A System Dynamics analysis of the Bottled Water Industry in the United States

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Abstract

The Bottled Water Industry has seen rapid growth since the early 1970's, until recently where a plateau has been seen in the sales of Bottled Water in the US. The purpose of this study was to understand this Bottled Water Industry behaviour by determining its key leverage points. Leverage points being points within a system where a small shift in one thing can produce big changes in everything. These 'leverage points' can be revealed by observation and study of the system in focus. They are then able to be used to create a System Dynamic model that replicates the real world behaviour of the system. This was the method followed in this paper, whilst focusing upon the Bottled Water industry in the United States. The model was also used to look at possible behaviour in the future of the Bottled Water Industry. Using these predictions it was hypothesized that that the Bottled Water Market will plateau with oscillation and then collapse.

1. Introduction

Since the 1970's the fastest growing beverage market in the United States has been Bottled Water. It is now the second largest beverage market behind carbonated soft drinks, with 30 billion bottles sold in the US in 2008 (Gleick P. , 2010). The making of plastic bottles for Bottled Water for sale in the US required the equivalent of 17 million barrels of oil last year and generated 2.5 million tons of carbon (Hays, 2008). Additionally, approximately 1.8 billion kilograms of PET plastic bottles end up in landfill or as roadside litter, partially due to a low rate of recycling (Hays, 2008).

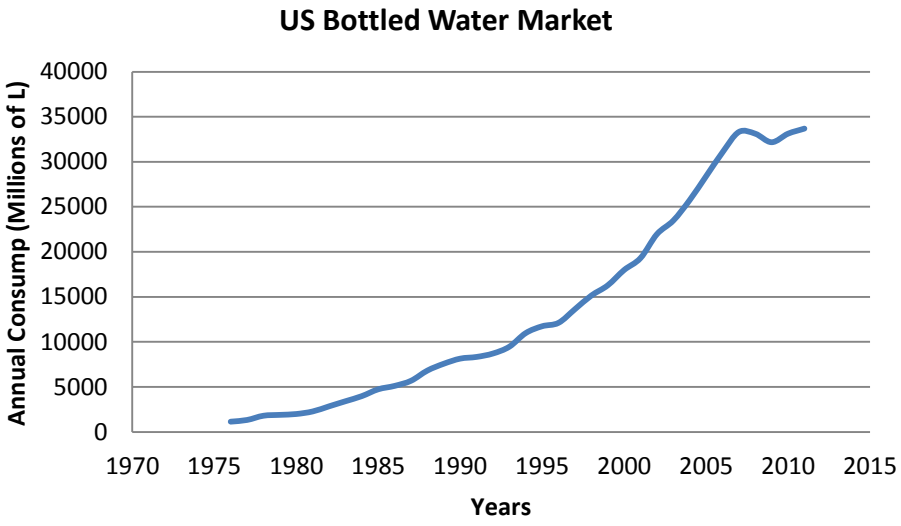

Figure 1: Real world data indicating the pattern of consumption of Bottled Water in the United States

1.1 Dynamic Hypothesis

The System Dynamic process as outlined by Sterman (2000) was followed in the completion of this research, the form of which can be seen in Figure 2. Thus far the problem has been articulated as being the environmental impact of the Bottled Water Industry. To formulate the dynamic hypothesis it was necessary to analyse the structure of the Bottled Water Industry.

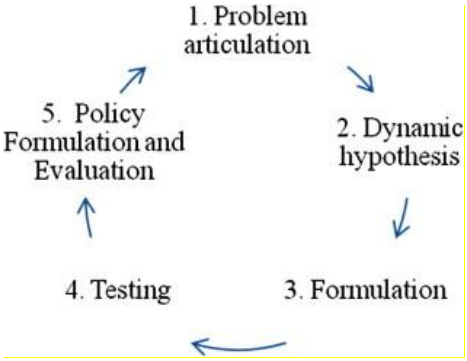

Figure 2: The System Dynamic Process (Sterman, 2000)

Market research was used for preliminary analysis of the leverage points of the system. Figures 3, 4, and 5 provide an insight into the motivation of customers to buy or not to buy Bottled Water.

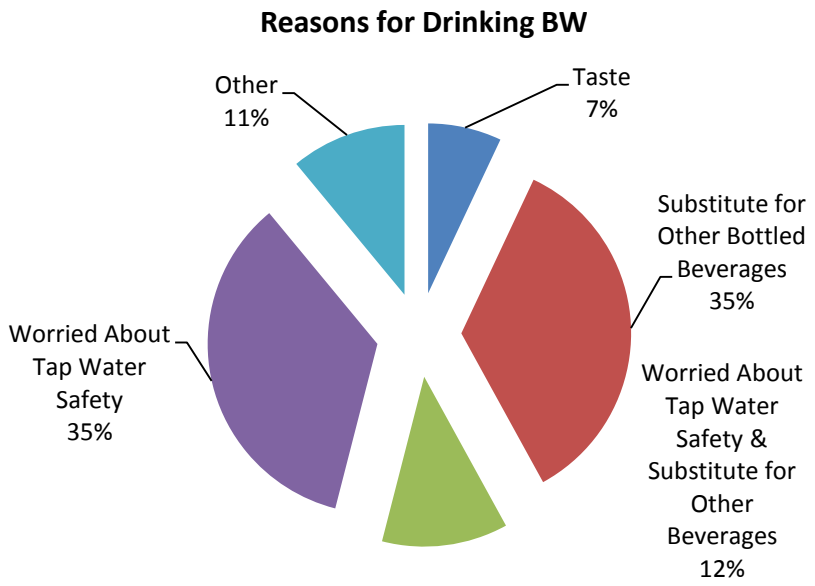

Figure 3: Results of a survey conducted on the reasons for drinking Bottled Water (Natural Resources Defense Council, 2013)

As can be seen in Figure 3 the 'healthy' image of Bottled Water plays a significant role in motivating consumption. A large proportion of Bottled Water customers, 47%, believe that Tap Water is potentially unsafe and therefore use Bottled Water as a healthy alternative. There is also the 'substitute for other bottled beverages', being a concern with 47% of customers. Ferrier (2001) states that Bottled Water is a healthy alternative to other beverages, thus supporting the idea that health perception is an important driver of the market. This 'health perception' of bottled water is reinforced in Figures 4 and 5.

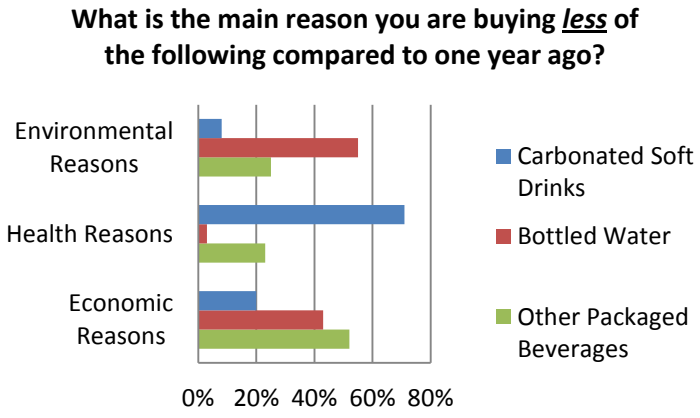

Figure 4: Results of a survery carried out to determine the reasons for buying less of certain beverages (Concept Catalysts, 2010)

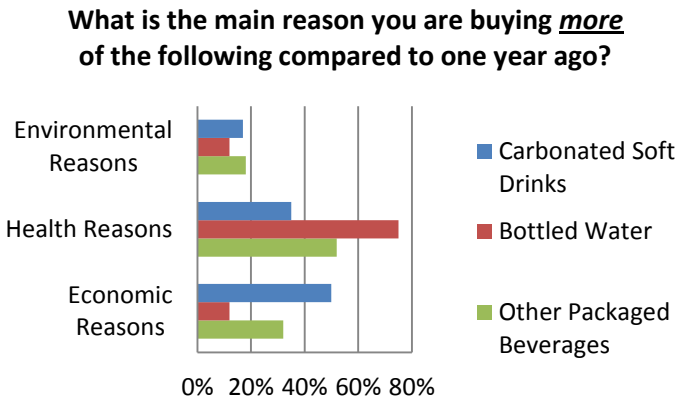

Figure 5: Results of a survery carried out to determine the reasons for buying more of certain beverages (Concept Catalysts, 2010)

Figure 5 also supports the idea that health perception is significant motivation for drinking bottled water. It is also apparent, from Figure 4, that environmental reasons are a prime cause of reducing bottled water intake. Based on this data the System Dynamic model appeared to possess at least one reinforcing loop, related to Health Perception, and one balancing loop, related to Environmental Impact. Economic concerns were considered and tested (looking specifically at water price per litre), however there did not appear to be a significant effect on system dynamics.

The dynamic systems containing a reinforcing and balancing loop are s-shaped growth, s-shaped growth with overshoot, and overshoot and collapse. Preliminary research indicated that delays would be a part of the Bottled Water system and therefore s-shaped growth was rejected. Further analysis indicated that the carrying capacity of the Bottled Water system was related to the perception of Bottled Water itself. If the perception of Bottled Water was positive then there would be growth, if the perception was negative then there would be a fall in Bottled Water consumption. The potential of collapse lead to the conclusion that the overshoot and collapse structure was the rational choice.

The key components of an overshoot and collapse system are balancing and reinforcing loops, some form of delay, and an eroding carrying capacity. Examples of overshoot and collapse systems have been seen in the tobacco industry (Zagonel, 2011), illicit drug industries (Sterman, 2000) and even the soft drink industry (ACCUVAL, 2010).

The tobacco industry was considered one of the greatest health challenges of developed nations in the 20th century, and it is still the greatest cause of preventable health problems in the US. However, for many decades the negative side of the tobacco industry was not known by the wider population. Research carried out by Zagonel (2011) looked at the societal lifecycle of cigarette smoking observing the interplay the balancing and reinforcing loops using the System Dynamic technique. They deduced that the two main leverage points in the industry are ‘awareness of health consequences’ and ‘exposure to smoking’.

‘Exposure to smoking’ represents the reinforcing loop in the System Dynamic model, the concept increasing smoking behaviour. ‘Awareness of health consequences’ is the driver diminishing the growth of the tobacco industry. This pattern of opposing forces seen in the tobacco industry can also be observed in the Bottled Water industry. It is therefore interesting to observe the behaviour of the

tobacco industry over the 20th century. The per capita consumption of cigarettes can be seen in Figure 6. It is apparent from this diagram that the tobacco industry has undergone a massive decline after a long period of growth. From the labels on the diagram it is also apparent that industry growth was curtailed after the negative consequences of smoking became increasingly obvious. A similar market pattern can be seen in illicit cocaine use in the United States in the 1980's.

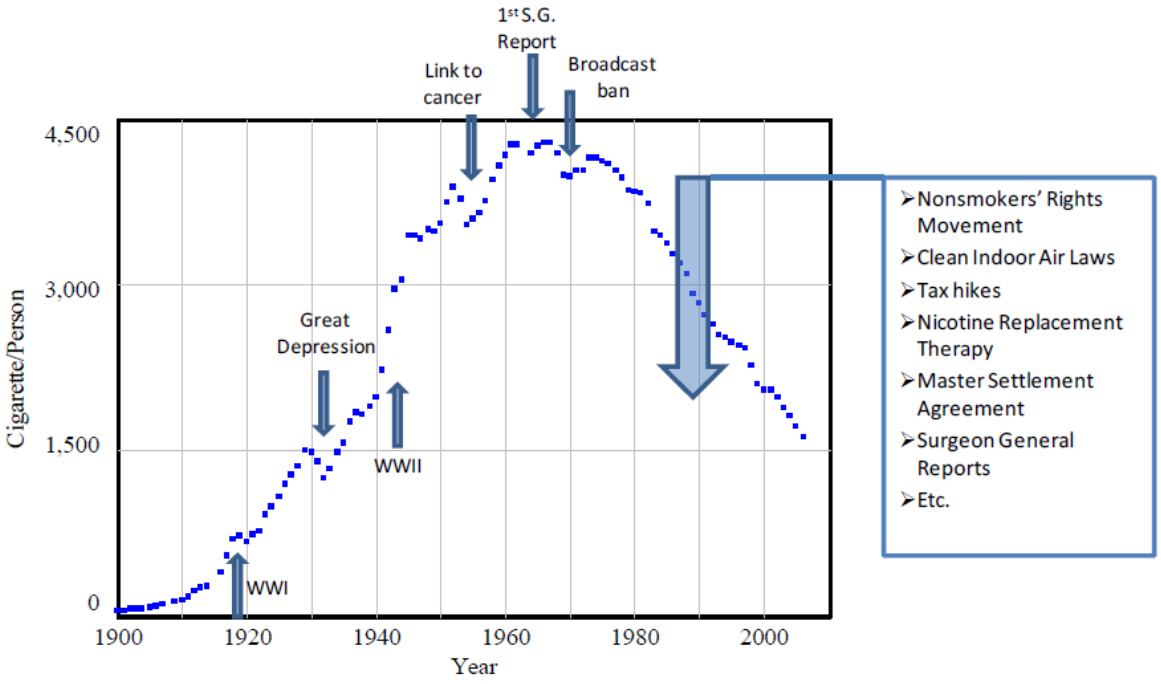

Figure 6: Pattern of sales of cigarettes (Zagonel, 2011)

In the 1980's the United States underwent a dramatic increase in cocaine use (Sterman, 2000). It was a drug that was initially seen as benign, non-addictive and posing little health risk. However, this changed as the negative health effects became increasingly apparent (Sterman, 2000). This coincided with a crackdown on cocaine use, with stiffer penalties for possession, with the aim of reducing the flow of the drug into the US. The opposing feedback loops in this scenario can be summarised as 'Social Exposure' verses 'Legal and Health Risks' involved in cocaine use.

To understand this decline in the growth of the Bottled Water industry this study aims to determine the key leverage points of the United States Bottled Water Industry. Leverage points being points within a system where a small shift in one thing can produce big changes in everything (Meadows, 2008). These 'leverage points' can be revealed by observation and study of the system in focus (Meadows, 2008). They are then able to be used to create a System Dynamic model that replicates the real world behaviour of the system. This was the method followed in this paper, whilst focusing upon the Bottled Water industry in the United States. The model was also used to look at possible behaviour in the future of the Bottled Water Industry. Using these predictions it was hypothesized that *that the Bottled Water Market will plateau with oscillation and then collapse.*

2. Model Development

The chosen stocks were 'Tap Water' and 'Bottled Water'. These stocks were chosen because a water industry dynamic was desired; therefore it was necessary to have at least two similar products. Bottled Water is the focus of this paper (therefore an essential component of the model) and Tap Water was chosen because it is a potential solution to the problems articulated previously; increased energy use and plastic pollution (Clean Up Australia, 2010). The stocks measure the market share of each of the products. There is a bi-flow connection between the stocks to simulate market fluctuation.

Once it was determined that Environmental Impact and Health Perception would be the key drivers, which was reinforced by Figures 3, 4 and 5, it was necessary to find surrogates (metrics to determine real life patterns).

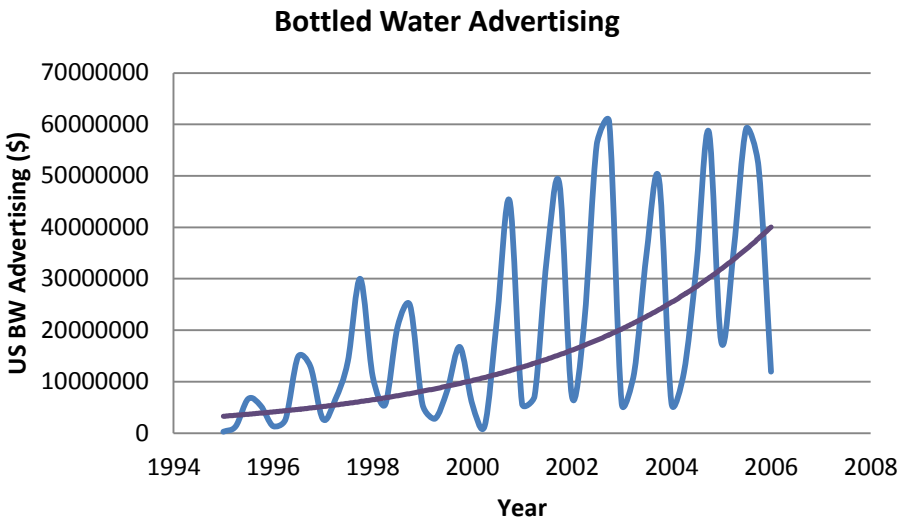

Figure 7: A summary of US spending on the marketing of Bottled Water (Kaiser, 2006)

Bottled Water advertising expenditure was chosen as a surrogate for the 'Health Perception' of Bottled Water. The rationale being that Bottled Water advertising emphasizes the purity and cleanliness of its product, sometimes even commenting on the impurity of Tap Water. As expenditure increased in spreading the message of Bottled Water health benefits, the assumption was made that the healthy image of bottled water was strengthened amongst the targeted population. The pattern of advertising expenditure can be seen in Figure 7. A line of best fit has been added to emphasize the gradual increase in spending. The surrogate for the Environmental Impact can be seen in Figure 8.

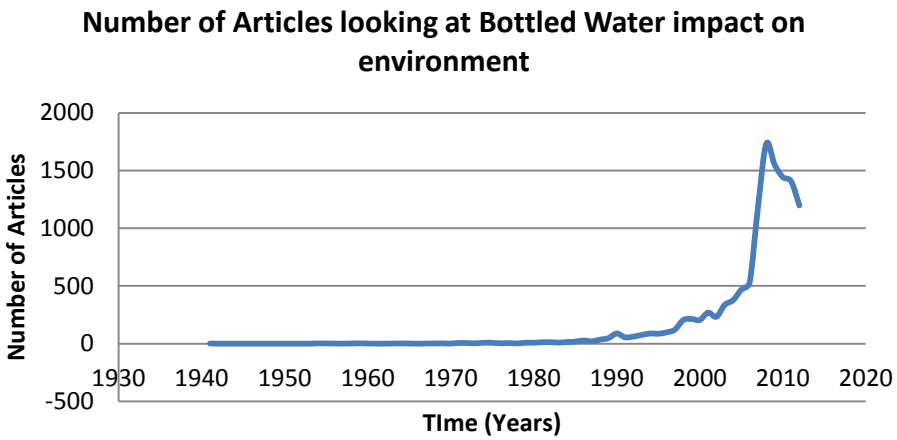

Figure 8: Number of articles written related to the environmental impact of Bottled Water (Proquest, 2013)

Figure 8 shows the number of articles, since the 1940's, that have a connection to the environmental impact of Bottled Water. The types of articles include newspapers, journals, theses and magazines. It is possible to observe the sharp increase in publication since the mid-1980's, about a decade after Bottled Water started showing significant growth. Besides consideration of surrogates for system drivers it is also necessary to consider any delays.

Two delays seemed apparent; the interval between Bottled Water pollution and the subsequent impact it has on the human population, and the broadcast of advertisements and its effect on public perception.

3. Results

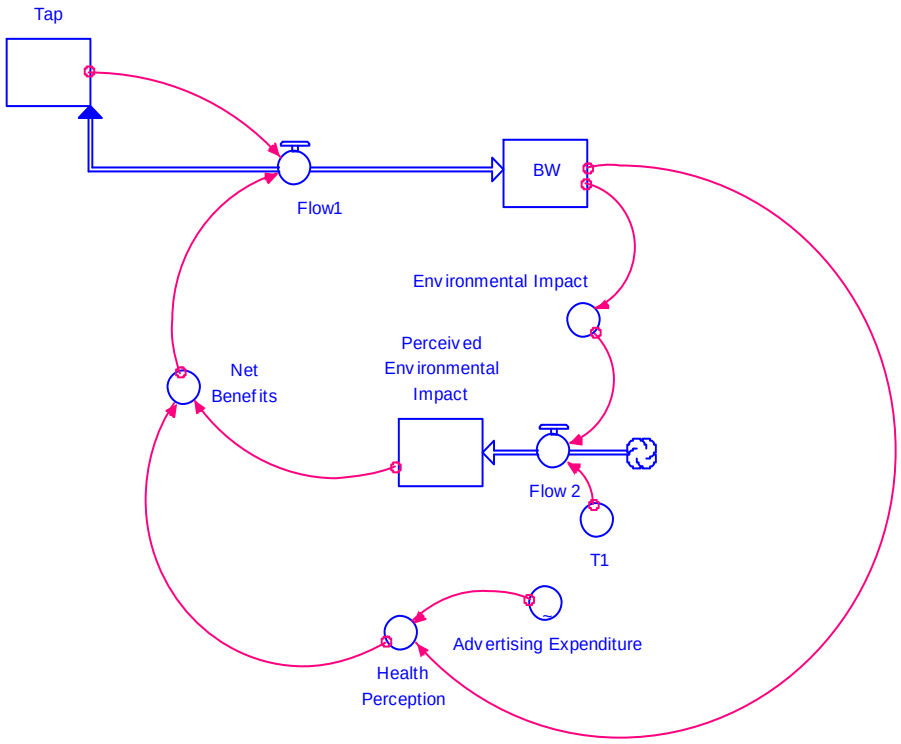

Figure 9: The STELLA model summarising the dynamics of the Bottled Water Industry

The resulting stock and flow diagram from the method described in the preceding section can be seen in Figure 9. It consists of two stocks, 'Tap' and 'Bottled Water' which are connected via a biflow. This represents the flow of consumers between the two products. Testing involved initial conditions representing a market dominated by tap water. The sum of the two stock initial conditions equalled '1' and signified one hundred per cent of the market. The value of the stocks indicated the percentage market share of each product. The 'Tap' and 'BW' stocks were the central component of the balancing loop and reinforcing loop.

The reinforcing loop focused upon the effect of advertising expenditure on the Bottled Water market. A graphical function was used to replicate the data found in Figure 7, which can be seen to follow an exponential increase. The advertising expenditure acted as a metric for the health perception of Bottled Water. A scaled subtraction of 'BW' from 'Advertising Expenditure' provided the basis for 'Health Perception'. A delay function was also added to represent the gradual diffusion of the advertising message amongst the target population.

The balancing Environmental Impact loop also had the added complication of a delay, representing the gradual perception of the environmental impact of Bottled Water. It is possible to use the in-built delay function in STELLA however this did not seem to replicate real life patterns. The assumption was made that from the beginning of the Bottled Water Industry there was some realisation of potential environmental impact. The decision was made to create a third stock to represent the 'Perceived Environmental Impact', which was a percentage of the actual 'Environmental Impact'. This delayed the full environmental effect of Bottled Water without creating a period of time where there was no perception of potential damage.

Modification of variable and stock values has varying effects on the system dynamic. A summary of these effects can be seen in Table 1.

Table 1: A summary of the effect of variable change on the Bottled Water (BW) stock

	Sensitivity (Degree of impact on BW market share)	Effect of Increase	Effect of Decrease
Advertising Expenditure	High	Increase BW stock levels	Decreases BW stock levels
Environmental Impact	Moderate	Decreases BW stock levels	Increases BW stock levels
T1	Low	Decreases BW stock levels	Increases BW stock levels
Health Perception Delay	Moderate	Causes oscillation during growth	Smoother growth
Health Perception	High	Increases BW stock levels	Decreases BW stock levels
PEI Stock	High	Decreases BW stock levels	Increases BW stock levels
Tap & BW initial value	Low	Minor change in dynamic pattern	Minor change in dynamic pattern
PEI initial value	Moderate	If larger than Health Perception, then no dynamic	Longer delay in BW stock decrease

The output from the stock and flow diagram can be seen in Figure 10. It is evident from this diagram that system collapse is the predicted future. The match between the real world data and the System Dynamic simulation is significant. Even the fluctuation around 1995 has been accounted for in the simulation. However, it should be noted that the oscillation occurring during the plateau is not seen in the simulated market behaviour. It is possible that further development of the model may be necessary.

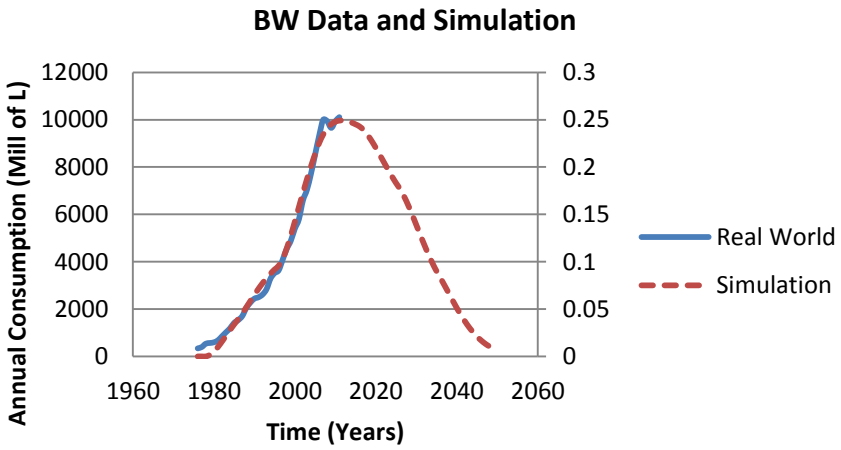

Figure 10: Real world data on consumption of Bottled Water (BW) compared with the STELLA simulation

4. Discussion

As stated in the dynamic hypothesis, this research characterises the Bottled Water market as a potential overshoot and collapse system. The overshoot and collapse system is a type of system containing a carrying capacity that diminishes over time. In many instances, carrying capacity systems look at over-consumption of finite resources; the carrying capacity being the amount of resource able to be consumed without causing harm to the system. In the case of an overshoot and collapse situation there is also an additional factor causing the carrying capacity to diminish, such as an increasing population.

However, the situation is different when looking at Bottled Water. Although, the market is dealing with finite resources (oil and water) there are still considerable reserves available. Instead, the carrying capacity is related to the interplay between the positive and negative perceptions of the 'product'. Referred to in Figure 9 as the 'net benefit'.

Using information from marketing research the positive attribute of Bottled Water has been summarised as 'Health Perception' while the negative characteristic as 'Environmental Impact'. When the positive perception dominates the result is a growing market, when the perceptions are equal the market is in equilibrium, and the market falls when negative perception is strongest. Previous studies, which were mentioned earlier, have looked at similar situations; namely tobacco,

illicit drugs and carbonated soft drinks. Each of these past studies had finding that were of relevance to the Bottled Water Industry

4.1 Tobacco

As discussed earlier, there does appear to be correlation between the tobacco industry and the Bottled Water Industry. The study by Zagonel (2011) introduced the idea of a memory effect on tobacco. A memory effect relates to the level of exposure individuals have to the negative effects of a product, in this case tobacco. When smoking occurs at high levels it is more probable that a population experiences its ill effects, such as lung cancer, either personally or through acquaintances. As smoking decreases this exposure also decreases. It is possible that renewed industry growth can occur because of this pattern. It is something worth considering with the Bottled Water Industry. Particularly since the negative effect of Bottled Water (environmental impact) is less tangible than ill health.

4.2 Cocaine

The Cocaine Industry has also been related to the Bottled Water Industry, in the context of overshoot and collapse behaviour. This provides the possibility in predicting future behaviour of the Bottled Water Industry. However, although the cocaine market did collapse in the 1990's the drug market as a whole did not disappear. After the negative effects of cocaine became increasingly apparent, other illicit drugs took its place. This suggests that when there is sufficient need for a market, products will evolve to fill this requirement.

4.3 Carbonated Soft Drink

It is also worth noting that Carbonated Soft Drink appears to be following a growth and collapse pattern. This collapse period overlaps with the growth period in the Bottled Water market. This can be seen in Figure 11. There are certainly some potential reinforcing loops that could be proposed; such as taste and social exposure, as well as a 'health perception' balancing loop. The fact that this pattern is already occurring in the beverage industry creates a stronger link with Bottled Water.

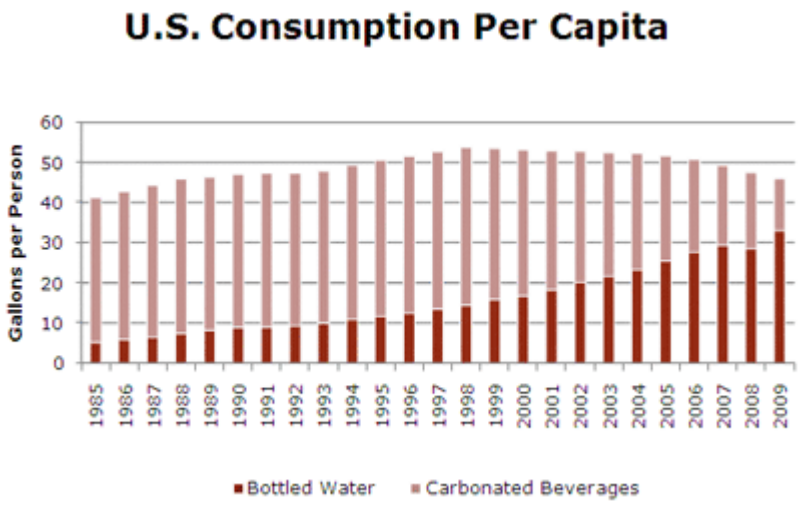

Figure 11: Pattern of sales of soft drink (ACCUVAL, 2010)

5. Conclusion

The Bottled Water industry shows similarities with the tobacco, cocaine and soft drink markets. Market saturation does not occur; the negative attributes of the product become more apparent and diminish their market share.

Tobacco, cocaine and soft drink's negative attributes are health related. However, bottled water is environmental. There is a larger disconnect between the product and the negative effect on the consumer in the bottled water industry. It is likely that this would lead to a longer lifetime (in comparison to tobacco, cocaine and soft drink) for the market. Decreased exposure to the negative attributes of Bottled Water (due to this disconnect or a market collapse) increases the potential for a memory effect to occur, where the negative attributes of Bottled Water are forgotten. This may lead to the regrowth of the Bottled Water market.

It may be possible to predict what the next product will be in the cycle of the market if the negative attribute can be specified. For example, the negative health perception of soft drink could have played a role in the growth of the bottled water industry. Consideration of a soft drink stock is highly recommended in any future development of this dynamic model.

Bibliography

ACCUVAL. (2010, August). *Carbonated Soft Drinks: Is demand fizzing out?* Retrieved March 7, 2013, from http://www.accuval.net/insights/industryinsights/detail.php?ID=142

American Water Works Association Research Foundation. (1993). *Consumer Attitude Survey on Water Quality Issues.*

Bottled Water Matters. (n.d.). *Bottled Water Matters*. Retrieved March 6, 2013, from http://www.bottledwatermatters.org/economics

Clean Up Australia. (2010). *Bottled Water.* Clean Up Australia.

Concept Catalysts. (2010). *Environmental Concerns: The impact on beverage and package decisions.* BeveragePulse.com.

Ferrier, C. (2001). Bottled Water: Understanding a Social Phenomenon. *A Journal of the Human Environment*, 118-119.

Gleick, P. (2010). *Bottled and sold: The story behind our obsession with bottled water.* DC: Island Press.

Hays, M. (n.d.). *The Social and Environmental Impacts of Bottled Water.* Corporate Accountability International.

Kaiser, H. &. (2006). *Measuring the Impacts of Generic Fluid Milk and Dairy Marketing.* New York: National Institute for Commodity Promotion & Research Evaluation.

Meadows, D. (2008). *Thinking in systems: a primer.* Vermont: Chelsea Green.

Natural Resources Defense Council. (2013, February 21). *Bottled Water: Pure drink or pure hype?* Retrieved from NRDC: http://www.nrdc.org/water/drinking/bw/chap2.asp

Proquest. (2013, February 27). *Proquest: Bottled Water and Environmental Impact*. Retrieved from Proquest: http://search.proquest.com/results/13CC8EA8F69B4D355E/1/$5bqueryType$3dbasic:OS$3b+sortType$3drelevance$3b+searchTerms$3d$5b$3cAND$7ccitationBodyTags:bottled+water$3e$5d$3b+searchParameters$3d$7bNAVIGATORS$3dsourcetypenav,pubtitlenav,objecttypenav,languag

Sterman, J. (2000). *Business Dynamics.* Irwin McGraw-Hill .

Zagonel, A. e. (2011). Developing a theory of the societal lifecycle of cigarette smoking: Explaining and anticipating trends using information feedback. *ICSDS.*