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# A Growth Model of Weight Preferences, Food Consumption and Public Policy

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# A Growth Model of Weight Preferences, Food Consumption and Public Policy[*]

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Abstract

In this paper we unify existing theories and empirical evidence on the origins of obesity and examine the e¤ects of …scal policy on the dynamic evolution of weight. We build a dynamic general equilibrium growth model, with two sectors, one producing food and the other producing a composite consumption good. Weight is a function of rational choice as well as labor allocation between the two sectors. By estimating utility from weight and calibrating the US economy we show that (i) technological advances in agriculture decrease food prices and increase weight but not necessarily through higher food consumption but through lower calorie expenditure, (ii) reducing capital taxation, initially depresses weight levels through higher food prices; steady state food consumption decreases due to a price substitution e¤ect but weight soars due to lower calorie expenditure, (iii) reducing taxation on food increases food consumption and weight levels in equilibrium. Labor reallocation towards the less sedentary sector on one hand and higher income on the oty(to)Ulenct3lleighsetoc(pri)1s.(1)10(3)]TJ/F5410.f

# 1 Introduction

framework where technological advances in agricultural production of the US economy lower the price of food, shift labor towards the more sedentary sector and result to an increase in

This fact points to a trade o¤ between production and consumption of food. The increase in production results in higher calorie expenditure reducing weight whereas greater food consumption increases weight. Our method complements the literature by identifying the prevalence of the consumption over the production e¤ect, based on the trade o¤, for the US economy.

Our study complements the analysis of Yaniv, Rosin and Tobol (2009) in two ways. First, following rational choice theory (Dragone (2009), Dragone and Savorelli (2011)) we take into consideration the direct e¤ect of weight on utility and, second, we incorporate it in a macroeconomic quantitative environment. In addition to the fat tax we investigate the e¤ect of capital income taxation on weight gain in a dynamic framework. Both taxes, once reduced, cause an increase in income and food consumption. However, the di¤erence between the two policy instruments investigated is highlighted in our dynamic analysis. Following the reduction in capital tax, food price increases suppressing food consumption, while labor reallocation from agriculture to the capital intensive sector decreases calorie expenditure. This prompts contradictory forces on weight accumulation, however, in steady state weight surges. On the other hand, following the food tax reduction, after tax price of food increases causing food consumption to shrink while labor reallocates towards the agricultural sector instigating weight loss. Policy makers should therefore consider the e¤ectiveness gap between the two policy instruments, since the capital earnings tax seems to be working better towards the decrease in food consumption but favors labor reallocation to the sedentary sector. Our identify a single cause and certainly the answer is not a simple one. However, incorporating key elements in the model, we can evaluate some of the competing claims about the sources of increasing obesity rates.

## 2.1 Households

The economy is made up of a large number of identical, in…nitely lived households, normalized to unity. Agents value consumption of food, $f$, and a composite consumption good, $c$, and derive utility from their weight level, $(W)$. Food thus impacts utility directly through consumption and indirectly through weight. Households save in the form of capital assets, $k$; and supply labor inelastically.[1] The representative agent seeks to maximize lifetime utility given by

$$\max U = \sum_{=0} [\ \ln(f\ ) + (1 - \ )\ln(c\ ) + \ (W\ )] \qquad (1)$$

where $\in (0;1)$ is the discount factor and $\in (0;1)$ measures agent valuation of food versus consumption of the composite good. The objective function is subject to the intertemporal budget constraint

$$k_{+1} = (1 + r\ (1 - \ ))k\ + w\ + T\ - c\ - p\ (1 + \ )f \qquad (2)$$

where $r$ denotes the interest rate of capital stock, $w$ is the wage rate, $p$ is the relative price of food, is a tax rate on capital income, denotes the tax rate on food consumption

xaaandl9Torsue lvTdIn1(g)11(e)Tf81tadgh338(t)(a)11.955h276(v)66(838(8)9(r)1o6.18i)e in agriculture is more strenuous and thus allow for a di¤erential $(1 - u\ )$ in the calorie expenditure between the two sectors. [2] Parameter $\ > 0$ transforms calories into weight.

On the relationship between utility and weight we follow the intuition of Philipson and Posner (1999) on the inverted U-shape:

$$(W) = {}_0 + {}_1W + {}_2W^2 \tag{4}$$

where the ${}_0$ and ${}_1$ are positive and ${}_2$ is negative. Individuals are assumed to have an ideal weight $W$ . When $W < W$ increases in weight lead to an increase in $(W)$, while for $W > W$ , $(W) < 0$. The sign of the above parameters is veri…ed through regression analysis.

The household acts competitively by taking prices and policy instruments as given. The interior solution of the household problem including constraints (2) and (3), gives the optimal path of consumption for $f$ and $c$ as follows:

$$c = \frac{c_{+1}}{(1 + r_{+1}(1 - \ ))} \tag{5}$$

$$\frac{}{f} = \frac{(1 - \ )p(1 + \ )}{C} + (1 - \ )(\frac{1}{})(\frac{}{f_{+1}} - (1 - \ )(1 + \ )\frac{p_{+1}}{C_{+1}}) - (a_1 + 2a_2W_{+1}) \tag{6}$$

Equation (6) shows that the marginal utility from food at time t has to be equal to the marginal loss from the reduction in $c$, the marginal loss in $c_{+1}$ and the gain/loss in $W$ and $W_{+1}$.

## 2.2 The Firms

On the production side we have two sectors. Sector 1 produces the composite consumption good. We follow Alonso-Carrera and Raurich (2007) in that we split labor in the two sectors, without making any human capital speci…c demands for either of them. The production

[2] Several studies (among others Philipson and Posner, 1999) argue that less sedentary jobs, like agricultural occupations, o¤er "free" exercise time to the worker and hence lower obesity levels. In environments with more service oriented industries, agents are expected to have higher weight levels.

function in the composite good sector is:

$$Y = AK_1 (u)^1 \tag{7}$$

A stands for total factor productivity, $K_1$ is sector 1 speci…c capital and u is the fraction of the labor force employed in Sector 1.

$$Z = \quad K_2 (1 - u)^1 \tag{8}$$

Sector 2 produces food, Z. Total factor productivity in the production of food is denoted by , $K_2$ is the capital used in the production of food. Fraction $(1 - u)$ of the labor force works in food production.

The pro…t maximization problem of the …rm producing c is given by

$$\max \quad {}_1 = AK_1 (u)^1 \quad - r_1 K_1 - w_1 u \tag{9}$$

Under perfect competition, both factors of production earn their marginal products and hence:

$$w_1 = A(1 - \quad) K_1 \; u \tag{10}$$

$$r_1 = A \; u^1 \quad K_1 \quad {}^1 \tag{11}$$

The …rm producing food has the following objecting function:

$$\max \quad {}_2 = \quad K_2 (1 - u)^1 \quad - r_2 K_2 - w_2 (1 - u) \tag{12}$$

Consequently, factors of production are paid the following earnings:

$$w_2 = p \; (1 - \quad) K_2 \; (1 - u) \tag{13}$$

$$r_2 = p \quad K_2 \quad {}^1 (1 - u)^1 \tag{14}$$

A word of caution at this point. Capital stocks are determined from aggregate individual savings. But in equilibrium the two rates of return have to be equal to prevent any arbitrage opportunity. In order for this to happen we allocate capital stocks in the two sectors such that their marginal returns are equal. This is done after the individuals make their savings decisions, so this equilibrium condition does not alter individual choices.

## 2.3 Government

On the revenue side, the government taxes return on capital at a rate 0 < < 1 and food consumption by 0 < < 1. On the expenditure side, it provides lump-sum transfers to agents, T: The following equation represents the government balanced budget:

$$r k + p f = T \tag{15}$$

## 2.4 The Dynamic Competitive Equilibrium

In this section we solve for a competitive equilibrium which holds for any feasible policy and analyze its properties.

De…nition 1

$r_1; r_2; r; w_1; w_2; w$ $K_1$ $K_2$ $u; s ; k ; f$

$c ; W$

$c ; f$

$W$

$K_1; K_2$ $u$

$$u + (1 - u) = 1$$

$$K_1 + K_2 = k \qquad s$$

$$K_1 = s k \qquad K_2 = (1 - s )k$$

$$f = K_2 (1 - u)^1$$

$$r_1 = r_2 = r \qquad w_1 = w_2 = w:$$

Using the market clearing conditions, no arbitrage conditions and the government budget constraint, after some algebra, the dynamics of the competitive equilibrium are obtained as follows:

# 3 Data and Calibration

use instrumental variable analysis in order to avoid invalid inference. The instrument we use is individual height, which is exogenous to happiness and endogenous to BMI. F-stats on the instrument are significantly bigger than 10 and hence we can follow our estimates. Estimated regression coefficients for the quadratic relationship $hap = \;_0 + \;_1 BMI + \;_2 BMI^2$, between happiness (hap) and BMI, confirm our hypothesis of an ideal weight, since $\;_0$ and $\;_1$ are positive and $\;_2$ is negative.

Regarding other parameters, we set the elasticity of capital on industrial production function, $\; = 0.34$; as is commonly used by the literature (we also tried parametric range $\; = 0.3 - 0.36$ with no change in the results). In addition, we set the capital share on food production function to be $\; = 0.22$ (our results are robust for $0.15 < \; < 0.32$), implying a relatively labor intensive sector, while the production function of the composite good, as the existing literature suggests, is capital intensive. $\;$ is set at 0.5 implying identical individual preferences for the two goods. Agents are assumed not to like or dislike one good more compared to the other. This assumption is significant in order for the results not to be driven by exogenous preference parameters. Time preference parameter, $\;$, is set, as usual, to 0.96 (we tried the range $0.95 - 0.98$ given by the literature and the results remain robust). We also set the weight accumulation parameters $\; = 0.1$; $\; = 1$ and $\; = 0.001$ such that

f(d)271022(4)9(s)9(3-211(2(b)6(0)(829)11(-a)10P(t3(h674-21.l)(r)171pTJ/F5012211.95527)-271(r)11(e)93227P)10(o))8(o)8Tf51

good and leads to a reduction in food price and increase in real wage. As a consequence, food consumption jumps upwards. The agent then finds himself to be overweight with reference to his ideal weight, a fact that in turn induces lower food consumption. This decreases the demand for labor in agriculture and induces a shift of labor to the sedentary sector (higher u) until it reaches its new steady-state level (Table B). Despite the decrease in food price,

## 4.3 Decreasing the fat tax

In this subsection, we examine the steady-state and dynamic e¤ects of a decline in the food tax rate. Overall, following the food tax cut, our steady-state results show that food consumption and weight increase, composite good consumption decreases, while wages and prices remain at the same level (after tax price increases).

Similar to the consequences of capital tax reduction presented above, we observe opposite forces resulting from a food tax cut. On one hand, the decrease in food tax increases food consumption and weight as intuitively expected. On the other hand, labor reallocation towards agriculture, increases calorie expenditure reducing weight. Our calibration of US economy shows that the …rst e¤ect prevails since the tax cut has a clear positive monotonic e¤ect on weight.

Regarding the dynamic transition to the new steady-state, a lower food tax makes food cheaper initiating a substitution and an income e¤ect, the e¤ects of which work in the same direction, increasing food consumption. At the same time the relative price of food and the wage rate jump up. Greater price functions as a disincentive for food consumption whereas the income increase works in the opposite direction. The sudden increase in food consumption following the initial shock is followed by a monotonic and concave decrease. This can be due to two reasons. First, food price and wage rates drop substantially right after the shock. The decrease in wage most likely dominates that of prices. Second, since agents don't have stronger preference for either good, consumption smoothing behavior results in lower food consumption and greater composite good consumption. Despite the reduction in food levels following the initial surge, food converges to a higher steady state level than before the tax cut. The permanently higher levels of food consumption on one hand and the greater calorie expenditure due to labor reallocation on the other, translate into an increasing but concave evolution of weight. Steady state levels of food consumption and weight produced by the dynamics above are in line with stylized facts given by Lakdawalla and Philipson (2002) and Lakdawalla et al. (2005).

## 5 Conclusions

In this paper we unify existing theories and empirical evidence on the origins of obesity and examine the effects of fiscal policy on the dynamic evolution of weight. We build a dynamic general equilibrium growth model, with two sectors, one producing food and the other producing a composite consumption good. Weight depends on food consumption and work strenuousness. Agriculture is defined as work that exerts greater physical effort. Our aim is to first replicate the stylized facts for the US regarding technological advances in food production. Once we successfully complete this first step we dig into the model by investigating the potential impact of alternative public policy tools.

In particular, we analyze and quantify the steady-state and dynamic trade-offs between,

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Baum II, C.L., and Ruhm, C.J., 2009. Age, socioeconomic status and obesity growth. Journal of Health Economics, 28(3), 635-648.

Yaniv, G., Rosin, O., and Tobol, Y., 2009. Junk-food, home cooking, physical activity and obesity: The e¤ect of the fat tax and the thin subsidy. Journal of Public Economics, 93(5-6), 823-830.

# 7 Tables

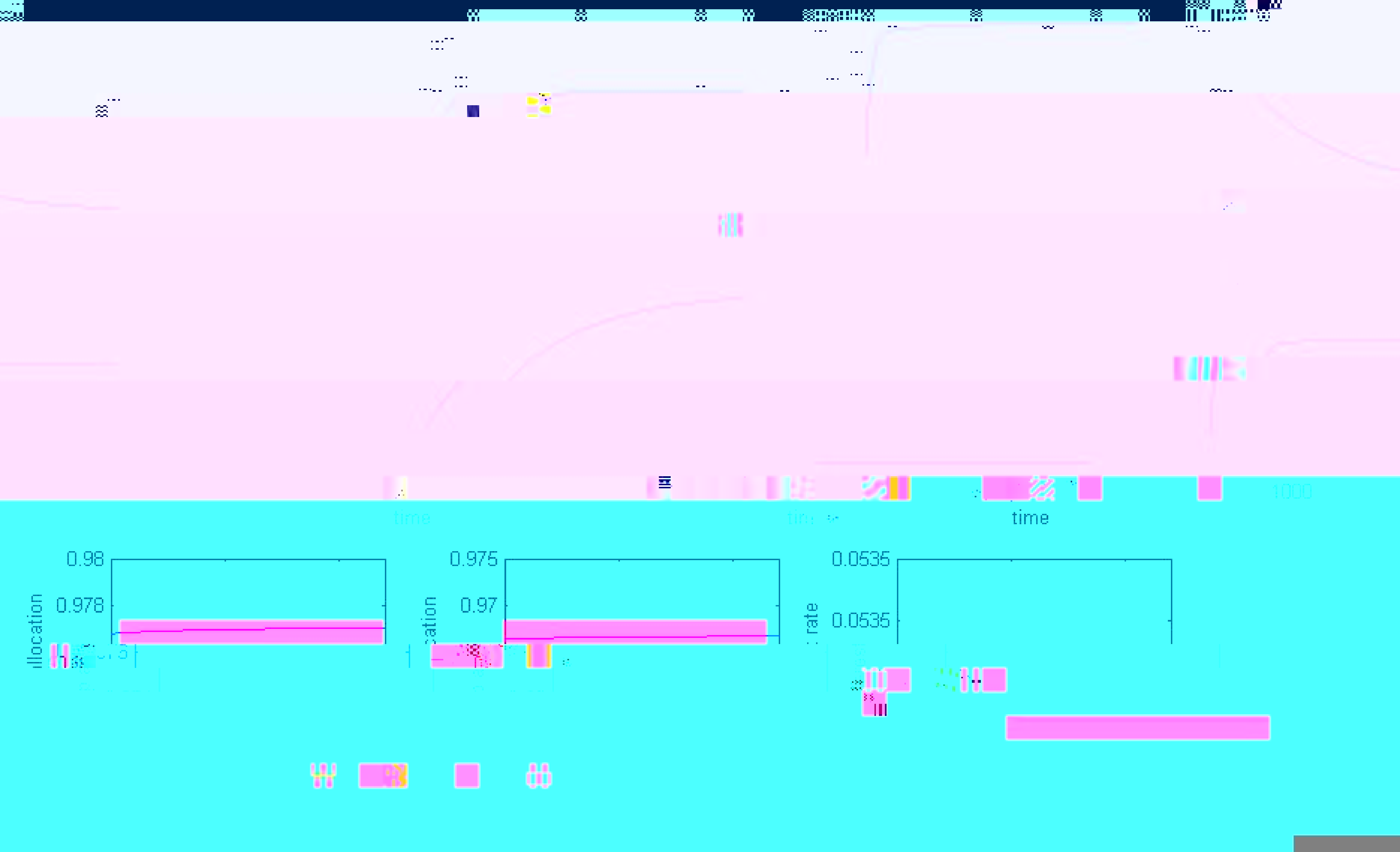
Table A. Values for the parameters

| Parameter | Description | Value |
|---|---|---|
| | share of capital in the composite production function | 0:34 |
| | share of capital the food production function | 0:26 |
| | e¤ect of labor allocation on weight | 0:1 |
| | preference for f vis a vis c in utility function | 0:5 |
| A | aggregate productivity in composite good | 1 |
| | aggregate productivity in agriculture | 1− 1:5 |
| $a_1$ | estimated weight preference | 0:222 |
| $a_2$ | estimated weight preference second order e¤ect | −0:00345 |
| | rate of time preference | 0:96 |
| | tax rate on capital | 0:22 − 0:15 |
| | tax rate on food | 0:22 − 0:15 |
| | tranformation rate of food to calories | 1 |
| | depreciation rate of weight | 0:001 |

Table B. Steady-State Results

| W | u | s | f | c | K | p | w | r |
|---|---|---|---|---|---|---|---|---|

Figure 4: Effects from [illegible]



Figur[illegible] Effects f[illegible]om a pemane[illegible]

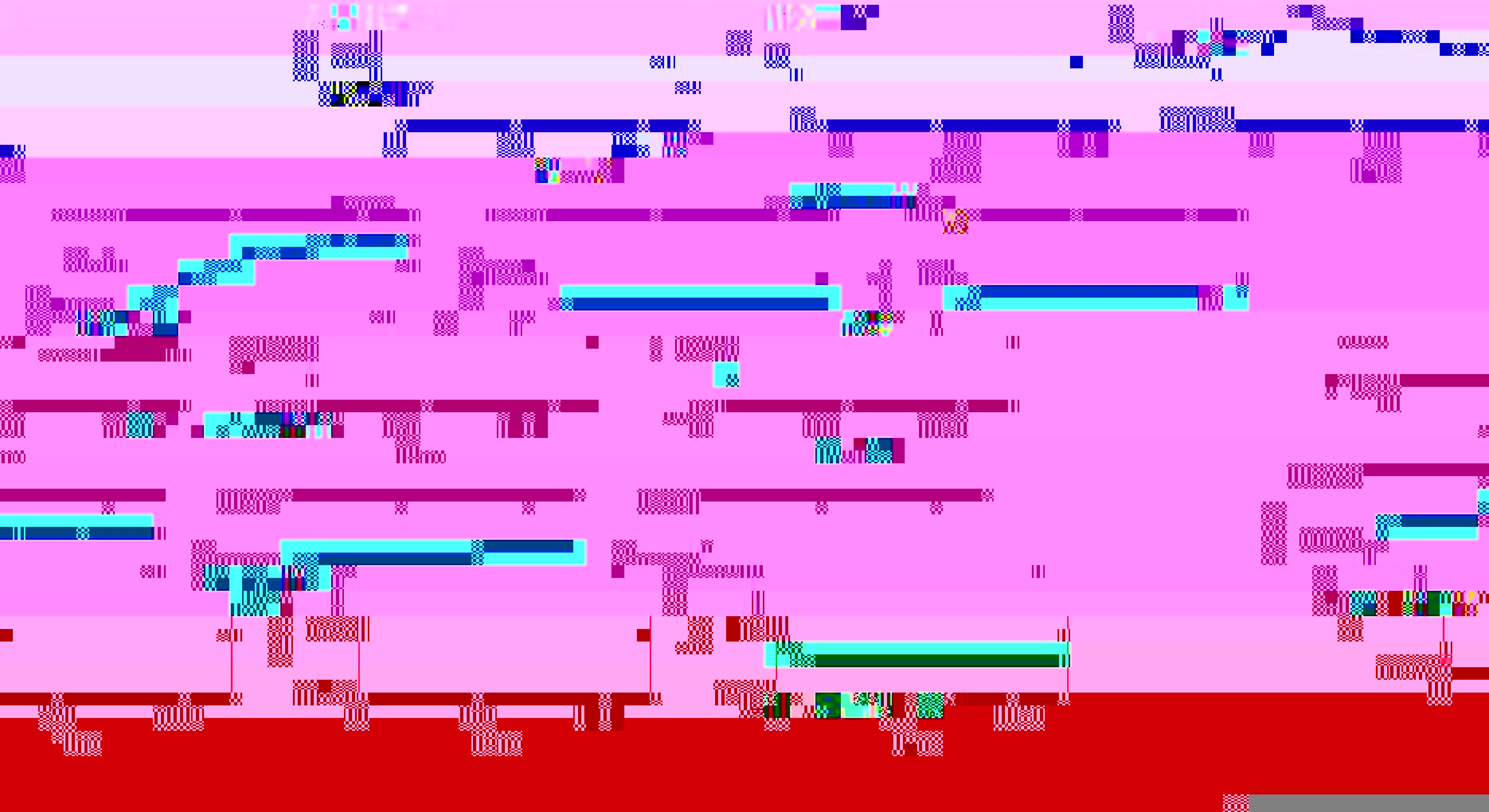


Figure 3: Effects of a permanent decline on the tax rate of food