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Macroeconomic impact of the obesity pandemic on emerging economies: a methodological proposal

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Macroeconomic impact of the obesity pandemic on emerging economies: a methodological proposal

By Carlos J. García*

We present a methodology to estimate the economic impact of healthy food consumption in emerging countries. The results indicate that a country may be giving up a substantial portion of its growth by not adequately addressing the obesity pandemic. Remarkably, evidence indicates agents do not seem to internalize these potential benefits despite the associated growth of real wages and profits. This market failure opens the possibility to implement public policies to increase the consumption of healthy food, including taxes, subsidies, cultural changes, and the promotion of the workplace as the appropriate locus for workers to access healthy food—adequately regulated by government agencies.
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I. Introduction

In this study, we propose a general methodology to quantify the impact of food on the economy. We begin by measuring whether there is a connection between healthy eating and productivity and then explore the mechanisms, if any, through which the availability of healthy food affects the rest of the economy. Therefore, the question we seek to answer in this study is whether the effects and benefits of healthy eating beyond the direct effects on workers' health are relevant or not. Thus, we seek to measure the impact of this diet at an aggregate level—which we define as the general equilibrium effect on the economy.

Another way to understand the objectives and results of this study is to ask the opposite question. If healthy eating is systematically reduced, then what would be the aggregate economic costs associated with an obesity pandemic? The association here is that poor nutrition (energy-dense food) has been shown to be a major factor in the obesity pandemic—usually measured by the high body-mass index (BMI)—which several countries are experiencing, which in turn is

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associated with major diseases such as cardiovascular disease, diabetes mellitus, chronic kidney disease, many cancers, and an array of musculoskeletal disorders that negatively affect workforce productivity GBD (2017). In other words, this pandemic and healthy eating are two sides of the same coin: one is the absence of the other. Thus, internalizing both the costs of this pandemic and the aggregate economic benefits of healthy eating can help accelerate targeted public policies to more decisively address this issue.

Our focus is on developing economies, particularly small open economies, that have been characterized by market reforms and which have been categorized as emerging ones. These economies have made significant achievements, including the growth of their gross domestic product (GDP), insertion in international trade, access to capital flows, success in controlling inflation rate, and the reduction of poverty. Despite these achievements, however, their performance in terms of worker nutrition is disappointing, following a trend found in the more developed countries. For instance, figure 1 indicates two interesting stylized facts: the obesity pandemic is independent of income level, as the levels of overweight and obesity in emerging economies are similar to those shown by high-income countries (HICs) and, furthermore, the different emerging economies coincide in these levels in general, the exceptions are Indonesia and the Philippines.

The literature on the connection between economic growth and health is extensive. In their comprehensive review, Bloom, Kuhn, and Prettner (2018) highlight three challenges that every study must address: (i) there is double causality between health and economic growth (and income level), as well as the participation of third variables (as also highlighted by Weil (2014); (ii) this causality changes with the level of economic growth; and (iii) different dimensions of health could have different economic effects.

Much of the literature uses the empirical methodology proposed by Barro and Sala-i-Martin (1995). In this line, for example, Lorentzen, McMillan, and Wacziarg (2008), analyzing cross-country data, find that an increase in adult mortality reduces economic growth in Africa. Bhargava et al. (2001) find a positive but decreasing relationship between health and growth, using lags in levels and differences as instruments.

A number of methodologically different studies develop models based on a standard production function to directly account for the effect of health on labor productivity (Weil (2007); Bloom, Canning, and Sevilla (2004); Bloom et al. (2014)). For example, Weil (2007) strategy consists in multiplying labor by two types of human capital (namely, education and health), which affect productivity and the rest of the macroeconomic variables. His results are lower than those obtained with cross-country data regressions. Bloom, Kuhn, and Prettner (2015), in turn, develop a general equilibrium model in which they disaggregate labor into men and women and then use calibration to quantify the impact of women's health on economic growth.

The connection between food, health, and economic performance has also been studied extensively (see, for example, Gyles et al. (2012)). Evidence indicates that ensuring adequate nutrition, improving normal diets through the addition of micronutrients, incorporating healthy foods, and eliminating some unhealthy foods can all be a powerful force for improving both the health and economic performance of a society.

A number of studies indicate that the gains from providing healthy food are greater than the costs. Fiedler and Macdonald (2009) analyze the costs and benefits of interventions—namely, biofortification with multiple nutrients—in 48 countries, finding that the benefits outweigh the costs by 3.6 times in the worst-case scenario. Asaria et al. (2007) find that reducing salt intake by 15% in 23 countries—at a cost of US$0.40–1.00 per person per year—would have prevented 13.8 million deaths over ten years. On obesity, Frier and Greene (2005) and Popkin et al. (2006) estimate that by 2025, the cost of obesity will be $99 billion annually for the United States and close to 9% of GDP in China. Gyles et al. (2010) find that functional food—that is, food that goes beyond a basic diet and reduces diseases such as coronary heart disease, diabetes, and cancer—could reduce the cost of health care by up to 2.5 billion Canadian dollars per year.

Most of these studies are case specific and thus do not provide a general framework for analyzing all the effects involved, especially the various connections between economic growth, health, and nutrition. One study that seeks that generality is OECD (2019), which analyzes the economic cost of overweight and obesity in 52 countries, using a strategy similar to that of Weil (2007). The results indicate that GDP is 3.3% lower in OECD countries each year because of overweight and obesity.

We take several of the challenges identified in the literature by proposing a general framework for specific countries that explicitly considers: the dual causality of variables, the difference between mortality and morbidity, and the effects of healthy eating on the economy, based on the initial health of workers. Specifically, our methodology consists of two fundamental parts: the micro-foundations of overweight and obesity and the integration of this structure into an aggregate model to measure the general equilibrium effect.

We assume that the energy effect of the foods needed to produce goods is rapidly reduced as workers' diets move away from healthy eating defined by medical parameters. However, it is not enough to consume excess food only in certain periods, but this excess must be systematic over time, to produce overweight and obesity, and, therefore, specific diseases that affect the working capacity of the workforce, that is, its productivity. We put this idea into practice by multiplying excess food consumption by the accumulated probability of contracting diseases related to overweight and obesity. This multiplication can be interpreted as the expected value of contracting a serious illness through unhealthy eating.

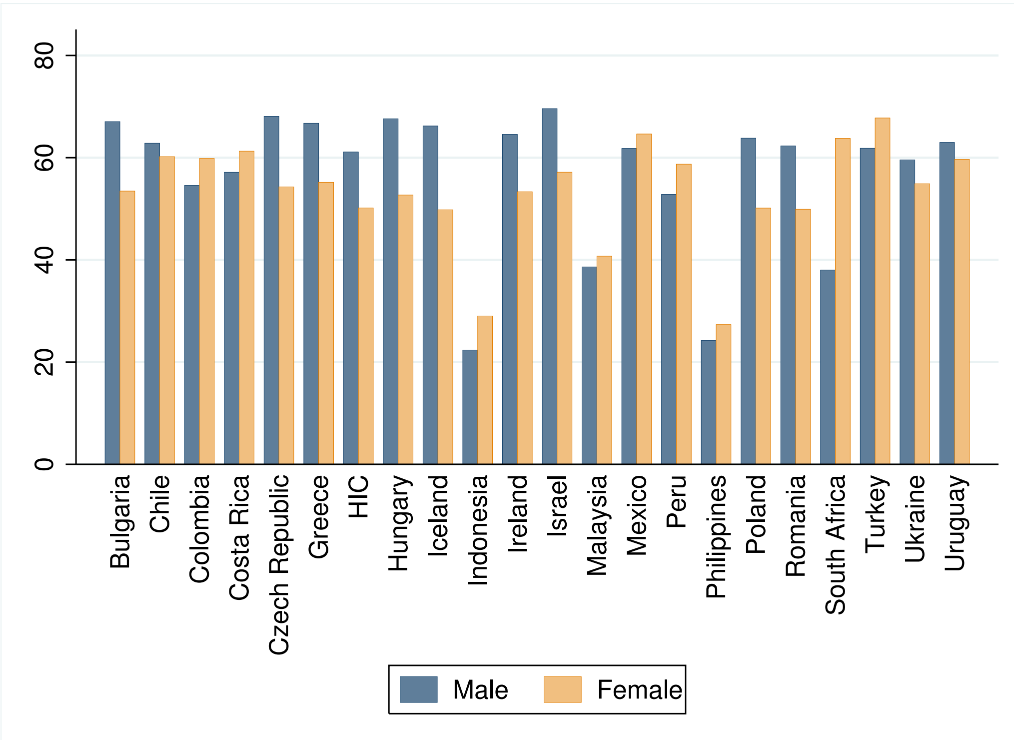

Figure 1. Overweight and Obesity in Emerging Countries and High Income Countries(HIC).

Note: The figure shows differences in overweight and obesity by gender as a percentage of the adult population in emerging countries that meet this criterion: small economies open to trade and capital flows. This percentage is an average between 2010 and 2016, obtained from the World Bank. High income countries as defined by the World Bank.
Source: Authors' elaboration, based on data from the World Bank.

Since the probability considered is the cumulative one, it increases only marginally due to a certain excess of food. For example, if a population's workforce has maintained a healthy diet in the past, a particular increase in food above levels considered healthy has no tangible effect on productivity. The opposite is true if workers have consistently eaten an unhealthy diet. In other words, the effect that we model is more related to persistent obesity (a BSI greater than or equal to 30 kg/m2) which produces serious and disabling diseases rather than a simple overweight (a BSI greater than or equal to 25 kg/m2).

Implicit in all this modeling is the assumption that excess food consumption is in all types of food, including junk food. Therefore, it is natural to also assume that not only productivity is affected by an obesity pandemic, but also the labor supply itself. We implement this assumption by multiplying the long term labor supply by the cumulative probability, mentioned in the previous paragraph, of both men and women. Thus, a higher level of unhealthy diet produces a transition to a new equilibrium in which the labor supply is lower.

Then, we construct a structural model—commonly used in macroeconomics—to measure the aggregate effects of food on the economy. With this model, we can measure many of the impacts on specific variables, such as workers' health and productivity, and on more aggregated variables, such as growth, consumption, real wages, the labor supply, and investment.

An example of the mechanisms we are trying to measure in this study is the following. An increase in the consumption of healthy food has direct effects on both workers' health and their productivity, as we measure in section II. Productivity gains could also produce a virtuous cycle, whereby the resulting increase in consumption, investment, labor supply, and so on would reinforce productivity gains through increases in the labor supply and in the demand for goods from workers in various sectors of the economy. Only a model that explicitly takes into account the main connections within an economy will not only identify specific effects of an increase in healthy food and quantify the full final effect, but also clarify the connections between these effects and the final result. Thus, the structural assumptions of the model—namely, preferences, production frontiers, trade, government, technology, health, etc.—make it possible to identify precisely the propagation mechanisms through which an increase in healthy food affects the rest of the economy.

The model is estimated econometrically using Bayesian econometrics, so it lies between the purely empirical literature inspired by Barro and Sala-i-Martin and more structural—but generally calibrated—works such as Bloom, Kuhn, and Prettner (2015). We used Chile to apply our methodology because this case has many characteristics found in other emerging economies about the topics covered in this article. Indeed, this emerging country has been a champion of market reforms for the last fifty years; it has high levels of overweight and obesity for both men and women, like many other emerging economies (see figure 1); and despite the fact that the population recognizes the importance of healthy food, neither consumers nor firms seem to incorporate this knowledge in their economic decisions. Figure 2 illustrates this point: a survey conducted by Laborum.com shows that workers believe that companies are not interested in food issues at work. Worse still, the workers themselves, who recognize the serious health problems associated with poor nutrition, decide to consume foods that produce overweight and obesity.

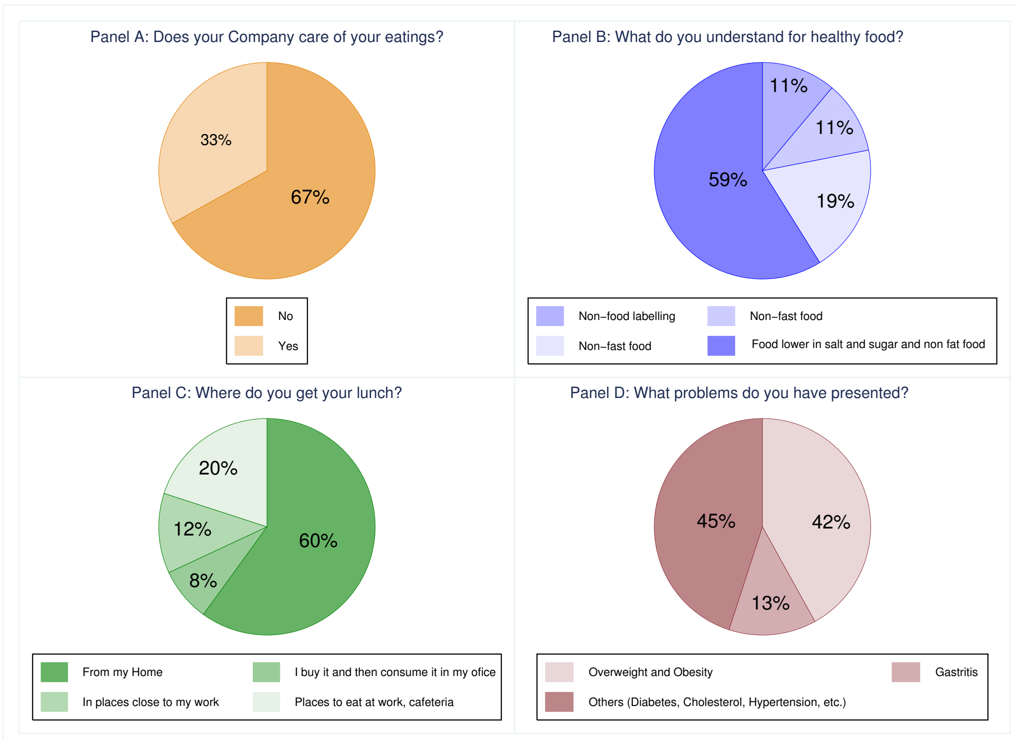

Figure 2. Survey on Food in the Workplace in Chile

Note: The survey was sent to more than 400,000 people, of which 3,556 responded. Of the total participants, 60.2% were women, 39.8% were men, and 68.8% were between 25 and 44 years old.
Source: laborum.com .

The results of the article are as follows: i) an increase in healthy eating produces the results found by many other studies, both in economics and medicine: healthier workers leads to a natural increase in the labor supply for men and women; ii) this connection between health and food is stronger while there are fewer healthy workers, confirming the positive impact of public policies that encourage healthy eating, in a scenario where companies and workers tend not to internalize the positive effects of this diet; iii) despite the positive connection between health and food, the final effect on the economy goes much further than having healthier workers; iv) the general equilibrium effect is mainly due to an increase in private consumption that in turn drives investment and even more so the labor supply of women; v) for example, in our case of study, in terms of GDP growth, the general equilibrium effect doubles the positive effects of increasing workers' health. In contrast, a reduction in healthy eating, which triggers an obesity pandemic, substantially reduces the country's growth potential.

The paper is organized as follows. Section II describes the model and its methodological implications. Section III presents the estimations, results, and simulations. Section IV concludes with a discussion of the economic policy implications.

II. Model

An overview of our model that characterizes emerging economies and food-related issues is as follows. To begin, it assumes an open economy, but with frictions in the flow of foreign capital. The open flow of trade is necessary because some foods are imported and some are exported. Financial friction is also necessary because in these countries the consumption of goods, including the consumption of food, cannot be completely smoothed through time.

Then, the production of food—like other goods—requires a mix of capital, labor, and imported goods. This assumption allows us to assess, for instance, the costs of improving food to healthier levels—not only because of an increase in quantity, but also because of increases in relative food prices. Therefore, the demand for more food produces increases both in production and in the price of these products relative to other goods. This is always the case, even though some products have fixed prices on international markets (grains, sugar, dairy products, etc.). This last point is very important in the model, because the demand for food depends not only on relative prices, but also on the economy's growth. The model thus considers causality from health to growth and also from growth to health.

In addition, labor is separated into men's and women's labor to consider the different food patterns observed between the two groups (see figure 1). Firms need a mix of both types of labor, but food consumption may affect the productivity and health of each type of labor differently. How different these effects are is an empirical question that we answer in this study.

Moreover, and as explained in the introduction, we consider both the direct impact of healthier food on productivity—that is, the contribution of the caloric energy necessary to improve labor efficiency in firms—and the long-term effects of this diet on workers' health. Improving nutrition therefore has a positive impact on the demand for workers (due to higher productivity) and on their supply (due to healthier workers). But, as noted in the introduction, the increase of an excessive diet in energy-dense foods produces instead the opposite effects on productivity and labor supply.

Finally, although the model is competitive, we also assume that households and firms do not make decisions about healthy food. On the contrary, healthy eating is considered an exogenous parameter in the decisions of families and firms. In other words, we assume that economic agents do not individually internalize the benefits of a healthier diet or,which is equivalent ,the cost of an energy-dense diet.

While this last assumption is a simplification of reality, this is consistent with the existing evidence for these countries: economic growth is accompanied by significant increases in a diet rich in sugar, fat, and sodium, which contributes to the emergence of many diseases despite the available knowledge of the advantages of a healthy diet. Given this serious market failure, there is potential for the government to play a role through public policies. We assume that greater consumption of healthy food—i.e. a reduction in energy-dense foods—can be achieved through the implementation of subsidies, taxes, other policies, and cultural changes that may gradually affect habits in the long term. We briefly discuss these issues at the end of Subsection II.D.

A. Households, Consumption, and Labor Supply

The model considers a continuum of family units, indexed by $i \in [0,1]$, composed of men and women. There are two types of families: a fraction $(1-\lambda_c)$ of families has access to the national and international capital market, and a fraction λ_c is restricted to income from work. The preferences of the first families are given by a Greenwood–Hercowitz–Huffman (GHH) utility function (equation (1)), in which $C_t^o(i)$ is consumption and $N_t^M(i)$ and $N_t^F(i)$ are the labor supply of men and women, respectively:

$$\max_{\Xi_{t=0}^{\infty}} E_o \sum_{t=0}^{\infty} \beta^t \frac{\left(C_t^o(i) - \frac{\Psi^M N_t^M(i)^{1+\rho_M}}{1+\rho_M} - \frac{\Psi^F N_t^F(i)^{1+\rho_F}}{1+\rho_F} \right)^{1-\sigma}}{1-\sigma}, \tag{1}$$

where $\Xi = \left\{ C_t^o(i), N_t^M(i), N_t^F(i), B_t^o(i), B_t^{o*}(i) \right\}$, the coefficient σ measures relative risk aversion, ρ_M and ρ_F measure the disutility of working - and are the inverse of the elasticities of hours worked to the real wage, and Ψ^M and Ψ^F are parameters related to the probability of getting sick in the long term, which we explain in details in Subsection II.C.

The families are price takers, and the budget constraint is given by:

(2)
$$P_t C_t^o(i) \leq W_t^M(i) N_t^M(i) + W_t^F(i) N_t^F(i) + B_t^o(i) - S_t B_t^{o*}(i) + D_t^o - \frac{B_{t+1}^o(i)}{R_t} + \frac{S_t B_{t+1}^{o*}(i)}{\Phi_t R_t^*} - T_t$$

where W_t^M and W_t^F are men's and women's wages, respectively; $B_t^o(i)$ and $B_t^{o*}(i)$ are domestic and external debts, respectively; S_t is the nominal exchange rate; D_t^o corresponds to dividends; T_t are lump-sum taxes, and R_t^*, R_t, and Φ_t are the gross foreign interest rate, the gross domestic interest rate, and the country risk premium function, respectively.

Restricted families are subject to the following budget constraint:

$$P_t C_t^R(i) = W_t N_t, \tag{3}$$

where W_t and N_t correspond to the aggregate wage and employment and these families do not pay taxes.

B. Firms

We assume that there are firms units, indexed by $s \in [0,1]$ that produce goods, maximize profits, and are price takers. We also assume that the aggregate production function of the economy $Y_t(s)$ is given by a constant elasticity of substitution (CES) function, which depends on three inputs—namely, capital $(K_t(s))$, imported inputs $(M_t(s))$, and labor $(N_t(s))$:

$$Y_t(s) = A_t \left[\alpha_1 K_t(s)^{\frac{\varepsilon-1}{\varepsilon}} + \alpha_2 M_t(s)^{\frac{\varepsilon-1}{\varepsilon}} + (1-\alpha_1-\alpha_2) N_t(s)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}. \tag{4}$$

The CES function allows the possibility of considering different values in the elasticity of substitution between inputs, which are measured by the parameter $\varepsilon \in [0,\infty]$. This parameter is estimated directly from the sample. On the other hand, the aggregate labor of the economy is formed by a mix of men's and women's labor:

(5)
$$N_t(s) = \left[\alpha_1^N \left(\left(ef_t{}^M\right)^{coef_1} N^M(s)\right)^{\frac{\varepsilon^N-1}{\varepsilon^N}} + \left(1-\alpha_1^N\right)\left(\left(ef_t{}^F\right)^{coef_2} N_t^F(s)\right)^{\frac{\varepsilon^N-1}{\varepsilon^N}}\right]^{\frac{\varepsilon^N}{\varepsilon^N-1}},$$

where the work of men and women, $N^M(s)$ and $N^F(s)$, is weighted by effective food ef^j, $j = M, F$. The interpretation of this assumption is that workers need energy to do their work, and the energy is provided by food.

The impact of ef^j on each type of labor is measured by the parameter $coef_j \in [0, 1]$, a value that is estimated directly from the sample. For example, if these coefficients—$coef_1$ and $coef_2$—are equal to one, then the effect of food on labor productivity is complete. If this value is close to zero, it means that food contributes nothing to workers' productivity.

As in the aggregate function, $\varepsilon^N \in [0, \infty]$ measures the elasticity of substitution between men's and women's labor, a parameter that is also estimated with the information obtained from the sample. To the extent that the value of ε^N is close to zero, this substitution becomes increasingly difficult. In contrast, the larger the value of ε^N, the more easily firms substitute between the two types of labor.

If firms maximize profits, then one of the ways that the effects of food are transmitted to the economy is through the demand for labor. A bad diet—an excess or deficit of food—translates into a lower demand for workers and lower wages. The effect is direct: inadequate food consumption reduces the productivity of workers in relation to other inputs, causing a reduction in the demand for labor.

Lastly, to improve the empirical adjustment of the macroeconomic model, we assume that there are lags in the demand responses for all inputs in the domestic sector.

C. Productivity, Food, and Health

The study incorporates food directly into the production function of the economy (see equation (5)), allowing workers' productivity to be modified. However, it is not the food that is directly consumed that modifies productivity. Rather, we must account for the impact that food has on health, discounting the negative effect if consumption is above or below the optimal level. Furthermore, we assume that this negative effect is not linear, but increases as the imbalance grows.

As explained above, companies do not internalize the benefits of healthy eating on productivity. While this is a strong assumption, it is in line with the poor diet, lack of infrastructure, and limited availability of healthy food observed in many companies in emerging countries. For example, the Food and Agriculture Organization (FAO) characterizes Latin America as having a lack of "food paradises" (healthy food) and an excess of "food swamps" (junk food) in or near workplaces (Intini, Jacq, and Torres (2019)).

We propose an indicator to measure the real impact of food on labor productivity: effective consumption. Thus, if workers' consumption is above the optimal level, then their effective food is lower than the food they actually consume, and their labor productivity increases less than it would under optimal consumption. If workers consume less than the optimal, their effective food falls more, reducing productivity, but in this case due to insufficient food.

To measure the negative impact, the excess or deficit food consumption must be weighted by the possibility—probability—that workers will become ill from this excess or deficit, thereby affecting their ability to work. We define the level of effective food by the following functional form:

$$ef^j = rf^j - \frac{\bar{\theta}^j}{2}\left(rf^j - of^j\right)^2, \quad j = M, F. \tag{6}$$

where ef^j is effective food (that is, accounting for the impact on the productivity of labor, disaggregated by gender), rf^j is the real food actually consumed by workers, and of^j is optimal food. $\bar{\theta}^j$ is the probability that food surpluses or deficits will affect the ability to work.

The functional form of equation (6) indicates that as effective food moves further above or below the optimal food level, the effects become larger (hence the square parenthesis). The functional form—although arbitrary—allows us to measure the marginal effect of an additional unit of food by a simple expression:

$$\frac{def^j}{drf^j} = Marginal\ effect^j = 1 - \bar{\theta}^j\left(rf^j - of^j\right), j = M, F. \tag{7}$$

Thus, for an additional unit of food consumed (see equation (7)), we must discount the negative effect of the excess or deficit, adjusted for the probability of becoming ill. For example, if that probability is zero, then having inadequate food has no effect on productivity: $ef^j = rf^j$. In contrast, if $\bar{\theta}^j > 0$, then $ef^j < rf^j$. This last case is relevant to analyze the obesity pandemic, so the discount corresponds to the expected value of getting seriously ill from a diet rich in energy-dense foods.

On the other hand, we assume that food excesses or deficits increase the possibility of becoming ill, which negatively affects the labor supply. For this purpose, we use the cumulative distribution of an exponential probability function to model probability $\bar{\theta}^j$:

$$\bar{\theta}^j = probability\left(imbalance < \left(r\bar{f}^j - o\bar{f}^j\right)\right) = 1 - e^{-\beta^j\left(r\bar{f}^j - o\bar{f}^j\right)^2}, j = M, F. \tag{8}$$

We conjecture that the cumulative distribution is the appropriate function. This is because the negative effect of consuming an inadequate diet must also account for past food imbalances. For example, the damage to health from the consumption of sugar-sweetened beverages depends not only on the current level of consumption, but also on having consumed these products excessively in the past.

We also assume that the effect is exponential, that is, the cumulative probability tends to approach one quickly if food consumption is substantially different from the optimal level in the long term. In other words, an inadequate diet that is increasing and permanent over time tends to produce a more rapid deterioration in the health of workers. In the model, we do not allow changes in health levels in the short term. Rather, they only occur to the extent that food habits become permanent.

In addition, the term $\left(rf^j - of^j\right)$ of the exponential function in equation (8) is squared to consider that both excesses and deficits are detrimental to workers' health. The parameter β^j is positive and indicates how fast $\bar{\theta}^j$ approaches one: the bigger the β^j, the faster $\bar{\theta}^j$ converges to one.

In the model, the probability $\bar{\theta}^j$ not only affects the demand for workers, but also the supply of labor in the long term. We therefore define the parameters Ψ^H and Ψ^H of equation (1) as:

$$\Psi^j = 1 - \bar{\theta}^j, j = M, F. \tag{9}$$

In this way, work in the long term is $\left(1 - \bar{\theta}^j\right) N^j$. Consequently, if $\bar{\theta}^j$ falls, then long-term work—always in steady state—is higher. Thus, in the model we allow the labor supply to also expand through better permanent health levels.

D. Food Demand, Food Supply, and Healthy-Food Shocks

As explained above, one of the key assumptions is that families make decisions not about healthy food, but about the food consumed, rf_t, which may or may not be healthy. We assume that the total consumption of goods is a CES function, so demand for food, rf_t, is a function of relative prices and total consumption:

$$rf_t = \varphi \left(\frac{P_t^F}{P_t}\right)^{-\eta_P^{D,F}} C_t^{\eta_Y^{D,F}} e^{u_t^{D,F}}, \quad u_t^{D,F} \sim N\left(0, \sigma^{D,F}\right), \tag{10}$$

where $\frac{P_t^F}{P_t}$ is the relative price of food, $\eta_P^{D,F}$ is the price elasticity of demand,

$\eta_Y^{D,F}$ is the income elasticity of demand, $u_t^{D,F}$ is a specific food demand shock, and φ is a parameter.

In relation to the food supply, we assume constant returns at the aggregate level, but a certain inertia at the micro level. Therefore, we can model the food supply with a positive slope:

$$rf_t = \left(\frac{P_t^F}{P_t}\right)^{\eta_P^{S,F}} e^{u_t^{S,F}}, \quad u_t^{S,F} \sim N\left(0, \sigma^{S,F}\right), \tag{11}$$

where $\eta_P^{S,F}$ is the price elasticity of the supply, and $u_t^{S,F}$ is a specific food supply shock. For reasons of simplicity, we do not consider the accumulation of inventories in food production in the model.

Next, we model an increase in healthy food as an exogenous shock (see equation (12)). As explained in the introduction, this shock can be understood as an improvement in diets through the addition of micronutrients, the elimination of unhealthy foods, and the promotion of functional foods. For example, if the government wants the level of long-term healthy eating to be equal to $o\bar{f}_t^j$, then it can implement shocks u_t^{of} to reach that level.

$$of_t^j = \left(o\bar{f}_t^j\right)^{1-\rho^F} \left(of_{t-1}^j\right)^{\rho^F} e^{u_t^{of}}, \quad u_t^{of} \sim N\left(0, \sigma^{of}\right). \tag{12}$$

A positive shock is shown as an increase in demand from point A to point B, resulting in an increase in both quantity and price in figure 3. This positive shock can be implemented, for example, through a cultural change driven by policies such as labelling foods to indicate whether they are high in sugar, fat, sodium, etc., a policy that Chile has been implementing since 2017, for more details, see Taillie et al. (2020).

Another example of a positive shock is the promotion of the workplace as a locale for meal provision and education nutrition initiatives as proposed by Wanjek (2005). Since many workers are present at least eight hours a day, five days a week, he argues that there is a possibility to intervene by providing the employee with access to nutritious food - through canteens and cafeterias, food vouchers, kitchens or nice places to eat, on-site farmers' markets, vending machines that offer healthy options, or simply the provision of fruit bowls.

A healthy-food shock could also be implemented through a subsidy. For example, using equation (10), and assuming for simplicity that $\eta_P^{D,F} = \eta_Y^{D,F} = 1$, then at point A of figure 3, the parameter φ represents the share of food expenditure in total expenditure:

$$\left(\frac{of^A}{C}\right)\left(\frac{P^F}{P}\right)^B = \varphi. \tag{13}$$

If the government wants to increase the consumption of healthy food in $of^B = of^A u^{D,F}$, then it must subsidize the final price $\left(P^F/P\right)^B$ in $(1-t)$, so as to increase the share of healthy food:

$$\left(\frac{of^A u^{D,F}}{C}\right)\left(\frac{P^F}{P}\right)^B = \left(\frac{of^B}{C}\right)\left(\frac{P^F}{P}\right)^B = \frac{\varphi}{(1-t)}. \tag{14}$$

While the alternatives are equivalent in their effects, they are not equivalent in terms of financing. Labelling policies need minimal funding. In contrast, a subsidy of the size BC in figure 3 or the promotion of healthy food options in the workplace requires direct funding—which can be obtained, in part, by taxing the food that is being discouraged. Whether or not this increased expenditure will be a burden on the economy depends on whether the increase in healthy food is expansive at the macroeconomic level. If this shock is sufficiently expansive, the higher growth more than offsets the costs of financing the subsidies or the food at work.

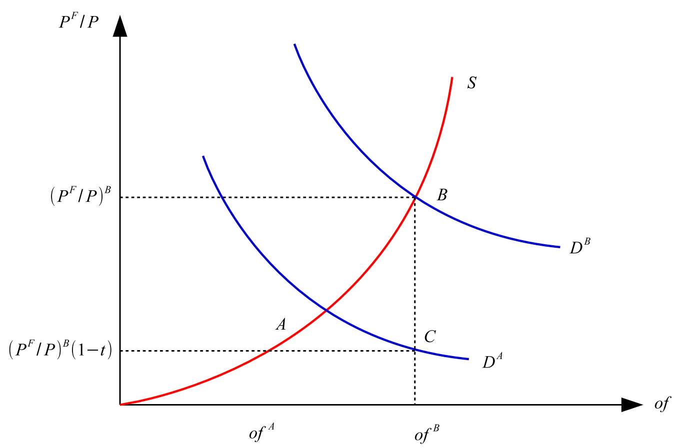

Figure 3. Increasing Optimal Food in the Food Market

Note: The figure shows a permanent shock to the demand for healthy food, from D^A to D^B, given a supply S.

E. Investment, Government, Exports, and Equilibrium

In this section, we discuss the additional elements of the model. Although not directly related to food, they do play an important role in the overall balance of the economy and thus have an impact on the total benefits of an increase in healthy food. Without these elements, we would be restricting the analysis to only the direct effects of this phenomenon, which, as we show in section III, account for less than 50% of the total benefits of increasing healthy food consumption.

We assume a very simple form of capital accumulation, in which that there are firms units, indexed by $h \in [0,1]$, maximize the benefits of leasing capital subject to market prices, adjustment costs, and depreciation at every moment in time. Therefore, we maintain the assumption that these firms are also price takers. If we define investment and adjustment costs as $I_t(h)$ and $\phi(h)$, respectively, then the maximization problem of capital-producing firms is:

$$\max_{\{I_t(h)\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left(Z_t K_t(h) - P_t I_t(h) \right), \tag{15}$$

subject to:

$$K_{t+1}(h) = (1-\delta) K_t(h) + \phi\left(\frac{I_t(h)}{K_t(h)}\right) K_t(h), \tag{16}$$

where Z_t, P_t, and $\Lambda_{0,t}$ are the capital rental price, the investment price, and the stochastic discount rate, respectively, and δ is the depreciation rate of the capital stock.

Regarding fiscal policy, fiscal expenditure depends on structural revenues IT. Therefore, expenditure can be diverted from these revenues only temporarily by shocks u_t^G and it is financed by changes in public debt:

$$G_t = IT^{1-\rho_G} \left(G_{t-1}\right)^{\rho_G} e^{u_t^G}, \quad u_t^G \sim N\left(0, \sigma^G\right), \tag{17}$$

and fiscal budget constraint is:

$$P_t G_t = \frac{S_t B_{t+1}^{G*}}{\Phi R_t^*} + \frac{B_{t+1}^o}{R_t} + T_t - B_t^o - S_t B_t^{G*}. \tag{18}$$

In the model, we assume that total non-mining exports X_t^D depend on international economic activity GDP_t^*, and they have a certain degree of inertia:

$$X_t^D = \left(X_{t-1}^D\right)^{\Omega} (GDP_t^*)^{1-\Omega}. \tag{19}$$

Total exports are:

$$X_t = Q_t X_t^D + Q_t P_t^{CU} Q_t^{CU}, \tag{20}$$

where Q_t is the real exchange rate, P_t^{CU} is the copper price, and Q_t^{CU} is copper production—which, in turn, depends on the copper price. Both the copper price and external activity are considered exogenous to the Chilean economy. In the Chilean case, food exports are included in X_t^D, but in other countries they could be part of commodity exports (for instance wheat, sugar, rice, etc.). This point in the model is particular to the Chilean economy, but it can easily be adjusted to consider other alternatives, such as including other commodities or even exports without including commodities.

As in Schmitt-Grohé and Uribe (2003), we close the model by assuming that country risk depends on external debt over GDP, as follows:

$$\Phi_t = \Phi\left(\frac{b_{t+1}^*}{GDP_t}, \frac{b_{t+1}^*}{Q_t^T K_{t+1}} \frac{Q_t}{Q_{t+1}}\right), \tag{21}$$

where $b_t^* = \frac{S_t B_t^*}{P_t}$, $B_t^* = B_t^{o*} + B_t^{G*}$, and $B_t^{o^*} = \int_{\lambda_c}^1 B_t^{o^*}(i)di$. The second term in the risk premium corresponds to the financial accelerator proposed by Gertler, Gilchrist, and Natalucci (2007) for a small open economy. This term connects the exchange rate with financial distress - measured by the value of external debt, including expectations of real exchange rate depreciation - with respect to the value of capital - as a measure of the collateral for the economy. Both effects produce an upward-sloping supply of funds, indicating that the economy faces financial frictions in the external credit markets.

We assume additionally that mining production affects the market for domestic goods:

$$Y_t = C_t + I_t + G_t + X_t, \tag{22}$$

where $Y_t = \int Y_t(s)ds$, $C_t = \int_0^{\lambda_c} C_t^R(i)\,di + \int_{\lambda_c}^1 C_t^o(i)\,di$, $I_t = \int I_t(h)\,dh$, and $N_t^j = \int N_t^j(i)\,di = \int N_t^j(s)\,ds$, $j = F, M$.

Finally, once we sum each of the restrictions (from families, government, and firms), we get the total restriction of the economy:

$$
\begin{aligned}
(23) \qquad & \underbrace{P_tC_t + P_tI_t + P_tG_t}_{DOMESTIC\ SPENDING} \leq \underbrace{P_tY_t}_{OUTPUT} \underbrace{-S_tM_t - S_tP_t^{OIL}OIL_t}_{INPUTS\ AND\ OIL\ IMPORTS} \\
& \underbrace{+\frac{S_tB_{t+1}^*}{\Phi_tR_t^*} - S_tB_t^* +}_{FOREIGN\ DEBT} \underbrace{\Gamma(S_tP_t^{cu}Q_t^{cu})}_{COPPER\ INCOME},
\end{aligned}
$$

Finally, the model is completed with the definition of competitive equilibrium, which will be estimated, calibrated, and simulated in section III. Before solving the model, it is expressed in real terms by using P_t and P_t^* which are the domestic and external price level, respectively. All the results of this study are restricted to a competitive equilibrium for the reasons given in the introduction.

DEFINITION 1: *Competitive Equilibrium.*
A competitive equilibrium is a set of prices in real terms:

$$
\left\{\frac{W_t^M}{P_t}, \frac{W_t^F}{P_t}, Q_t, Q_t^T, \frac{P_t^{OIL}}{P_t^*}, \frac{P_t^{cu}}{P_t^*}, \frac{Z_t}{P_t}, \frac{R_tP_t}{P_{t+1}}, \frac{R_t^*P_t^*}{P_{t+1}^*}, \frac{P_t^F}{P_t}\right\}_{t=0}^{\infty},
$$

such that households maximize utility (equations (1), (2) and (10)), firms maximize profits (equations (4), (5), (11), (15), and (16)), and markets clear (equation (22) and (23)). Agents take as given prices in real terms, technological (equations (4) and (5)) and biological constraint (equation (6), (8), (9), and (12)), external activity and (19)), domestic (equation (3)) and external (equation (21)) financial frictions, government expenditure (equation (17)), initial debt and capital conditions, and shocks.

III. Results

A. *Time Series of Consumption of Food*

One of the challenges of the study was to calculate the amount of food consumed per person for the period 2009–18. The information that tends to be available in emerging countries is the basket of goods used to calculate the consumer price index (CPI) over time. We augment this information with (i) the evolution of CPI prices by category; (ii) the per capita consumption of families, from the national accounts; and (iii) the elasticities of demand by food group, which are available from the United States Department of Agriculture for many countries. We are then able to approximate real consumption by type of food.

The calculation of the amount of each type of food consumed consists first in obtaining the amount of each type of food—defined as meats, dairy products, bread and flour, fruits and vegetables, fish and shellfish, oils, and sugars—consumed in the fourth quarter of 2013, as a percentage of the aggregate per capita consumption for that quarter:

$$Q_t^i = \left(\alpha_t^F \frac{P_t}{P_t^F}\right)\left(\alpha_t^{F,i} \frac{P_t^F}{P_t^{F,i}}\right)\left(\frac{C_t}{N_t}\right), \tag{24}$$

where α_t^F is the share of food in total expenditure, $\alpha_t^{F,i}$ is the share of food i in total food expenditure (see table 1), and N_t is the population over 15 years of age (approximately 13,819,000 people). With regard to the CPI, we take the 2013 basket that was used by the Chilean National Statistics Institute (INE) to construct the consumer price index. On the other hand, C_t is aggregate private consumption from the national accounts published by the Central Bank of Chile, at constant and seasonally adjusted prices (21.151 trillion pesos).

Second, by taking the price and income elasticities of demand for different types of food in Chile, which are available from the U.S. Department of Agriculture, we construct a time series for each type of food (see table 2). Elasticities allow us to calculate the variations in time of the quantities consumed, assuming stable food supplies:

$$\Delta \frac{Q_t}{Q_{t-1}} = \eta_P^{D,F} \Delta \left(\frac{P_t^A}{P_t}\right)\left(\frac{P_{t-1}}{P_{t-1}^A}\right) + \eta_Y^{D,F} \Delta \left(\frac{C_t}{N_t}\right)\left(\frac{N_{t-1}}{C_{t-1}}\right). \tag{25}$$

Table 1—Share of Each Type of Food in Total Food Expenditure

Food group	$\alpha_t^{F,i}$
Beef, pork, and chicken	0.28
Dairy products	0.15
Bread, cereals, and flours	0.19
Fish and seafood	0.04
Oils	0.06
Sugar	0.08
Fruits and vegetables	0.22

Note: Expenditure on sugar includes beverages, juices, nondairy desserts, snacks, baked goods, cookies, pastas, and prepared savory doughs, cereal, and bread. Only the percentage of sugar in these products was considered, according to the U.S. Department of Agriculture.
Source: Chilean National Statistics Institute (INE) and U.S. Department of Agriculture.

TABLE 2—DEMAND ELASTICITIES BY TYPE OF FOOD IN CHILE

Food group	Price elasticity ($\eta_P^{D,F}$)	Income elasticity ($\eta_Y^{D,F}$)
Beef, pork, and chicken	-0.51	0.62
Dairy products	-0.55	0.68
Bread, cereals, and flours	-0.31	0.38
Fish and seafood	-0.57	0.70
Oils	-0.33	0.40
Sugar	-0.69	0.95
Fruits and vegetables	-0.41	0.50

Note: Dairy products and sugar correspond to "other products" in Muhammad et al. (2011), who obtained their estimates using information from the World Bank's International Comparison Program (ICP). From Headey and Alderman (2019), it follows that these other foods in the ICP are substantially sugar-rich foods. On the other hand, the results of Muhammad et al. (2011) are within the ranges of the international literature that has estimated the price elasticity of sugar-rich products. The elasticity that we use is half that found in the recent study by Guerrero-López, Unar-Munguía, and Colchero (2017) for sugar-sweetened drinks in Chile, but we chose to use the lower value of Muhammad et al. (2011) because our study considers a wider variety of sugar-rich products than just sugary beverages. For example, we consider foods that are also in bread, cereals, and flours and in dairy products, with a price elasticity between –0.30 and –0.55 (see table 2). These products account for around 55% of the group that we consider to be sugar-rich foods, whereas sugar-sweetened drinks are only 9% of the total.
Source: U.S. Department of Agriculture and Muhammad et al. (2011).

B. Steady State and Calibrated Parameters

In this section, we present our strategy for calculating the steady state of the model. The methodology in general consists of calibrating the stationary state and estimating only the parameters related to the dynamics of the model, since the values and ratios of the stationary state are known with greater precision and, therefore, it is possible to obtain the values of certain parameters, which are directly related to the stationary state, without needing to be estimated.

To begin, we compute the average values of optimal and actual food consumption for the period 2009:1 to 2018:4 (see table 3). Besides, we calculate the average values for men and women of the probabilities $\bar{\theta}^j$ (see table 4), which are approximated by the probabilities of death from disease (see table 5), this provides a good indicator of the long-term cumulative effects of permanently consuming inappropriate levels of food.

Next, based on this the information, we can calculate the steady state in the labor market in the following way. We simultaneously can pin down the values of the probabilities $\bar{\theta}^j$ and the labor supplies with the values found for Chile, by accommodating the values of the parameters β^j from the equation (8). Thus, these are the parameters that we leave free in the model to be able to calculate the labor part of the steady state. Table 6 shows this steady state for death probabilities $\bar{\theta}^j$ of 30% and 36% for men and women, respectively. It is important to note that the only steady state variables that are not fixed before the estimates are labor and aggregate wage. This is not a problem because these variables are not needed to fix the rest of the steady state and only affect the dynamics of the model, thus they are obtained directly from the estimates.

Table 3—Real and Optimal Food Consumption

Variable	Averages Value, 2009:1–2018:4
Healthy food expenditure over total food	0.07
Total CPI over Food CPI	1.06
Total consumption per capita	1.53
Optimal food consumption	0.12
Food consumption	0.28

Note: Ratios are expressed in decimals, not percentages. Total and optimal consumption are measured in millions of pesos at constant prices. Optimal consumption is calculated as the product of Healthy food expenditure over total food times Total CPI over Food CPI times Total consumption per capita. Food consumption is calculated following the methodology of the section III.A.
Source: ECLAC (2019), Central Bank of Chile, Chilean National Statistics Institute (INE), and U.S. Department of Agriculture.

Table 4—Real and Optimal Food Consumption, by Gender

Gender	Real food consumption rf^j (1)	Probability $\bar{\theta}^j$ (2)	Optimal food consumption of^j (3)	Marginal effect $1-\bar{\theta}^j\left(rf^j-of^j\right)$ (4)
Men	0.55	0.3	0.23	0.90
Women	0.45	0.35	0.19	0.84

Note: Column (1) is obtained as a proportion of food consumption in table 3 (bottom row). According to the Ministry of Health of Chile (MINSAL), men's and women's consumption of the food groups are the following: meat: 0.62 and 0.38; dairy products: 0.47 and 0.53; bread, cereals, and flours: 0.59 and 0.41; fish and seafood: 0.55 and 0.45; fruits and vegetables: 0.5 and 0.5; oils: 0.5 and 0.5; fruits and vegetables: 0.5 and 0.5; and sugar: 0.57 and 0.43. These proportions are used to decompose rf obtained from table 3 and to calculate the $rf^j$of column (1). The probabilities of column (2) are obtained from table 5. Column (4) is expressed in the same units as column (1) but is calculated using equation (7) from the model and the first three columns of table 4. According to MINSAL, men need approximately 2,300 calories a day and women 1,900 calories. Using these values plus the values for rf^j and $\bar{\theta}^j$, we can calculate of^jin column (3). Column (4) is calculated using equation (8)from the model.

Finally, we use this information to calculate the rest of the variables needed for the model. However, we simplify the calculation by extracting the balanced growth of the economy from all the variables of the model, since this information is not necessary for the estimation in section III.C. Alternatively, a permanent shock will indicate the differences in growth with and without an increase in healthy food consumption. We begin by calculating the interest rate as a function of the subjective discount rate defined in equation (1) of the model:

$$r^S = \frac{1}{\beta} - 1. \tag{26}$$

TABLE 5—PROBABILITY OF DEATH FROM FOOD-RELATED DISEASES

Disease	Men	Women
Cancer of the gallbladder and extrahepatic bile ducts [a]	0.036	0.045
Type 2 diabetes and other types of diabetes [b]	0.033	0.053
Hypertensive diseases [c]	0.099	0.077
Ischemic heart disease [d]	0.041	0.050
Other heart disease [e]	0.084	0.102
Cerebrovascular Diseases [f]	0.011	0.031
Total	0.300	0.360

Source: The probability of death from each disease is calculated as the ratio of the number of deaths caused by that disease over total deaths reported by the Ministry of Health of Chile (MINSAL). The classification of the MINSAL is the following: [a] c23–c24, [b] e11–e14, [c] i10–i13, [d] i20–i25, [e] i30–i52, [f] i60–i69.

TABLE 6—STEADY STATE IN THE LABOR MARKET

Variable	Value
A. Women's labor over men's labor	0.40
B. Women's income over men's income	0.69
C. Employee income sharing	0.37
D. Men's labor	0.08
E. Women's labor	0.03
F. Men's wage	3.73
G. Women's wage	2.57
H. Total labor	0.06
I. Total wage	6.23

Note: Employment is adjusted by hours worked. Women's labor is calculated as $A * D$. Men's wage is calculated as $C/\ [D * (1 + A * B)]$. Women's wage is calculated as $B * F$. Aggregate work is calculated using equation (5) of the model and the estimations of $coef_1$, $coef_2$, and ε^N at 0.09 , 0.22, and 1.05, respectively. Finally, the aggregate wage is calculated from the wage index derived from equation (5).
Source: Authors' calculations, based on data from the INE and the Central Bank of Chile.

Then, we assume a production level Y and a real exchange rate equal to one in steady state. We can make these simplifying assumptions because equation (4) has an exogenous level of technology A and we can impose the law of one price. Thus, we can calculate the share of imports MS^S based on the ratio of imports to GDP:

$$MS^S = \left(\frac{M^S}{GDP^S}\right)\left(1 + \frac{M^S}{GDP^S}\right)^{-1}. \tag{27}$$

We then calculate the share of capital income KS^S, taking the workers' share as given, LS^S:

$$KS^S = 1 - LS^S - MS^S. \tag{28}$$

Given the ratio of imports to GDP, $\frac{M^S}{GDP^S}$, the ratio of GDP to Y is:

$$\frac{GDP^S}{Y^S} = \left(1 + \frac{M^S}{GDP^S}\right)^{-1}. \tag{29}$$

On the other hand, the steady state of the capital stock is:

$$K^S = \frac{KS^S}{r^S + \delta}. \tag{30}$$

The coefficients of the production function α_1 and α_2 (equation (4)) are calculated as:

$$\alpha_1 = \left(KS^{S\frac{1}{\varepsilon}}\right)\left(r^S + \delta\right)^{\left(\frac{\varepsilon-1}{\varepsilon}\right)}. \tag{31}$$

$$\alpha_2 = MS^{S\frac{1}{\varepsilon}}. \tag{32}$$

The parameter ε is unknown, and it is estimated directly from the data.These coefficients do not need to be known in advance to calculate the steady state, instead these parameters are needed to estimate the dynamics of the model.

The ratio of investment to Y and GDP is then:

$$\frac{INV^S}{Y^S} = \delta K^S \Rightarrow \frac{INV^S}{GDP^S} = \frac{INV^S}{Y^S}\frac{Y^S}{GDP^S}. \tag{33}$$

The ratio of consumption to GDP can be calculated as:

$$\frac{C^S}{GDP^S} = 1 - (1-\beta)\frac{B^{*S}}{GDP^S} - \frac{G^S}{GDP^S} - \frac{I^S}{GDP^S}. \tag{34}$$

Table 7—Steady State of the Economy

Variable	Value
r^s	1.3
δ	2.0
$\frac{C^S}{GDP^S}$	64
$\frac{I^S}{GDP^S}$	22
$\frac{X^S}{GDP^S}$	34
$\frac{M^S}{GDP^S}$	31
$\frac{B^{*S}}{GDP^S}$	51
$\frac{G^S}{GDP^S}$	13

Note: The interest rate (r^s) is consistent with a subject discount rate β of 0.987. Values are consistent with the assumed values for the interest rate, depreciation rate, labor's share of the economy, and the ratios of imports, external debt, and government spending over GDP.

The equilibrium of the model is indeterminate in relation to fiscal expenditure and the external debt over GDP, so we can fix these values arbitrarily and identically to the values observed in the economy. Finally, the ratio of exports to GDP is calculated considering the equation (22) of the model (see table 7):

$$\frac{X^S}{GDP^S} = 1 - \frac{C^S}{GDP^S} - \frac{G^S}{GDP^S} - \frac{I^S}{GDP^S}. \tag{35}$$

C. *Estimated Parameters*

The model is estimated with Bayesian econometrics for several practical reasons inherent to many emerging economies. Among them, we have a small data sample, only approximate data on key variables, and only an idea of the range for some parameter values. All this makes the Bayesian strategy for establishing priors and distributions for parameters more appropriate than a standard maximum likelihood or GMM estimate. First, we log-linearized the parameters around the previously calculated steady state. Once the model was in linear terms, we estimated it with Bayesian techniques, assuming death probabilities $\bar{\theta}^j$ of 30% and 36% for men and women, respectively. Nevertheless, many of the parameters were obtained directly from the steady state without being directly estimated, highlighting the importance of adequate model calibration, as reported in the section III.B.

Estimations were first made with 30,000 simulations and two Markov chains, using the Monte Carlo optimization routine to obtain the parameter mode. Then, taking that mode, we made four Markov chains of one million simulations each to obtain the final estimation of the parameters. The high number of simulations ensures the convergence of the parameter within and between Markov chains. In both steps, the Metropolis-Hastings algorithm was used to construct the subsequent distributions of each parameter.

Table 8 shows the estimates of all the parameters involved in the simulations in the section III.D, first showing the parameters related to food and then those related to the macroeconomic and labor market structure of the model. The logic of the food-related priors is as follows. First, the persistence of a healthy-food shock ρ^F was assumed to be high to indicate that food habits are difficult to modify. Second, the elasticities of demand, $\eta_P^{D,F}$ and $\eta_Y^{D,F}$, are in line with those obtained in table 2. Third, supply elasticity $\eta_P^{S,F}$ was assumed to be low because the sample consists of quarterly data (that is, insufficient time for the supply to react to a price change), so it is equal to half the elasticity of demand. Fourth, we did not have information for the values of the coefficients $coef_1$ and $coef_2$, so a uniform distribution was assumed, with boundaries of 0.05 and 0.8.

The priors related to the macroeconomic structure are generally in line with other studies. The substitution elasticities, ε and ε^N, were assumed to be low and equal to one, corresponding to a standard Cobb-Douglas function. The priors of the parameters ρ_M and ρ_F(which are the inverse of the elasticities of labor supply to real wages) indicate a stylized fact of the Chilean economy: although women's labor participation is low, women respond to changes in wages more than men. In this case, the priors must be established according to the economy in question.

The posteriors of the coefficients are generally similar to the priors of the parameters, but there are some important differences. First, the price elasticity of demand was higher than assumed by the prior, while the income and price elasticities of supply were in line with the priors. Second, two key parameters of the study, $coef_1$ and $coef_2$, have estimated values well below their priors, indicating that the effects of effective food consumption are more important in women than in men. Third, the elasticities of substitution, ε and ε^N, are slightly higher than one in both cases. This indicates that in the Chilean economy, the substitution between men and women is similar to the substitution between humans and machines (namely, capital and imported inputs, which are mostly imported machines).

Table 8—Bayesian Estimations of the Parameters Used in the Simulations Model

Parameter	Prior	Posterior	90% Interval		Prior distribution	Standard deviation
Food-related:						
ρ^F	0.900	0.900	0.884	0.916	Beta	0.010
$\eta_P^{D,F}$	0.400	0.667	0.568	0.771	Gamma	0.050
$\eta_P^{S,F}$	0.200	0.186	0.113	0.256	Gamma	0.050
$\eta_Y^{D,F}$	1.000	1.036	0.954	1.116	Gamma	0.050
$coef_1$	0.425	0.085	0.050	0.130	Uniform	0.217
$coef_2$	0.425	0.190	0.050	0.375	Uniform	0.217
Macroeconomic:						
σ	2.000	1.999	1.916	2.081	Gamma	0.050
ρ_M	1.880	1.872	1.790	1.955	Gamma	0.050
ρ_F	0.410	0.406	0.325	0.485	Gamma	0.050
λ_c	0.300	0.300	0.283	0.316	Beta	0.010
η_1	0.070	0.072	0.056	0.089	Gamma	0.010
η_2	0.010	0.005	0.000	0.011	Gamma	0.010
ε^N	1.000	1.064	0.729	1.388	Gamma	0.200
ε	1.000	1.081	0.889	1.272	Gamma	0.200
φ_{AC}	0.250	0.231	0.200	0.261	Gamma	0.020
Ω_Q	0.300	0.295	0.279	0.311	Beta	0.010
Ω_M	0.500	0.503	0.471	0.536	Beta	0.020
Ω_N	0.500	0.497	0.464	0.530	Beta	0.020
Ω_K	0.500	0.502	0.469	0.534	Beta	0.020
Ω_{NN}	0.500	0.499	0.466	0.533	Beta	0.020

Note: The parameter η_1 measures the impact of the external-debt-to-GDPratio on country risk. The parameter η_2 measures the impact of the external-debt-to-GDPcapital value ratio on country risk. Together with λ_c, these parameters measure financial frictions. φ_{AC} measures the adjustment costs of the new investment. Ω_Q measures the inertia in the uncovered interest rate parity equation and explains the evolution of the real exchange rate. Ω_M, Ω_N, and Ω_K measure the inertia in the hiring of imported inputs, labor, and capital. Ω_{NN} measures the inertia in the hiring of men versus women in the cost minimization condition between both types of labor. All these parameters were used to improve the fit of the model.

To check the stability of the estimated parameter of the four Markov chains, we compared the values of each parameter with respect to the within and between mean according to the standard methodology of Brooks and Gelman (1998). As shown in figure 4, the two criteria indicate convergence of the parameters: both lines converge and are relatively stable only after 500,000 simulations.

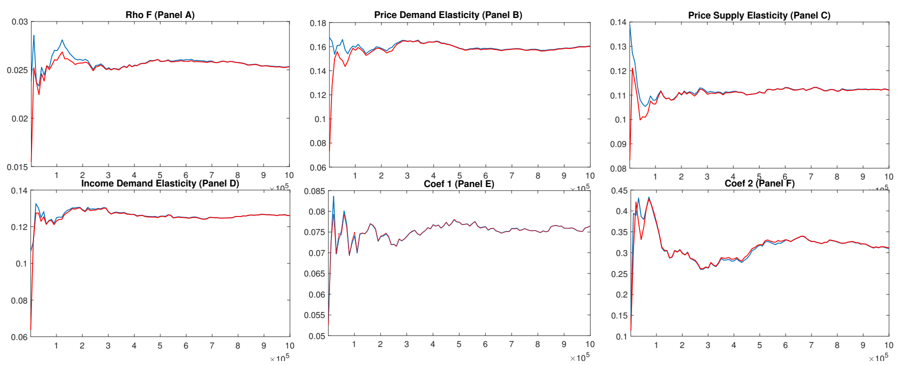

Figure 4. Stability of the Estimated Parameters Associated with Food

Note: The figure shows the differences of the values of the estimated food-related parameters —(see table 8) with respect to the within and between mean according to the standard methodology of Brooks and Gelman (1998). The blue line corresponds to the convergence between the chains, whereas the red line is the convergence within the chains.
Source: Author's calculations.

D. *Competitive Equilibrium Simulations*

To measure the impact of the increase in healthy food on the economy, we performed several simulations with the estimated model. Figure 5 shows a 1% shock in the increase of food under several alternative scenarios. These scenarios aim to shed light on the different effects involved in that shock and thus to determine which of these effects is most relevant from an economic perspective.

The first comparison that can be made in figure 5 is the difference in the effect of the shock depending on the initial health of the workers. The orange line in each of the panels is a positive shock to healthy food consumption of 3%. In contrast, the red line in each of the panels graphs the same 3% positive shock, but in this case there was a previous increase in healthy food of 27%—that is, workers are starting from a higher initial health level. The difference in terms of probability $\bar{\theta}^j$ in the first case is 29% for men and 34% for women, versus 19% and 23%, respectively, in the second case. Thus, the effect will be greater to the extent that workers are less healthy initially. This is directly explained by equation (7), where the penalty in a healthier country is lower, due to both a fall in the probability of becoming ill and the difference between real and optimal food.

The second comparison is to establish whether there is significant propagation, i.e., the general equilibrium effect, of an increase in healthy food to the rest of the economy. In other words, we want to see if the effects of this phenomenon are restricted to a single health issue or whether there are significant aggregate economic implications. In figure 5, the green line in each of the panels represents a shock when the probability $\bar{\theta}^j$ is 29% and 34% for men and women, respectively, but assuming that the parameter ρ^F is only 0.1 and not 0.9 as in the orange line. By decreasing the parameter ρ^F to 0.1, we are assuming that the intertemporal substitution mechanisms that affect consumption, labor, and investment decisions are minimal. As indicated by the very large difference between the orange and green lines, that intertemporal propagation mechanisms—both demand and supply—make a substantial difference in the economic impact of an increase in healthy food. While the origin of the shock is the increase in workers' health and individual productivity, its effect on the economy is largely due to the spillover that occurs through subsequent increases in household consumption, which—because of its magnitude—leads to increases in investment in physical capital and in female labor. This last element is important to consider in economies where women's participation in the labor market is low, as the shock, together with $coef_1 < coef_2$, causes employment to increase more for women than for men.

The third comparison is between the effects of demand and supply propagation. Equation (9) showed that as workers become healthier, the labor supply expands. The blue line in each of the panels of figure 5 represents a shock in which the probability $\bar{\theta}^j$ is 19% for men and 23% for women (as in the red line), but assuming that equation (9) does not operate. As the figure shows, the blue line is below the red line, indicating that the propagation effect is clearly weakening, but the difference between the orange and green lines is greater. In other words, the general equilibrium effect is mainly through consumption, and this is larger than the propagation effect that occurs through labor supply. While both effects are important, propagation through increased consumption via aggregate demand is determinant.

We conducted a second set of simulations featuring a permanent 30% shock that is evenly distributed over ten years to establish the relationship between healthy diet and the obesity pandemic. The magnitude and duration of the shock are not arbitrary: the observed gap between real and optimal food consumption in Chile is 30%, and the United Nations has established a period of ten years for the promotion of healthy food worldwide to combat this pandemic. This is a reasonable length of time for changing the habits of several million people from a diet rich in sugars, fats, and sodium to a healthier diet. In the simulation, we

Figure 5. A 1% Shock in Healthy Food Consumption

Note: The colors indicate the following scenarios. Orange is a shock in which healthy food consumption increases from 0 to 3%. Red represents a scenario in which the increase is from 27 to 30%. Blue is similar to the red, but without considering the increase in the labor supply of men and women due to the improved health of workers. Green is similar to orange, but the shock is not transmitted to the rest of the economy through the intertemporal effects of the model.

assume that over the course of ten years, habits are effectively changed—through taxes or subsidies, cultural changes, and the promotion of healthy food options in the workplace, as discussed above—and that the population gradually adopts a diet that favors health, productivity, and, ultimately, economic performance.

The results are presented in table 9. As the table shows, considering all the propagation mechanisms discussed above, GDPgrowth rises 0.2 per quarter, or almost one additional percentage point of GDPgrowth each year. As has been discussed, this additional growth is achieved by a boost in consumption (33%) and by a healthier workforce and greater capital formation (16%), highlighting the growth in women's labor (18%). This derives from the increased productivity following a change in food habits that reduces the probability of death from 36% to 23%. Otherwise, the obesity pandemic will cause at least similar economic losses.

Another relevant issue in the simulations is the growth of real wages. In both figure 5 and table 9, real wages grow even though the relative price of food also grows. In other words, families can finance the increase in food prices, which rise because of higher demand (see equation (10) and figure 1). The result of table 9 indicates that despite rising food prices, real wages still increase. However, this result must be taken with caution because in many emerging countries, a large share of workers earn the minimum wage, which tends to be fixed for long periods of time and is only adjusted to reflect inflation. In these cases, larger minimum wage adjustments should be considered to offset the increase in food prices.

Table 9—Simulation of the Model of a Permanent 30% Shock Distributed over Ten Years

Year	Posterior mean	90% interval		Posterior mean	90% interval	
	GDP			Investment		
1	0.023	0.020	0.025	0.016	0.014	0.018
2	0.047	0.082	0.104	0.031	0.055	0.069
3	0.071	0.087	0.111	0.047	0.057	0.072
4	0.094	0.103	0.130	0.061	0.067	0.084
5	0.116	0.119	0.151	0.076	0.077	0.098
6	0.137	0.136	0.172	0.089	0.088	0.112
7	0.156	0.151	0.192	0.102	0.099	0.125
8	0.174	0.167	0.211	0.115	0.110	0.139
9	0.191	0.181	0.229	0.126	0.119	0.151
Long run	0.219	0.203	0.256	0.161	0.150	0.189
	Consumption			Women's labor		
1	0.031	0.027	0.034	0.007	0.006	0.008
2	0.067	0.117	0.149	0.025	0.043	0.055
3	0.104	0.127	0.161	0.045	0.055	0.069
4	0.140	0.152	0.192	0.064	0.070	0.088
5	0.173	0.178	0.225	0.083	0.085	0.108
6	0.205	0.203	0.257	0.101	0.100	0.127
7	0.235	0.228	0.289	0.118	0.114	0.144
8	0.263	0.251	0.318	0.133	0.127	0.161
9	0.289	0.273	0.346	0.148	0.140	0.177
10	0.314	0.294	0.372	0.162	0.151	0.192
Long run	0.328	0.304	0.385	0.178	0.165	0.209
	Men's wage			Food prices		
1	0.007	0.006	0.008	0.028	0.024	0.031
2	0.022	0.038	0.047	0.058	0.100	0.127
3	0.037	0.046	0.058	0.087	0.106	0.134
4	0.053	0.057	0.073	0.115	0.125	0.158
5	0.068	0.070	0.088	0.141	0.145	0.183
6	0.082	0.081	0.103	0.166	0.165	0.208
7	0.095	0.092	0.117	0.190	0.184	0.233
8	0.108	0.103	0.130	0.212	0.202	0.256
9	0.119	0.113	0.143	0.232	0.220	0.278
10	0.130	0.122	0.154	0.252	0.236	0.298
Long run	0.143	0.133	0.168	0.265	0.246	0.312

Note: The permanent 30% shock is evenly distributed over ten years (3% each year). The value in the long term—and in each year as well—is the permanent growth with respect to the situation without the shock.

IV. Policy Implications and Conclusions

The issue of food and related diseases is increasingly important, but workers, businesses and governments do not seem to be internalizing the costs of the obesity pandemic. Overweight and obesity levels in emerging and developed economies alike exceed 50% of the population, regardless of gender. This contributes to a number of serious diseases—such as diabetes, heart disease, and many cancers, etc.—which conspire not only against the general well-being of the population but also against productivity and macroeconomics performance of these countries.

In this article, we present a general methodology for estimating the economic impact of an increase in the consumption of healthy food, fulfilling a series of requirements that the literature has detected as necessary to adequately measure this impact. The results—based on a particular example, but generalizable to any emerging economy—indicate that a country may be foregoing substantial potential growth by not adequately considering this issue in its public policies.

The significance of healthy food far exceeds the issue of workers' health, the lack of it affects the economy through a substantial reduction in consumption, investment, wages, and labor supply, what we define as the general equilibrium effect. In other words, the results indicate that if the benefits of healthy eating are lost, countries will incur the costs of an obesity pandemic, undermining their ability to grow.

Our methodology is applied to Chile, an emerging country that has implemented numerous pro-market reforms, however, workers, businesses and the government do not seem to internalize the benefits of healthy food. In Chile, one third of deaths are associated with diet-related diseases. According to our estimates using the methodology proposed in this study, policies that combat the obesity pandemic, through a 30% increase in the healthy diet over the next ten years will produce an extra one percentage point growth in GDP per year in the long run. Furthermore, these policies lead to the growth of real wage and profits.

The lack of internalization of the economic costs of a pandemic—not only in Chile but in most emerging economies—opens the possibility of implementing public policies to promote healthy food consumption. The need to implement taxes, subsidies, cultural changes, and concrete measures to improve this situation is urgent, especially if the benefits far outweigh the costs, as we find in this study. Therefore, it is difficult to understand the absence of food-related issues in countries' occupational health and safety policies, which should be aimed at ensuring a healthy and productive workforce.

One concrete measure is to promote access to healthy food in the workplace—appropriately regulated by government agencies to ensure infrastructure and adequate food quality. Indeed, the workplace is one of the key areas where we share, socialize, and learn group behaviors, which define our food habits and patterns. When companies provide their workers with a supply of or access to healthy food, they contribute not only to improving the quality of life and general well-being of their workers, but also to preventing chronic diseases above mentioned. In this study we show that this investment in the workplace is more than offset by the final increase in economic activity due to general equilibrium effects.

The potential limitations of our study should also be considered. Indeed, the study suffers from several limitations that are necessary to simplify the model in order for it to be estimated with standard methods. For instance, the model was linearized to allow estimation by standard Bayesian methods. The application of a permanent shock of 30% in a linear model was implemented with small shocks of 3%, in which each one has a different steady state. Thus, we used the staggered implementation of a shock so large that it exceeds the precision of a linear approximation.

In addition, it is always recommendable to have several levels of disaggregation to correctly analyze the relationship between growth, health, and food. In this study, we only consider differences by gender and by financial frictions. Accounting for age heterogeneity with overlapping generations would provide more realistic but complex simulations. Similarly, incorporating income distribution issues would support a more complete modeling of financial frictions. These expansions of the model are pending for future research.

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