Assessing the Impacts of Three Potential Interventions on Fruit and Vegetable Consumption in Urban Kenya Using Participatory Systems Modeling

APPENDIX: Detailed Model Description

Model Description

The model is designed to replicate the observed limited growth in fruit and vegetable consumption per capita. The current model version represents 2015 observed consumption levels in "dynamic equilibrium" beginning in 2018 with unchanged market or promotion conditions, then examines the impacts of changes to factors that would affect consumption. The model represents 5 years (with a weekly time unit of observation) starting with 2018. The current model focuses only on a single "generic" fruit and vegetable product that is more representative of leafy greens.

The structure for the supply chain components of the model (farm production, intermediaries[1], and vendors) is based on the supply chain formulation in Sterman (2000, Chapter 20), modified in this case to reflect multiple linked supply chain actors for fruit and vegetable products. In Sterman's formulation, prices from sellers to buyers are determined by inventory coverage (the amount of product in storage at a market level divided by current sales and expected product losses—spoilage). Sales prices generate revenues, which along with costs for production and distribution determine profits. Profitability of farmers, intermediaries and vendors determines the level of initiation of new production (for farms) or marketing (purchases/orders, for intermediaries and vendors), which become part of available inventories with a delay (e.g., time is required to increase production and to contract for purchases and receive deliveries from suppliers). Prices also determine the demand for product by intermediaries, vendors and consumers.

Although in some supply chain models, perfect coordination is assumed (orders are coordinated throughout all levels of the supply chain), we do not assume that the fruit and vegetable supply chain for Nairobi demonstrates this degree of coordination. Rather, farmers, intermediaries and vendors are assumed to operate independently and thus may make supply or purchase decisions not entirely aligned with the purchase or production decisions of supply chain partners. *However, the model does assume that each value chain actor can perceive and has some ability to respond to changes in sales volumes and profitability, that is, without explicit external coordination or communication.*

Potential intervention points are represented for each of the market actors.

[1] *Intermediaries* are defined for the purposes of the model as the first buyer of product from farmers, and the sellers of product to *vendors*, who are assumed to sell directly to individual consumers (households). This is a simplification in the sense that there can be multiple intermediaries between farmers and vendors, but this aggregation likely does not affect the outcomes of the model.

Farm Level View Description

- Farm planting of product depends on previously-experienced profitability (based on the price to intermediaries less unit costs of production inputs). Yields depend on the availability and use of production inputs.
- There is a delay between planting and production, and not all production can be marketed (based on the perishability of the product at the farm level).
- The inventory (stock) of the product at the farm level is determined by harvested amounts, sales and the proportion of product not marketable or that spoils.
- Farmers sell to intermediaries. The price charged to intermediaries is based current inventories of product relative to sales plus product losses. (This quantity is called relative inventory coverage.)
- ***Interventions*** represented include:
  - technology to increase yields, either increases over time (RAMP) or sudden changes (PULSE)
  - technology to reduce farm-level product losses
  - the proportion of inputs available (which affects product yields)
  - improved product quality (which increases farm production costs)

Intermediary View Description

- Intermediary purchases from farmers depend on profitability of current volumes marketed; as profitability increases, more product is demanded from farmers to be marketed to vendors.
- Profitability depends on prices received from vendors less marketing costs, including the cost of sourcing the product from farmers.
- There is a delay between the time orders are placed and when product is available to intermediaries. This could be due to a standard ordering and delivery procedures or lack of current product availability at the farm level.
- The inventory (stock) of product at the level of the intermediary depends on orders received from farmers less sales or product losses (product not marketable or that spoils)
- Intermediaries sell to vendors. The price charged to vendors is based current inventories of product relative to sales plus product losses.
- ***Interventions*** represented include:
  - technology to reduce intermediary-level product losses
  - improved product quality (which increases intermediary marketing costs)

Vendor View Description

- The quantity of vendor purchases from intermediaries depends on the profitability of current volumes marketed; as profitability increases, more product is demanded from intermediaries to be marketed to consumers.
- Profitability depends on prices received from consumers less marketing costs, including the cost of sourcing product from intermediaries.

- Vendor profitability affects the number of vendors (increases in profitability mean more vendors), which affects the time cost required for purchases by consumers. (More vendors implies a lower time cost for consumers.)
- There is a delay between the time orders are placed and when product is available to vendors. This could be due to a standard ordering procedures or lack of current product availability at the intermediary level.
- The inventory (stock) of product at the level of the vendor depends on orders received from farmers less sales or product losses (product not marketable or that spoils)
- Vendors sell to consumers. The price charged to consumers is based current inventories of product relative to sales plus product losses.
- ***Interventions*** represented include:
    - technology to reduce intermediary-level product losses
    - improved product quality (which increases intermediary marketing costs)
    - impact of increases in income (which could include specific transfers to promote fruit and vegetable consumption)

Discussion of the Value Chain Linkages Among Farmers, Intermediaries, and Vendors

As noted above, the value chain components of the model are based on the supply chain formulation in Sterman. In this formulation, each of the actors (farmers, intermediaries, vendors) manages a "supply line" of physical product that is described by two stocks: product on order from a supplier (or in the field growing in the case of the farmer) and product inventory controlled by that actor. Orders are placed with suppliers (or crops are planted in the case of the farmer) based perceived profitability; higher perceived profitability results in larger orders or planting. There is a delay for receiving product after orders are placed (or crops planted). For crops, the growing period is assumed to be 8 weeks, based on information from Gogo et al. (2016) for leafy vegetables. The delivery time from farmers to intermediaries (which includes all processes after an order is received) is assumed to be 0.25 weeks (1.75 days), and the time required to supply vendors is 0.125 weeks (0.875 days). There is limited data for specification of these time delay values, but these parameters have a limited impact on model outcomes in response to interventions.

Product arriving from suppliers (or crops harvested for farmers) is assumed held in inventory until sold, with losses due to spoilage or insufficient quality specified as a proportion of inventory. Gogo et al. (2017) reported a total loss rate of 45% in the supply chain for leafy vegetables, with roughly equal proportional losses at various stages of the supply chain. Thus, the current structure assumes losses of 15% of product inventory per week for each of farmers, intermediaries and vendors. Given the short shelf life of many fruit and vegetable products, inventory turnover occurs rapidly, with sales occurring less than 0.5 weeks after delivery of the product.

As in the Sterman (2000) supply chain structure, the amount of product in inventory relative to sales rates and losses provides sellers with a signal of the current supply and demand balance in the market. Actors are assumed to have a desired level of "inventory coverage", that is, a number of days that product in inventory would cover at existing rates of sales and loss. Given the perishability of the product, all actors are assumed to have relatively short amounts of inventory they wish to hold, 0.5 weeks of product (i.e., the value of product equal to 3.5 days of sales plus product losses). When inventories fall below this amount of coverage, this is a signal to increase prices, and inventories higher than this amount are a signal to decrease prices. Price setting by supply chain actors uses what is called a constant-elasticity "multiplicative reference" form given by:

Sales Price = Reference Price x (Current Inventory Coverage / Reference Inventory Coverage)^Sensitivity of Price to Inventory Coverage

The sensitivity of prices to inventory coverage is described by a single parameter and is set equal to -0.5 in each case based on other studies of agricultural commodity markets (Nicholson and Stephenson, 2015a). The reference inventory coverage is as stated above, 0.5 weeks. [The sensitivity of model outcomes to these assumptions will be assessed once there is consensus regarding the model structure and other data inputs.] Prices set by farmers are the unit cost for intermediaries, the prices set by intermediaries are the unit costs for vendors, and prices set by vendors are those paid by consumers. Thus, prices and physical flows of product provide the main linkages among participants in the value chain—there is no more sophisticated coordination strategy as is relevant for many non-agricultural supply chains (Nicholson and Stephenson, 2015b).

As noted above, profitability determines orders and profitability is defined as revenues less costs. Currently the model focuses on variable costs due to the nature of available data, but fixed cost components could be incorporated if relevant information became available. Costs for farmers include those for production and marketing, with a distinction made between costs of inputs and other variable costs. For intermediaries and vendors, costs include those for the acquisition of product (based on the prices from their suppliers) and other variable costs. Note that for all of the supply chain actors, their costs of acquiring product <u>per unit of good sold</u> will be higher than their cost <u>per unit product acquired</u> due to losses. For example, intermediaries will by roughly 8% more from farmers than they can sell given losses due to spoilage, so their cost per unit product sold will be higher than the farm price.

Each supply chain actor responds to relative profitability per unit by modifying orders (or plantings for farmers), relative to a reference value of orders. The reference value of profitability is calculated based on the approximate retail price in Nairobi for kale and mangoes from the 2015/16 Kenya Integrated Household Budget Survey (Kenya National Bureau of Statistics, 2018), 50 KSh/kg. Because there is no current or specific information on supply chain costs for kale and mangoes in Kenya, the proportional allocation of costs and benefits was assumed based on the supply chain actor margin information from Chemonics (2013) for Kenya's tomato value chain. Orders (or plantings) are defined based on:

Orders to Supplier (Plantings) = Reference Orders (Plantings) x Effect on Orders (Plantings){Current Profitability/Reference Profitability}

Where the "Effect of…" is an asymmetric nonlinear function (a "LOOKUP" in the language of Vensim) rather than a single elasticity. A nonlinear function provides greater flexibility than a formulation with a single supply elasticity parameter and can allow for relative profitability that is (temporarily) negative without production declining immediately to zero. The form of this function is assumed as follows:

Input	Output
-0.5	0.25
-0.2	0.5
0.5	0.85
0.95	1
1	1
1.05	1
1.5	1.1
2	1.25
5	1.5

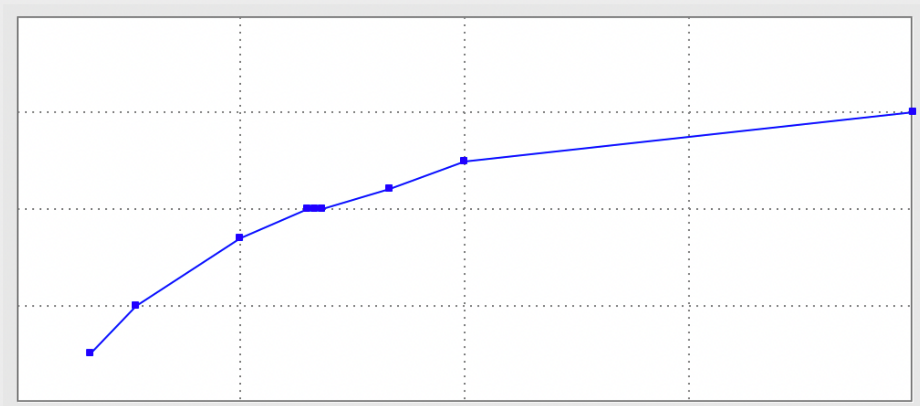

Figure A4-1. Nonlinear ("LOOKUP") Function Indicating how Relative Profitability Affects Orders (X axis [Input] is relative profitability, Y axis [Output] is multiplicative effect on orders)

This function indicates that when the current profitability equals the reference profitability, orders will be equal to reference orders. When profitability is below the reference value, orders will be decreased more rapidly, and when profitability increases, orders will be increased, but more slowly due to potential existence of constraints in expanding the delivery of fruit and vegetable products. [Model outcomes may be sensitive to the shape assumed for this function, so this will be evaluated with sensitivity analysis.]

The "reference values" of stocks are those that result in "dynamic equilibrium", which means that the values of the stocks (e.g., inventories) are constant over time, but the associated inflows and outflows are non-zero. Ultimately, the initial stock values are derived from the reference quantities of consumer demand for fruits and vegetables.

Consumer Effects View Description

- A number of consumer perceptions affecting consumption of fruits and vegetables are modeled as adaptive expectations (exponential smoothing) structures, where perception adapt over time to changes in the underlying reality. [This formulation derives from Sterman (2000, pp. 428-432) and is common in SD models representing perceptions.]
- The perceptions modeled include those for:
    - Safety and hygiene of products

- Quality and freshness of products
- Convenience (e.g., time required to prepare for cooking)
- Time cost (which is affected by the number of vendors)

- Each of these perception effects is modeled as a proportional change from a reference (baseline) value of 1, with an exponential 'sensitivity' (response) parameter. If a value of perception increases above 1, this increases demand from its baseline level[2].
- Consumer awareness of the nutritional benefits of products is modeled in a similar manner.
- Interventions to increase quality are explicitly included in this model version to illustrate how this could be analyzed, but similar effects easily could be included (but are not yet) for safety, convenience and time cost.
- Another set of effects represents perceptions of fruit and vegetable consumption as a "good choice" as interacting with the current level of emotional benefits from consumption of fruits and vegetables. Both of these variables are modeled as stocks that are modified by education (for "good choice" perceptions) the level of the other stock (emotions positively affect "good choice" perceptions and vice versa). This implies a reinforcing feedback process between the two effects.
- "Ultimate" outcomes can be linked to consumption of fruits and vegetables (very simplified in the current version for obesity only).
- Impacts of positioning at point of sale and "encouragement" (and/or information) from vendors have also been included as multipliers that affect consumer demand for the product.
- ***Interventions*** represented include:
    - Resources to change cultural perceptions of "good choice"
    - Resources to change awareness of the nutritional and health benefits of fruit and vegetable consumption
    - Other effects to examine the impacts of safety/hygiene or convenience (or add factors in addition to number of vendors to the impact on time cost).

More Detailed Description of Consumption Computations

It is helpful at this point to expand on how the different factors affecting consumption were modeled, and to describe the (rather limited) evidence base available. Demand for fruits and vegetables is modeled with an equation that aggregates a number of "multiplicative" effects—this is quite common in SD modeling. Each of these is based around a reference value (often equal to 1), and are used in an equation like:

*Demand = Reference Demand*Effect of Price*Effect of Income*Effect of Quality…*

and a number of other effects. Reference Demand is based on the amounts of vegetables consumed per capita from the Global Dietary Database for 2015 multiplied by the population of

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[2] The specific formulation is Effect of Perception on Demand = Perception Value^Sensitivity of Demand to Perception. Demand is modeled as Reference Demand Quantity * Effect of Perception on Demand. The base value for "perception" variables is 1, which implies demand equal to the reference level.

Nairobi from the Kenya Integrated Household Budget Survey (KNBS, 2018) conducted in 2015/16. Most of the effects are modeled using a common formulation in SD, a "constant elasticity" formulation, that has the form:

Effect = (Current Value/Reference Value)^Sensitivity

where the Reference Value is exogenous (assumed, based on data), the current value is part of the stock-flow-feedback structure and so changes with interventions, and the sensitivity determines how large a change occurs in response to a change in the ratio of the current to the reference value. When the current value equals the reference value, that ratio is equal to 1, and the "Effect" has the value of 1—which means that it does not affect the amount of demand compared to the Reference Demand. As a more specific example, it is quite common in economic SD models to model price effects as:

Effect of Price = (Current Price/Reference Price)^Price Elasticity

where typically, the value of the Price Elasticity < 0 because an increase in price reduces the amount demanded. Although this is a relatively simple formulation and in some economic settings a more complicated one may be appropriate (an example would be to account for the impact of how changes in the prices of other commodities affect demand for F&V—this is a "cross-price elasticity" effect), this is generally a good start as an approximation to the most important effects. It is also what in model speak we call "parametrically parsimonious", that is, it only requires a few pieces of information, namely, the specification of the reference price and the sensitivity value. This limited number of parameters to represent these effects also facilitates sensitivity analyses, because many simulations can be run with changes to just these two values.

This leads to an important discussion of the consumer-related interventions that affects how to interpret the model outputs. In the case of nearly all of the consumer effects, we don't have any data on the current state, say, of a value like "quality", which in any case could imply multiple measurements of freshness, taste, appearance or nutritional value. (In the current formulation, "safety and hygiene" is considered as a separate effect, although for some consumers this might be an element of "quality".) Because we have no data on actual quality, the model assumes that the current value of "quality" is equal to 1, and this is the "reference value" for the purposes of the computation of "Effect of Quality". (The model also assumes that current consumer perceptions of quality are equal to this reference value, which is necessary to begin in dynamic equilibrium.) This means that the "Effect of Quality" will be calculated as:

Effect of Quality = (Perceived Quality/Reference Quality)^Sensitivity of Demand to Perceived Quality

To analyze this, the actual quality is assumed to be increased, which, with a delay, increases consumer perceptions of quality and increases demand based on the sensitivity of demand to increased quality. Because the reference value of quality equals 1, the assumed amount of the increase will be of a similar order of magnitude. The analysis reported below for quality improvement assumes an increase in quality (however measured) of 20%, so that the Effect of Quality = (1.2/1)^Sensitivity Value. As you would guess, both the size of the assumed quality increase and the value of the Sensitivity parameter are important determinants of the effect on consumer demand. The assumed improvement in quality is within the control of the modeler, but the sensitivity value must be specified—and there are limited data upon which to base this.

For example, the sensitivity values for quality, safety & hygiene and convenience are developed based on two studies of essentially the same dataset (Ngigi et al 2011 Urban Consumers' Willingness to Pay for Quality of Leafy Vegetables along the Value Chain The Case of Nairobi Kale Consumers Kenya, and Lagerkvist et al 2011 Consumers' Willingness to Pay for Food Safety in Nairobi The Case of Fresh Vegetables) that examined the willingness to pay for safety & hygiene but also compared these to 'quality' and 'convenience'. These studies indicated that consumers were willing to pay a price premium of about 8 KSh/kg of Kale or a 39% price premium based on values reported in open-air markets as a part of the data collection. This difference in WTP was assessed for kale produced with "typical" methods (not very hygienic) versus kale with clean irrigation water, rinsed in clean water and with chemical residues within acceptable limits[3].

With a few assumptions, this WTP value can be converted into a sensitivity value for safety & hygiene, using the above equation. This assumes that people would be willing to pay a higher price for same quantity, so using elements of the equation described above:

Demand = Reference Demand(Improved Safety & Hygiene/Reference Safety & Hygiene)^Sensitivity of Demand to Safety & Hygiene*(Increased Price/Reference Price)^Price Elasticity*

If we assume that there is no change in demand with the higher price (part of the definition of WTP), we can write:

Reference Demand = Reference Demand(Improved Safety & Hygiene/Reference Safety & Hygiene)^Sensitivity of Demand to Safety & Hygiene*(Increased Price/Reference Price)^Price Elasticity*

dividing both sides by Reference Demand gives:

1 = (Improved Safety & Hygiene/Reference Safety & Hygiene)^Sensitivity of Demand to Safety & Hygiene(Increased Price/Reference Price)^Price Elasticity*

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[3] *Although I have not done a lot of work in this area, WTP studies seem to tend to overestimate what people would actually pay in a real setting—I'm most familiar with the evidence for this for organic milk in which far more households indicated a WTP the premium for organic milk than actually do. Thus, we might best think of this 8 KSh/kg value as an upper limit.*

filling in values related to prices:

1 = (Improved Safety & Hygiene/Reference Safety & Hygiene)^Sensitivity of Demand to Safety & Hygiene(1.39/1)^(-0.75)*

where the 1.39 implies a 39% increase in price based on the WTP analysis, and the price elasticity of demand (-0.75) is from another study (Bundi et al. 2013). If we assume a fairly substantive increase in safety & hygiene based on the comparison scenarios for the WTP study, say, 50%, then we can write:

1 = (1.5/1)^Sensitivity of Demand to Safety & Hygiene(1.39/1)^(-0.75)*

This can then be solved for a value of the sensitivity of demand to safety and hygiene, which yields a value of about 0.6. The same studies indicated that quality attributes related to "nutrition" and "sensory" were ranked somewhat higher than for safety & hygiene, and with convenience about half as important as safety & hygiene. Thus, as a first approximation, the sensitivity of demand to quality was also set equal to 0.6 and the sensitivity for convenience was set at half that value, 0.3. The sensitivity to time cost was set as the negative of this value, -0.3, given the connection between convenience and time cost.

I have set values of sensitivity of additional awareness of nutritional benefits and the combined effects of emotions and perceptions of good choices to lower than for safety & hygiene (values of 0.1) based on the information in Obel Lawson 2006 (THE EFFICACY OF AWARENESS CAMPAIGNS BY THE AFRICAN LEAFY VEGETABLES PROJECT ON NUTRITION BEHAVIOUR CHANGE AMONG THE KENYAN URBAN POPULATION THE CASE OF NAIROBI) and Rekhy and McConchie 2014 (Promoting consumption of fruit and vegetables for better health Have campaigns delivered on the goals?) which tend to suggest that the impacts of these are likely to be small.

It is often the case that one of the main contributions of the model is structuring logical, quantitative thinking, and identifying data needs. Ultimately, it is understandable to want "the answer" but this will typically be based on probabilities rather than on certainty, as in, which combination of interventions is <u>most likely</u> to have the most desirable impacts (given the uncertainties in the data). One way to formalize this is to specify likely ranges of values (e.g., 0.05 to 0.5 for the Sensitivity to Awareness) and to use sensitivity analyses to assess which strategies appear best given these ranges. It would also make for a stronger analysis to have information on the costs of interventions to match with the likely impacts—although this is probably more difficult to acquire than the basic parameter values.

Components Not (Yet) Included in the Model Structure

These include:

- Product specifics (e.g., mango versus dark green leafy vegetables, seasonality of production)

- Different types of intermediaries or vendors
- Different types of consumers (e.g., by socio-economic status)
- Growth of population, income or trends in prices

(*NOTE: the above may be needed for more specific targeting but are easily incorporated into the model structure if sufficient data can be made available*)

APPENDIX 5: Model Diagrammatic Structure and Parameter Assumptions

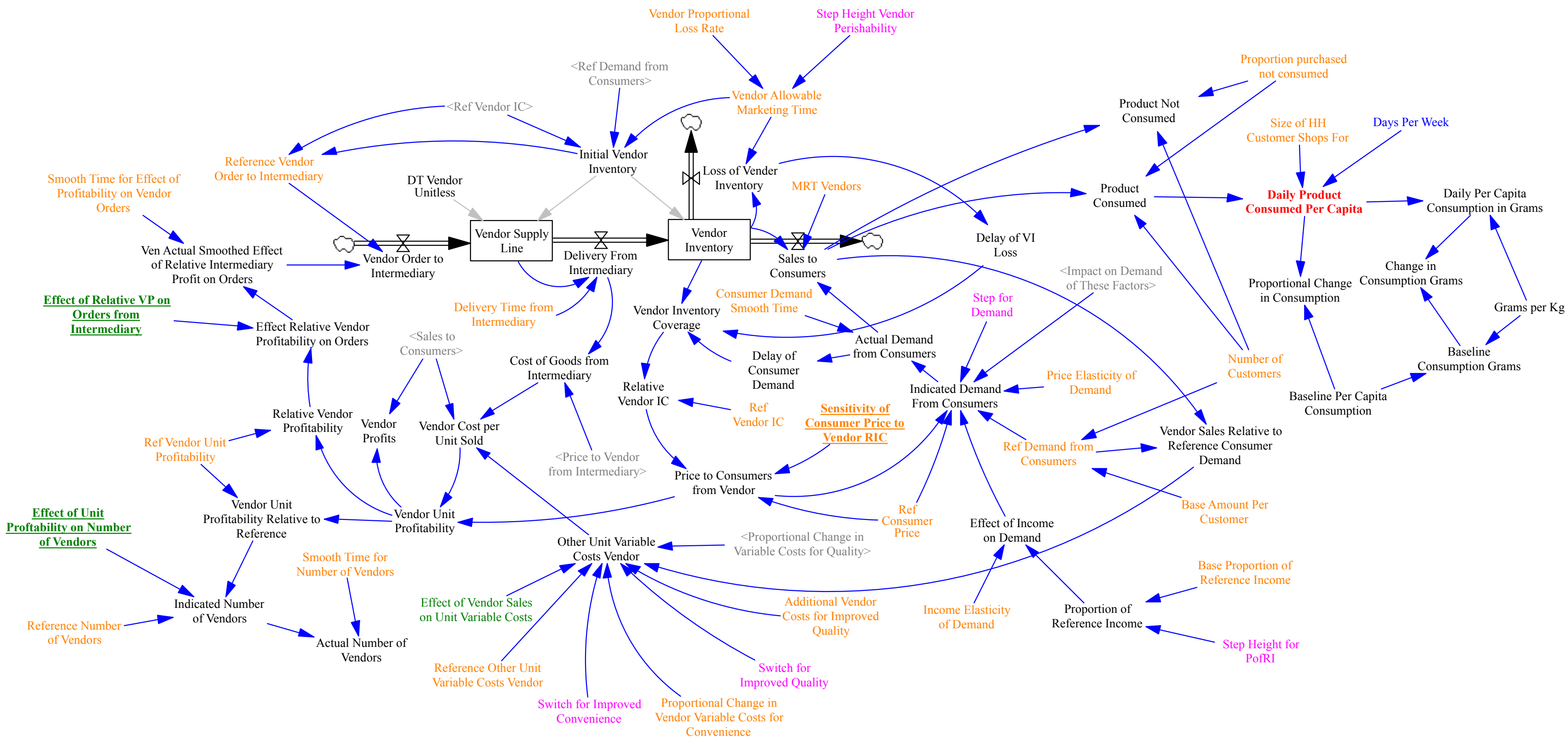

Figure A5-1. Structure of Vendor Supply Chain and Consumer Purchases "View"

Orange = Parameter value assumed for analysis
Green = "Lookup" response function
Pink = Intervention point (parameter or switch)
Red = Key outcome variable
Blue = Identity relationship (e.g., 1 week = 7 days)

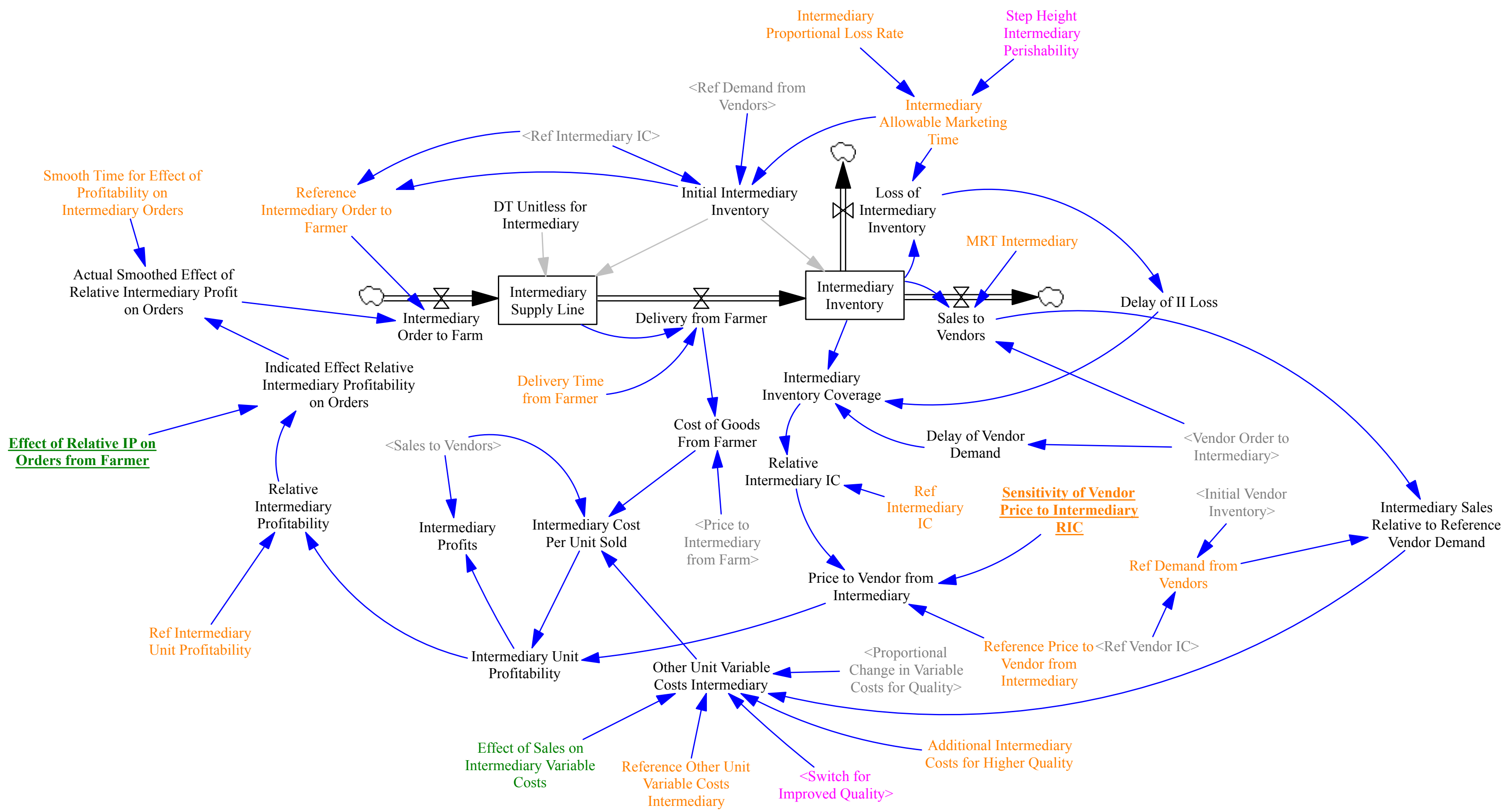

Figure A5-2. Structure of Intermediary Supply Chain "View"

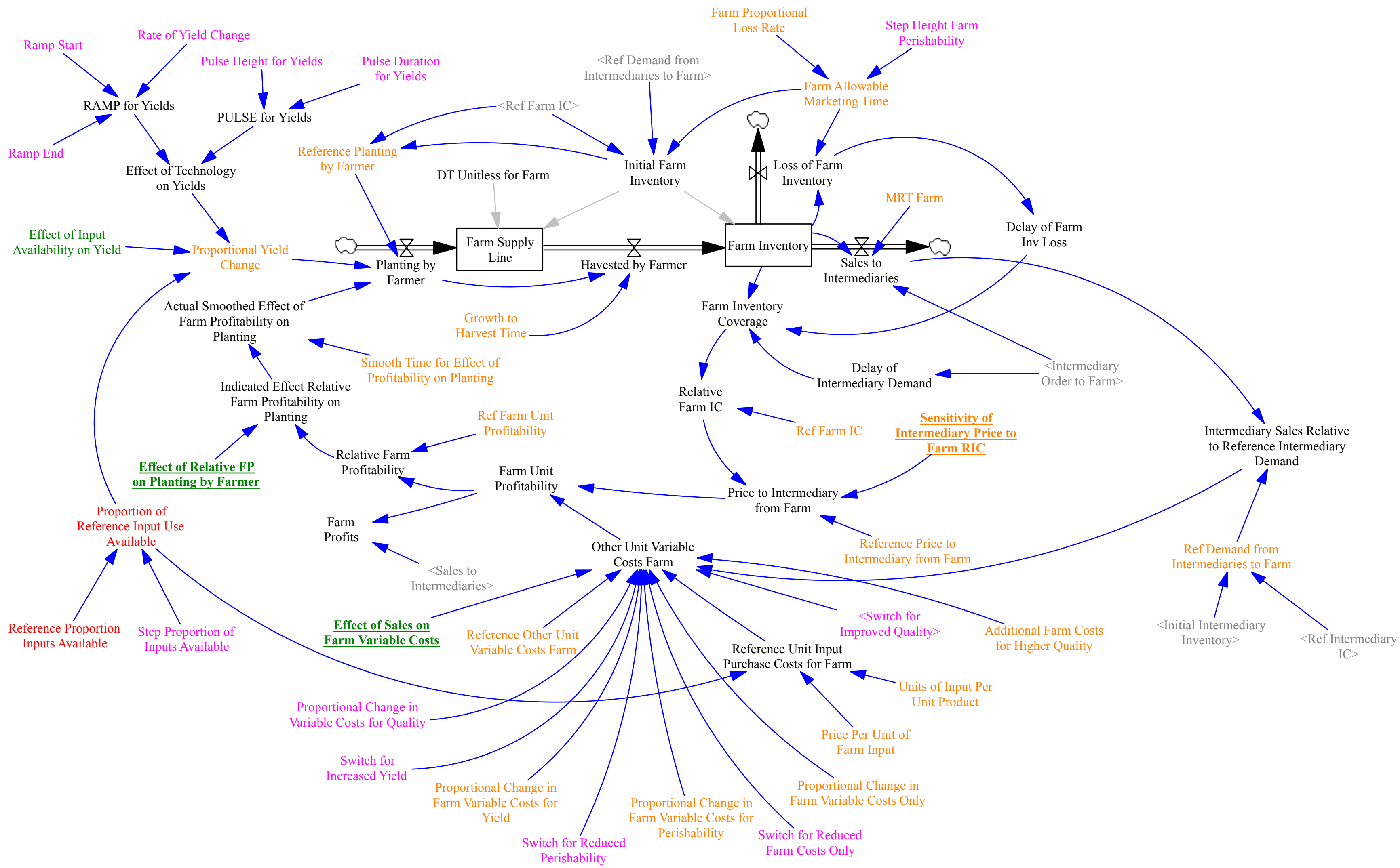

Figure A5-3. Structure of Farm Production "View"

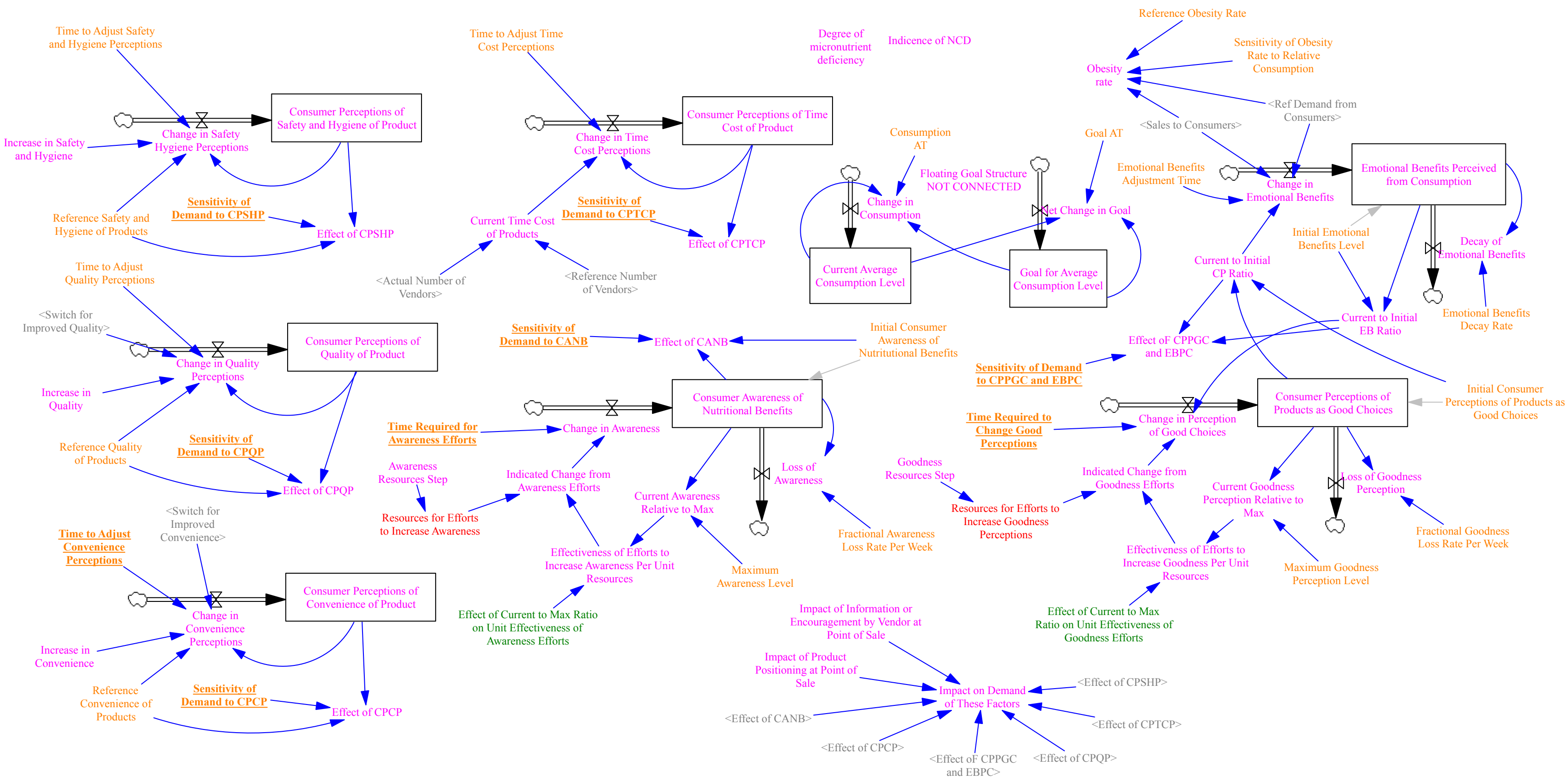

Figure A5-4. Structure of Consumer Perceptions and Other Effects "View"

Table A5-1. Summary of Model Parameter Assumptions and Information Sources

Model View, Parameter	Current Value or Function	Comment	Sources
Farmer View			
Farm Perishability Time Parameter	6.667 weeks	Equates to 15% loss at harvest	Gogo et al. 2017 for ALV
Growth time to harvest	8 weeks	4-8 weeks for vegetables	Gogo et al. 2016 for ALV
Min Residence Time Farm	0.125 weeks	Minimum time in farm inventory, provides first-order control for farm inventory stock 0.125 weeks = 0.875 days	
Reference Farm Unit Profitability	9.00	KSh/Unit, from Supporting Calculations	Chemonics (2013) and KIHBS data used
Ref Farm IC	0.5 week	No data but probably small amount of inventory held	
Sensitivity of Intermediary Price to Farm RIC	-0.3 DMNL	Sensitivity of price charged by farmer to first buyer based on relative IC. Value derived from April workshop	
Smooth Time for Effect of Profitability on Planting	4 weeks	This is the smoothing time for the effect of profitability on planting decisions. It reflects time for collecting and analyzing data and making decisions based on them.	
Reference Price to Intermediary from Farm	22.00	KSh/Unit, from Supporting Calculations	Chemonics (2013) and KIHBS data used
Units of input per unit product	1 DMNL	Simplified version with one aggregated input is assumed; could include more disaggregated inputs if appropriate	
Price per unit of input	6.50	KSh/unit of aggregated inputs purchased, from supporting calculations. Assumes that 50% of farm costs are for production inputs, 50% for labor, etc.	

Model View, Parameter	Current Value or Function	Comment	Sources
Reference Other Unit Variable Costs Farm	6.50	Assumes that 50% of farm costs are for production inputs, 50% for labor, etc.	
Reference Proportion Inputs Available	1 DMNL	Proportion of inputs available for production. Initial value assumes that inputs are not limiting production	
Effect of sales on variable costs	Decreasing function as volumes increase	Assumes economies of scale in production. Modified with input from April workshop.	
Effect of profitability on planting	Increasing function, with flattening	Nonlinear supply response to profitability. Modified with input from April workshop.	
Effect of input availability on yield	Increasing function, with flattening	Nonlinear response to additional input availability.	
Intermediary View			
Intermediary perishability time parameter	6.667 weeks	Equates to 15% loss at harvest	Gogo et al. 2017 for ALV
Min Residence Time Intermediary	0.125 weeks	Minimum time in intermediary inventory, provides first-order control for farm inventory stock; 0.125 weeks = 0.875 days	
Delivery Time from Farmer	0.25 weeks	Time required for delivery from farmer. No data but unlikely to be sensitive parameter. 0.25 = 1.75 days	
Sensitivity of Intermediary Price to Intermediary RIC	-0.75 DMNL	Sensitivity of price charged by intermediary to vendor based on relative IC; value derived from April workshop	
Smooth Time for Effect of Profitability on Intermediary Orders	4 weeks	This is the smoothing time for the effect of profitability on intermediary ordering decisions. It reflects time for collecting and analyzing data and making decisions based on them.	

Model View, Parameter	Current Value or Function	Comment	Sources
Ref Inventory IC	0.5 week	No data but probably small amount of inventory held	
Reference Price to Vendor from Intermediary	45.00	KSh/Unit, from Supporting Calculations	Chemonics (2013) and KIHBS data used
Reference Other Unit Variable Costs Intermediary	14.00	KSh/Unit, from Supporting Calculations	Chemonics (2013) and KIHBS data used
Reference Intermediary Unit Profitability	5.70	KSh/Unit, from Supporting Calculations	Chemonics (2013) and KIHBS data used
Effect of Sales on Intermediary Variable Costs	Decreasing function as volumes increase	Assumes economies of scale in production. Modified with input from April workshop.	
Effect of Relative IP on Orders from Farmer	Increasing function, with flattening	Nonlinear supply response to profitability. Modified with input from April workshop.	
Vendor View			
Reference number of vendors	8500 Vendors	Based on consumption data from Global Dietary Database	
Reference Vendor Unit Profitability	1.75	KSh/Unit, from Supporting Calculations	Chemonics (2013) and KIHBS data used
Reference Other Unit Variable Costs Vendor	2.5	KSh/Unit, from Supporting Calculations	Chemonics (2013) and KIHBS data used
Smooth Time for Effect of Profitability on Vendor Orders	4 Weeks	This is the smoothing time for the effect of profitability on Vendor orders. It reflects time for collecting and analyzing data and making decisions based on them.	
Delivery Time from Intermediary	0.125 weeks	Time required for delivery from farmer. No data but unlikely to be sensitive parameter. 0.125 = 0.875 days	
Ref Vendor IC	0.5 week	No data but probably small amount of inventory held	

Model View, Parameter	Current Value or Function	Comment	Sources
Sensitivity of Consumer Price to Vendor RIC	-0.75 DMNL	Sensitivity of price charged by vendor to consumer based on relative IC. Value derived from April workshop.	
Ref Consumer Price	53.65	KSh/Unit, from Supporting Calculations, accounting for losses	Chemonics (2013) and KIHBS data used
Vendor perishability time parameter	6.667	Equates to 15% loss at harvest.	Gogo et al. 2017 for ALV
Base Amount Per Customer	2.9 kg/household/week	Based on data from Global Dietary Database	
Base Proportion of Reference Income	1 DMNL	Assumes the reference income initially	
Number of customers	1,040,076	Nairobi Households shopping at selected outlets (Kiosk, Open Air, General Shop)	Based on KIHBS (2018) data.
Price elasticity of demand	-0.75 DMNL	Value for Kale, value for Mango = -0.292	Bundi et al. 2013 using 2009 data sources
Proportion purchased not consumed	5%	Estimate of household waste of food, no data	
Size of HH Customer Shops For	3.00	Persons per Nairobi household = 2.97 per data from KIHBS	KIHBS data
Income Elasticity of Demand	1.10	Expenditure elasticity is 1.103 for mangoes, 1.142 for Kales	Bundi et al. 2013 using 2009 data sources
Consumer Effects View			
Time to Adjust Convenience Perceptions	18 weeks	Value derived from April workshop Will affect timing but not overall response.	
Sensitivity of Demand to CPCP	0.9 DMNL	Value derived from April workshop. Value based on WTP estimates for safety hygiene and relative ranking of "convenience" would be 0.3.	Ngigi et al 2011 WTP estimates

Model View, Parameter	Current Value or Function	Comment	Sources
Time to Adjust Quality Perceptions	24 weeks	value derived from April workshop. Will affect timing but not overall response.	
Sensitivity of Demand to CPQP	0.9 DMNL	Value derived from April workshop. Value based on WTP estimates for safety hygiene and relative ranking of "sensory" and "nutrition" would be 0.6.	Ngigi et al 2011 WTP estimates
Time to Adjust Safety and Hygiene Perceptions	24 weeks	Value derived from April workshop. Will affect timing but not overall response.	
Sensitivity of Demand to CPSHP	0.6	DMNL based on WTP estimates, assumes 50% better safety to determine sensitivity factor	Ngigi et al 2011 WTP estimates
Time to Adjust Time Cost Perceptions	24 weeks	Value derived from April workshop. Will affect timing but not overall response.	
Sensitivity of Demand to CPTCP	-0.8 DMNL	Assumes the same magnitude but opposite sign of convenience	
Time Required for Awareness Efforts	27 weeks	Value derived from April workshop. Value from Obel-Lawson (2006) was 12 weeks. Will affect timing but not overall response.	Based on information in Obel-Lawson, 2006 for ALV promotional campaigns
Sensitivity of Demand to CANB	0.6 DMNL	Value derived from April workshop Will affect timing but not overall response. Obel-Lawson 14% reported dietary shifts as a result of campaign, but study lacked controls, and 91% were aware at the end of the promotional campaign. Value from that source would be 0.1.	Based on information in Obel-Lawson, 2006 for ALV promotional campaigns
Maximum Awareness Level	0.8 DMNL	Essentially, the maximum value is that 80% are aware. Can be modified as appropriate.	Based on information in Obel-Lawson, 2006 for ALV promotional campaigns

Model View, Parameter	Current Value or Function	Comment	Sources
Fractional Awareness Loss Rate Per Week	4 weeks	No data, but can be tested with sensitivity analysis	
Resources for Efforts to Increase Awareness	1 DMNL	Relative resources, so <>1 implies proportional increase or decrease	
Time Required to Change Good Perceptions	27 weeks	Value derived from April workshop. Value from Obel-Lawson (2006) was 12 weeks. Will affect timing but not overall response.	Based on information in Obel-Lawson, 2006 for ALV promotional campaigns
Maximum Goodness Perception Level	0.8 DMNL	Essentially, the maximum value is that 80% are aware. Can be modified as appropriate.	Based on information in Obel-Lawson, 2006 for ALV promotional campaigns
Fractional Goodness Loss Rate Per Week	4 weeks	No data, but can be tested with sensitivity analysis	
Initial Consumer Perceptions of Good Choices	0.4 DMNL	Assumes initial awareness of 40%	
Sensitivity of Demand to CPPGC and EBPC	0.6 DMNL	Value derived from April workshop.	
Emotional Benefits AT	1 week	No data, but can be tested with sensitivity analysis	
Emotional Benefits Decay Rate	100 weeks	No data, but can be tested with sensitivity analysis	
Impact of Information or Encouragement by Vendor at Point of Sale	0	This is the proportional impact on demand assumed for vendors providing more information and encouragement at the point of sale. Currently set equal to 0, no effect, given limited information.	

Model View, Parameter	Current Value or Function	Comment	Sources
Impact of Product Positioning at Point of Sale	0	This is the proportional impact on demand assumed for improved product positioning at the point of sale. Currently set equal to 0, no effect, given limited information.	

Note: "DMNL" means that units for the parameter are "dimensionless", for example a proportion or an elasticity parameter.