

# **Nutritious Food Market Transformation: Analysis of Non-communicable Disease Dynamics and Prevention**

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## **Abstract**

This paper examines, at a meso-economic level, challenges and opportunities for policy actions that transform healthy living behaviour. We examine how policies and other decisions, made by various types of actors (i.e. consumers, industry, agriculture, government, NGOs, and global institutions) at multiple levels, evolve as they interact and collectively shape healthy living behaviour over time. The transformation of such a dynamically complex socio-economic-system, characterized by multiple feedbacks and long-term delays, and involving disjointed public and private level interactions, produces counterintuitive behaviour. Such behaviours include tipping-points and “worse-before-better” behaviour. To develop an in-depth understanding of the major challenges and identify high-leverage strategies in transitioning away from low nutrition / high motivational based food system we have developed a behavioral dynamic model with a broad and further expandable scope. Key actors in the models include consumers, individual and collectively oriented food producers, and policy-makers. In this paper we describe the model and carry out simulation experiments designed to examine barriers to self-sustaining market shifts between supply and demand factors. In particular, we show that collective action among producers to improve nutrition, while important in achieving nutritional change, are slow to build up and failure prone, due to a range of compensating supply and demand feedbacks. We analyze and discuss differences across different initiatives, including those oriented around marketing and R&D. We conclude by discussing the importance of coordination and commitment across actors and propose important model extensions.

## **Introduction**

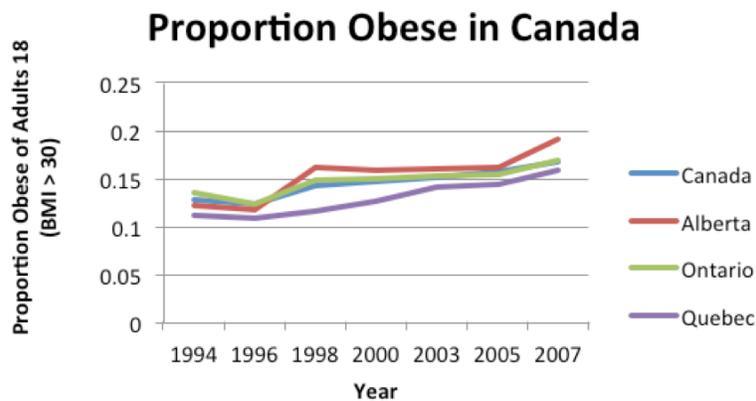
Health challenges are mounting globally as many countries face severe overweight and obesity problems within their population. Such problems are aggravated with some populations aging, others undergoing rapid lifestyle changes during demographic transitions, or not being able to escape development and double burden traps (WHO 2003) Hence it is crucial to understand collective forces that shape the transitions towards healthier living, involving both practices and goods. However, healthy living dynamics are complex, as their transitions are guided by multiple feedbacks involving multiple disjoint agents. For example, once triggered, social network structures can be important loci for cascading change in norm and behaviors, including those related to eating and activity (Kawachi and Berkman 2003). However, absent the perceived availability of healthy alternatives offered by the retail industry, such latent shifts will not occur. In turn, retailers will have limited incentives to provide alternatives when their expected demand is low. Many more feedback interactions govern healthy living market transitions, the specifics depending on the problem and region of interest. For example, obesity prevalence depends on nutrition and active life, which are jointly conditioned by interactions between factors such as community- and school-level behavioral attitudes, habits, and normative pressures (affecting food choice

and volume, activity, and television and sleep time); the built environment, including infrastructures (such as retail outlets, parks, and availability of transport modes); retailers' and producers' product offerings, -branding, -marketing, -inputs, and – development (within the formal as well as informal economy); agricultural landuse and incentives; policy efforts by governments, at various levels; and, efforts by other institutional actors (Das and Arora 2010). Consequently, effective health policy should be based on a behavioral and composite problem analysis.

This research project will examine challenges and opportunities for policy actions that transform healthy living behaviour at a meso-level. Our analysis traces how policies and other decisions by various actor types (consumers, industry, agriculture, government, NGOs, and global institutions) at multiple levels evolve as they interact and collectively shape healthy living behaviour over time. Our analysis emphasizes a long time horizon and broad scope, including interactions between socio-behavioural-, economic/organizational-, and infrastructural/built environmental factors. We highlight the development of the model and core mechanisms at the conceptual level. Specifically, this project focuses on the role of interactions between demand, supply, and policy around initiatives aimed to reduce chronic diseases caused by obesity. To demonstrate the merits of formal, dynamic, policy analysis using the behavioural dynamic simulation model, this paper will concentrate on initiatives to improve the nutritional quality (low nutrition - LN and high nutrition - HN) of food intake by children, through the reduction of LN food advertisement.

### Healthy Living and its Interventions

As many other countries, Canada continues to experience a marked growth in rates of obesity in recent years. Statistics Canada data from 1994 to 2007 indicate a gradually rising rate of obesity across the nation.



**Figure 1.** Proportion of Adults 18 and over Obese in Canada (except pregnant women). Source: Statistics Canada.

Many interventions have been adopted in the past and present in North America in an attempt to stem the growth rate of obesity (Table 1). Initiatives have involved actors among government, industry and community entities at community, provincial and national levels. An early example is the government of Quebec banning marketing of all products to children in 1980. Since then nutrition guides have been updated, labels improved, and action plans have been created. Private companies have also moved to stemming obesity. Examples include recent self-imposed bans on marketing to children and the expansion of company product mix to include healthier products. There are also numerous examples of community grassroots efforts that have taken place.

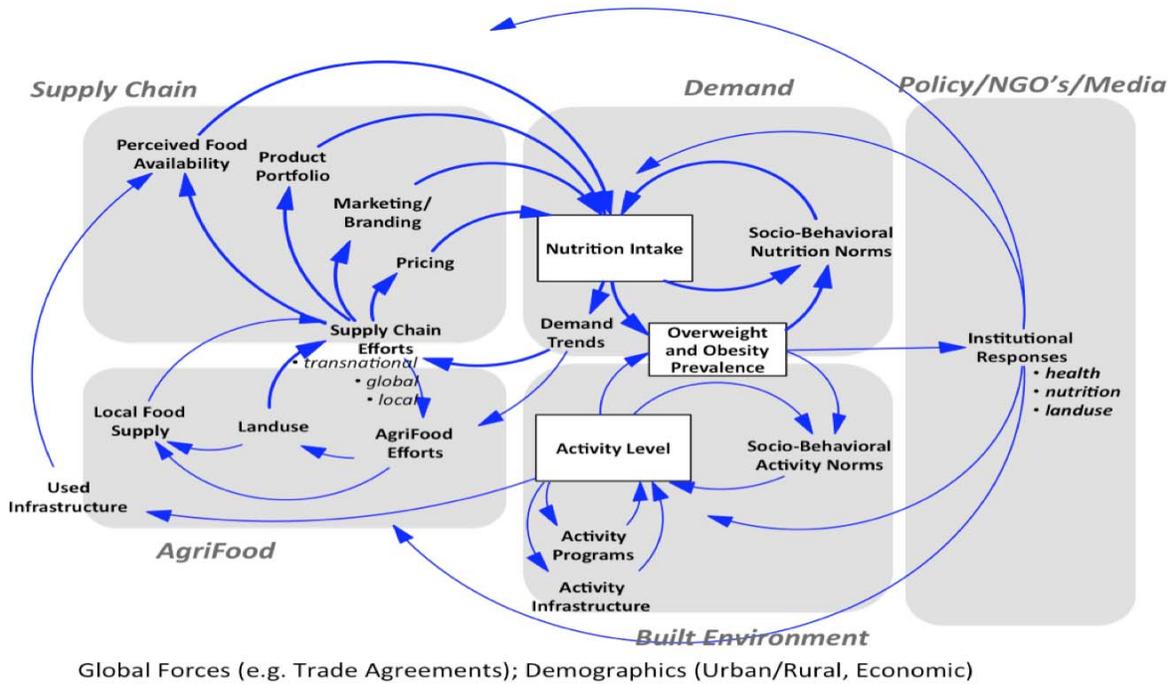
**Table 1.** Timeline of Interventions (Source: compiled by authors)

<b>Year</b>	<b>Public Policy</b>	<b>Industry (Collective)</b>	<b>Industry (Individual)</b>
<b>1980</b>	Quebec Marketing Ban		
<b>1982</b>	Canada's Food Guide Revised		
<b>1986</b>		Community-Supported Agriculture Begins in US	
<b>1995</b>		Équiterre Begins Community-Supported Agriculture	
<b>1998</b>			PepsiCo Buys Tropicana
<b>2001</b>			Loblaws Bans GMO-free Label
			PepsiCo Buys Quaker Oats
<b>2003</b>			McDonald's launches Healthy Choices Menu
<b>2005</b>	Pan-Canadian Healthy Living Strategy	Local Food Plus Certifies Local Sustainable Food Systems	
<b>2006</b>	Quebec Action Plan		
<b>2007</b>	Fitness Tax Credit	Children's Advertising Initiative (Canada)	Coca Cola Buys Glacéau
	Mandatory Nutrition	Children's Advertising	

	Labelling (Canada)	Initiative (United States)	
	Food Organic Certification		
	<i>Mettez le Québec dans votre assiette</i> Begins		
	Trans fat Ban and Mandatory Calorie Posting in New York		
<b>2009</b>	BC Trans fat Regulation	Healthy Weight Commitment Foundation	
<b>2010</b>	Let's Move		
	WHO Recommendations		

<b>Legend</b>	Advertising and Information	Agriculture	Lifestyle	Nutrition
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To examine the integrated dynamics, resulting from interactions between actors and inertia across the system, this project follows the methodology of system dynamics, specifically developed to study change in complex systems (Forrester 1961; Sterman 2000), our analysis will emphasize a long time horizon and broad scope, including interactions between socio-behavioral-, economic/organizational-, and infrastructural/built environmental factors. Figure 2 shows, at a conceptual level, important market-level factors and their reciprocal causal relationships. Obesity prevalence is affected by nutritional behavior. Supply chains (local, global, transnational), in responding to nutritional demand trends, adjust their marketing, product portfolio and retail channels, as perceived by consumers. Consumers themselves respond to various supply incentives. In addition, nutritional choices are anchored to behavioral habits and to social norm pressures. Further, changes in inputs, especially locally, are enabled and constrained by agricultural landuse shifts, depending on incentives within the agro sector. Initiatives will be absorbed in the larger food supply chain and will invoke responses by other players. The activity level within the population, important for obesity prevalence as well, is itself affected by social norms and behavioral routines, programs and infrastructure. Consumer activity patterns also affect their exposure to retail channels (infrastructure).



**Figure 2** Boundary of the Nutrition Market System.

Finally, governments and NGO’s respond to changes in overweight and obesity patterns, influencing with their health, nutrition, and agricultural policies the various sectors. Within this system, various types of stakeholders each respond to the current and recent state of the system, as perceived by them, not processing the full interdependencies. Furthermore, each has markedly different positions, and incentives. Then, critical to understanding what separates successful from less successful interventions, is to offer a thorough understanding of the interdependency across stakeholders, relevant problem scope, and critical underlying mechanisms. Clearly policies are strongly interdependent. Here we seek to understand how market shifts benefits from policy coordination. The projects main focus is on demand and supply interactions governing nutritional change product substitution.

**Methodology**

Our preliminary question was as follows: What mix of policies can be implemented, by government and/or food companies, to stem the growth of obesity in Canada? Previous studies of chronic disease using various system dynamics methodologies have concentrated in areas such as public health systems (Homer and Hirsch 2006), chronic disease dynamics (Jones, Homer et al. 2006), or obesity and weight gain dynamics (Abdel-Hamid 2002; Burke and Heiland 2007). We have however limited understanding of nutrition market transformation dynamics. This paper presents our first analysis in this

direction. We developed a list of variables covering firm, government, and consumer action (see Appendix I). After thorough research into the interventions that have already taken place (summarized in table I), we then narrowed the focus of our study on firm level advertising and product improvement initiatives. Many advertising initiatives have been tried in the past, including an outright ban of all marketing to children in Quebec starting in 1980, a self-regulated ban starting 2007 and this subject has also been recently brought back into light by the World Health Assembly in 2010. We chose to focus our study on the effects of marketing and product changes across different food categories, to examine how firms and consumers jointly condition nutrition market formation. Food companies have a significant role in shaping patterns of food consumption, and their drive for profit and market share affect their behaviour.

We follow the specification by Jones and Homer (2006), in seeking to create a structure that is both generic enough to be adaptable for other chronic diseases and realistic enough to reproduce national-level historical data on the prevalence of obesity. Similarly the model must be allow the examination of practical policies without over-disaggregating the population into demographic categories of age, sex, race/ethnicity, or other individual attributes; broad enough to encompass a spectrum of policy measures that are being considered; and grounded enough in empirical experience that it does not require speculation beyond what the project participants themselves could agree upon or what credible evidence could support..

### **Nutrition Improvement Example: The Canadian Children’s Food and Beverage Advertising Initiative**

This paper focuses, as an illustration of the dynamic multi-actor transformation analysis, on the Canadian Children’s Food and Beverage Advertising Initiative (2007). In April 2007, fifteen Canadian food and beverage companies signed on to the *Canadian Children’s Food and Beverage Advertising Initiative* (CFBAI) which is coordinated through *Advertising Standards Canada* (ASC), an advertising self-regulating body. The companies that have signed onto the initiative are committed to devote 50 per cent of their television, radio, print and Internet advertising directed primarily to children under 12 years of age to promote products that represent healthy dietary choices, or not direct advertising primarily to children under 12. Since 2010, this had been increased to 100%, and has also been expanded to include video and computer games, DVDs and movies, company-owned websites and mobile media targeted to those under 12 (Advertising Standards Canada 2007). The details of the pledges (such as what constitutes a healthy dietary choice, what constitutes something targeted to those under 12) and are left to the individual companies to determine, and are submitted to, then have to be approved by the ASC. Nineteen companies (the original fifteen plus four more who signed on later) have since submitted their pledges.

***Key Stakeholders***

The signatories to the Canadian Children’s Food and Beverage Advertising Initiative cover many large food companies active in Canada: Burger King, Cadbury, Campbell’s, Coca-Cola, Ferrero, General Mills, Hershey, Jane Family Foods, Kellogg, Kraft, Mars, McCain, McDonald’s, Nestle, Parmalat, PepsiCo, Post Foods, Unilever and Weston Bakeries. Other food companies that have not signed on would also be interested on the effect that the initiative has on the companies that have signed on and themselves, and may also consider signing on themselves. We will trace firm decisions pertaining to advertisement, in particular to children, through various channels as well as to product offerings. Since signatory decisions also invoke strategic responses by non-signatories in the food industry, we represent relevant interactions within and between both groups.

The federal and provincial governments seek to understand the effects of policies and spending and intervene, especially in the health department, and the public health agency Canada. They would also be interested in the effect this has on the food industry and the demographics of the population. Depending on the responses in the industry, they may also choose to act further such as enacting regulations against advertising to children or changing elements in a school environment. Municipal governments may also be interested in this, and may enact further policies on a local level. We will examine, through counterfactual analysis other forms of coordination, including regulatory, with similar scope as the CAI, aimed to achieve reduced child exposure to food advertisement. Community grassroots movements may also change depending on the success of this voluntary initiative.

The population is the ultimate decision makers of what they consume, and the health outcome also affects them. We are interested in factors that affect food intake behavior. However, our conceptualization of the problem reveals that this requires an explicit representation of product exposure and purchasing behavior as well. Although our main focus is the school-aged population we will represent households of all ages. We do so for two main reasons: first, exposure to, and purchasing of food is partially performed by other subject (e.g. senior household members); further, we are interested in the long-term effects of changed food intake behaviour.

***Key issues with a self-regulated ban and alternative options***

The 2008 compliance report (looking at the first year of compliance) noted only two minor compliance issues, noting that they were inadvertent and immediately corrected by the participants. An ASC spokesperson noted that “participating companies successfully met the commitments they set for themselves – even exceeding the program requirements” referring to the fact that eight companies did not advertise at all, and the remaining companies directed 100% of their funds to foods exceeding their defined criteria, instead of only the 50% required (CNW 2009).

However, the Coalition québécoise sur la problématique du poids, sponsored by the Association pour la santé publique du Québec, and association for the healthy well-being of Québécois was quick to criticize the first compliance report. They noted that the health criteria established by the companies were “extremely diversified, not very structured and difficult to compare” (CNW 2009; Trading Markets 2010). After the publication of the second report in 2010 (Advertising Standards Canada 2010), the Coalition du poids noted three companies that recognised their guilt for advertising to children, but were not mentioned in the report. In a CBC report (Canadian Broadcasting Corporation 2009), it noted that cereals must have less than 12 grams of sugars in each serving to be advertised. Three cereals, Lucky Charms, Chocolate Lucky Charms, and Nesquik had over this limit before the initiative came into place. However, they met the requirements after the initiative took place. This was not due to a change in the recipe, however, but the serving size was lowered so that each food would meet the threshold. So unless parents were lowering the amount of food in each bowl, children were consuming the same amount of sugar. A report published in the National Post noted that there continues to be ads for Corn Pops and Frosted Flakes on Teletoons, a children’s television channel. The author calls the manufacturer’s self-created nutrition guidelines to be too weak and ineffective (Shaw 2010).

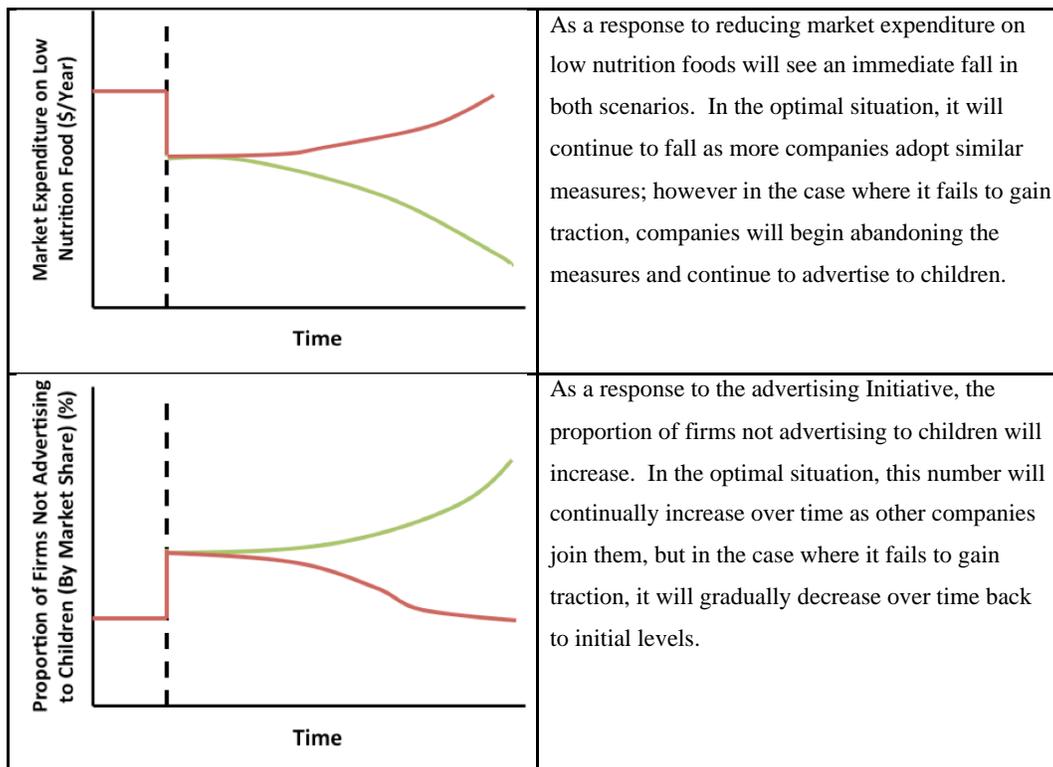
Many firms are reluctant to change the recipe of their products to make them more nutritious because of fears that the changes would affect food sales. In addition to the example of cereals given above, McDonald’s, which announced that it would change to using a new oil for frying foods that would result in a 48% reduction in trans fatty acids, 16% less saturated fat, and increase polyunsaturated fat by 167%, announced that it was delayed indefinitely due to concerns that sales would be adversely affected. (Brownell 2004, p. 256).

Because of this concern, companies find other strategies to shift into the healthier market. Some choose to expand into healthier products. For example, PepsiCo bought Tropicana in 1998 and Quaker Oats in 2001 in an effort to expand their product line, while Coca Cola bought Glacéau in 2007, the manufacturer of enhanced waters such as Smartwater, VitaminWater and Fruitwater. Others create new product lines. McDonald’s introduced new products such as salads and apple dippers, Coca-Cola Zero and Pepsi Max were introduced to capture the health-conscious market. Changes sometimes involve only few ingredients to have a healthier version of an unhealthy product. For example, General Mills introduced whole grain cereal products. However, one notes that although it adds whole grain, sugar is still the first (and primary) ingredient (Simon 2006, p. 95).

Being conscious of the importance of consumer perception and image some companies may introduce products that seem healthier, but in fact are no different or little different than the product they were meant to replace.

**Research Question**

Many initiatives like the CFBAI have existed or exist. However, it remains open what long run implications of focused nutrition improvement initiatives by private and public parties. How long do parties need to commit themselves for initiatives to become self-sustaining? To what extend benefit all public, private and other players from intensive collaboration. For example, consider the CFBAI type of initiative in which a collective of firms decides to commit themselves to reduce advertisement of low nutritious food. Then, one may imagine, at least, two types of paths, without much intuition on what is more likely to be realized: the green lines represent an optimal situation, in which the initiative is successful, and the red lines represent a situation where the initiative fails to gain traction. The graphs are intended to be qualitative patterns, but can be compared in their expected response time. Time horizon: 2010 to 2050.



<p>Low nutrition Food Product Availability Share (%)</p> <p>Time</p>	<p>Initially, because of outstanding initiatives to make processed foods healthier, the amount of low nutrition products available is gradually falling. In the optimal situation, this will continue into the future and bottom out at some point as companies continue producing healthier foods. However in the case that this becomes a fad rather than something that sticks, the amount of low nutrition food products will return to original levels.</p>
<p>Consumers' Exposure to Low Nutrition Food Advertising (hours/week)</p> <p>Time</p>	<p>Because the initiative is an advertising-based initiative, the exposure to advertising will see immediate impact. In the optimal situation, this will continue to decrease over time, while if the initiative fails to gain traction, it will increase back to initial levels.</p>
<p>Low Nutrition Food Consumption By Consumers' Peers (Calories/Day)</p> <p>Time</p>	<p>In the optimal situation, as a response to the lowering levels of low nutrition food availability, and lowering levels of advertising, consumers will consume less calories of low nutrition foods daily, eventually flattening out in a steady state. However in the case that that doesn't happen, low nutrition food consumption will increase back to initial levels.</p>

	<p>In the optimal situation, because of the reduction of consumption of low nutrition foods, the average number of calories consumed daily will lower over time, eventually flattening out at a steady state. However, in the case that it doesn't catch on, calories consumed daily will remain relatively consistent.</p>
	<p>Snacks tend to be of lower nutritional value than meals. As the number amount of low nutrition foods consumed is lowered, so will the amount of snacking. However, if the initiative doesn't catch on, there will be little change to consumer's snacking habits.</p>
	<p>If consumers continue to snack and eat low nutritional foods at present levels, the average BMI will continually increase as there are excess calories consumed. However, in the optimal case, the average BMI will decrease over time, and eventually bottom out at a certain point.</p>

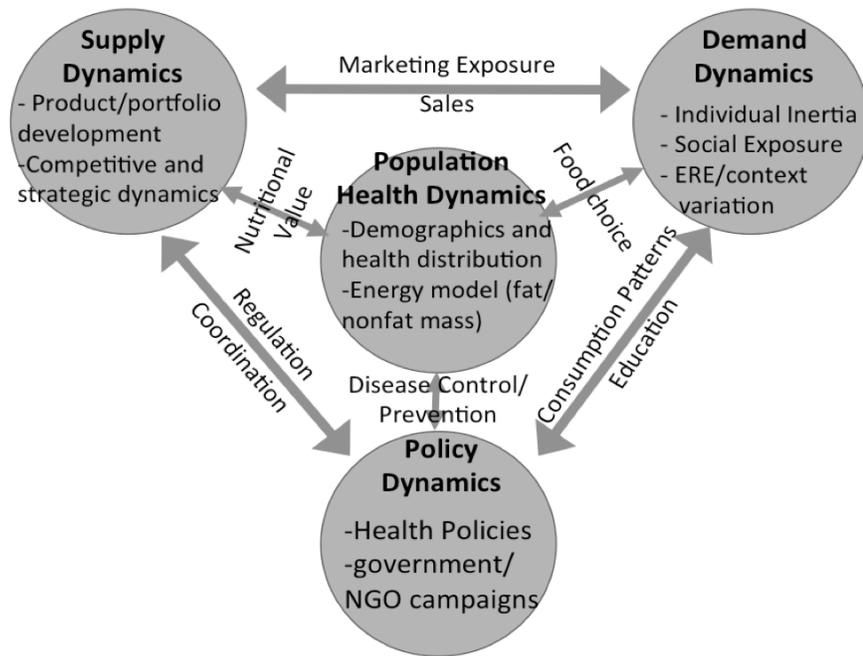
In relation to the reference modes above, after the shock is implemented, market expenditure on low nutrition foods, the proportion of firms not advertising to children and the consumer's exposure to low nutrition advertising should all see immediate reductions. In the optimal situation (green line) other companies will gradually join the initiative, and this number will just keep growing. As a result, the consumption of low nutrition foods, snacks and the total calories consumed will fall gradually over time, resulting in lower BMIs and lower incidence of chronic disease related to obesity.

However, in the case that the signatories to the initiative lose faith in it and begin to abandon it, consumer's exposure to advertising will go back to pre-initiative levels. As a result, the consumption of low nutrition foods and snacks will stay stagnant, and may even increase further as addiction and inertia

effects come into effect. As a result, the average BMI and Chronic Disease will stay the same and may even increase over time as the long-term effects of overeating come into effect.

**A model of nutritious food market transformation**

Retailers that traditionally have focused on High Motivational/Low Nutrition (HM/LN) Food will have limited incentives to transfer their portfolio to LM/HN Food, absent the anticipation of demand. Consumers, on the other hand, are not likely to alter existing consumption patterns rapidly without being familiar with alternatives. Likewise, effective policy interventions should be based on an understanding of such and many other “chicken-and-egg” feedback interactions. In this light, we develop of a behavioral dynamic approach to understanding market transitions.



**Figure 3** Scope of the model

The core decision constructs for both the supply and demand models are based on standard, theoretically and empirically robust multinomial and bounded rational choice structures (McFadden 1963; 2000; March and Simon 1963; Sterman 2000). Building on the problem formulation, we develop here at a conceptual level the feedback processes at work at the aggregate market level, as actors (comprising independent firms, governments, diverse consumers) undertake interventions to shift the motivational/nutritional quality of food consumption towards sustainable pathways. A central insight from the conceptual model derives from highlighting the structural components involving behavioral feedback interactions and inertia. Following this conceptualization we develop a detailed simulation model which we employ to further improve our understanding of what collective initiatives offer high

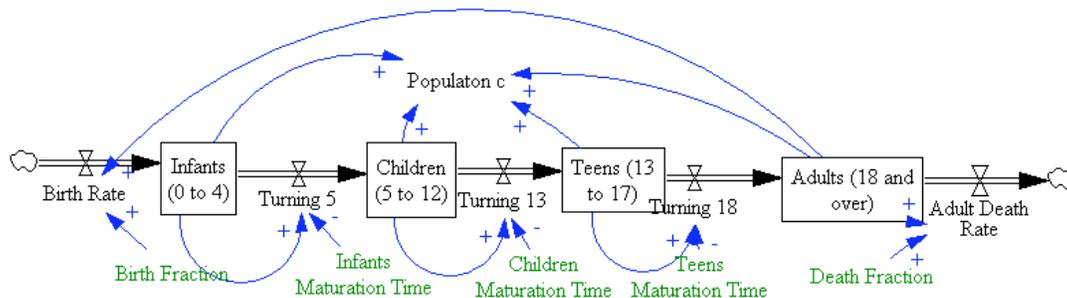
leverage in doing this successfully. Below we discuss first the demand dynamics, which is followed by the supply dynamics. We close by developing dynamic hypotheses related to supply and demand interactions. This will set the stage for scenario development.

Demand dynamics are triggered by intrinsic attributes (taste, price, availability and nutrition). However, consumers also make choices based on marketing influences and also what they and others have previously consumed. A model where these two are weighted is called “anchoring and adjustment” and empirically established (Tversky and Kahneman 1986). We are comparing this model to a familiarity model, which instead of applying weights to pressure and affinity multiplies them together. Although we will be concentrating on the familiarity model, we will be constantly comparing the two models to verify the validity of it. Supply dynamics focuses on the continual evolution of the food product offering. Food profits can be reinvested either in improving marketing (that sees an immediate, one time effect on consumption) or the food’s intrinsic attributes that in tandem with food-making experience will see cumulative experience built up over time.

**Population Dynamics**

The model traces the caloric intake, based on food, categorized by {snack, meal} and {healthy, unhealthy}. The categories can be distinguished by the attributes parameters of the food, including the calories per portion. For example, unhealthy snacks have the highest caloric density. The flow of caloric intake results in equilibrium BMI levels as, expenditure adjusted as weight changes, balance intake. Structural assumptions and parameters derive from the Health Canada

The population is disaggregated into different cohorts to reflect the important variation in exposure and consumption decisions. Thus, we distinguish between age groups = {Infants, Children, Teens, Adults}. To illustrate some of the differences, children aged 5-12 are consuming partially at schools, but have little influence on the purchase decisions. In contrasts, teens have much more ability to determine their own consumption behaviour.

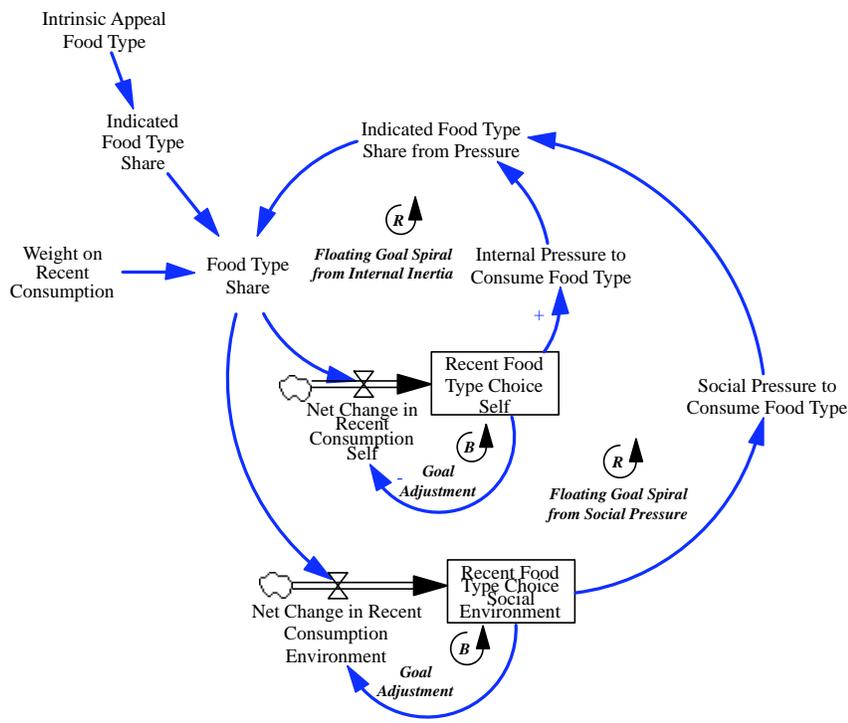


**Figure 4.** Population and aging chain

In addition we distinguish between gender {Male,Female} and socioeconomic situation {Urban, Rural}.

**Demand dynamics**

Consumers respond to changes in the intrinsic product characteristics, over a range of attributes. In particular, we consider product taste, price, nutritional value. In addition consumers value product availability (their presence in stores and variety). However, besides these objective factors, a key aspect to take into account is that consumption is triggered by socio-behavioral factors, a well established empirically and theoretically (Simon 1958). Consumption behavior is difficult to change because of internal inertia (Dockner and Feichtinger 1993; Dubé et al. 2010, Blumenthal and Gold 2010), social norms/ peer pressure (Abrahamson and Rosenkopf 1997). More generally valuation is contingent and subject to floating anchors (Tverskey and Kahneman 1974). We capture these important social behavior (implicit) pressures on consumption patterns (See Figure 5), separating internal pressures (Dubé et al. 2010) and social peer pressures (Abrahamson and Rosenkopf 1997).



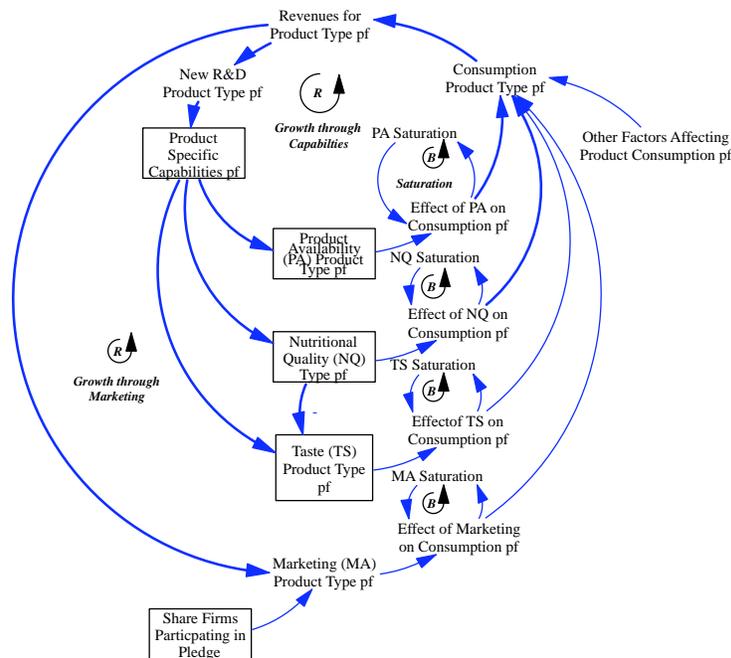
**Figure 5.** Demand-side feedback structure with floating goals.

Anchoring and adjustment implies that consumption is the weighted sum of the consumption share indicated by the “objective” valuation (here the intrinsic food appeal of a food type) and the recent consumption pattern (by the self and/or others in the environment). Then, anchoring and adjustment

introduces a positive feedback between recent consumption and current consumption. If the “objective” valuation is held constant, anchoring and adjustment just has a slowing effect on the adjustment to the “objective” trigger. However, when the “objective” valuation is itself a function of consumption, as influenced by supply factors, consumption dynamics may become path-dependent and consumption may settle at different levels, depending on the initial conditions. The inertia in adjustment introduces further perverse dynamics on the supply-side. Hereto we now examine the core supply dynamics.

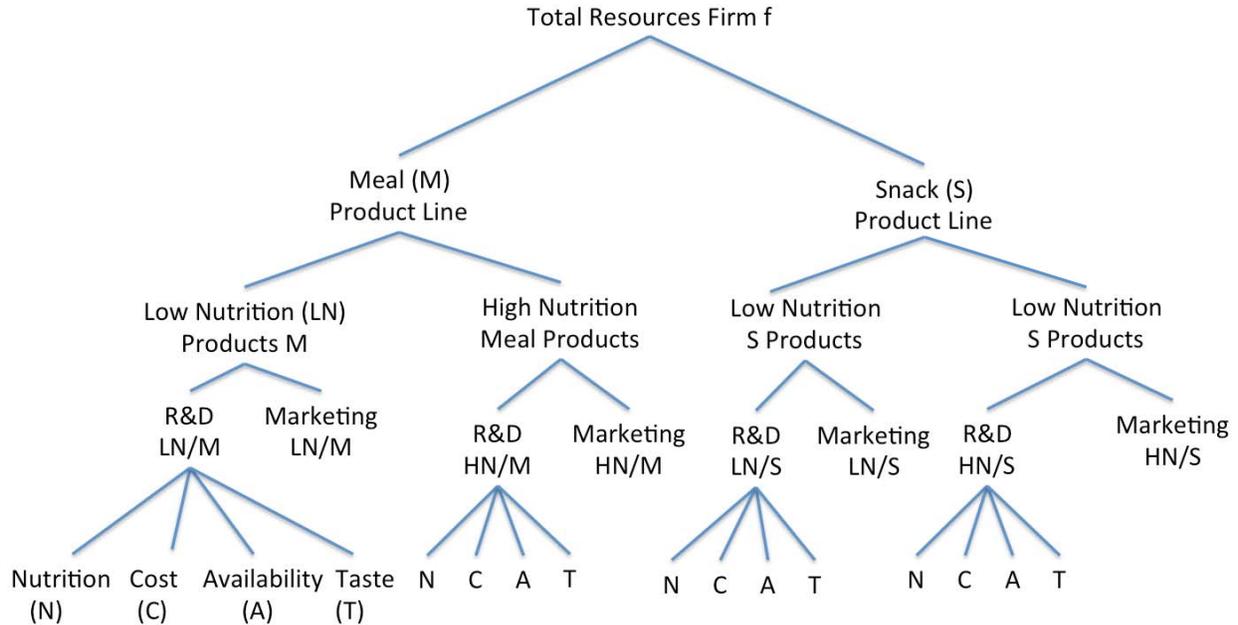
**Supply Dynamics**

We distinguish between N different firm categories (choosing N=1 or 2 in the paper). Firms can differentiate themselves by the initiatives they undertake and the associated and subsequent evolution of their product portfolio. The central supply mechanisms evolve around a positive feedback in improving a products appeal, across the intrinsic attributes (of cost, taste, and nutrition), its availability, and consumers’ awareness (Figure 4). Further, realization that it takes time to build capabilities around a product, and develop a market, because of the repeated actions necessary to gain experience to improve a product (Arrow 1962; Epple and Argote 1990). This time may not be the same for all efforts. For example, improving nutritional quality of a hot processed product, requires the buildup of novel capabilities, which takes much effort and time, compared to boosting sales through traditional marketing.



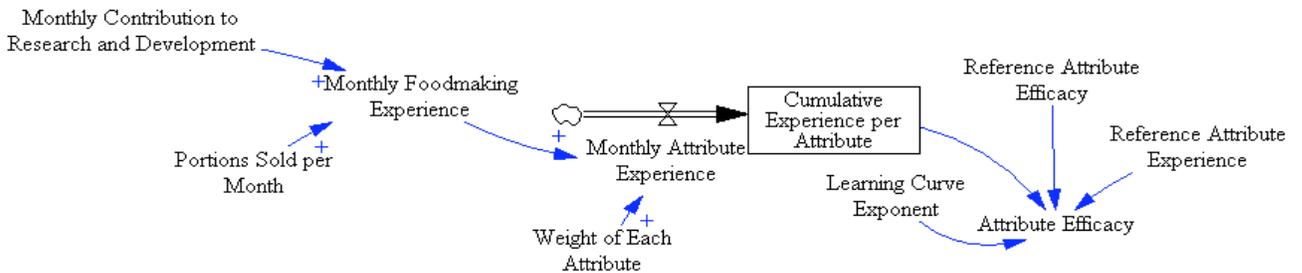
**Figure 6.** Supply-side feedback interactions with capability building and resource allocation

Firms resources are constrained by portions sold and margins per portion. Firms allocate more resources those product categories, involving {HN, LN} and {meal, snack}. Resource allocations increase overall with as profits increase. Allocations are done based on a nested resource allocation structure.



**Figure 7.** Nested Resource allocation structure affecting resource shares within each nest.

First, firms invest more into the product categories that offer higher perceived marginal benefits to invest. Next, within each category, firms distribute resources between marketing and R&D (short term effect), taste change, nutrition change and new product introductions (medium term effect). Finally, within research and development, firms allocate resources to the most taste change, nutrition change, availability change and cost. Together these resource allocation decisions affect the attribute efficacy.



Further, firms compete with each other in the market. Including this is important, for example, in the case when only a partial share joins the pledge. As firms make decisions on joining/leaving a pledge, by considering perceived marginal benefits and loyalty to the pledge.

## Analysis

The goal of the following analysis is to derive insights and develop internally consistent hypotheses on critical mechanisms, producing unanticipated side-effects of favourable and unfavourable nature, in response to policies aimed at shifting the nutritious component of the food markets. Our focus is on a subset of interactions, supply-demand interactions, with emphasis on food-category substitution. To achieve this, we conduct our experiments as follows.

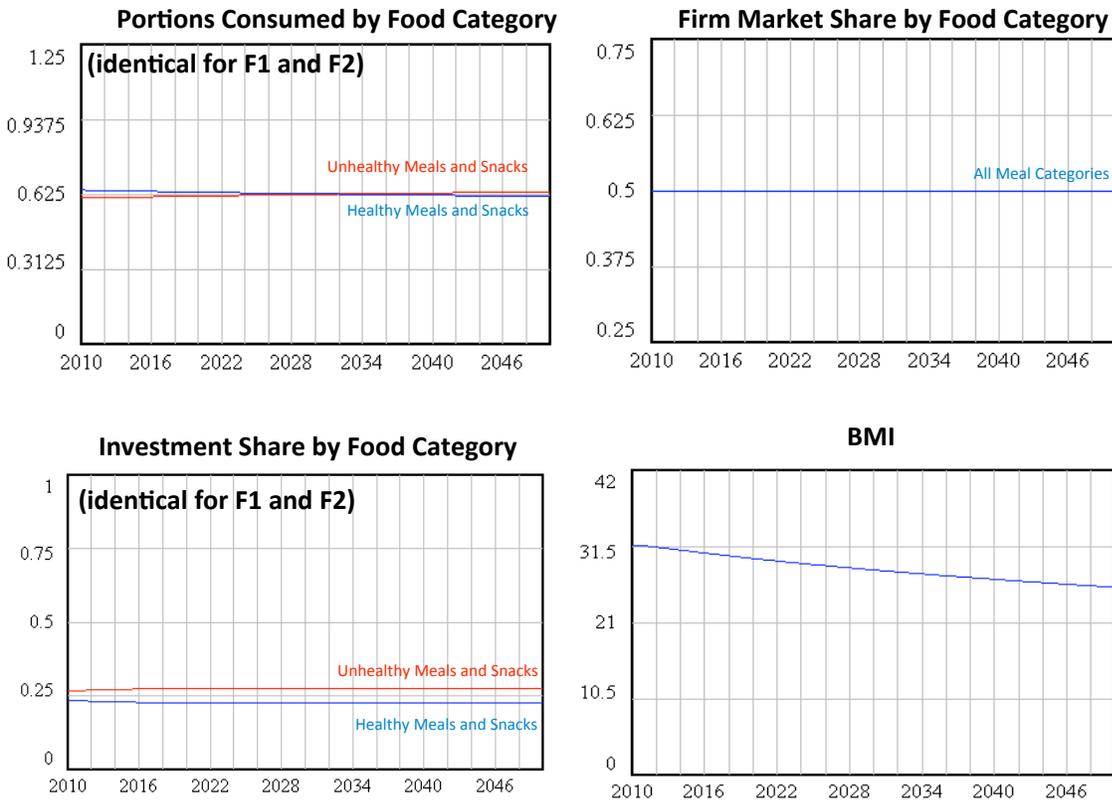
Throughout our analysis, we assume two groups of firms, both entailing multiple firms, and offering food products, along four food categories, high nutritious meals (HNM), high nutritious snacks (HNS), low nutritious meals (LNM) and low nutritious snacks (LNS). From here on we refer to each group as “firm 1” or “F1” and “firm 2” or “F2” respectively. Both firms start with 50% in market share in each category. After 12 month F1 implements a policy while the other (F2) does not. We will analyze the firm and consumer response to the implementation of various policies, and different contexts.

For our analysis we consider two different contexts. We begin with a stylized “base case” involving equal share of consumption between high and low nutritious (HN and LN) food. While this base case is not empirically motivated, analyzing this helps gaining confidence in the basic dynamics of the model. We will configure another contexts, which has a higher rate of consumption of unhealthy food than healthy food. This context represents more closely the food shares in OECD type countries. In either case total population and consumption is held constant. We vary the “context” by setting the initial conditions asymmetrically for HN and LN food, changing social pressure and production experience for attributes of food, the availability parameter (which will be endogenized in later versions). making this uneven for HN and LN food.

To differentiate between HN and LN food, we vary the intrinsic attribute efficacies across them. In the base case, we set the relative attribute efficacy for the HN food categories equal to 1 for all attributes (Price, Taste, Availability and Nutrition); for the LN food categories we taste is higher (1.15) and nutrition is lower (0.5). Consumer sensitivity to all attributes is equal to 1, except for nutrition, which is 0.5. These settings can be interpreted as follows: first, for HN food, price, taste and availability contributes to equally of the utility (and change thereof), when production experiments and investments are identical along these categories. Consumers are less responsive to nutrition, which is half of that; second, the taste attribute contributes twice as much to LN consumer utility (and change thereof) as does HN taste, under equal production experience and investments.

**Base Case Simulation**

The base case represents an equilibrium situation in terms of consumer consumption habits and their distribution across LN and HN food, snacks or meals. This test is conducted to gain confidence in the model. This base case does not represent a particular empirical situation – in very few societies such consumption patterns can be observed. Rather, most societies exhibit unbalanced food consumption, with LN categories high and increasing. Figure 8 shows the simulation, absent any F1 intervention.



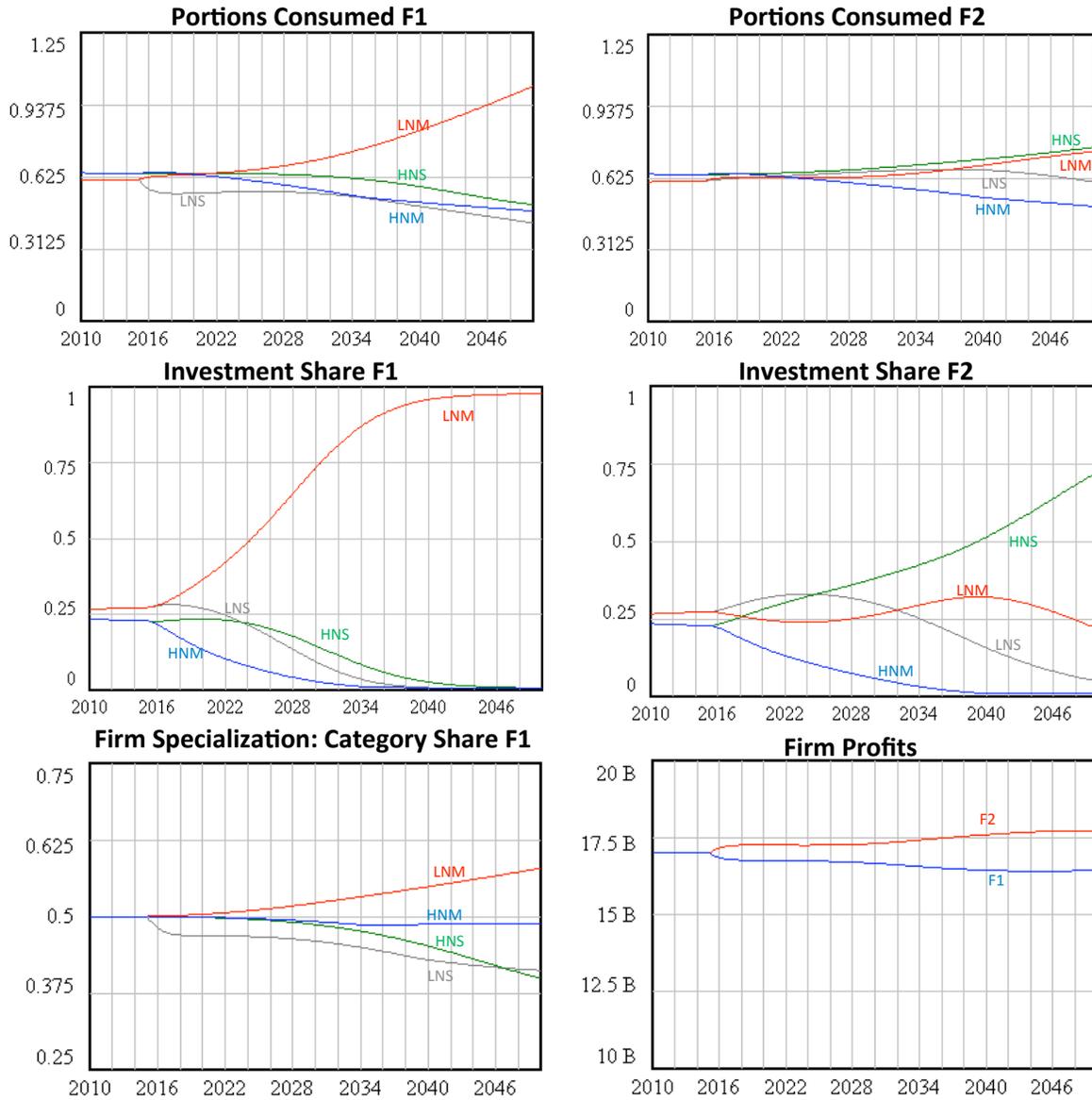
**Figure 8** base case simulation

Consumption of HN, LN food, as well as firm investments essentially stay in equilibrium. The BMI falls gradually however. The fact that BMI decreases, counter empirical realities derives from the fact that we have identified an equilibrium in which investment and consumption of HN and LN food is equal, with ongoing investment in nutrition improvement. Company profits are steady at 17 billion. We will now introduce an intervention, initiated by F1. Any results should be evaluated in relation to this base case.

**Low Nutritious Snack Intervention: Improving Nutrition (at the cost of taste)**

The first test involves a traditional nutrition improvement intervention, with tradeoffs, resembling a case where a subset of firms replace their LN snacks, such as cookies, chips, soft-drinks, by those that

contain a low sugar and salt version. Doing this has however, conventionally at least, an associated cost incurred by deteriorating the state of the taste component. In our simulation we capture this as follows: F1 gives low nutritious snacks (LNS) a boost in nutrition, doubling the nutrition content (halving the calories) instantaneously, while at the same time reducing the taste of that category for F1 by 50%. From this shock, we observe (Figure 9), first, that consumers move away from the F1's LNS category: consumers are more sensitive to taste than to nutrition. Hence, consumers substitute towards other products, including, initially, F2's LNS. This is driven by social and internal habituation pressures that sustain LN consumption, as well as limited cross-meal/snack category substitutability. Other consumers move towards unhealthy meals, in particular towards those of F1. This is driven by a combination of social and internal habituation that sustain LN consumption, as well as brand/product line familiarity. Over time, as consumers move away from the LNS, even firm 2 loses ground with LNS. Firm 2 responds by investing heavily into healthy snacks.

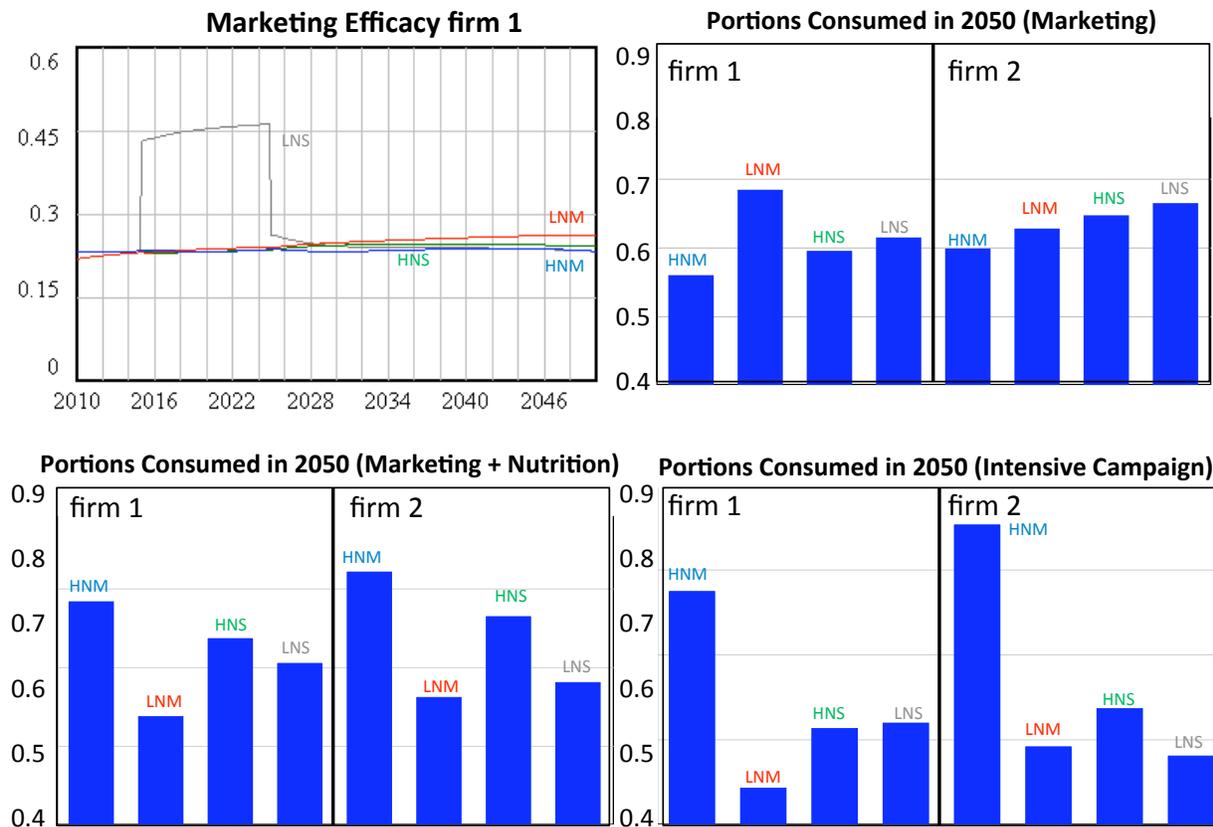


**Figure 9** base case simulation with nutritious improvement of the low nutritious snack (LNS) category

We observe here a particular case of dynamic category substitution, mediated not only by the direct product cross-elasticities involving economic and fixed preferences, but also how the social factors mediate such shifts. Firm investments, responding to the changes in attributes, as well as, in turn, consumer choice reflects this behaviour as well. Altogether it is firm and consumers that jointly shape an alternative consumption pattern. Firms begin to specialize, for F1 it becomes less and less attractive to focus on LNS, and more on LNM. With that, its HNS category also loses ground. F1 becomes a meal producer. This overall outcome is however, while path-dependent, intuitive. We observe also that the Firm 2, not having performed the intervention, benefits, while F1 loses out. The case illustrates, intuitively, why firms do not easily tend to resort to such interventions.

### Low Nutritious Snack Intervention with Marketing Campaign

The response experienced in the first test is less than desirable for firms that modify products of the LNS category. One likely policy is that F1 will accompany an aggressive campaign to boost initial sales of their new, modified nutritionally improved, though still low in nutrition category. In this case, we have, first, introduced a marketing campaign for low nutrition snacks for a ten-year duration (see chart below, Figure 10, top left). As a result, we see that the LNS category does much better, for both firms (Figure 10, top right). Nevertheless, LNM ends up being the dominant category, just as before. Not shown: The campaign is costly since the firm incurs opportunity costs related to R&D and the marketing of other category. Firm 2 (the non-acting firm) still has higher profits than firm 1.



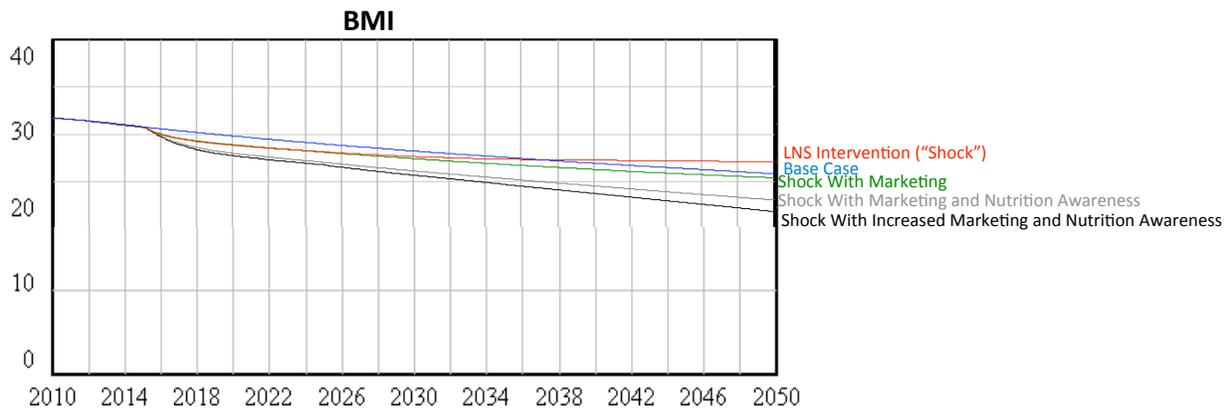
**Figure 10.** Firm 1 improving low nutritious snack nutrition, with campaigns. Top left effect of marketing campaign (about doubling of exposure for the category for the duration of 10 years). Top right: the long-term effect of the campaign. Bottom left: long term effect of a temporary campaign that includes marketing and nutritional awareness. Bottom right: Intense campaign

The dominance of unhealthy meal category is not a necessary outcome. This is illustrated when we intensify the marketing campaign, or add a nutritional value campaign. Understanding that consumers will not be very responsive to changes in nutrition, firms and government may decide to launch

campaigns to increase consumer awareness of nutrition. Figure 10 bottom left shows the effect of a joined marketing and nutrition campaign. The nutrition campaign is implemented as a shock, making consumers more sensitive to changes in nutrition (50% increase). With heightened awareness for nutrition, consumers change their substitution patterns more sensitive to changes in overall nutrition. In this case, we see that healthy meals and healthy snacks have higher adoption rate, although just marginally. Unhealthy snacks are still not catching on. Notably, Unhealthy Meals do not catch on in this circumstance. With further marketing or nutrition awareness pressures, we begin to see an interesting dynamic. In the example of Figure 10, bottom right, we have increased the marketing efficacy of unhealthy snacks over the same duration, and increased the effectiveness of the nutrition awareness campaign. The more interesting dynamic is that the HNM category experience a dramatic increase in consumption. Nevertheless, Firm 2 retains the higher profits in all scenarios.

**Effects of Unhealthy Snack Shock Scenarios on BMI**

The scenarios we discussed above all change the population BMI, compared to the base case. Introducing the shock without any campaign leads, however, to a better-before-worse scenario at the societal level. Early success results from reduced consumption of unhealthy snacks. However, consumers switch to LNM, in which F1 becomes to specialize. For scenarios with campaigns, the consumption of the HN foods increases, which has a beneficial effect on BMI.

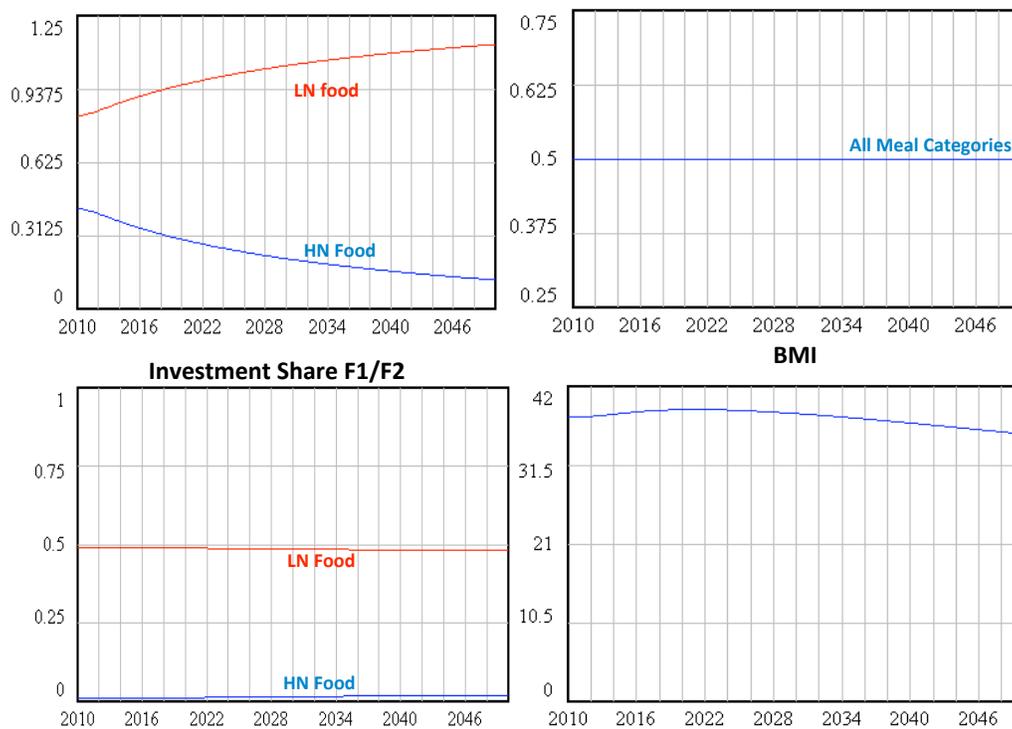


**Figure 11.** BMI under various scenarios

The situation with the most successful decline in BMI is the situation with increased marketing and nutrition awareness, where the HNM gain traction. Combinations in which both marketing and nutrition awareness is raised experienced better results in reducing BMI.

### Contexts dominated by Low Nutritious Food Consumption

We now alter the context in which the experiments take place. We simulate a context where unhealthy foods are far more accessible than healthy foods. This is the case in many places in North America, where processed foods dominate supermarkets and restaurant selections are typically fast food chains and greasy spoons. To illustrate this difference, we set identify an equilibrium with LN food dominant, altering the initial conditions for social exposure pressures and production experience. In addition, we set the availability attribute of LN foods 2.5 times to that of HN food (in subsequent analysis, availability will be endogenized). Figure 12 shows this scenario resembling a region dominated by LN food consumption.

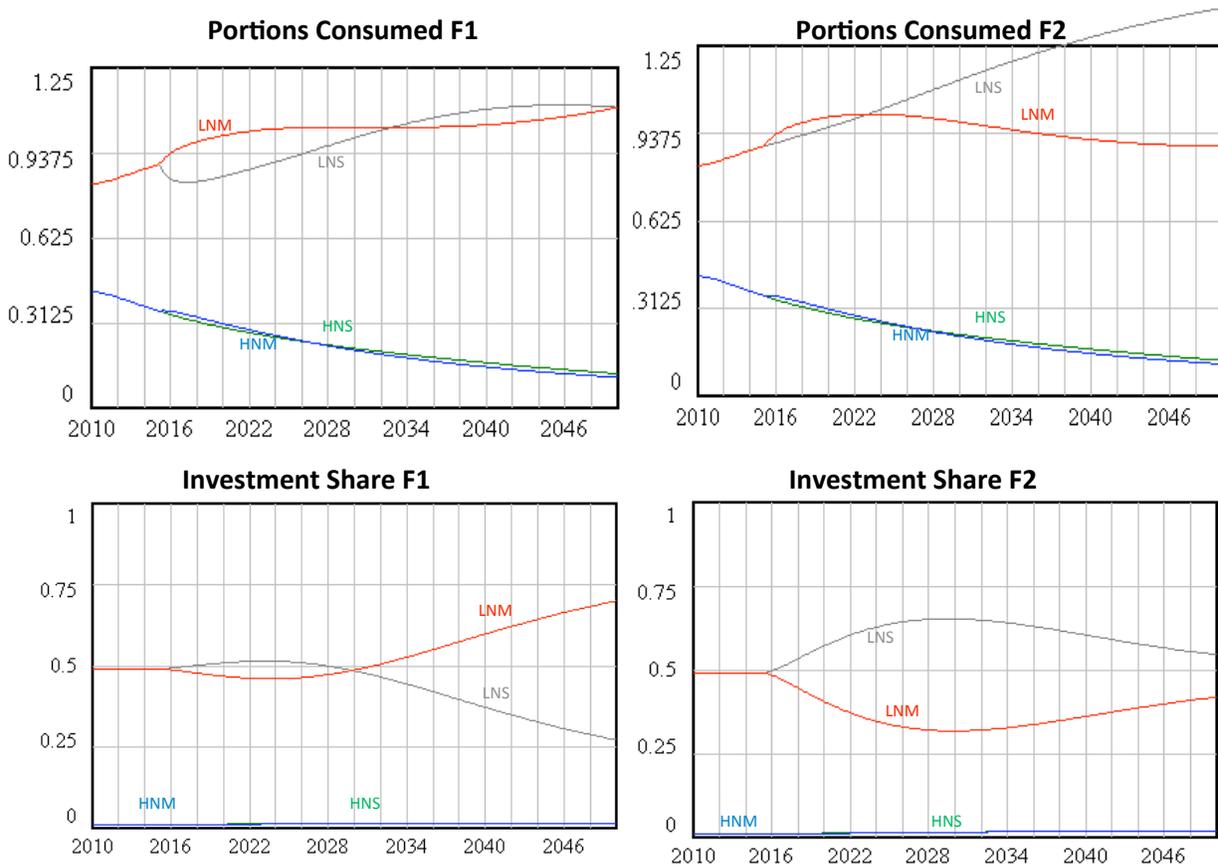


**Figure 12.** reference case for region dominated by LN-food consumption

We note that investment shares in HN food are low, because of the limited market share, consumer sensitivity, and availability, returns on investment are low. Nevertheless, little effort has high impact, hence BMI, decreases eventually. While limited in various ways, this scenario serves as a very useful reference for examining the effect of intervention in regions dominated by LN food consumption.

### Low Nutritious Snack Intervention in Regions Dominated by Low Nutritious Food

We now analyze, for the region dominated by LN food consumption, some of the same interventions as we did in the base case and compare this with the zero intervention as well as with the base case results. Figure 13 shows the intervention (no campaign).

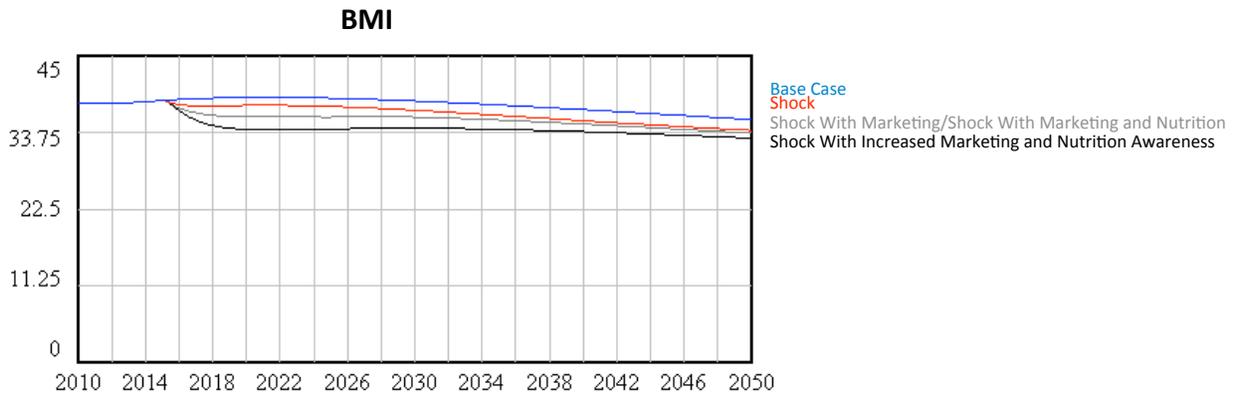


**Figure 13.** nutritious improvement of the low nutritious snack (LNS) category in a region dominated by LN Food

We observe a major difference compared to the intervention on the base case: in regions dominated by LN-food consumption, substitution occurs mainly within the HN or LN categories, rather than between. Because of this, unhealthy snack remain a dominant category, though within the unhealthy food categories, consumers tend to prefer F2’s snacks over F1’s snacks.

Tests involving campaigns (Marketing and Nutrition Awareness) do little to alter substitution between healthy and unhealthy foods. Unlike the more balanced consumption scenario, consumers primarily switch within the health category (between meals and snacks). This has also consequences for the BMI. First, the intervention does have a positive effect, mainly because the important LNS category improves.

Nevertheless, improvements are low and campaigns have barely any improvements in the long run, despite an initial and immediate impact (shifting consumers from LNS F2 to LNS F1).



**Figure 14** BMI under various scenarios for region dominated by LN food consumption

Marketing and nutrition campaigns seem generally effective in reducing BMI levels. However, in the experiments run, there was not one that encouraged a trend towards eating healthier foods. Increased marketing and Nutrition Awareness generally helped reduce BMI levels, though none to the level seen in the A1 base case.

### Conclusion, implications, and next steps

From our analysis, we can highlight the main dynamics of consumer and firm response at work. Consumer response to changes in the intrinsic the attractiveness of a product, but also to changes in the mix of product, depending on the degree of them being substitutes. From the study, we found that efforts to improve unhealthy snacks by improving its nutritional value were often met with resistance because of varying consumer expectations on various food attributes. We found that the only condition where the modified unhealthy snacks were found to be popular was with an extended market campaign and heightened nutritional awareness. In all other situations, consumers went for alternative products. Another noteworthy effect of product substitution includes the situation where the changing of unhealthy snacks actually resulted in the increase of consumption in healthy meals. If unhealthy snacks are promoted well enough, this lowers the consumption of healthy snacks, which would in turn increase the consumption of healthy meals.

Firm decisions across meal and health categories are based primarily on market forces and what the market wants. This could explain the reluctance of many companies to modify their unhealthy products. Investment decisions that are based on the market forces in turn shape the future consumption of snacks

and meals. This would imply that without a shock or intervention, consumers would be more and more biased towards food categories they are already eating.

One important implication from this study is the effect of cross-substitution. The cross-substitution effect, where investment and change was made to one category, that actually benefitted another category more, is a very interesting dynamic that warrants further study. This implies that decision makers should not only be aware of how changes would affect consumption in that food category, but how it would change across all food categories. We have reported research underway in an iterative process. We can further expand upon and refine this firm response and consumer product substitution model by refining the parameters and assumptions made with more real data and information from other academic studies. Because this model takes from such a wide spectrum of study areas, new research into consumer response and behaviour, firm response and behavior and product selection and substitution is coming up every day and can be incorporated into the model.

Decision-making can occur in different ways depending on factors such as age, location, socio-economic group, marital status and other factors in the community. Results may be different depending on the situation, as one consumer group may respond entirely differently from another group.

Firms, but also other actors in the nutrition market system have a whole arsenal of actions available to them. The pricing of food is typically completed in a supply/demand fashion, not based solely on cost, and we have observed that healthy foods may carry different costs and different profits levels than unhealthy foods. Government has also been considering adding taxes to certain foods to affect the consumer behavior. Finer detail could be added in the pricing mechanism. Finally, this is a meso-level analysis. Results from this study could be combined together with a macro-level study to see what macro-level implications government and firm decisions would have on the national economy.

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### Appendix I – Detailed Variable List

The following variables will be represented from 2000-2030.

- Marketing Expenditure LN food
- Proportion of firms not Advertising to Children (by market share)
- LN food product availability share
- Consumer’s Exposure to LN food Advertising
- LN food consumption by consumer’s peers
- Calories Consumed Daily
- Proportion of Food Consumed
  - o through snacks (as opposed to through meals)
  - o LN (as opposed to HN)
- BMI

<b>Population</b>	<b>Demographic</b>	<ul style="list-style-type: none"> <li>o Population [People]                             <ul style="list-style-type: none"> <li>• By age group                                     <ul style="list-style-type: none"> <li>- Infants (0 to 4)</li> <li>- Children (5 to 12)</li> <li>- Teens (13 to 17)</li> <li>- Adults (18 and over)</li> </ul> </li> <li>• By sex                                     <ul style="list-style-type: none"> <li>- Male</li> <li>- Female</li> </ul> </li> </ul> </li> <li>o Birth and Death Rates [People/Year]</li> </ul>
	<b>Health</b>	<ul style="list-style-type: none"> <li>o Overall rates of obesity, measured with BMI [kg/m<sup>2</sup>]</li> <li>o Average Height [m], Weight[kg] by age group</li> <li>o Incidence of NCDs by age group [cases/year]</li> <li>o Physical activity [hours/week] by age group</li> <li>o Effect of excess calories on weight [calories/kg]</li> <li>o Estimated daily calorie expenditure [calories/day] by age group and sex</li> </ul>

	<p><b>Consumption</b></p>	<ul style="list-style-type: none"> <li>○ Snack Calories Consumed [calories/day] <ul style="list-style-type: none"> <li>● Proportion of snacks unhealthy [dmnl]</li> <li>● Effect on calories gained by consuming unhealthy snacks [dmnl]</li> <li>● Normal snack calories [calories/day] by age group and sex</li> </ul> </li> <li>○ Meal Calories Consumed [calories/day] <ul style="list-style-type: none"> <li>● Proportion of meals unhealthy [dmnl]</li> <li>● Effect on calories gained by consuming unhealthy meals [dmnl]</li> <li>● Normal meal calories [calories/day] by age group and sex</li> </ul> </li> </ul>
	<p><b>Exposure</b></p>	<ul style="list-style-type: none"> <li>○ Average ad exposure [hours/week/person], by age group <ul style="list-style-type: none"> <li>● In this first project all media types are aggregated. Media types include: <ul style="list-style-type: none"> <li>- Radio</li> <li>- Television</li> <li>- Internet</li> <li>- Video on Mobile Phone</li> <li>- Print media (newspapers, magazines)</li> <li>- Outdoor (billboards, bus ads, food sample stands, etc.)</li> </ul> </li> </ul> </li> <li>○ Ad Content [%] <ul style="list-style-type: none"> <li>● Snacks</li> <li>● Soft Drinks</li> <li>● Fruit Drinks</li> <li>● Fast food</li> </ul> </li> </ul>
<p><b>Private Companies</b></p>	<p><b>Marketing Expenditure</b></p>	<ul style="list-style-type: none"> <li>○ Marketing Expenditure: Combinations of the Following [%, \$/Year] <ul style="list-style-type: none"> <li>● By channel</li> <li>● By target audience [\$/year]</li> <li>● By food group [\$/year,%]</li> </ul> </li> </ul>
	<p><b>Private Initiative</b></p>	<ul style="list-style-type: none"> <li>○ Companies Voluntarily Banning Marketing to Children</li> <li>○ The market share of those companies</li> <li>○ Severity (Effectiveness) of Voluntary Ban</li> </ul>
	<p><b>Product Decisions</b></p>	<ul style="list-style-type: none"> <li>○ Average healthiness of product offering</li> </ul>
<p><b>Consumer and Health Orgs.</b></p>		<ul style="list-style-type: none"> <li>○ Expenditure on negative marketing (marketing that is targeted to reduce the consumption of unhealthy foods)</li> <li>○ Overall budgets</li> <li>○ Number of organizations</li> </ul>
<p><b>Government Policy</b></p>	<p><b>Food</b></p>	<ul style="list-style-type: none"> <li>○ Regulation on the restricting of marketing to children</li> </ul>