# A system dynamics pilot study to demonstrate the impact of border intervention on tobacco related activities in New Zealand

Robert Y. Cavana[a], Frances M. Broatch[b] & Leslie V. Clifford[b]

[a]Victoria University of Wellington, PO Box 600, Wellington, New Zealand.
Email: bob.cavana@vuw.ac.nz

[b]New Zealand Customs Service, PO Box 2218, Wellington, New Zealand.
Email: Frances.Broatch@customs.govt.nz & Leslie.Clifford@customs.govt.nz

*Abstract*

This paper summarises the collaborative work undertaken by a group from Victoria University, the NZ Customs Service (NZCS) and the NZ Ministry of Health. It shows how the system dynamics methodology was used to demonstrate the value of the relationship of Customs outputs to desired Government outcomes in relation to the collection of tobacco excise duties and cigarette smoking in New Zealand. Group model building workshops addressed the organising question: "*What are the affects of price on tobacco consumption in New Zealand*?". A demonstration system dynamics simulation model using the ***ithink*** dynamic simulation software was developed, consisting of 7 sectors: NZCS Air & Marine sector; duty paid cigarette imports; duty free cigarettes; NZ tobacco manufacturing sector; NZCS duty collection; NZ tobacco products market; and a health sector. The model variables are simulated on an annual basis from 2000 to 2010. Policy experiments with the model include examining the effects of changes in tobacco excise duties.

## Introduction

This paper discusses the system dynamics (SD) pilot study undertaken as part of the NZ Customs Service (2002) Demonstrating Value Project, involving NZCS and Ministry of Health (MOH) personnel. The SD study was used to answer research questions that :

- focused on causality between Customs' outputs and Government's desired outcomes; &
- where Customs' border and excise interventions fit into/affect related cross agency intervention strategy.

An outcome as described in the Public Finance Act is the impacts on, or the consequences for, the community of the output or activities of the Government. Two outcomes desired by Government were considered in this project:

(a) NZCS outcome – collection of tobacco excise & import duties
Government legislation that states how much excise/duty is to be collected on tobacco products that come across the boarder influences this outcome is one example.

(b) MOH outcome – reduce smoking in NZ
This outcome is influenced for example by media-led tobacco cessation campaigns that increase awareness of the harm of smoking.

Examples of the research questions examined within this project include:

- What influences the desired outcomes?
- How do the variables interact and with what sensitivity?
- How will the activity level change if funding increases/decreases?
- What is the level of outcome risk present immediately after Customs intervention?
- What is the impact on Outcome A of an increase/reduction in resourcing for Customs' Output Z of, say 10%?

The system dynamics methodology (eg see Forrester, 1961; Coyle, 1996; Sterman, 2000) was used for this project since earlier work by Cavana and Clifford (1998, 1999) had demonstrated the potential of the methodology, particularly the qualitative aspects, of addressing complex problems involving relationships between Government inputs, outputs and outcomes. The general approach used in this project is based on the recent book, '*Systems Thinking & Modelling: Understanding Change & Uncertainty*" by Maani and Cavana (2000) The following five phases were used in this project:

Figure 1. Systems thinking and modelling methodology

| **Phases** | |
|---|---|
| 1 | Problem Structuring |
| 2 | Causal Loop Modelling |
| 3 | Dynamic Modelling |
| 4 | Scenario Planning and Modelling |
| 5 | Implementation and Organisational Learning |

*Source*: Maani and Cavana (2000, Table 2.1, p16)

This paper outlines a number of aspects of this project. This includes the group model building workshops and development of causal loop diagrams. This is followed by an outline of the simulation model, plus the base case run of the model. A policy experiment involving an increase in the tobacco excise duties is presented next, followed by some concluding comments.

**Problem structuring**

Following the initial setting up of the project, the problem structuring phase involved mainly the group model building workshops, which were held in March/April 2002. These were facilitated by the VUW co-author and involving about 12 people (9 from NZCS and 3 from MOH). A couple of training sessions were held first including the development of causal loop diagrams, then a group workshop was to address the organising question:

"*What are the affects of price on tobacco consumption in New Zealand*?"

Rationale for this question was that it involved an important area of revenue collection by NZCS on behalf of the Government. It also involved officials from Ministry of Health, because of their concerns of the health implications of tobacco consumption.

Hexagons were used as a facilitation tool to write down the group issues/concepts that were identified as being of relevance to the topic. These were then clustered into groups with similar issues/concepts etc. The method used is outlined in Cavana *et al* (1999), and Maani and Cavana (2000), based on the work of Hodgson (1994) and Kreutzer (1995).

The workshop group developed the following clusters. Two clusters are presented for illustrative purposes. Figure 1 represents a cluster with some of the NZCS issues/concerns expressed, and Figure 2 is a cluster with some of the health related issues etc grouped:

- Illegal Activities
- Demand Factors
- Production/Supply Factors
- Tobacco Products & Utensils
- State Intervention Methods
- Whole of Government Approach
- Market Outcomes
- Customs (see Figure 1)
- Health Related Consequences & Treatments (see Figure 2)
- Research Issues & Activity
- Social Influence Factors

In Figures 1 & 2 below, factors that were chosen as initial ideas/concepts/issues/concerns are shown as numbered clear hexagons. The numbered hexagons that are shaded were the ones that were strong held views of the individuals

who chose them, and the ones with the doubled lined hexagons (without numbers) are the variables chosen for the initial causal loop modelling, and subsequent dynamic modelling.

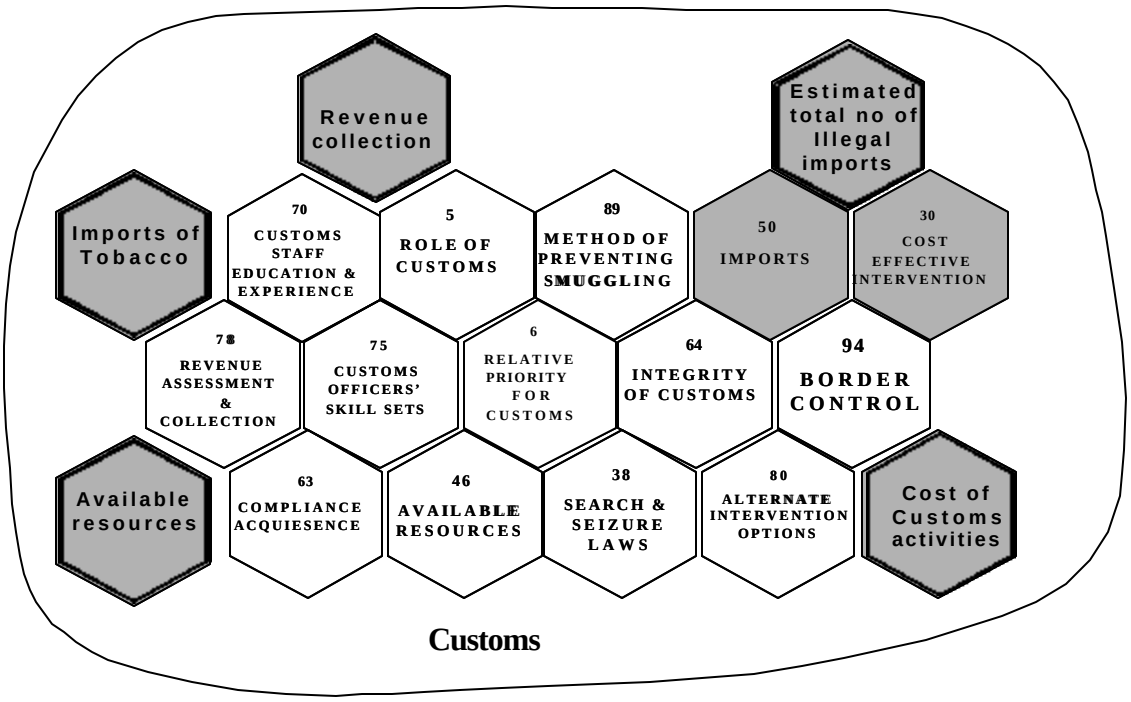


Figure 1. Example of a cluster related to Customs issues

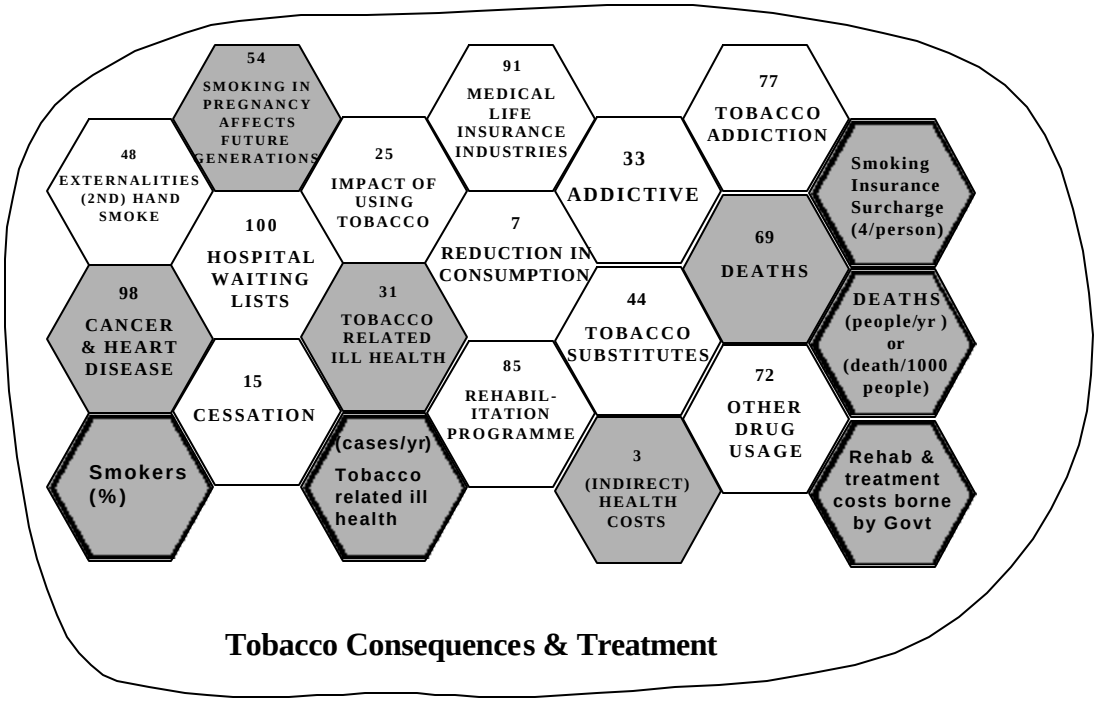


Figure 2. Example of a cluster related to Health issues

## Causal loop modelling

From the clusters created in the group model building workshops, a small number of variables associated with each cluster were identified by the group members. Once these had been identified the chosen variables were used in the next process, which was developing an initial causal loop diagram (CLD). This initially involved identifying the 'pairs' of variables that were linked, then determining whether changes between the variables were in the same (s) direction, or in the opposite (o) direction.

The initial CLD was built with some of the variables that were chosen from each cluster as important by group members. These variables were then linked together to form a provisional CLD. Figure 3 below shows the initial CLD diagram for the NZ tobacco products industry, which gives a framework for seeing the interrelationships between a set of variables (or factors) operating on the tobacco industry and associated consumption.

Some variables were not explicitly stated in the initial CLD. For example Health Sector variables; but implicitly included in the variables:

Social acceptability – public perception
WoG ? tobacco related activities (WoG = whole of Government)

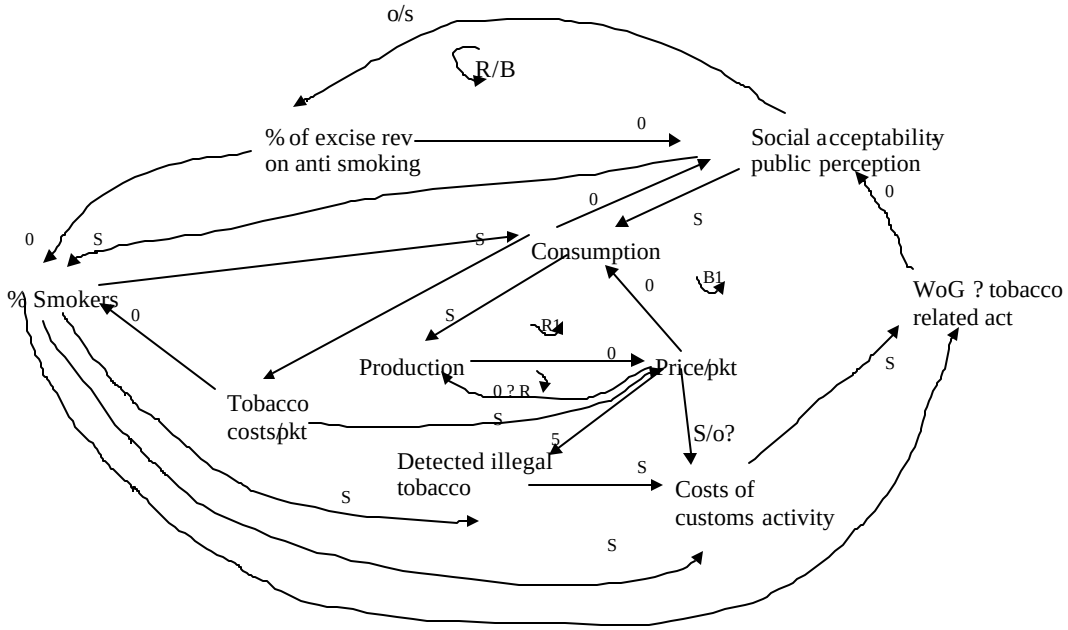


Figure 3. Initial CLD for the NZCS Tobacco Demo SD model

The initial CLD contained a range of balancing and reinforcing loops. The reinforcing loops are engines of growth, driving a system at an ever-increasing rate either

up or down. The balancing feedback loops in the system have the effect of slowing or switching the direction of some of the reinforcing loops.

Also the direction of the causal links between a number of variables was at first unclear, hence the 'o/s' notation on a number of links.

This diagram was amended continually in the process of dynamic modelling, as different variables originally seen to be necessary, were determined to be no longer relevant or vice versa. For example '% of excise revenue on anti-smoking' was a variable in the initial CLD but not in the final CLD, which appears in Figure 4.

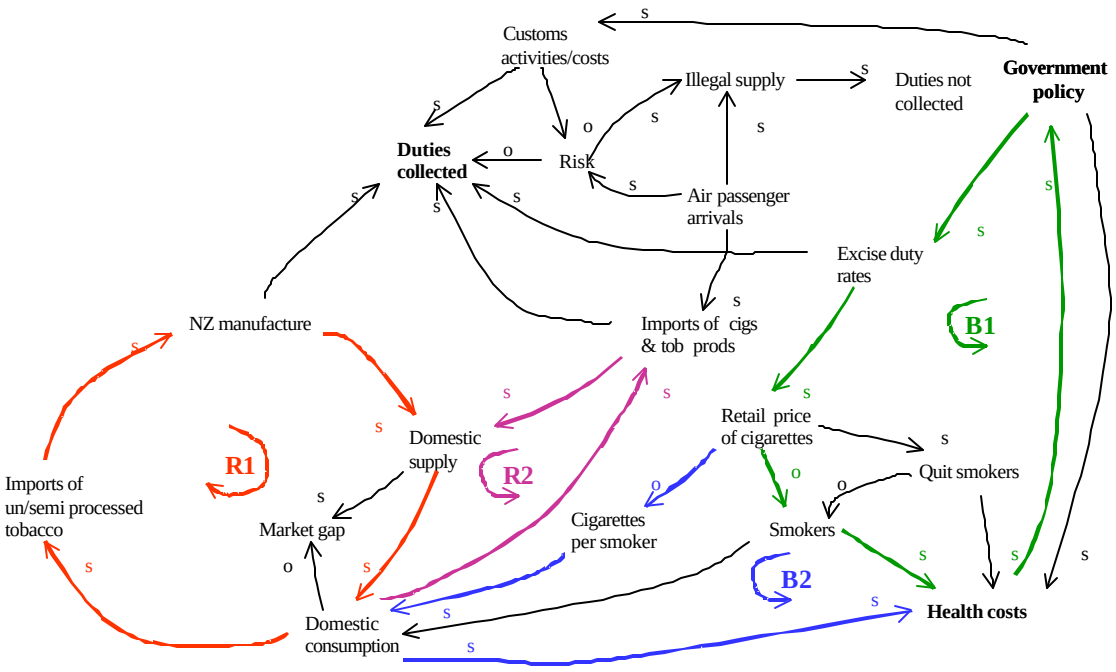


Figure 4. Simplified causal loop diagram for the NZCS tobacco demo SD model

This simplified causal loop diagram provides a "whole of government" view of how price influences the use and consequences of tobacco. This diagram gives somewhat more detail for Customs interventions than other variables and shows illegal supply only in the context of Customs' Air and Marine activities.

In brief it shows the following:

- domestic consumption influences tobacco imports and local manufacture that provides domestic supply
- from the New Zealand manufacture, duties are collected which involve Customs in activity and cost
- Customs activity arises from Government Policy which sets the excise rates, which influence the quantum collected

- Customs activities relate to risk – in this instance the risk of undeclared imports from air passengers
- The excise rate influences retail price, which influences cigarette consumption and the number of smokers generating health costs.

The main reinforcing feedback loops are:
*Loop R1* - Reinforcing or growth loop linking *domestic consumption* with the import of unprocessed or semi-processed tobacco, and the manufacturing of tobacco products in NZ.
*Loop R2* - Reinforcing loop linking *domestic consumption* with the imports of cigarettes and tobacco products.

The main balancing feedback loops are:
*Loop B1* – Balancing or control loop linking **Gov't policy** regarding excise duties on cigarettes, and the impact on the *average number of cigarettes smoked per smoker* and the subsequent health costs.
*Loop B2* - Balancing loop linking **Gov't policy** regarding excise duties on cigarettes, and the impact on the *number of smokers* and the subsequent health costs.

## Dynamic modelling

*Overview of the tobacco demo model*

Following the group model building exercise, a smaller number of NZCS and MOH participants continued with developing the NZCS tobacco demonstration SD model. Responsibility was allocated to three subgroups to develop separate models for:

- The NZ tobacco industry sub-model – NZ tobacco manufacturing sector, Duty paid cigarette imports, Duty free cigarettes, NZCS duty collection, NZ Tobacco products market.
- Customs sub-model - NZCS Air & Marine sector
- Health sub-model - Health sector

The three separate sub-models were developed under the supervision of the VUW co-author. Then these were combined into a single SD simulation model. An overview of the main sectors in this model is provided in Figure 5. This figure shows the information flows (thin lines) and physical flows (solid lines) between the different sectors.

The stock flow diagrams and documented equations for the system dynamics simulation model are provided in the Annex by Cavana, Broatch & Clifford (2002) to NZCS (2002). The model simulates values of the model variables on an annual basis from 2000 to 2010. Input data for the model has been collected from Customs and Health personnel, as well as officially published statistics where they exist. The model is developed on the computer using the ***ithink*** dynamic simulation software (Richmond & Peterson, 2001).

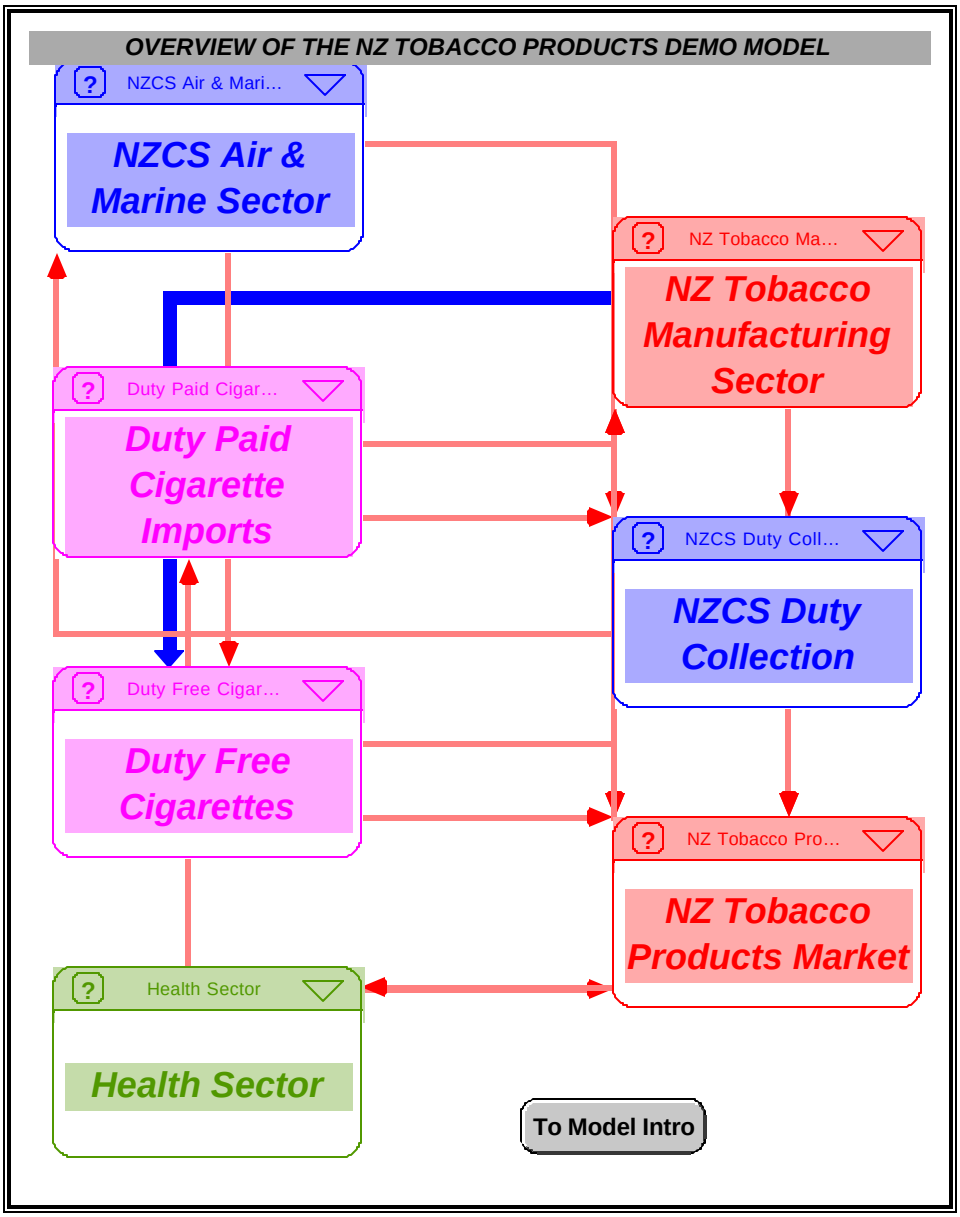


Figure 5. Overview of the NZCS tobacco demo SD model

Brief descriptions are provided for each of these sectors:

- *NZ Tobacco Manufacturing* –this sector consists of imports, exports, and stocks of un-manufactured and semi manufactured tobacco (see Figure 6).

The tobacco is then processed into both cigarettes and loose tobacco which is sold to New Zealand retailers, to the duty free stores or exported. It is assumed that 3 months stocks are held of unprocessed tobacco and processed tobacco products.

- *Duty Free Cigarettes* – duty free cigarettes and tobacco are imported direct or obtained from the NZ manufacturers (see Figure 6).

  These stocks are sold to arriving and departing passengers.

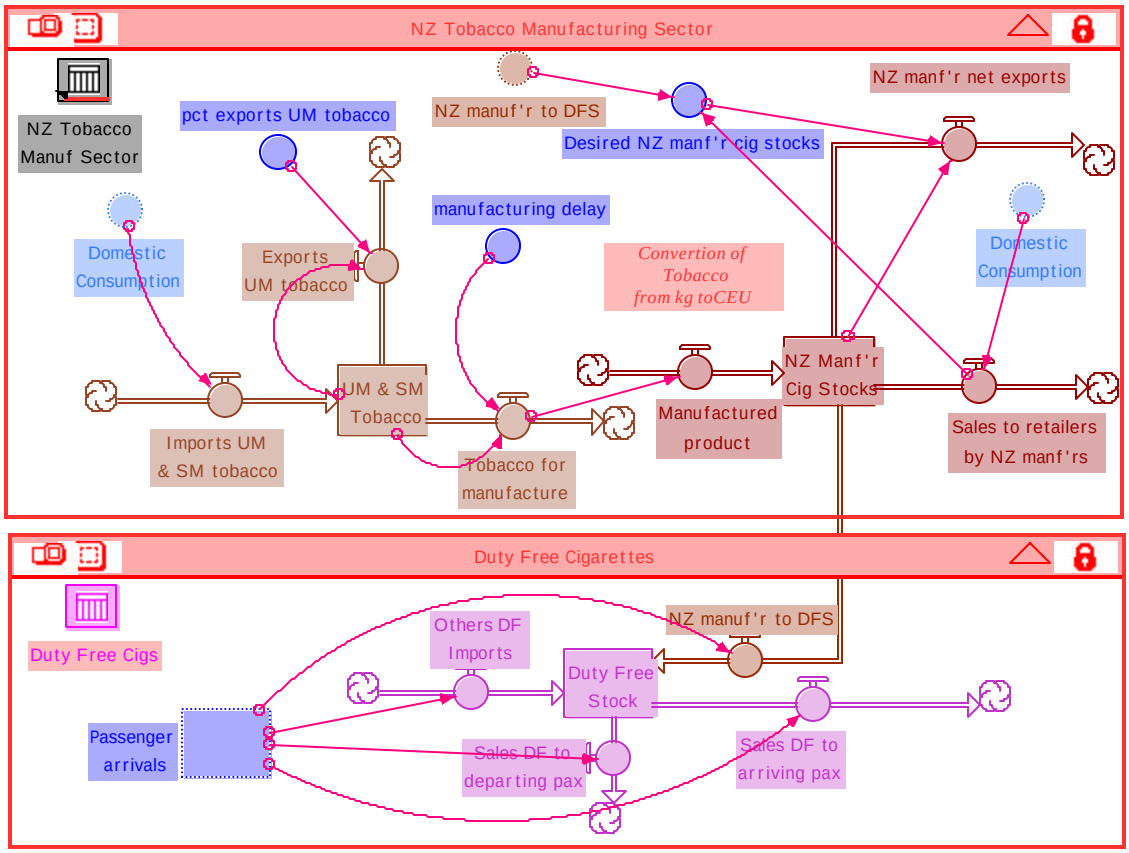


Figure 6. Stock flow diagrams for the NZ tobacco manufacturing & duty free cigarette sectors

- *Duty Paid Cigarette Imports* – cigarettes and final tobacco products are also imported with import and excise duties paid on importation.

  Some of these imports (about 10%) are re-exported with duties refunded (drawbacks) and the remainder are sold to the New Zealand public.

- *NZCS Duty Collection* – this sector provides the calculations for the excise and import duties collected on:

  - tobacco products manufactured in New Zealand and sold to retailers
  - cigarette and tobacco products imported with duties paid at the border (less drawbacks on re-exports)
  - duties and fines collected on detected illegal imports by arriving passengers to NZ.

  The excise duty in 2000 is assumed to be $254/CEU (ie per 1000 cigarettes or 1000 grams (1 kg) of loose tobacco not for further manufacture) and duties on imported final tobacco products is assumed to be $283/CEU (including an advalorem tariff of 5% max).

  These duties are weighted averages based on the initial composition of cigarettes and other tobacco products that have slightly different duty rates. The NZ Customs Service is responsible for excise and import duty collection on all tobacco products.

- *NZCS Air and Marine* – this sector includes equations for air passenger arrivals and the Air & Marine (A & M) passenger processing activities and costs at the NZ airports (see Figure 7).

  This includes a simplified index for A & M passenger processing activities. For the purposes of this pilot model, the 2000/01 level of Air & Marine passenger processing activity is assumed to be 100. We have used an index since this activity includes a range of A & M activities at NZ airports, including passenger profiling, questioning and searching (personal & baggage); writing up seizures; and receipting moneys collected.

  Estimates of A & M passenger processing costs in 2000 are provided in the model. The average A&M CO/SCO salary is doubled to account for overhead/resource costs etc. An estimated number of A & M staff are involved in airport passenger profiling & detection activities. However, it should be emphasised that only a small percentage of these costs are allocated to tobacco related activities.

  This sector also includes variables for tobacco detections, detected cigarettes destroyed, and estimates for cigarettes undeclared by arriving passengers.

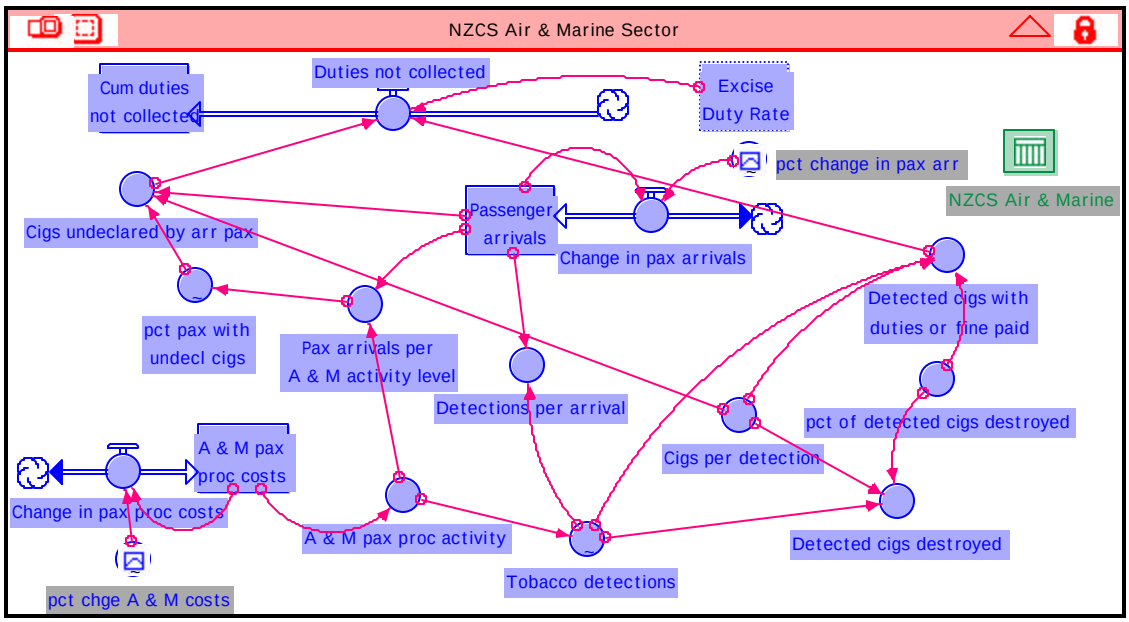


Figure 7. Stock flow diagrams for the NZCS Air & Marine sector

- *NZ Tobacco Products Market* – the legal domestic supply of cigarettes and tobacco products consists of sales to retailers by NZ manufacturers, duty paid imports sold to consumers, duty free cigarettes sold to arriving air passengers into NZ, and detected cigarettes with duties or fines paid.

  Domestic consumption consists of smoking by the population over 15 years of age, and estimates for under age smoking. Based on a weighted average of survey data it is assumed that smokers over 15 consume an average of 12.3 cigarettes per day in 2000, and under 15 year smokers consume an average of 3 cigarettes per day. Equations are included to incorporate the change in price (excise duties) on cigarette consumption.

  A price elasticity of demand of -0.6 is assumed based on NZ and international data. (This is "the extent to which consumers' demand for a good changes in response to a price change" (Jha & Chaloupka, 1999, p41)

  Finally the market gap is estimated by the 'legal' estimated domestic supply less the estimated domestic consumption of cigarettes & 'roll your own' (RYO) tobacco pa. When the 'market gap' is positive, this suggests that domestic supply exceeds domestic consumption; whereas when the 'gap' is negative, this suggests that consumption is higher than domestic 'legal' supply, hence the presence of a 'black market' or illegal market for cigarettes and tobacco in New Zealand.

- *Health* – the health sector in the model (see Figure 8) includes estimates for the numbers of smokers and quit smokers in New Zealand, and the primary and secondary care activity and costs of smoking related illnesses. In 2000 it is estimated

that about 25% of the population of 15 and above are smokers and quit smokers (nearly 740,000 in each category).

It is assumed that the average for people starting to smoke is about 16 years old, and 36% of this cohort start smoking. It is also assumed that the average age of deaths is 80 years for 'never smokers', 74 years for 'quit smokers' and 70 years for 'smokers'.

No net population increase is attributable to immigration in this model.

It is assumed that half the effect of a change in excise duties will increase the quit smoking rate and the other half will affect the average number of cigarettes smoked per day. Estimates are provided for smoking related visits to General Practitioners, and referrals involving hospitalisation and the associated costs.

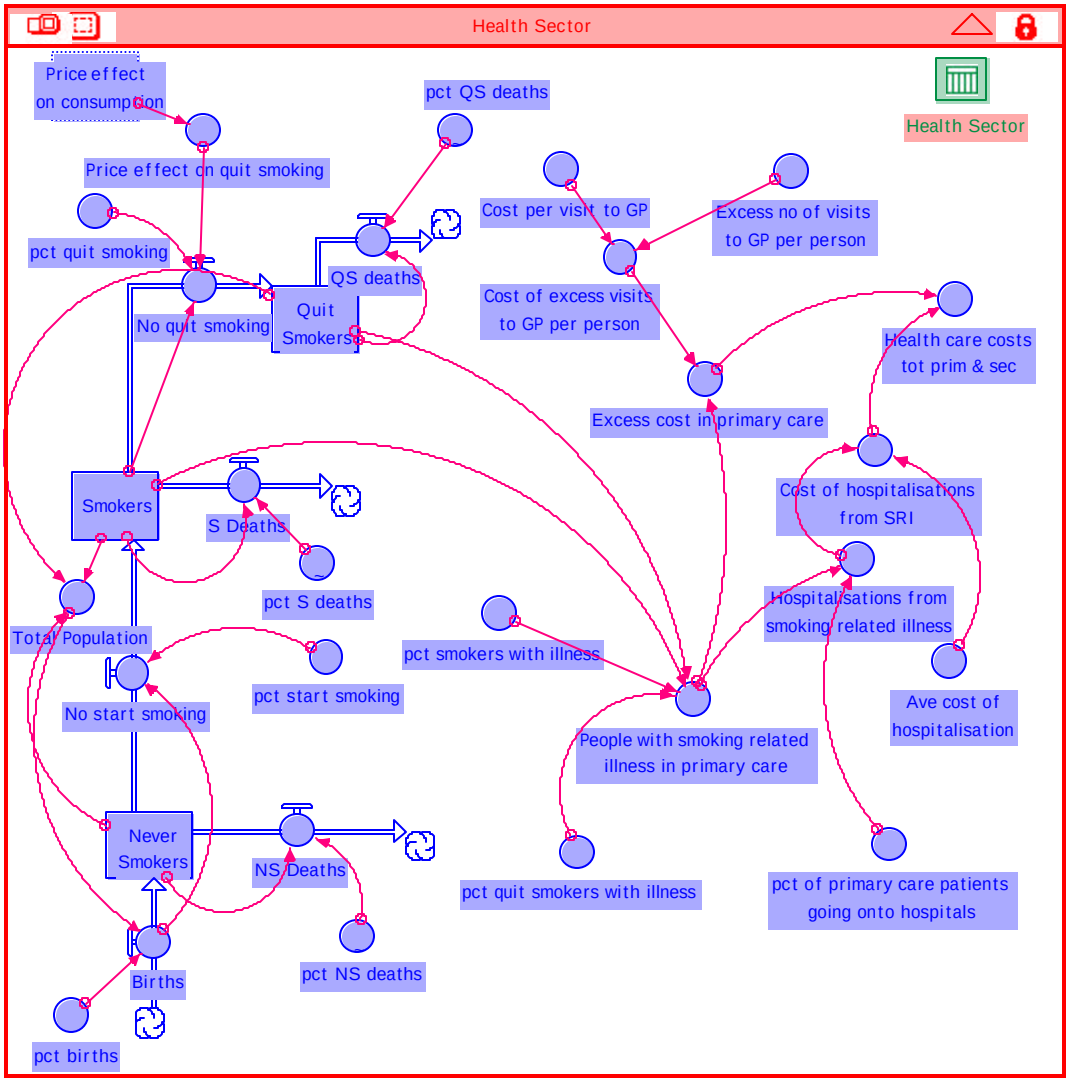


Figure 8. Stock flow diagram for the health sector

Note: the system dynamics model was developed to demonstrate how the system dynamics methodology could be utilised to explore the type of policy and research questions that the NZCS demonstrating value project is concerned with. The model is a 'prototype' only, hence does not contain all the variables and relationships that would be necessary to answer the research questions in depth. Hence the model provides indicative results only, and the discussions of the research questions in Cavana et al. (2002) are based on the prototype model as developed and not any additional information.

However, the model can be developed subsequently to provide more robust answers to specific research questions. The model is designed to start simulation in 2000 and to run for 10 years until 2010. Data for constants, graphs and relationships are estimated for the year 2000, and all assumptions are provided in the documented equations for the model. Monetary values in the model are expressed in constant $2000 (New Zealand dollars). The model generates data on an annual basis but estimates can also be generated on a quarter yearly basis. Also cumulated totals can be provided over the 10-year simulation run.

*User Interface for the Model*

The user interface for the model is provided in Figure 9. This shows the policy parameters that can be adjusted readily by the policy analysts, managers, or others experimenting with the model. (eg percentage change in Air & Marine passenger processing costs, or percent change in excise duty rates). Also sensitivity analysis and scenario analysis can be undertaken by undertaking 'what if' experiments with the user interface (ie changing the assumptions regarding cigarettes smoked per day, price elasticity of demand, or passenger arrivals to New Zealand). The final values for some of the main variables and performance measures are also provided after simulating the model to 2010. Graphical and tabular output are provided for selected variables also.

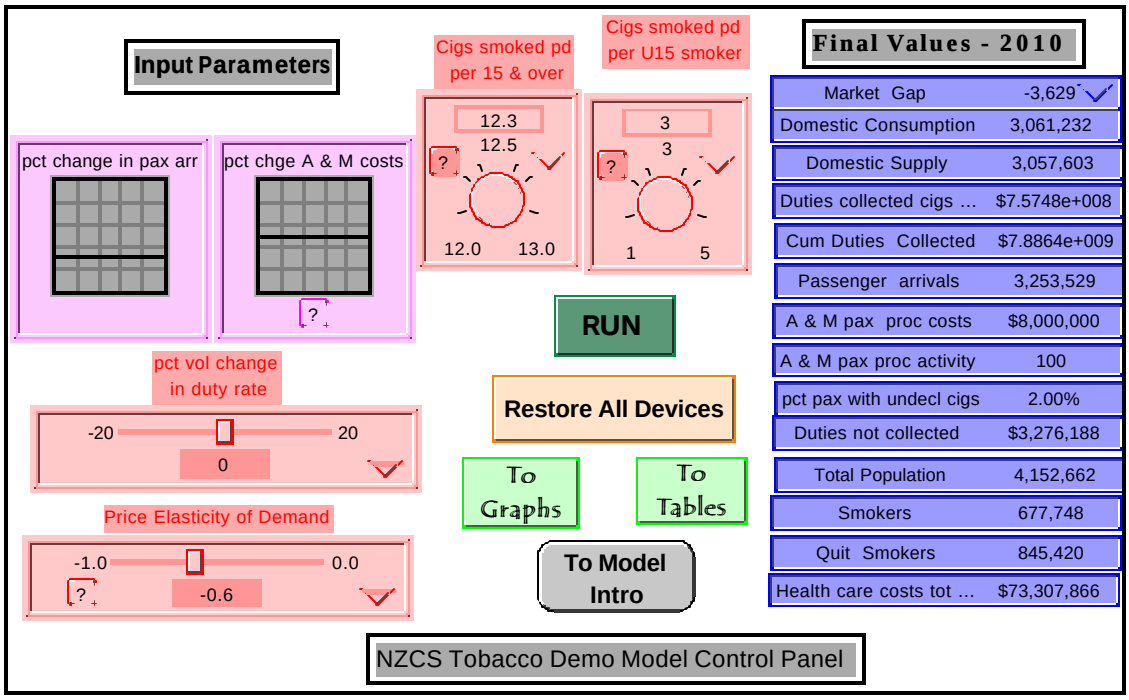


Figure 9. User interface for the NZCS tobacco demo SD model

## Base case run of the model

The model output for selected variables for the base case run of the model is provided below in Figure 10 and Table 2. The base case run is the output from the simulation run from 2000 to 2010 with the initial set of model assumptions (as shown in the documented model equations in Appendix 4 to Cavana et al. 2002).

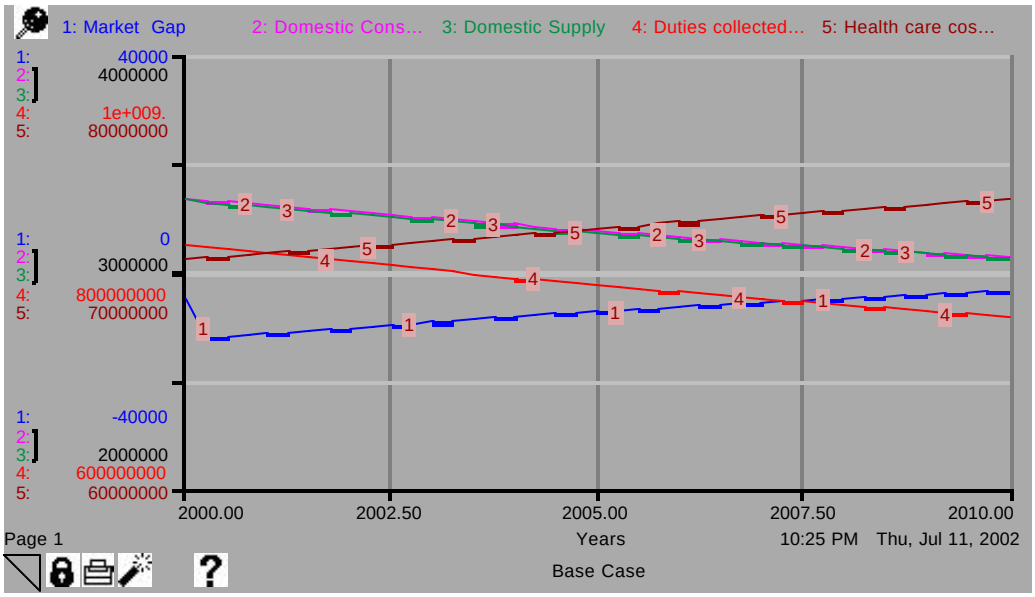


Figure 10: Base case run for the NZCS tobacco demo SD model

Figure 10 shows that the domestic consumption and domestic supply of tobacco products, and excise duties collected by NZ Customs Service are expected to steadily decrease between 2000 and 2010. Health costs are steadily increasing and the 'market gap' ie the difference between legal supply and consumption of tobacco products declines initially (due to the initial model conditions), but increases thereafter. Since the gap is negative, this implies that consumption is higher than legal supply over the 10 year period, suggesting the presence of a small illegal or 'black market' for tobacco products in New Zealand. The reasons for this model output are explained more fully following the discussion of the values contained in Table 2 below.

Table 2. NZCS tobacco demo SD model - Base Case

| Year | Duties collected on cigs & tobacco ($million/yr) | Cumulated Duties Collected ($million) | Market Gap (CEU/yr) | Percent market gap (%) | Domestic Consumption (million CEU/yr) | Domestic Supply (million CEU/yr) | Passenger arrivals (million people/yr) | Total Population (million people) | Smokers (000 people) | Quit Smokers (000 people) | Health care costs - total primary & secondary ($million/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | $824 | $0 | -5,288 | -0.16% | 3.334 | 3.329 | 3.25 | 3.83 | 739 | 739 | $70.50 |
| 2001 | $816 | $821 | -11,676 | -0.35% | 3.302 | 3.291 | 3.25 | 3.86 | 731 | 750 | $70.79 |
| 2002 | $808 | $1,633 | -10,648 | -0.33% | 3.272 | 3.261 | 3.25 | 3.89 | 725 | 762 | $71.09 |
| 2003 | $801 | $2,439 | -9,655 | -0.30% | 3.242 | 3.232 | 3.25 | 3.92 | 718 | 773 | $71.38 |
| 2004 | $794 | $3,237 | -8,696 | -0.27% | 3.213 | 3.205 | 3.25 | 3.96 | 712 | 784 | $71.66 |
| 2005 | $787 | $4,028 | -7,770 | -0.24% | 3.185 | 3.178 | 3.25 | 3.99 | 705 | 795 | $71.94 |
| 2006 | $780 | $4,812 | -6,876 | -0.22% | 3.159 | 3.152 | 3.25 | 4.02 | 699 | 806 | $72.22 |
| 2007 | $774 | $5,590 | -6,013 | -0.19% | 3.133 | 3.127 | 3.25 | 4.05 | 694 | 816 | $72.50 |
| 2008 | $768 | $6,361 | -5,183 | -0.17% | 3.108 | 3.103 | 3.25 | 4.09 | 688 | 826 | $72.77 |
| 2009 | $762 | $7,127 | -4,387 | -0.14% | 3.084 | 3.080 | 3.25 | 4.12 | 683 | 836 | $73.04 |
| 2010 | $756 | $7,886 | -3,629 | -0.12% | 3.061 | 3.058 | 3.25 | 4.15 | 678 | 845 | $73.31 |

This table shows that although the total New Zealand population is steadily increasing during the simulation run from 3.83 million in 2000 to 4.15 million in 2010, the number of smokers is declining from 739,000 in 2000 to 678,000 in 2010. This is causing a decline in the domestic consumption of cigarettes and other tobacco products, from 3.334 to 3.061 million CEUs[1] (1 CEU = 1000 cigarette equivalents) over this period. Since domestic cigarette production and imports of duty paid cigarettes is linked to consumption then the 'legal' domestic supply of tobacco products also declines from 3.329 to 3.058 million CEUs from 2000 to 2010. However, throughout the simulation run there is a gap between the 'legal' domestic supply and the domestic consumption of tobacco products (a negative gap indicates consumption is greater than supply, and a positive gap indicates supply is greater than consumption). This starts out as 5,288 CEUs per year in 2000, increases to 11,676 CEUs in 2001 (due to initial starting conditions of the model), and finally drops to 3,629 CEUs by 2010. This suggests that there is a persistent illegal supply or 'black market' for cigarettes and tobacco products in New Zealand of somewhere between 3.6 to 11.7 million cigarettes pa (or equivalent in loose tobacco). However, relative to the total 'legal' domestic supply of cigarettes and tobacco products, this gap is relatively small, ie between 0.12 to 0.35% of domestic supply. It must also be emphasised that this is a 'pilot model' hence the results are indicative only. Nevertheless, NZCS was aware that a 'market gap' existed, but no estimate of its size was previously available.

Meanwhile, although the number of smokers is steadily declining from 739,000 to 678,000 between 2000 to 2010, the number of 'quit smokers' is increasing from 739,000 to 845,000. Hence the total of smokers and quit smokers increases from 1.48 to 1.52 million over the period, causing tobacco health related costs to increase from $70.5 million in 2000 to $73.3 million in 2010, thus putting a further pressure on the public and private health system in New Zealand.

Due to the steady decline in the consumption of tobacco products during the 'forecasting' period, the total excise and import duties collected by New Zealand Customs Service (NZCS) on tobacco products declines from $824 million in 2000 to $756 million in 2010. The cumulated duties collected on tobacco products by NZCS over the 10 year period is $7.9 billion. The other main assumptions in the base case that

[1] 1 CEU = 1 cigarette equivalent unit = 1000 cigarettes or equivalent tobacco content of 'roll your owns'.

should be noted are that there are no migration flows in the model, and air passenger arrivals are assumed to remain constant at 3.25 million passengers per year.

**Policy analysis with the model**

The Ministry of Health outcome (reduce smoking in New Zealand) depends on the numbers of smokers in New Zealand and on their average daily consumption of cigarettes (or equivalent tobacco products). Smokers depend on the starting rate of smokers, quitting rate and deaths. The number of new smokers starting is assumed to be an exogenous percentage (which can be varied in the model and was calculated from results from a health survey), and the demographic age structure in NZ. On average, new smokers are assumed to start smoking at age 16. The base run assumes that 35.6% of this cohort starts smoking. This outcome is influenced by changes to the price of cigarettes and tobacco products, ie by the excise & import duty rates. (Note that other factors also influence "new smoker" numbers – eg Television education campaigns)

Changes to excise duty influence the numbers quitting smoking and also the daily consumption of cigarettes (sensitivity between price and tobacco). Hence the 'change in excise duties' can be used as a policy variable to influence the amount of smoking in NZ, and the subsequent impacts on numbers and costs in the NZ health system. The user interface in Figure 9 shows how this policy parameter can be adjusted readily by the policy analysts, managers, or others experimenting with the model.

The effects on the supply of tobacco products and the change in consumption because of the price effects of the excise duty can be examined with a simulation run of the model. Price can see seen as a deterrent to risk.

Note that this model only looks at price and health effects. There are other factors influencing both why people smoke and how many they smoke, hence other government policies have an effect on outcomes. For example people with housing problems and/or who are unemployed are more likely to be smokers and more likely to have poor health whether or not they smoke.

In the 'Taking the Pulse – The 1996/1997 New Zealand Health Survey' (Ministry of Health, 1999, p34) it is shown that people with higher smoking levels tended to be:

- Young people
- People on low incomes
- People with less education

An example of the price sensitivity of tobacco products is given in Tobacco Facts May 2001 (Ministry of Health, 2001, p12) where it is stated that in May 2000, there was an approximately 20% price increase in tobacco products. This change was associated with an 18% decrease in total tobacco consumption. Consumption of loose tobacco increased by 1% while manufactured cigarette consumption decreased 23%. This shows how the price of tobacco products has an effect on their consumption (sensitivity).

We used the demonstration SD model to analyse the effects of a 20% real increase in excise duties (price sensitivity) in 2003. The graphical results for the main variables are shown in Figure 11, where the sharp increase in duties collected occurs in 2003, although

there is a sharp decrease in the domestic consumption and supply of cigarettes and tobacco products.

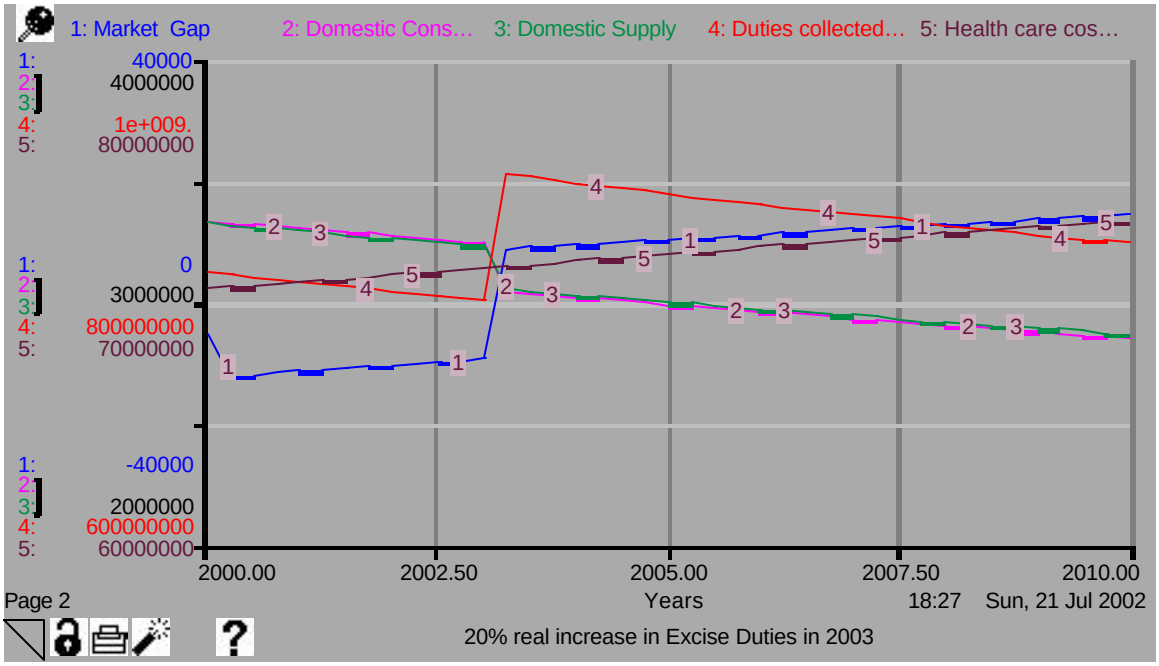


Figure 11. A policy experiment with the NZCS tobacco model

Table 3 summarises the initial values for the base case (in 2000) compared with the final values (in 2010) for the model experiment (20% increase in excise duty in 2003) compared with the base case. However, these are indicative figures only as this is only a demonstration model.

With respect to the price of cigarettes, the demand for them is elastic if its price elasticity is less than –1, inelastic if its price elasticity exceeds –1 and unit elastic if its price elasticity is equal to –1. Since the price elasticity of demand in this model is fairly inelastic (-0.6), then the total excise duties collected increases. This is because demand decisions for cigarettes are not very responsive to a change in price.

Table 3. NZCS tobacco demo SD model: Effects of a change in excise duty rates

| | Duties Collected on Cigs & Tobacco (million/yr) | Cumulated Duties Collected (million) | Market Gap (CEU/yr) | Percent Market Gap | Domestic Consumption (million CEU/yr) | Domestic Supply (million CEU/yr) | Total Population (million people) | Smokers (000 people) | Quit Smokers (000 people) | Health care costs total prim & sec (million/yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| Initial Values - 2000 | | | | | | | | | | |
| *Base Case* | $824 | $0 | -5,288 | -0.16% | 3.334 | 3.329 | 3.83 | 739 | 739 | $70.50 |
| Final Values - 2010 | | | | | | | | | | |
| *Base Case* | $756 | $7,886 | -3.629 | -0.12% | 3.061 | 3.058 | 4.15 | 678 | 845 | $73.31 |
| Final Values - 2010 | | | | | | | | | | |
| *20% increase in Excise Duty rate in 2003* | $848 | $8,554 | 14,257 | 0.50% | 2.849 | 2.863 | 4.15 | 671 | 852 | $73.36 |

The table indicates that a 20% increase in the excise duty rate in 2003 would result in about a 7% reduction in total cigarette and tobacco consumption by 2010 and the number of smokers would be about 1% lower than the base case. The number of smokers is linked to the price elasticity of demand for cigarettes. However, the annual excise and import duties collected on tobacco products would increase by about 12% ($92 million). (This differs of course from the results of the May 2000 price increase of 20% that led to an 18% decrease in consumption. Reasons are shown in the "Whole of Government" type response presented in base case section of this paper.)

As highlighted in the figure, the market gap (with the 20% increase in the excise duty rate in 2003) for 2010 is clearly not what we would have expected. We would have expected the market gap to remain negative (ie legal supply to be less than demand).

However, this 'counterintuitive' result could be justified since tobacco companies put up their prices in addition to the changes in the excise duties to preserve their profit margins. Hence tobacco products production may not decrease by as much as consumption following a significant excise duty increase, hence resulting in a positive market gap (ie the legal supply in NZ would be greater than estimated consumption). This would suggest some extra stockpiling, and it may be appropriate to revisit this part of the model. Alternatively, consumption may not drop by as much as our model calculates.

Nevertheless, this demonstration model can be used by Government officials to 'think through' the implications of the 'illegal' market for tobacco products in New Zealand.

## Conclusions

Finally it must be emphasised that the results discussed in this paper are indicative only, as they are based on the demonstration system dynamics model developed for illustrating the impact of border intervention on tobacco related activities in New Zealand.

While we are confident that the NZCS tobacco model can be used to demonstrate the potential use of system dynamics for policy analysis and sensitivity testing, the

demonstration model has not been fully validated and some data has been provided based on 'guesstimates' rather than soundly researched.

Nevertheless the modelling work undertaken for this project has provided some very useful insights into the Customs and Health related activities associated with the supply and consumption of tobacco products in New Zealand. The model can be used as the basis for a more comprehensive policy tool that could be developed either for New Zealand or any other country trying to grapple with the implications of the tobacco industry in their countries.

Further details of how the NZCS demo SD model was used to address the remaining research questions outlined in the NZCS Demonstrating Value Project are provided in the report by Cavana et al. (2002). These will be discussed in a forthcoming paper by the authors.

## Acknowledgements

The authors would like to thank the NZ Customs Service for permission to publish this paper, which is based on material developed during the NZCS Demonstrating Value Project. They would also like to thank Philip Bullen, Ray Grant, Winnie Ho, Nicola Holden, Mike Lewin, and Simon Williamson from NZ Customs Service, and Alison Roberts and John Stribling from the NZ Ministry of Health for their contributions to the NZCS project. However, the interpretations and opinions in this presentation are their own.

## References

Cavana RY, Clifford LV. 1998. Using Systems Thinking Concepts to Relate Outputs to Outcomes for the NZ Customs Service. *Proceedings of the 16th International Conference of the System Dynamics Society*, Quebec City, Canada, 20-23 July 1998, p 25.

Cavana RY, Clifford LV. 1999. *The Matrix, the Spiderweb & the Influence Diagram: Developments in Systems Thinking at the New Zealand Customs Service*, Graduate School of Business and Government Management, Victoria University of Wellington. (The GSBGM Working Paper Series, Working Paper 3/99).

Cavana RY, Davies PK, Robson RM, Wilson KJ. 1999. Drivers of quality in health services: different worldviews of clinicians and policy managers revealed. *System Dynamics Review* **15**(3): 331-340.

Cavana RY, Broatch FM, Clifford, LV. 2002. A System Dynamics Pilot Study to Show the Impact of Border Intervention on the Collection of Tobacco Excise Duties and Smoking in New Zealand. Annex to: NZ Customs Service(2002). *NZCS Demonstrating Value Project*. New Zealand Customs, Wellington (forthcoming).

Coyle RG. 1996. *System Dynamics Modelling: A Practical Approach*. Chapman & Hall: London.

Forrester JW. 1961. *Industrial Dynamics*. MIT Press: Cambridge, Mass.

Hodgson AM. 1994. Hexagons for Systems Thinking. In John D.W.Morecroft and Sterman, J.D. (eds) *Modeling for Learning Organisations*. Productivity Press: Oregon.

Jha P, Chaloupka FJ. 1999. *Curbing the epidemic: Governments and the Economics of Tobacco Control*. The World Bank: Washington, DC.

Kreutzer DP. 1995. FASTBreak$^{TM}$: A Facilitation Approach to Systems Thinking Breakthroughs. In Chawla, S. and Renesch, J. (eds), *Learning Organisations: Developing Cultures for Tomorrow's Workplace*, Productivity Press: Portland, OR, pp. 229-241.

Maani KE, Cavana RY. 2000. *Systems Thinking and Modelling: Understanding Change and Complexity*. Pearson Education (NZ) Ltd: Auckland.

Ministry of Health. 1999. *Taking the Pulse, The 1996/97 New Zealand Health Survey*, Ministry of Health: Wellington.

Ministry of Health. 2002. *Tobacco Facts: May 2002*. (Public Health Intelligence Occasional Report No. 2). Ministry of Health: Wellington.

NZ Customs Service. 1999. *Customs Controlled Areas*. (NZCS Fact Sheet No. 18). New Zealand Customs Service: Wellington.

NZ Customs Service. 2001. *Annual Report 2000-2001*. New Zealand Customs Service: Wellington.

NZ Customs Service. 2002. *NZCS Demonstrating Value Project*. New Zealand Customs: Wellington (forthcoming).

Richmond B, Peterson S. 2001. *Ithink Version 7.03 for Windows 2001*. High Performance Systems: Hanover NH.

Sterman JD. 2000. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. Irwin McGraw-Hill: Boston.