (see Fedderke, 2003: 127).

Table 4.3: Augmented Dickey-Fuller and Perron tests for relevant variables, 1970-2003

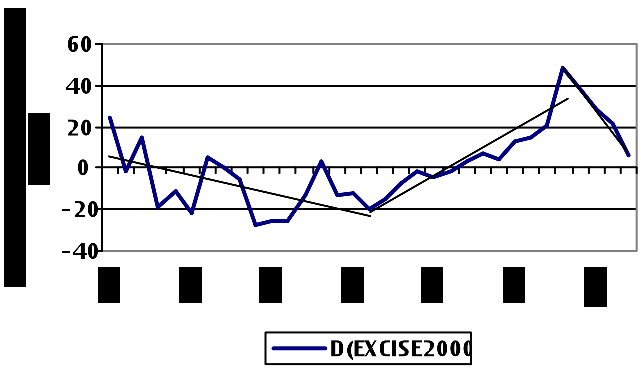
	ADF test with no trend in test equation (No. of lags in parentheses)		Perron tests on first differences for break in (No. of lags in parentheses)					Conclusion
Variable	Levels	1st diff.	1991	1992	1993	1986 & 1998	1986 & 1999	
Q	-1.60 (1)	-3.06^{*} (0)						I(1)
PDI_{2000}	1.50 (2)	-5.95^{*} (1)						I(1)
P_{2000}	-0.88 (2)	-1.65 (2)	$-3.66\ (0)^{§}$	$-5.63^{*}\ (0)^{§}$	$3.37\ (2)^{§}$			I(1), with one structural break
$EXCISE_{2000}$	-1.46 (1)	-2.19 (0)				$6.93^{*}\ (2)^{§§}$	$4.78\ (2)^{§§}$	I(1), with two structural breaks
AD_{2000}	-1.17 (1)	-3.48^{*} (0)						I(1)
$TOBPP_{2000}$	-3.71^{*} (0)							I(0)
$PAPER_{2000}$	-0.49 (0)	-4.36^{*} (0)						I(1)
CR4	-1.77 (1)	-3.79^{*} (0)						I(1)

* Significant at 5 per cent level of significance.
§ No trends included in test equation.
§§ Trends included in test equation.

The ADF statistics suggest that Q, PDI_{2000}, AD_{2000}, $PAPER_{2000}$ and CR4 are I(1), while $TOBPP_{2000}$ is I(0). A graphical analysis of P_{2000} (see Fig. 4.1) indicates that the structural break occurred in the early 1990s, and the Perron test suggests that 1992 was the point of the break. A graphical analysis of D($EXCISE_{2000}$) indicates that there were two structural breaks in this variable: one in 1986, followed by one in 1998.[15] These structural breaks should be accounted for by including appropriate deterministic components in estimation.

Given that the time-series under scrutiny are generally non-stationary, the implication of these results is that an approach that does not test for cointegration might yield spurious results. Thus, in order for these results to be economically meaningful, at least one cointegrating relationship must be found. This is the focus of the following section.

15. See diagram below:



4.4.4 Testing for cointegration

In establishing the number of CVs in the VAR, one can specify whether intercepts and/or trends are included in the cointegrating space or not. As the default in this study, the intercepts were unrestricted, but no trends were included, on the grounds that the inclusion of trends in the long-run and short-run relationships imply quadratic trends in the data, which, given a graphical representation of the data, seems inappropriate in this context (Patterson, 2000: 627).[16]

The VAR was estimated for the period 1971 to 2002, and is based on thirty-two annual observations. The first step was to determine the lag length of the VAR. Patterson (2000: 649) indicates that the SIC performs well in the context of simultaneously estimating the lag length and the cointegrating rank of the VAR, and based on this information criterion the optimal lag length was found to be equal to one. Given that the data is annual, this result is not implausible. The results presented here are based on a VAR with a lag length of one.[17]

In establishing the number of CVs, one can use either the maximal eigenvalue or the trace statistic approach. These two approaches often give the same result, but exceptions are possible. Since the trace statistic has better power properties for small samples and is more robust to skewness and excess kurtosis in residuals, the trace statistic, rather than the maximal eigenvalue, was employed in this study (Fedderke, 2003: 215).

As was pointed out above, it is well known that the Johansen technique is very data intensive, and ideally one would want to work with more than thirty-two observations. The unfortunate result of using so few observations is that the econometric results are very sensitive to small changes in the specification. The results of the analysis are shown in Section 4.4.5 below. In the process of getting to these results a large number of different specifications were investigated, tested and discarded. The following paragraphs aim to reflect on some of these attempts. Hopefully this discussion will address some of the questions that the reader might have about why certain approaches were followed.

Number of CVs: The number of CVs was generally found to be positively related to the number of endogenous variables specified in the model and the number of lags included in the VAR. Depending on the specification of the system, the number of CVs varied between one and four. Since it is intuitively apparent that the system should include a supply and demand equation, the preferred outcome was to establish the existence of two CVs. In the chosen specification, five variables (Q, P_{2000}, $EXCISE_{2000}$, AD_{2000} and PDI_{2000}) were regarded as

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16. Johann Fedderke (personal communication: 2004) argues against the inclusion of a trend term in the VAR because it is “an admission of ignorance”.
17. A substantial amount of experimentation with different lag lengths, and the inclusion or exclusion of trends and/or intercepts in the VAR suggested that higher order lags in some cases also gave “good” results. However, since extra lags in the VAR use up many degrees of freedom, it was decided to use a modest lag length, at the risk of underparameterising the model.

endogenous, and it was clear that there were two CVs. However, if a longer lag structure were chosen, a specification that endogenised most variables often yielded more than two CVs. In cases like these, one could then assume that the variables of interest (usually the price and the quantity) are endogenously determined, while other variables are regarded as exogenous. According to Sims's general-to-specific methodology such an ad hoc approach is unsatisfactory, because the researcher would force his/her will on the data, and not allow the data to lead the researcher (Enders, 2004: 263). Fortunately, in the model presented here, such restrictions have not been placed on the data.

Solving the model: In estimating the long-run coefficients, the model is solved iteratively using either the backward substitution or modified Newton-Raphson algorithm (Pesaran and Pesaran, 1997). Given the paucity of data, the model often did not converge, and an alternative specification was then required. As a result, a number of specifications could not be investigated. In particular, the deterministic components[18] that were required to account for the structural breaks in P_{2000} and $EXCISE_{2000}$ could not be included in the model presented below, because their inclusion resulted in non-converging parameters.

Input costs: The two single most important variable inputs in the production of cigarettes are raw tobacco and paper products (Anton du Plessis, manager of Paarl factory, personal communication: 2004). One would expect a negative relationship between the real costs of each of these inputs and the quantity of cigarettes produced. The real price of raw tobacco ($TOBPP_{2000}$) was found to be I(0) and thus entered the system only through the ECM.[19] The cost of paper used in the cigarette manufacturing process ($PAPER_{2000}$) was proxied by the producer price index of "paper and paper products", and deflated by the overall PPI. Of course, price movements in the various paper requirements of the cigarette manufacturing industry may differ from an aggregated index, but unfortunately no better data were available. Given its importance in the manufacturing process, $PAPER_{2000}$ should be included in the supply equation, but the estimated coefficient consistently had the wrong (i.e. positive) sign. Attempts to use the prices of other paper-based products, like newsprint and kraft paper, and corrugated cardboard boxes, did not yield any meaningful results either. Regretfully and reluctantly, this input cost variable was excluded from the VAR.

18. D86plus (1970-1985 = 0, 1986-2003 = 1), D92plus (1970-1991 = 0, 1992-2003 = 1), D98plus (1970-1997 = 0, 1998-2003 = 1)
19. The implication is that the real price of raw tobacco has not been subject to long-term trends. The real price of flue-cured and air-cured tobacco is presented in Table 5.4, and clearly does not display long-term upward or downward trends. This result should not be surprising. The real price is defined as the price of a commodity, divided by an appropriate price index. The price index, in turn, is comprised of a large basket of commodities. It thus follows that the weighted average real price of all the commodities included in the price index remains constant from one period to the next. Thus, while some commodities may experience an increase in the real price, other commodities may experience decreases, and some may not experience any change over time. Using other price indices to deflate the nominal price of raw tobacco did not change the basic conclusion that this variable was stationary.

Industry concentration: As pointed out before, the cigarette manufacturing industry is highly concentrated and, viewed from a very long term perspective, has become more concentrated over time. Four-firm concentration (CR4) indices for the tobacco industry were presented in footnote 11. In principle, one would expect a positive relationship between the degree of concentration and the retail price of cigarettes. Irrespective of the chosen specification, the relationship was found to be statistically insignificant. While at first sight this result seems strange, an analysis of the data suggests that there has been very little variation in CR4 since the early 1970s. Although the Dickey-Fuller test suggests that CR4 is I(1), a visual inspection of the data indicates that the data is stationary (see footnote 11). Also, the CR4 data indicates some counterintuitive decreases in concentration in 1982, 1988 and 1993, which are presumably the result of changes in the definition of "tobacco industry" and/or changes in the coverage of the manufacturing censuses.[20] Given these data problems, and the insignificance of the variable, CR4 was discarded from the analysis.

Advertising expenditure: Product promotion consists of a number of activities, of which advertising is probably the most visible and well-known. Other promotional activities include price discounts, special offers, personalised marketing activities and smokers' parties. While the US requires tobacco companies to declare all their promotional activities, there is no such obligation on South African tobacco companies. Thus the advertising data used here is a subset of all promotional activities. This would not be a major problem if advertising expenditures remained a constant proportion of all promotional activities. In the US, advertising expenditure as a proportion of all tobacco promotional activities has decreased over time. This seems to be the case in South Africa as well, particularly after health warnings on packaging and advertising materials were introduced in 1995 and even more so after all advertising and sponsorship activities were banned in 2001.

Rather than using advertising expenditures as the appropriate explanatory variable, a small number of cigarette demand studies have used a stock concept (e.g. McGuinness and Cowling, 1975 and Radfar, 1985). This approach assumes that advertising has a cumulative, rather than just a transitory effect. Since the advertising impact dissipates over time, an appropriate depreciation rate needs to be applied. Presumably the depreciation rate is likely to be substantially higher than the capital depreciation rates used in growth studies, but the tobacco demand literature is too thin to provide credible guidance on this issue.

A further complicating issue are the health warnings on cigarette packaging and advertising material which were introduced in August 1995. This legislative intervention devalued the impact of advertising, to the extent that in the months after August 1995 the tobacco industry severely reduced its adverting expenditure (see chapter 7). One way of accounting for the

20. The CR4 figures might seem somewhat low, given that Rembrandt had an 85 per cent market share throughout the 1980s, and the next three largest cigarette manufacturing firms would have resulted in a CR4 percentage of at least 98 per cent. The explanation lies in the fact that the published CR4 figures refer to the "tobacco industry" and not only the cigarette manufacturing industry.

impact of health warnings is reduce the actual advertising expenditure numbers after 1995 by some percentage. The problem with this approach is that it is arbitrary. As an alternative, the advertising expenditure series was divided into two periods (before 1995 and after 1995), which allows the advertising effect to be measured before and after the introduction of health warnings. While this approach is presumably better than an arbitrary devaluation approach, the empirical results were weak. They were very sensitive to small changes in the specification of the model, and generally statistically insignificant.

Lastly, Schmalenzee (cited in High, 1999) argued that one should not only consider the absolute value of advertising expenditures on cigarettes, but the share of cigarette advertising, relative to the advertising expenditure on all goods and services. The argument is that if the advertising expenditure on a commodity (or group of commodities) increases, sales of that commodity would be expected to increase at the expense of all other commodities. However, if all commodities experience similar increases in their advertising expenditures, the impact would be self-cancelling.

The upshot of this discussion is that it is difficult to accurately capture the impact of cigarette promotion on consumption, because the variable is so difficult to measure. There are a number of permutations on how to incorporate its effects, none of which are completely satisfactory. While it may be possible, in principle, to run the model with a different specification of the advertising variable, such an approach could be criticised as data mining. The advertising data are simply not good enough to subject it to such pressure, and to do so would create an impression of sophistication that does not really exist.

4.4.5 Results

Given the discussion in the previous sections, the chosen VAR has a lag length of one year and consists of five endogenous variables (Q, P_{2000}, $EXCISE_{2000}$, AD_{2000} and PDI_{2000}) and three exogenous I(0) variables ($TOBPP_{2000}$, D82 and D92plus). D82 was included to neutralise the impact of an outlier, and D92plus was included to indicate a trend break in P_{2000}.[21] P92plus also proxies the change in the legislative and social environment since the early 1990s.

Both the trace and maximal eigenvalue statistics clearly established the presence of two CVs. The results are shown in Table 4.4.

21. Recorded cigarette consumption in 1982 was much higher than can realistically be explained by the exogenous variables. The only plausible explanation is that the Auditor-General's Report for 1982 included cigarette excise tax revenues accumulated over previous years, but that had not been reflected in those years. Since cigarette consumption is derived from tax revenue receipts, the consumption figures for 1982 might thus be overstated.

Table 4.4: Establishing the number of CVs in the VAR (unrestricted intercepts and no trends), 1970-2003

Eigenvalues in descending order:				
0.745 0.599 0.443 0.021 0.006				
Cointegration LR test based on maximal eigenvalue				
Null hypothesis	Alt. hypothesis	Test statistic	95% critical value	90% critical value
r = 0	r = 1	43.76	33.64	31.02
r ≤ 1	r = 2	29.26	27.42	24.99
r ≤ 2	r = 3	18.75	21.12	19.02
r ≤ 3	r = 4	0.71	14.88	12.98
r ≤ 4	r = 5	0.18	8.07	6.50
Cointegration LR test based on trace statistic				
Null hypothesis	Alt. hypothesis	Test statistic	95% critical value	90% critical value
r = 0	r ≥ 1	92.66	70.49	66.23
r ≤ 1	r ≥ 2	48.90	48.88	45.70
r ≤ 2	r ≥ 3	19.64	31.54	28.78
r ≤ 3	r ≥ 4	0.89	17.86	15.75
r ≤ 4	r ≥ 5	0.18	8.07	6.50

With two CVs, the just-identified cointegrating VAR can thus be represented as follows:

$$\begin{bmatrix} 1 & \beta_{12} & 0 & \beta_{14} & \beta_{15} \\ \beta_{21} & 1 & \beta_{23} & \beta_{24} & 0 \end{bmatrix} \begin{bmatrix} Q \\ P_{2000} \\ EXCISE_{2000} \\ AD_{2000} \\ PDI_{2000} \end{bmatrix} = \begin{bmatrix} e_1 \\ e_2 \end{bmatrix} \tag{4.3}$$

On the assumption that the demand for cigarettes is influenced by the retail price of cigarettes, and not by the level of the excise tax, it follows that CV_1 is specified as the demand equation. Similarly, on the assumption that the supply of cigarettes is not influenced by PDI_{2000}, it follows that CV_2 is specified as the supply equation. For CV_1 the long-run equation is normalised on quantity (Q), and for CV_2 the long-run equation is normalised on price (P_{2000}).

One over-identifying restriction ($\beta_{24} = 0$) was imposed on the system of CVs, on the grounds that advertising expenditure affects the quantity demanded, but not the quantity supplied. According to the Lagrange test of restrictions, the restriction is valid ($\chi^2(1) = 0.012$, p = 0.915). The rescaled CVs, with the associated standard errors, are shown in Table 4.5. Using a test of over-identifying restrictions on each of the individual coefficients, all coefficients, other than those on AD_{2000}, were found to be statistically significant at the 1 per cent level, as indicated in Table 4.5.

Table 4.5: Maximum likelihood estimates of CVs in the VAR (with unrestricted intercepts and no trends, annual data, 1971-2002)

	CV_1: Demand (normalised on Q_{DEMAND})		CV_2: Supply (normalised on P_{2000})	
	Coefficient (standard error)	χ^2 test (1 df) for over-identifying restriction on coefficient	Coefficient (standard error)	χ^2 test (1 df) for over-identifying restriction on coefficient
Q	1.000		-0.660 (0.125)	17.52*
P_{2000}	2.801 (0.254)	21.50*	1.000	
$EXCISE_{2000}$			-4.045 (0.538)	**
AD_{2000}	1.272 (0.608)	6.29		
PDI_{2000}	3.001 (0.160)	12.45*		

* Significant at the 1 per cent level.

** Model was unable to solve for these restrictions, but relatively small standard errors suggest that these coefficients are statistically significant.

In Table 4.6 a number of relevant elasticities are shown. The standard way of estimating elasticities when the equations are specified in linear terms is at the means. This approach was also adopted in this chapter.

Table 4.6: Elasticity estimates at the respective means, based on the CVs of the VAR, 1971-2002

	CV_1: Demand equation	CV_2: Supply equation
P_{2000}	-0.99*	0.54*
$EXCISE_{2000}$		-0.74*
AD_{2000}	-0.10	
PDI_{2000}	0.82*	

* Significant at the 1 per cent level.

The average price elasticity of demand for cigarettes is estimated at -0.99 for the period 1971 to 2002. This is somewhat higher in absolute terms than previous estimates (Reekie, 1994, Van Walbeek, 1996 and Van der Merwe and Annett, 1998) and is also at the high end of price elasticity estimates obtained in other developing countries (see chapter 3). This finding supports the assertion by ETCSA (2003: 59) that the absolute value of the price elasticity of demand is increasing over time.[22] If this is true, real excise tax and price increases are

22. There are at least two possible explanations for the increase in the absolute value of the price elasticity of demand. First, it could imply a linear, rather than a loglinear (constant elasticity) demand curve. As the real price of cigarettes increase, so the demand becomes more price elastic. Second, it could imply

becoming increasingly effective as a tobacco control tool. The flipside is that government revenue from cigarette excise tax increases is unlikely to increase as much as in the past. The issue of the impact of excise tax increases on government revenue is considered in more detail in chapter 5.

This result is not an artefact of the chosen specification. Based on a variety of specifications of the demand and supply systems (not shown here), there is little doubt that there is a strong negative relationship between the real cigarette price and the quantity consumed. However, many of the alternative specifications indicated a somewhat less price elastic demand (with ε_P ranging between -0.7 and -0.9) than the results shown here.

The average income elasticity of demand is estimated at 0.82, which suggests that cigarettes are normal goods. This elasticity estimate is significantly higher than previous estimates by Van Walbeek (1996), who obtained income elasticity estimates between 0.48 and 0.58. The current income elasticity estimates are substantially lower than Van der Merwe and Annett's (1998) estimates of around 1.60. As was pointed out in chapter 2, a relatively high income elasticity of demand for cigarettes is not surprising because, given the high degree of poverty in South Africa, a modest increase in income is likely to cause a substantial increase in cigarette smoking among the poor, since cigarettes are one of the few "luxury" goods that they can afford.

The advertising elasticity of demand is estimated at -0.10, suggestive of a counterintuitive negative relationship between advertising expenditure and cigarette consumption. However, it is not statistically significant. In fact, in practically all alternative formulations of the model (not shown here), the coefficient on AD_{2000} was statistically insignificant. The conclusion is that, with the available data, there is no evidence to support the thesis that there is a direct relationship between cigarette advertising expenditure and cigarettes consumption. However, this does not necessarily mean that there is no relationship between these two variables whatsoever. The direct relationship between advertising expenditure and cigarette consumption could have been disturbed by variations in the effectiveness of cigarette advertising, the introduction of health warnings on advertising material and packaging in 1995, and the possibility that cigarette advertising has a long-term indirect impact on cigarette demand (for example, by enhancing the social acceptability of smoking).

On the supply side, the evidence suggests that the supply of cigarettes is relatively price inelastic (ε_S = 0.54). In this specification of the model the coefficient is statistically significant, but in many other specifications (not shown) a non-significant price elasticity of supply was found. The reported results thus indicate a relatively slow supply response to changes in the price of cigarettes.

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more illegal cigarette sales than was previously thought. If actual cigarette consumption is more than the consumption figures on which the demand analysis is based, a given increase in the retail price will cause an exaggerated decrease in consumption, which is reflected in a more price elastic response.

The model indicates a strong negative relationship between the excise tax and quantity supplied, as one would expect. *Ceteris paribus*, a one per cent increase in the level of the real excise tax decreases quantity supplied by an average of 0.74 per cent. This negative relationship between quantity supplied and the excise tax was found to be relatively robust, irrespective of the specification of the cointegrating VAR. As was noted in the introduction to this chapter, an important aspect is how the excise tax impacts on the retail price, and whether the industry bears some of the tax changes, or whether the tax changes are fully passed onto consumers. This aspect cannot be adequately investigated within the VAR context, but is explored more fully in chapter 5.

4.4.6 The error-correction model

Whereas the long-run cointegrating relationships are based on non-stationary data, the error-correction model (ECM) is based on stationary data. The ECM focuses on the short-run dynamics between the variables, and aims to describe how the system moves from one point of equilibrium to another. Crucially in an ECM is the inclusion of the lagged errors from the long-run CVs. These errors can be regarded as disequilibria in the long-run equation. Should there be a long-run equilibrium relationship between the relevant variables, as cointegration assumes, a short-run disequilibrium (i.e. an error in the CV) would dissipate over time. In terms of the Johansen procedure, this would imply that the coefficient on the lagged error from the cointegrating relationship be negative. The magnitude of this coefficient (which theoretically lies between zero and -2) would indicate how fast equilibrium would be restored.[23]

As was pointed out in section 4.4.1, the Granger Representation Theorem indicates that an ECM exists where there is a cointegrating relationship. Where there are two cointegrating relationships, two lagged error terms should be included in the ECMs.

Since five variables (Q, P_{2000}, $EXCISE_{2000}$, AD_{2000} and PDI_{2000}) were specified as endogenous, one can estimate five different ECMs. However, it would not make sense to estimate ECMs for all five variables. For example, even though PDI_{2000} is regarded as endogenous in the model, it would be odd to present a theory of income determination based on developments in the tobacco industry. Given that the normalisations were performed on Q and P_{2000}, these two are the more interesting ones, and their ECMs are reported here.

Generally speaking theory tells very little about the short-run dynamics and the movement from one position of equilibrium to another and thus the coefficients in the ECM, other than the lagged error terms, are generally not analysed in detail. As a practical matter, it proved particularly difficult to find two negative coefficients on the error-correction terms in the

23. If, for instance, the coefficient is -0.5, half of the disequilibrium error is bridged in one period. If the coefficient is -1, equilibrium is restored in one period, while if the coefficient is less than -1, this is indicative of overshooting (e.g. Dornbusch's model of exchange rate determination).

error-correction model. In most specifications of the cointegrating VAR, the ECMs had one positive and one negative coefficient on the lagged error term.[24] The results presented in Table 4.7 are far from perfect, but sounder than practically all other specifications.

Table 4.7: Short-run dynamics in the regression model

Dependent variable:	ΔQ	ΔP_{2000}
Explanatory variables	Demand equation (t-values in parentheses)	Supply equation (t-values in parentheses)
Constant	1005.0^{***}	306.2^{***}
	(3.41)	(3.34)
ΔP_{2000}	-1.01^{**}	
	(2.29)	
ΔPDI_{2000}	1.34^{**}	0.33
	(2.22)	(1.38)
ΔAD_{2000}	-0.18	-0.66^{***}
	(0.32)	(-3.67)
$\Delta EXCISE_{2000}$		1.01^{***}
		(3.24)
TOBPP	0.04	0.07^{***}
	(0.61)	(3.93)
D82	190.0	48.4^{***}
	(4.11)	(3.21)
D92plus	-43.0	42.7^{***}
	(-1.34)	(4.62)
$ECM1_{-1}$	-0.381^{**}	-0.237^{***}
	(-2.67)	(5.19)
$ECM2_{-1}$	0.31	0.005
	(1.62)	(0.06)
R^2 statistic	0.840	0.894
Adjusted R^2 statistic	0.784	0.855
Durbin-Watson statistic	1.59	2.58
Ramsey RESET test	$F(1,22) = 7.14^{**}$	$F(1,21) = 3.27^{*}$
	[0.014]	[0.085]
Jarque-Bera normality test	$\chi^2(2) = 0.58$	$\chi^2(2) = 1.02$
	[0.749]	[0.602]
White heteroscedasticity test	F(1,30) = 0.008	F(1,29) = 0.476
	[0.977]	[0.496]

$ECM1 = Q + 2.801\ P_{2000} + 1.272\ AD_{2000} – 3.001\ PDI_{2000}$

$ECM2 = P_{2000} – 0.660\ Q – 4.0453\ EXCISE_{2000}$

Note: Probability values for rejecting the null hypothesis in the diagnostic tests are shown in square parentheses.

24. This was, in fact, a fairly robust finding. For any particular cointegrating VAR, a very general ECM was specified. The least significant variables were removed from the ECM in a stepwise fashion, and the magnitudes on the lagged error terms were monitored after each step. While the removal of certain variables from the model often had a significant impact on the magnitudes of the coefficients on the remaining variables, they had surprisingly little impact on the sign and magnitude of the coefficient on the lagged error terms.

Although most applied time-series econometricians attach little value to the coefficients in the ECM, as pointed out above, some potentially interesting results follow from Table 4.7. For the dynamic demand equation the change in quantity is significantly negatively related to the change in the real price, significantly positively related to the change in personal disposable income, and insignificantly related to the change in advertising expenditure. The signs and significance of these coefficients are similar to those in the long-run equation. However, the absolute values of the coefficients on ΔP_{2000} and ΔPDI_{2000} are smaller than in the long-run equation, suggesting a less elastic price and income elasticity of demand. In fact, at the means, the short-run price and income elasticities of demand are estimated as -0.36 and 0.37, respectively.[25] The coefficient on the lagged ECM1 term (-0.38) implies that only 38 per cent of a disequilibrium error is eliminated in the following period. The coefficient on the lagged ECM2 term is positive but not statistically different from zero.

For the supply equation, the normalisation was done on P_{2000}, and thus the discussion will focus on price as the dependent variable, rather than quantity supplied. An increase in $EXCISE_{2000}$ increases the retail price, as one would expect. The coefficient of 1.01 suggests that the full amount of the tax increase is passed onto consumers in the form of a higher price. The positive coefficient on TOBPP suggests that a short-run change in the real price of raw tobacco leaf has an impact on the retail price. The coefficient on D92plus is positive and highly significant. The interpretation is that the retail price of cigarettes has increased by approximately 43 cents per packet each year since 1992, and that this increase is not accounted for by any of the other determinants included in the ECM. This result is expected, given the trend in the real industry price, shown in column 7 of Table 4.1, and the analysis of the industry's pricing strategy in chapter 5. The coefficient on the lagged value of ECM1 is -0.24 and highly significant, suggesting that deviations from equilibrium are eliminated rather gradually. The lagged coefficient on ECM2 is insignificant. With ECM1 referring to the long-run demand equation and ECM2 to the long-run supply equation, this analysis suggests that disequilibria in the cigarette market are solved by adjustments on the demand side, rather than on the supply side.

While the results from the ECM are interesting and potentially instructive, the regression results with the most policy impact are the long-run relationships. Tobacco control is a structural and long-term issue, and the results on tobacco production and consumption, and in particular smoking-related morbidity and mortality, are visible only over a period of decades, rather than months or even years. Being able to explain the movement from one short-run equilibrium to another, interesting though it is, is less important than being able to describe the longer term trends in the relevant variables.

25. The finding that the absolute values of the short-run elasticities are less than the absolute values of the long-run elasticities is consistent with the elasticities typically obtained from a rational, as well as a myopic, addiction model.

4.4.7 An alternative estimation approach

The Johansen approach has the distinct advantage in that it places fewer restrictions on the data than traditional econometric approaches, and allows one to investigate multi-equation systems in a structured way. Other than investigating the demand for cigarettes, the previous section also focused on the supply side. Unfortunately, because of a lack of data, the results were generally sensitive to specification changes, and thus have to be used with great care.

In this section an alternative approach to estimating the demand for cigarettes is presented. It is modest in that it does not use multi-equation estimation techniques, but takes a single-equation approach. This being the case, the estimates could suffer from simultaneity bias, although Hausman simultaneity tests suggest that the price could be regarded as exogenous (see below). The technique aims to estimate the ECM and the long-run equation simultaneously, but in a single equation context. It is based on the Engle-Granger two-step procedure (see footnote 9 and Harris and Sollis, 2003). However, where the Engle-Granger technique is sequential, the advantage of this approach is that the short-run and long-run coefficients are estimated jointly. The implication is that the short-run changes in the dependent variable are allowed to influence the long-run relation, while long-run disequilibrium effects are allowed to influence the short-term dynamics of the system. The ECM employs stationary data, which implies that the standard tests are applicable, and the relationship is not spurious (as could be the case with non-stationary data).

Instead of estimating the supply of cigarettes, this model assumes that the cigarette manufacturing industry sets the price of cigarettes exogenously, and that it will supply whatever quantity people demand at that price. It assumes that changes in the costs of the cigarette manufacturing industry do not have an impact on the retail price of cigarettes. Is there any empirical support for this assumption? Firstly, despite serious attempts to include cost factors other than $EXCISE_{2000}$ in the long-run supply equation in the previous analysis, none were found to be statistically significant. This "negative" finding might suggest that there is no consistent relationship between the retail price and the cost of manufacturing tobacco. Secondly, the real industry price (see column 7 of Table 4.1) has increased sharply since the early 1990s, but this increase in the industry price cannot be explained in terms of an increase in input costs (this aspect is discussed in detail in chapter 5). The industry price, and by implication the retail price, has apparently been set at a level that maintains (and even increases) the profitability of the cigarette industry, irrespective of changes in the cost structure of the industry. In fact, chapter 5 will show that, despite a sharp fall in cigarette consumption, real industry revenue has increased by about 20 per cent since the early 1990s. If this explanation holds, the supply curve can be presented as a horizontal line, where the industry sets the retail price, and supplies whatever is demanded at that price.

Given that the demand-related variables are all I(1), a stationary version of the quantity demanded can be represented in first difference form as follows:

$$\Delta Q_t = \alpha_0 + \alpha_1 \Delta P_t + \alpha_2 \Delta P_{t-1} + \alpha_3 \Delta P_{t-2} + \alpha_4 \Delta PDI_t + \alpha_5 \Delta PDI_{t-1} + \alpha_6 \Delta PDI_{t-2} + \alpha_7 \Delta AD_t + \alpha_8 \Delta AD_{t-1} + \alpha_9 \Delta AD_{t-2} + \alpha_{10} (Q_{t-1} - \beta_1 P_{t-1} - \beta_2 PDI_{t-1} - \beta_3 AD_{t-1}) + v_t, \quad (4.4)$$

where the variables are defined in Table 4.2. All relevant variables are in constant 2000 prices, but the subscripts denoting this have been suppressed for ease of reading.

The long-term relationship between consumption and its demand determinants is indicated in parentheses in equation (4.4). Deviations from long-run equilibrium are represented by the value of $(Q_{t-1} - \beta_1 P_{t-1} - \beta_2 PDI_{t-1} - \beta_3 AD_{t-1})$. The long-run price, income and advertising elasticities can be derived from the β coefficients. The α_{10} coefficient indicates the speed of adjustment to deviations from long-run equilibrium. The α_1 to α_9 coefficients indicate the dynamic responses of cigarette consumption to the demand determinants (Harris and Sollis, 2003: 93).

An issue of substantial importance is whether price is exogenously or endogenously determined. If price is endogenous, then the coefficients in equation (4.4) will be inconsistent when estimated using ordinary least squares. In contrast, in a VAR, all variables are assumed to be endogenous, and so the issue falls away. The Hausman test has been developed to test whether variables are endogenous or not (see Pindyck and Rubinfeld, 1998: 353-355).

From the demand and supply system presented in the previous sections, P_t can be represented in reduced form specification as a function of PDI_t, AD_t, $EXCISE_t$, $CR4_t$ and D82. Taking the residuals from this equation, one can then include them in the demand equation, specified in level terms:

$$Q_t = \gamma_0 + \gamma_1 P_t + \gamma_2 PDI_t + \gamma_3 AD_t + \gamma_4 \hat{e}_t + v_t, \quad (4.5)$$

where $\hat{e}_t = P_t - \beta_1 PDI_t - \beta_2 AD_t - \beta_3 EXCISE_t - \beta_4 CR4_t - \beta_5 D82. \quad (4.6)$

According to the Hausman test P_t is exogenously determined if γ_4 is not significantly different from zero, since this implies that that the correlation between $\hat{e}_t$ (which is the effect of P_t, "purified" of other factors that could affect it) and v_t is not statistically significant.

From the standard econometric texts it is unclear whether the Hausman test can be applied to non-stationary data, as well as stationary data (see Pindyck and Rubinfeld, 1998: 353-354). To ensure that the relationships are not spurious, the Hausman test was also applied to stationary data, i.e. where the relevant data in equations (4.5) and (4.6) are presented in first differences. The results are shown in Table 4.8

Table 4.8: Hausman tests to determine whether the price of cigarettes is endogenous or exogenous

Dependent variable	Q_t	Dependent variable	ΔQ_t
Independent variables	Coefficient (t-statistic)	Independent variables	Coefficient (t-statistic)
Constant	1324.2***	Constant	19.88
	(11.86)		(1.28)
P_t	-2.14***	ΔP_t	-1.56***
	(-12.15)		(-3.48)
PDI_t	2.96***	ΔPDI_t	0.82
	(19.83)		(0.88)
AD_t	0.34	ΔAD_t	0.69
	(0.70)		(0.98)
$\hat{e}_t = P_t - \beta_1 PDI_t - \beta_2 AD_t - \beta_3 EXCISE_t - \beta_4 CR4_t - \beta_5 D82_t$	1.27* (1.82)	$\hat{e}_t = \Delta P_t - \beta_1 \Delta PDI_t - \beta_2 \Delta AD_t - \beta_3 \Delta EXCISE_t - \beta_4 \Delta CR4_t - \beta_5 D82_t$	0.97 (1.38)
Adjusted R^2-value	0.963	Adjusted R^2-value	0.422
DW-statistic	0.99	DW-statistic	1.89

Notes: *** Significant at the 1 per cent level
* Significant at the 10 per cent level (all tests are two-sided).

In the Hausman test where the variables are specified in levels, the test is not conclusive. The null hypothesis that P_t is exogenous can be rejected at the 10 per cent level but not at the 5 per cent level. For the Hausman test specified in first differences, one can conclude that P_t is exogenous. While the evidence is admittedly not overwhelming either way, the analysis proceeds on the premise that the price of cigarettes is indeed exogenously determined.

The implication of this finding is that one would not require a multiple equation approach to model the demand for cigarettes. The quantity of cigarettes demanded is the only endogenous variable, specified as a function of a number of exogenous variables.

Table 4.9 presents the regression results of three alternative specifications of model (4.4). Model 1 is a more parsimonious version of model (4.4), and includes only one lag on the differenced variables. In model 2 two variables are added, i.e. D82 (to account for an outlier, see footnote 21) and D92plus (a dummy variable taking the value of one from 1992 forward). D92plus aims to account for tobacco control measures other than the increases in the excise tax, which started taking effect in the early 1990s. Model 3 has a more generous specification than the previous two, with more lagged difference variables and D82 and D92plus included.

Other than the fact that model 2 seems to suffer from model misspecification, there are no compelling reasons why one model is significantly better than the others. All three models are presented to indicate the sensitivity of the results to changes in the specification.

Table 4.9: Single-equation demand estimation

Dependent variable: ΔQ_t	Coefficients (t-values in parentheses)		
Explanatory variables	Model 1	Model 2	Model 3
Constant	904.85**	678.02**	836.89**
	(2.67)	(2.59)	(2.83)
ΔQ_{t-1}	0.414**	0.102	0.105
	(2.12)	(0.63)	(0.59)
ΔP_t	-1.016**	-0.749**	-0.900**
	(-2.55)	(-2.30)	(-2.58)
ΔP_{t-1}	-0.069	-0.158	-0.073
	(-0.12)	(-0.37)	(-0.15)
ΔP_{t-2}			0.401
			(0.88)
ΔPDI_t	1.300	1.630**	1.310
	(1.51)	(2.54)	(1.65)
ΔPDI_{t-1}	-1.538	-0.835	1.162
	(-1.71)	(-1.19)	(-1.46)
ΔPDI_{t-2}			-0.847
			(-0.86)
ΔAD_t	-0.237	0.541	0.683
	(-0.29)	(0.80)	(0.95)
ΔAD_{t-1}	-0.337	-0.296	0.195
	(-0.36)	(-0.43)	(0.23)
ΔAD_{t-2}			1.10
			(1.43)
D82		141.77***	178.14***
		(3.20)	(3.21)
D92plus		-96.55**	-112.88**
		(-2.64)	(-2.85)
Q_{t-1}	-0.592***	-0.544***	-0.649***
	(-2.98)	(-3.71)	(-3.96)
P_{t-1}	-1.357**	-1.131***	-1.424***
	(-2.62)	(-2.91)	(-3.23)
PDI_{t-1}	1.738**	1.814***	2.385***
	(2.71)	(3.71)	(3.68)
AD_{t-1}	-0.198	0.111	-0.38
	(-0.31)	(0.22)	(-0.65)
R^2 statistic	0.732	0.869	0.888
Adjusted R^2 statistic	0.584	0.774	0.769
Durbin-Watson statistic	2.05	1.55	1.75
Ramsey RESET test	$F(1,19) = 3.34^{*}$	$F(1,17) = 8.75^{***}$	$F(1,14) = 3.70^{*}$
	[0.083]	[0.009]	[0.075]
Jarque-Bera normality test	$\chi^2(2) = 0.73$	$\chi^2(2) = 0.06$	$\chi^2(2) = 1.55$
	[0.695]	[0.968]	[0.460]
White heteroscedasticity test	F(1,30) = 0.003	F(1,30) = 0.271	F(1,30) = 0.017
	[0.955]	[0.607]	[0.896]

Note: Probability values are shown in square parentheses

In the dynamic components of the three models presented, the evidence suggests that there is a statistically significant negative relationship between changes in the retail price and changes in cigarette consumption. This is to be expected. Regarding the relationship between changes in personal disposable income and changes in cigarette consumption, the statistical evidence is less conclusive, but the weight of evidence seems to support a positive relationship. There is no evidence of any meaningful relationship between changes in advertising expenditure and changes in cigarette consumption. This result is consistent with the findings in the previous VAR analysis. The coefficient on D92plus is consistently and significantly negative. The interpretation of this coefficient is that non-excise related tobacco control measures decreased cigarette consumption by approximately 100 million packs of cigarettes per year between 1992 and 2002.

While the dynamics of the model convey some information, the main focus of this analysis is on the long-run relationships, i.e. on the coefficients on the lagged variables in level terms. In order to obtain meaningful and interpretable coefficients on P, PDI and AD, the coefficients were normalised on Q.[26] These normalised coefficients, as well as the relevant elasticities at the means, are presented in Table 4.10.

In all three specifications of the model the coefficients on price and income were highly significant. The estimated price elasticity of demand (calculated at the means) varied between -0.74 and -0.81, depending on the specification of the model. The absolute value of these estimates are slightly lower than the price elasticity estimate of -0.99, obtained using the systems estimation approach. However, as was pointed out in Section 4.4.5, alternative specifications of the systems approach often yielded price elasticity estimates in the -0.70 to -0.90 range. The estimated income elasticity of demand using the single equation approach varied between 0.80 and 1.00, suggesting that cigarettes are a normal good. These estimates are of the same magnitude as those obtained with the multi-equation system approach (ε_Y = 0.82).

As was the case with the systems estimation approach, no significant relationship was found between advertising expenditure and cigarette consumption. The advertising elasticity estimates are presented in Table 4.10 for the sake of completeness only; the analysis did not find any evidence to suggest that aggregate advertising expenditure has a consistent impact on total cigarette consumption.

26. For example, the long-run component in Model 1 is estimated as $-0.592\ Q_{t-1} - 1.357\ P_{t-1} + 1.738\ PDI_{t-1} - 0.198\ AD_{t-1}$. Normalising on Q_{t-1} means that this relationship can be presented as $-0.592\ (Q_{t-1} + 2.292\ P_{t-1} - 2.936\ PDI_{t-1} + 0.334\ AD_{t-1})$.

Table 4.10: Normalised long-run demand equations and relevant elasticities

	Model 1	Model 2	Model 3
Normalised coefficient on			
P_{t-1}	2.29	2.08	2.19
PDI_{t-1}	-2.94	-3.33	-3.67
AD_{t-1}	0.33	-0.20	0.58
Elasticity estimates			
Price	-0.81	-0.74	-0.78
Income	0.80	0.91	1.00
Advertising	-0.02	0.02	-0.05

4.5 Conclusion

The aim of this chapter was to investigate the demand for cigarettes in South Africa. In the descriptive section it was shown that the demand for cigarettes has been decreasing sharply since the early 1990s, reversing a trend of rapidly increasing cigarette consumption during the 1970s and 1980s. The sharp increase in the real retail price of cigarettes since the early 1990s was triggered by rapid increases in the excise tax, but the industry also aided the process by increasing the real retail price by far more than the increase in the excise tax.

Despite the fact that cigarette consumption decreased by about a third since the early 1990s, total real government revenue from cigarette excise taxes more than doubled as a result of the sharp increase in the real excise tax per pack.

In order to understand the magnitudes of the relationships between the tobacco-related variables and other determinants, a cointegration analysis was performed using the Johansen technique. This proved to be difficult and frustrating because with only thirty-two annual observations available, the results were very fragile. Relatively small changes to the specification of the system and/or the time period yielded significantly different results. As an alternative, a single equation estimation methodology was applied and gave surprisingly similar results on the demand side. Some results from the systems approach seem to be relatively robust: (1) the real price (negative) and real income (positive) have a strong impact on the demand for cigarettes; (2) the quantity supplied is negatively affected by an increase in the excise tax; (3) no readily available input cost factor was found to have a significant impact on the quantity supplied, and (4) no evidence was found to suggest that advertising expenditure is significantly related to cigarette consumption.

In previous studies (see Van Walbeek, 1996, and ETCSA, 2003) the analysis of demand was used to estimate the relationship between cigarette excise tax increases and likely tax revenues to be gained. In chapter 5 the impact of past excise tax changes on cigarette prices, consumption and government revenue is investigated, and some simulation analyses on possible future scenarios are presented. Furthermore, as has been alluded to before, the reaction of the cigarette manufacturing industry to the excise tax increases of the past decade has been very interesting and deserves further attention.