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A Macroeconomic Analysis of Obesity*

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Abstract

This paper tries to understand the underlying causes of the rapid increase in obesity rates over recent decades. In particular, we propose a dynamic general equilibrium model to derive the quantitative implications of a decline in the relative (monetary and time) cost of food prepared away from home on the caloric intake of the average American adult over the last forty years. Two channels that lower this relative cost are considered. First, productivity improvements in the production of food prepared away from home. We find that this channel is qualitatively consistent with expenditure trends in food items, but falls short of accounting for the magnitude of the observed changes. We then consider actual declines in income taxes and in the gender wage gap, which increase the cost of preparing food at home from scratch. Our model accounts for three quarters of the observed changes in calorie consumption, and is consistent with trends in aggregate food expenditures, time use, and key macroeconomic variables. Our results indicate that changes in the relative cost of food prepared away from home play an important role in our understanding of the increased weight of the American population during the last 40 years.

JEL Classification: E1, E2.

Keywords: Taxes, Gender Wage Gap, Female Labor Participation, Obesity.

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1 Introduction

Many countries have experienced a startling increase in obesity rates over the last 10-20 years. For the first time, the number of overweight individuals around the world rivals the number who are underweight and developing nations have also joined the ranks of countries troubled by obesity. In 2003, the World Health Organization (WHO) reported that more than 1 billion adults were overweight and at least 300 million of them clinically obese. That's a 50% increase in the number of obese people, from 1995, when there were 200 million.[1] Coincident with these trends, there has been a growing consensus about the health risks of obesity and physical inactivity.[2] Thus, understanding the underlying causes of the rapid increase in obesity rates is paramount to a sound debate over policies designed to reverse the trend in the coming years.

What is behind this increase in weights? There is consensus in the obesity, and medical literature, that people gain weight when calories consumed are greater than calories expended.[3] Thus higher weights must be due to lower physical activity and, or, higher calorie consumption. A number of papers find that sedentary lifestyles in the U.S. are important factors when explaining obesity *levels*.[4] However, Cutler, Glaeser and Shapiro (2003) find that the observed decline in energy expenditure in the U.S. is too small to account for the observed *changes* in weights from 1965 to 1995. The authors present evidence showing that most of the switch to a sedentary lifestyle ended by the 1970s, while obesity rates continue to increase. It is well established, nevertheless, that American adults have increased their caloric intake. Hence, understanding what and where households eat is an important issue to consider when analyzing the obesity epidemic.

In this paper, we use dynamic general equilibrium theory to perform a quantitative study of the increase in caloric intake of the average American adult. We consider different food choices, and the associated implications for calorie consumption for the average household. Nationally representative data of food consumption by U.S. individuals suggests that this increase in caloric intake can be attributed to a dramatic increase in calories consumed from foods prepared away from home (restaurants, fast food, snacks, frozen pizza eaten at home, etc.), which compensated the decline in calories consumed from foods prepared at home from scratch.[5] Motivated by these findings, we study the quantitative impact of two different channels that lower the relative cost of food prepared away from home, and may ultimately explain its higher consumption. The first channel is productivity improvements in the production of processed foods. The second is actual declines in income taxes and in the gender wage gap, which increase the opportunity cost of cooking at home from scratch, and thus the economic cost of eating home prepared meals. Households respond optimally to this decline in relative costs by consuming more food prepared away from home. Our task is to determine how much of the

[1] The standard definition of obesity is a BMI (body mass index which is weight divided by height squared) over 30 kg/m^2. BMI is a routinely used indirect measure for body fatness, specifically obesity, in epidemiological research and is highly correlated with other direct measures like Dual-energy x-ray absorptiometry (DEXA) for older populations.

[2] See the National Heart, Lung, and Blood Institute, National Institutes of Health (2000) report for more on this issue.

[3] See Binkley, Eales, and Jekanowski (2000), and Forreyt, Walker, and Poston (2002) for more on this topic.

[4] Philipson and Posner (1999) stress this hypothesis in explaining the increase in obesity over time.

[5] See for example, Guthrie, and Frazao (2002), and Nielsen, Siega-Riz, and Popkin (2002).

observed changes in calorie consumption can be accounted for by the proposed channels.

Our analysis takes as given the well documented fact that people consume more calories, fat, saturated fat, carbonated soft drinks, and lower intakes of vitamins, fruits, and vegetables per dollar spent on food prepared away from home than when they consume home made meals prepared from scratch.[6] Several explanations have been proposed to rationalize this fact. Experimental studies show that humans have a weak innate ability to recognize foods with a high energy density and to regulate the consumption of these foods. Moreover, it is well established that foods prepared away from home tend to have higher energy density than foods prepared at home from scratch.[7] Furthermore, several studies have shown that individuals consistently consume more calories when presented with foods with higher energy density.[8] Higher density foods lead to greater consumption of calories because these foods provide neurobiological rewards,[9] are easier to metabolize,[10] and are less satiating[11]. Hence, regular consumption of foods prepared away from home are likely to result in the consumption of excess energy, and to promote obesity. Other than biological factors, technological considerations also play a role in explaining the high calorie content of food prepared away from home. In particular, the development of trans fats lead to longer shelf life, but trans-fats have also been linked to higher obesity rates [**reference**]. Finally, lower fixed costs, from improved production techniques for foods prepared away from home, may be behind the increase in portion sizes documented by Nielsen and Popkin (2003), and Young and Nestle (2002) from 1977 to 1998. These higher portion sizes have been consistently linked to higher calorie consumption and obesity. [**reference**]

To evaluate the question at hand, we build on Becker's (1965) theory of household production within the context of a dynamic general equilibrium model. Our work follows a large body of literature wherein household production theory has been embedded into the neoclassical growth model. Closely related studies are Greenwood, Seshadri and Yorukoglu (2005) and Jones, Manuelli and McGrattan (2005) who study how changes in technology and a lowering in the gender wage gap have affected the labor participation of married women during the last fifty years. These papers abstract from different food choices, and the associated implications for calorie consumption of the average household. Thus, our analysis provides an explicit link between changes in the production technology of foods prepared away from home, the observed declines in the gender wage gap and income taxes, and the type of food consumed by American households. Moreover, we consider single and married households explicitly. This is useful because a decline in the relative cost of food prepared away from home impacts married and single households differently. Specifically, married individuals have more possibilities of specialization across home and market activities than singles do. Abstracting from this heterogeneity will tend to reduce the overall caloric impact of the channels examined in this paper.

[6]See for example, Bowman and Vinyard (2004), Lin, Guthrie, and Frazao (2002), and Paeratakul et. al. (2003) for more on this issue.

[7]Energy density is the amount of energy stored in a given system per unit volume.

[8]See Rolls, Bell, Thorwart (1999); Rolls, Bell, Castellanos, Chow, Pelkman, Thorwart (1999); Prentice, Jebb, (2003) for more on this topic.

[9]See for example Mela (1999) and Smith (2002)

[10]See Golay and Bobbioni (1997)

[11]See Rolls (1995)

Our quantitative analysis considers a calibrated version of our model such that its equilibrium time series match certain key observations of the U.S. economy during the 1960s. We then derive the implications of the theory for food consumption choices and average caloric intake by considering two sets of experiments. First, we hold income taxes and the gender wage gap constant, and increase the productivity of the food prepared away from home sector relative to that of the overall economy for the 1990s. We find that technological advancements in the food prepared away from the home sector are qualitatively consistent with food expenditure trends, but fall short of accounting for the magnitude of the observed changes. Secondly, we abstract from productivity improvements in the food prepared away from home sector and feed into the model actual income taxes and gender wage gap trends. In this case, the theory can account for 78% of the observed increase in calorie consumption. The model is also consistent with the trends in aggregate expenditures on food away from home, groceries, non-food consumption goods, aggregate investment, and GDP occurring in the U.S. data. Finally, lower income taxes and gender wage gap can also account for the observed decline in aggregate cooking time as well as the total 2-fold increase in hours worked by married females.

The mechanisms driving our quantitative results are as follows. Productivity improvements in the food prepared away from home sector lower its price. A substitution effect then causes households to demand more food prepared away from home, and less food prepared at home. Because time and ingredients are assumed to be complementary in the production of food at home, the lower demand for food prepared at home from scratch pushes cooking times and groceries expenditures down. However, when productivity is set to match the observed expenditure increase in food away from home, the model generates a too large decline in groceries expenditures. Similarly, when productivity is set to match the decline in cooking times or groceries expenditures then the theory falls short of accounting the increased consumption of food prepared away from home. In a second set of experiments, we consider lower income taxes and gender wage gap which increase the cost of time, and thus the cost of consuming food prepared at home from scratch. But a lower gender wage gap has also an additional impact on food choices. A lower gender wage gap changes specialization patterns within married households so that women work more and cook less. Hence, a lower gender wage gap amplifies the impact of any given decline in the relative cost of processed foods on lower groceries consumption, cooking times, and on the increased consumption of food prepared away from home. This amplifying effect is capable of matching most the observed decline in groceries expenditures, the higher expenditures on food prepared away from home, and the higher labor force participation of women during the last forty years.

Certainly, many factors other than a lowering in the monetary or time costs of food away from home may have to be examined to understand fully U.S. obesity trends, as well as their relation to changes in time use of the average household. The transmission mechanisms we evaluate in this paper should then be seen as complementary to existing theories. Our results indicate, nevertheless, that the evolution of the monetary and time costs of food prepared away from home may be part of a successful theory of the weight increase of American adults during the last 40 years.

The remainder of the paper is organized as follows. Section 2 presents a summary of the key data features that need explanation, as well as some of the observations required to calibrate our model. The model and our main results are presented in Section 3. Section 4 concludes.

2 Background Data

In this section we document facts about obesity, calories consumed and important macroeconomic observables in the U.S. over the last forty years. As a result of the different frequencies at which data is collected the periods reported in the tables below may not always coincide. However, closest periods were always considered. Sensitivity analysis to period selection was performed whenever possible finding always similar results to the data reported below. See the Appendix for the sources and computations involved in all of our data tables.

2.1 Obesity and calorie consumption in the U.S

According to the National Health Examination and National Health and Nutrition Examination surveys, the average weight of an American adult female has increased by 14 pounds since the early 1960s, going from 140 to 154 pounds. Similarly, the average weight of an adult male has increased by 16 pounds, from 166 to 182. Moreover, the highest increase in weight has been among married individuals, particularly married women as reported by Cutler, Glaeser, and Shapiro (2003). Using data from the National Health and Nutrition Examination Survey (NHANES) one can obtain obesity rates by marital status. Table 1A provides this information.

Households	**1971-75**	**1988-94**	**Δ%**
Married couples			
Female	14.5	34.5	138%
Male	12	25	108%
Single females			
Females	18	32	77%
Single males			
Males	9	18	100%

Table 1B: Obesity rates by marital status.

As we can see from Table 1A, there are some differential increases in obesity by demographic group. The group that has increased the most weight, over the period considered, has been married couples. Single households have increased the least weight. A puzzling observation that emerges from Table 1A is that, at the cross-sectional level, the groups with higher opportunity cost of time, are less likely to be obese at a given point in time. The theoretical framework we that we will employ links an increase in the opportunity cost of cooking at home with higher consumption of foods prepared away from home, and thus higher calorie consumption. This positive correlation between time changes in the opportunity cost of time and obesity rates implied by our theory is not inconsistent with the well known negative correlation, at the cross sectional level, between obesity*levels* and income or education levels. Specifically, there is evidence suggesting a negative correlation between energy density and energy costs.[12] Hence, high-fat, energy-dense diets are consumed by low-income groups because such foods are more affordable than diets based on lean meats, fish, fresh vegetables and fruit (all of which are lower in energy density). In summary, if low nutritional value/high calorie foods are inferior while high quality foods are normal goods, then people with high opportunity costs of time (and thus higher income) should be less likely to be obese at a given point in time. As we document later on, people with the highest opportunity cost of time have gained the most weight over time.

But where is all that weight coming from? During the last forty years there has been an important change of where households obtain their food. In what follows, we follow the criteria in the nutrition literature. Foods away from home are defined based on where the foods are obtained, as opposed to where they are eaten. Foods at home are those purchased at a retail store, a grocery store, a convenience store, or a supermarket and prepared for home consumption.[13] Foods away from home include those obtained from fast-food outlets, schools, restaurants, other public places, and vending machines. Away from home foods are typically ready-to-eat and consumed "as is,' and the consumer has less control over portion size and nutritional content.[14] Table 1B reports the per capita daily calories of different types of foods by gender. This data is taken from the Continuing Survey of Food Intake 1977-1978 and 1994-1996.

ideally we would have calories per outlet and marital status, de momento podemos utilizar lo que encontraste

Cuando mire a los referee reports, no vi que se quejaran de que no teniamos calories per outlet and marital status. Lo que si se quejaban era "richer females should be more obese but the data suggests otherwise". Creo que eso lo podemos resolver mirando los expenditures promedio de ese grupo de personas

Aggregate economy	**1965**	**1995**	**Δ%**
Total calories	1996	2232	12%
From Groceries	1557	1496	-4%
From Food Away from Home	439	736	67%
For Males	2450	2666	9%
For Females	1542	1798	18%

Table 1B: Per capita total daily calories of different types of foods by gender.

The data in Table 1B suggests that the increase in calories observed between 1965 and 1995 was driven by the increase in calories consumed from food away from home. Notice also that the percentage increase in total calories consumed by female adults is twice as big as that of males.

12 See Andrieu, Darmon, and Drewnowski (2006), Drewnowski and Darmon (2005), and Drewnowski and Specter (2004) for more on this topic.

13 See Lin, Guthrie, Frazao (1999) for more on this definition.

14 See Lin, Guthrie, Frazao (1999) for more on this definition.

To further explore what component of food away from home is the most important, Nielsen, Siega-Riz and Popkin (2002) further dissagregate the types of food and their origin. These authors study the trends in locations and food sources of Americans stratified by age group for both total energy and the meal and snack subcomponents. Their findings are summarized in Table 1C.

Type of Food	**1977-78**	**1994-96**	**Δ%**
Meals			
19-39 Years			
At Home	73	56.8	%
Away from Home	27	43.2	%
40-59 Years			
At Home	78.2	66.1	%
Away from Home	21.8	33.9	%
Snacks			
19-39 Years			
At Home	10	12.2	%
Away from Home	90	87.8	%
40-59 Years			
At Home	76.9	70.8	%
Away from Home	23.1	29.2	%

Table 1C: Trends in energy intake by eating ocasion and location (% energy).

Although all age groups have increased their consumption of meals from restaurants/fast-food establishments, the 19 to 39 year-olds have consumed the greatest percentage of restaurant/fast-food meals. In 1996, snacks from the store eaten out represented up to 12.2% of all energy from snacks, whereas meals from the store eaten out represented only up to 5.6% of all energy from meals for this age group. It seems then that only snacks are not going to account most of the increase in obesity rates in the U.S.

The idea that lower food costs are behind recent obesity trends is pervasive in the empirical literature. A prominent example is Cutler, Glaeser, and Shapiro (2003) who conclude that a technological revolution in the mass preparation of food translated into a dramatic decline in the time cost and market price of food, particularly of mass prepared foods. The lower time cost and increased availability of processed foods are, according to these authors, key factors behind the dramatic decline in cooking times and home meals, and also behind the higher consumption of processed food, which may account for the observed increase in caloric intake.

For completeness, we report in Figure 1 the trends in existing data on the price of groceries (labeled food for off-premise consumption in the U.S. NIPA), and the price of food prepared away from home relative to the GDP deflator. The relative price of groceries declined almost monotonically from 1955 until 1973 when it jumped up by almost 15%. It remained high all through the mid 1970s and early

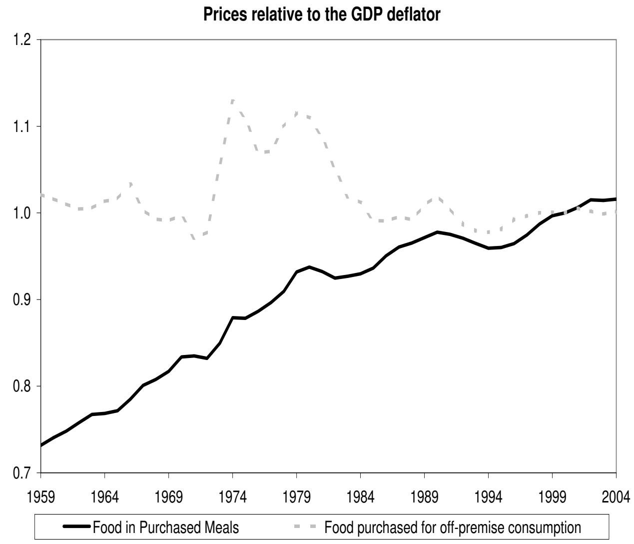

Figure 1: Price of food relative to the GDP deflator.

1980s. By 1982 the relative price of groceries was back at its 1972 level. From 1982 to the present this price has remained relatively constant. On the other hand, the aggregate price of food away from home has increased over the period examined. Of course, aggregate price indexes reported by the U.S. NIPA may not fully adjust for changes in portion sizes, nor quality. Data on changes in portion size of the aggregate "food prepared away from home" through time is not available. Given that Young and Nestle (2002) find evidence that there has been substantial increase and variance regarding portion size of many processed food items since the 1970s, we cannot make precise quantitative assessments of the price of food away from home.

2.2 Trends in macroeconomic observables

The idea that changes in opportunity cost are behind lower costs of processed food is consistent with the findings of Prochaska and Schrimper (1973), who established a high positive correlation between different measures of opportunity cost of the household manager and the expenditure and frequency of consumption in meals prepared away from home.[15] Moreover, Jensen and Yen (1996) find that the effects of a wife's employment are significant and positive on both the consumption frequency and level of expenditure on lunch and dinner consumed away from home.[16]

[15] See Byrne, Capps, and Saha (1996), and Dong, Byrne, Saha and Capps (2000) for more recent analysis.

[16] Similarly, Mutlua and Gracia (2006) find that income, household characteristics and the opportunity cost of women's time are important factors determining food consumption patterns away from home in Spain. Moreover, income and

At the aggregate level we report annual expenditures of households as well as hours worked by marital status and gender, and time devoted to food preparation and clean up. Table 2A reports real per capita annual expenditures, relative to a 2% average growth rate, for the two periods considered in the model. T **ideally we would expenditures by marital status**

Aggregate economy	**Δ% (1955-65 to 1995-04)**
Exp. Groceries	-40%
Exp. Food Away from Home	41%
Exp. Non Food	19%
GDP	13%
Investment	38%

Table 2A: Per capita real annual expenditures for the different types of goods relative to a 2% trend.

Table 2A, indicates a significant shift in the expenditure patterns of American households over the last 40 years. In particular, per capita real expenditures on groceries have decreased by 40% relative to a 2% trend. On the other hand, expenditures on food away from home have increased by 41% relative to a 2% trend.

Regarding the opportunity cost of time of females, at the international level, Bleich, Cutler, Murray, and Adams (2007) find that the increased female labor force participation is associated with increase caloric intake in OECD countries. Table 2B reports a summary of the hours worked by marital status and gender, and Table 2C reports the time devoted to food preparation and clean up, also by gender and marital status.**mention source**

Households	**1960**	**1990**
Married couples		
Hours worked (female)	10.7	22.2
Hours worked (male)	39.4	38.9
Single females		
Hours worked	22.4	24.7
Single males		
Hours worked	27.9	27.8

Table 2B: Average number of weekly working hours by gender and marital status.

The most striking features from Table 2B are, first, that the average number of hours worked by married women has more than doubled. Secondly, single women work 10% more now than during the 1960s. Finally, single men work basically the same number of hours in the two periods considered, while married males work a bit less with a 1% decrease in their working hours.

opportunity cost of women's time have a positive effect on the consumption of food prepared away from home.

Households	1965	1995
Married couples		
Hours food prep. (female)	13.0	6.4
Hours food prep. (male)	1.2	1.7
Single females		
Hours food prep.	7.0	3.8
Single males		
Hours food prep.	2.1	2.1

Table 2C: Average number of weekly hours devoted to food preparation and clean up by gender and marital status.

With respect to time spent in food preparation and clean up, Table 2C reveals that the average number of hours that married women devote to these activities has decreased by 50%. Similarly, single women spent 45% less time preparing home food and cleaning up in 1995 than in 1965. Married men devoted an almost insignificant amount of time to food preparation activities during the 1960s (less than 11 minutes per day). Married men devoted 30% more time to food preparation during the 1990s, but in absolute terms the time they allocate to cooking is very small (15 minutes per day).

The data reported on Tables 2B and 2C play an important role in our analysis. The 1960s data is used to calibrate some of the parameters of the model. Moreover, Tables 2B and 2C are also used to confront the 1990s time-use predictions from the model to the observations of the U.S. economy.

The size and nature of the "gender wage gap" has been well-documented, see Goldin (1990). Women working full-time earned on average 54% of what men earned in the 1960's. This ratio remained relatively flat until the late 1970s and then rose to about 74% by 1997. The "gender wage gap" is difficult to interpret as it can either measure the direct effects of discrimination or differences in unmeasured skills correlated with gender. To keep our analysis simple we take the data on the "gender wage gap" as given and introduce it into our model as a gender-specific tax. Similar results can be obtained in a model with endogenous skill differences by gender or glass ceilings; see Jones, Manuelli and McGrattan (2003).

One of the key mechanisms driving the shift in consumption and the increased obesity rates of all households explored in this paper is the increased opportunity cost of cooking at home. Changes in taxes are going to be important and will be directly incorporated into the model as reported in Table 3. Household taxes in this table correspond to the effective marginal tax rates for the average household by marital status and gender; see the Appendix for more details.

Effective Tax Rates	**1955-65**	**1995-04**
Households		
Labor income for married couples	22%	15%
Labor income for single females	22%	15%
Labor income for single males	22%	22%
Capital income	22%	15%
Firms		
Profits	43%	35%
Social security contributions	1%	4%

Table 3: Marginal corporate and personal income tax rates by gender and marital status.

The tax reform Act of the mid 1980s translated into a lowering of the personal income tax rate. In the case of single men, however, the reduction in the tax rate did not change as much as other households in the 1990s. On the other hand, single women and married households have seen their average marginal tax rates fall the most. Finally, taxes on profits have declined during our sample period, which in a competitive equilibrium translates into higher rates of return for capital. All of these changes have important implications on the opportunity cost of cooking at home for the different households.

The purpose of this paper is to account for the observed *changes* in the average weight of American adults. The theoretical framework we employ links an increase in the opportunity cost of cooking at home with higher consumption of foods prepared away from home, and thus higher calorie consumption. This positive correlation between time changes in the opportunity cost of time and obesity rates implied by our theory is not inconsistent with the well known negative correlation, at the cross sectional level, between obesity *levels* and income or education levels. Specifically, there is evidence suggesting a negative correlation between energy density and energy costs; see for example, Andrieu, Darmon, and Drewnowski (2006), Drewnowski and Darmon (2005), and Drewnowski and Specter (2004). Hence, high-fat, energy-dense diets are consumed by low-income groups because such foods are more affordable than diets based on lean meats, fish, fresh vegetables and fruit (all of which are lower in energy density). In summary, if low nutritional value/high calorie foods are inferior while high quality foods are normal goods, then people with high opportunity costs of time (and thus higher income) should be less likely to be obese at a given point in time. As we document later on, people with the highest opportunity cost of time have gained the most weight over time.

3 The Model

We consider a setting in which representative households –single women, single men, and married couples– must decide how to allocate their labor endowments across market activities and the production of food at home taking the prices of food as given. Households must also decide how much to spend on groceries for cooking food at home, on meals prepared outside the home and on other non-food items. We make the simplifying assumption that agents choose the types of meals they consume (prepared at home from scratch or away) but not the number of calories they consume. All households face a common set of technological restrictions, and each is taxed on the income earned in the market sector. We model the gender wage gap as a tax wedge that differs by gender. Households are the owners of capital, and they rent it to firms at a competitively determined interest rate.

Married Households

We now present the problem of a representative married couple, or partnership. We assume that the bargaining problem within the household is resolved efficiently, so that a weighted form of a planner's problem describes the decisions that the couple makes. The preferences of such a partnership over consumption of food, C_F, other consumption goods, C_{NF}, and leisure streams, $\hat{L} - L_h - L_m$, can be represented by:

$$\sum_t \frac{\beta^t}{1-\sigma}\{\lambda_f \left(\alpha (C^{pf}_{F,t})^{1-\sigma} + \nu\,(C^{pf}_{NF,t})^{1-\sigma} + (1-\alpha-\nu)\,\left(\hat{L} - L^{pf}_{h,t} - L^{pf}_{m,t}\right)^{1-\sigma}\right) + \tag{1}$$

$$(1-\lambda_f)\left(\alpha\,(C^{pm}_{F,t})^{1-\sigma} + \nu\,(C^{pm}_{NF,t})^{1-\sigma} + (1-\alpha-\nu)\,\left(\hat{L} - L^{pm}_{h,t} - L^{pm}_{m,t}\right)^{1-\sigma}\right)\};$$

where the first superscript p indicates partnership and the second indicates the type within the household; i.e., f (m) for female (male); the subscripts m, and h stand for market and household activities respectively and the subscript t represents time. Agents in this economy have an endowment of $\hat{L}$ hours.[17] The relative weight of the woman's utility in a partnership is λ_f, β is the discount factor, n denotes the population growth rate and σ, α and ν are preference parameters.

The problem of the partnership is to maximize equation (1) subject to several constraints. First, total food consumption in the married household, C^p_F, obtained through foods prepared away from home (F^p) and home meals (HF^p), is given by:

$$C^p_{F,t} = C^{pf}_{F,t} + C^{pm}_{F,t} = \left(\mu_1\,(F^p_t)^\gamma + (1-\mu_1)\,(HF^p_t)^\gamma\right)^{1/\gamma}; \tag{2}$$

where γ denotes the degree of substitution between foods prepared away from home and home prepared meals, and μ_1 represents the relative importance of food away from home. Home meals are produced using groceries, I^p, together with female and male cooking labor, L^{pf}_h and L^{pm}_h, respectively. We assume that time is complementary with groceries in the production of food. In particular, we have:

$$HF^p = min\left[I^p, \zeta_0 (L^{pf}_h)^{\zeta_1} (L^{pm}_h)^{1-\zeta_1}\right]; \tag{3}$$

where ζ_1 is the share of female cooking hours and ζ_0 is a conversion factor between groceries and labor cooking hours.

Consumption goods other than food are acquired in the market. Total consumption of non food

[17] Time-use studies show that Americans sleep 8 hours per day [14]. During the average day, 1 hour of time is used for eating and 1 hour for obtaining goods and services. Therefore, we assume each individual has 14 hours available per day, or $\hat{L}$=5488 hours per year.

items of the partnership is denoted by:

$$NF_t^p = C_{NF,t}^{pf} + C_{NF,t}^{pm}. \tag{4}$$

Households can also invest in the capital stock used in market activities, k_m^p, as well as in capital specific for the food away from home sector, k_f^p. These capitals evolve over time according to:

$$k_{m,t+1}^p = X_{m,t}^p + (1-\delta)k_{m,t}^p \tag{5}$$

$$k_{f,t+1}^p = X_{f,t}^p + (1-\delta)k_{f,t}^p; \tag{6}$$

where X represents investment, and δ denotes the depreciation rate. Finally, households face the typical budget constraint given by:

$$\begin{gathered} P_{F,t}F_t^p + NF_t^p + I_t^p + X_{m,t}^p + X_{f,t}^p + R_t b_t^p \leq \\ (1-\tau^p)\left(w_t((1-\tau_d)L_{m,t}^{pf} + L_{m,t}^{pm})\right) + (1-\tau_k)\left\{(1-\tau_c)(r_{t+1}-\delta)+\delta\right\}[k_{m,t}^p + k_{f,t}^p] + b_{t+1}^p + T_t^p \end{gathered} \tag{7}$$

where $L_m^{p,j}$ denotes hours devoted to market activities by the members in the partnership for j=f, m; b^p are bond holdings, τ^p denotes the tax on labor income, $(1-\tau_d)$ denotes the gender wage gap tax, and P_F corresponds to the price of food away from home relative to the GDP deflator. Following Hayashi (1982) and McGrattan and Prescott (2005), we map profits in the data to capital income in our model.[18] The tax rate on profits is denoted by τ_c. The tax rate on capital income, τ_k, is assumed to be common for single and married agents households. The latter is a technical condition required so that all households hold a positive amount of capital in equilibrium.

We assume the relative price of groceries equal to one, as data shows no significant change over the periods we consider. The wage rate is denoted by w, r corresponds to the rental rate on capital, R is the return on bonds, T^p are taxes rebated to households as lump sum transfers. To guarantee that the problem of the household is well defined, we restrict borrowing to be less than the present value of future wealth. Such a constraint does not bind along the balanced growth path.

Finally, this economy is also populated by representative single male and female households whose preferences and optimization problems are analogous to the partnership's problem.[19]

Technological Constraints and Aggregate Feasibility

Our economy has two representative competitive firms. One produces food away from home using capital and labor. Its production technology can be represented by:

$$K_f^{\theta_f}(A_f L_f)^{1-\theta_f}.$$

[18]Alternatively, one can write a model where firms are the owners of capital and pay dividends to households. Such a model results in equilibrium allocations identical to ours.

[19]The problem of the single female can be derived from the married households problem by setting $\lambda_f = 1$, and $\zeta_1 = 1$. Similarly, the problem of the single male sets $\lambda_m = 1$, and $\zeta_1 = 0$.

The other representative firm produces non-food goods, investment and services with the Cobb-Douglas technology

$$K_m^{\theta_m}(A_m L_m)^{1-\theta_m}_.$$

In the above equations K_i, A_i, L_i and θ_i denote the capital, productivity, labor and capital share in sector i=m, f. Firms produce and rent productive inputs taking prices as given. Constant returns to scale in a competitive framework implies zero profits for each one of the representative firms. Moreover, rental rates must equal marginal products, namely:

$$\begin{aligned} r &= \theta_f K_f^{\theta_f - 1}(A_f L_f)^{1-\theta_f} = \theta_m K_m^{\theta_m - 1}(A_m L_m)^{1-\theta_m}_, \text{ and} \\ w\,(1+\tau_{ss}) &= (1-\theta_f)\,K_f^{\theta_f}(A_f L_f)^{-\theta_f} = (1-\theta_m)\,K_m^{\theta_m}(A_m L_m)^{-\theta_m}_. \end{aligned}$$

where firms are required to make social security contributions at rate τ_{ss}.

Market clearing in the food away from home sector requires that the demand of food away from home of all households, F, is equal to the available production. Namely:

$$F = K_f^{\theta_f}(A_f L_f)^{1-\theta_f}_.$$

Similarly, market clearing in the second sector of the economy implies

$$NF + I + X_m + X_f = K_m^{\theta_m}(A_m L_m)^{1-\theta_m}_.$$

In the previous market clearing conditions, capital letters with no super-index denote the corresponding aggregate variable (weighted by the fraction of the population).

Equilibrium

A *competitive equilibrium* for this economy is a sequence of prices and allocations for the partnership, single households, and firms that solve the corresponding optimization problems, taking prices as given. For it to be equilibrium all of the aggregate resource constraints and market clearing conditions must also be satisfied. A *balanced growth equilibrium* is an equilibrium where expenditures grow at constant rates and time use variables remain constant through time.

3.1 Some Theoretical Predictions

A closed-form solution for all equilibrium variables of this model cannot be obtained, except for very specific parameterizations. In this section we characterize the equilibrium behavior of some of the key variables of the model. Our purpose is to develop the economic intuition of the forces driving our results, which will help in obtaining a better understanding of the quantitative findings that we derive, numerically, in the following sections of the paper.

Proposition 1 *In any equilibrium, the following relationships must hold:*

$$L_h^{pm} = \left(\frac{(1-\tau_d)(1-\zeta_1)}{\zeta_1} \right) L_h^{pf} \tag{8}$$

$$\left(\frac{\hat{L} - L_h^{pf} - L_m^{pf}}{\hat{L} - L_h^{pm} - L_m^{pm}}\right)^{\sigma} = \frac{\lambda_f}{(1-\lambda_f)(1-\tau_d)} \tag{9}$$

$$\frac{\frac{\partial C_F^p}{\partial F}}{P_F} = \frac{\frac{\partial C_F^p}{\partial L_h^{pf}}}{(1-\tau)(1-\tau_d)w + P_I \zeta_0 f(\tau_d)}, \tag{10}$$

where $f(\tau_d) = \left(\frac{(1-\tau_d)(1-\zeta_1)}{\zeta_1} \right)^{1-\zeta_1}$.

From Proposition 1 we can derive the following partial equilibrium corollaries for partnership households:

Corollary (1): Lower taxes and/or a lower gender gap increase the consumption of food away from home and lower female cooking time.

Notice first that the denominator of the right hand side of equation (10) is the economic cost of female cooking time. The first term in this sum is the opportunity cost of time. The second term reflects the complementarity between ingredients and time: Higher cooking time has an additional indirect cost because it involves higher expenditure in ingredients.

The intuition behind the first corollary is that lower taxes or gender gap increase the economic price of cooking. Hence, the household has incentives to lower cooking time and to substitute home meals for prepared meals. Analytically, lower taxes or gender gap increase the denominator of the right hand side of equation (10). Notice that the partial derivatives of C_F^p are decreasing in F and in L_h^{pf}. Hence, to restore the equality, either L_h^{pf} has to decrease, or F has to increase, or both.

Corollary (2): Lower taxes translate into lower cooking times for males.

Holding the gender gap constant, equation (8) shows that cooking times are proportional to each other and, as stated in our first corollary, lower taxes lower cooking times for females.

Corollary (3): A lower gender gap has an indeterminate effect on the male's cooking time. The total impact is approximated by:

$$\Delta\% L_h^{pm} \approx \Delta\% L_h^{pf} + \Delta\%(1-\tau_d).$$

A higher opportunity cost of female cooking time, via lower gender gap, motivates households into substituting female time by male cooking time. However, equation (8) also shows that lower female cooking pushes male cooking down (as cooking times are proportional). The result in corollary 3 is a straightforward implication of equation (8).

Corollary (4): A lower gender gap increases female market hours.

From Corollary 1, a lower gender gap lowers female cooking times. Moreover, equation (9) shows that a lower gender gap translates into lower female leisure. Hence, a lower gender gap pushes female market hours up.

As the previous corollaries illustrate, changes in taxes and the gender wage gap are key elements in explaining the increased opportunity cost of cooking at home. These theoretical results also show that changes in taxes and in the gender wage gap are not symmetric in terms of their effects on the opportunity costs faced by men and women. Changes in taxes affect both genders in a similar fashion. On the other hand, a change in the gender wage gap directly affects the opportunity cost of women. This asymmetry is especially important for married households since it implies different degrees of specialization in home production. Moreover, it can also help explain the different consumption and leisure patterns observed among the different single female and single male households.

In the next sections, we describe and perform the quantitative analysis. Our numerical results reveal that the channels presented in this section are also observed when all general equilibrium effects are considered.

3.2 Calibration

We set the values of the parameters so that the balanced growth equilibrium time series match some of their counterparts in the U.S. data during the period 1955-65. Estimates of the intertemporal elasticity of substitution found in the macroeconomic literature imply values for σ within the interval [1,2]. In our baseline experiment we set a value of $\sigma = 1.5$. Some parameters of the model are straightforward to calibrate. We set the depreciation rate for capital at 6%, the discount factor β so that the interest rate matches the average 4% in the data. The parameter of the aggregate production function for the market good, θ_m, is set so that the share of income going to labor from the model matches its data counter part, θ_m=0.34. Similarly, parameter θ_f is such that the model matches the capital-labor ratio of the restaurant industry, which results in θ_f=0.08. The growth factor of the exogenous technology parameter for the numeraire good is set at 1.02 so that the model matches the average growth rate of per-capita GDP of the U.S. economy.

There is a large body of empirical literature devoted to the analysis of food consumption choices of American households. A recent study by Piggot (2003) develops a nested empirical model including most of the commonly employed demand systems for food in the United States. The author reports values for the price elasticity of food away from home that range between -2.3 and -1.16. In our model, the price elasticity of food away from home is determined by parameter γ. We set at $\gamma = 0.87$ to match the middle point of the values reported by Piggot, i.e. a price elasticity of food of -1.73.

Regarding married households, there are six parameters left to be calibrated: the weights in the utility of food and non-food consumption goods, which are given by α, ν, respectively; the weight of the female in the total household utility in the married household, given by λ_f; and a set of food technology parameters μ, ζ_0, and ζ_1. The values of these parameters are jointly determined from steady state equations so that the model matches six U.S. averages for 1955-65. In particular, we match the hours worked and hours preparing food from Tables 2A and 2B (4 observations for married households), a ratio of aggregate expenditure in consumption other than food to food away from home equal to 18, and a ratio of aggregate expenditure in ingredients to food away from home of 3.[20] The four parameters associated to the single households $(\alpha, \nu, \mu, \zeta_0)_{s,i}$ are calibrated to match hours worked and preparing food of single adults (two observations each) and the two ratios of aggregate data used for married households.

3.3 Results

In this section we perform a quantitative analysis of two different mechanisms that lower the relative cost of food prepared away from home, which may help understanding the increased weight of American adults. All experiments depart from a common balanced growth path that we associate to the 1955-65 U.S. economy. We study each channel independently. First, we hold income taxes and the gender wage gap constant and feed into the model an exogenous increase in the productivity of producing food away from home. Finally, we feed into the model the observed trends in income taxes and the gender wage gap, holding the productivity of the food away from home sector constant. We compute the balanced growth equilibrium associated to each one of these changes and assume this new equilibrium corresponds to the 1995-04 U.S. data. We then derive the quantitative implications of these mechanisms and compare the predictions of the model to their data counterparts in the following dimensions: aggregate expenditure in food prepared away from home, in ingredients for preparing food at home, in non-food consumption, time use, and a set of key macroeconomic aggregates like GDP and Investment. We consider GDP and Investment because the two channels that we are examining have strong implications for these two macroeconomic aggregates. In particular, changes in productivity directly affect the rates of return and in turn affect investment. Similarly, a decrease in taxes increases the after tax return thus directly affecting investment.

3.3.1 Changes in the production technology of food away from home

Technological advancements in the production of food prepared away from home that result in lower prices are a common explanation for the observed trends in consumption of food prepared away from home, food at home, and cooking times. We use our model to derive the quantitative implications of this mechanism.

We capture technological improvements in the food away from home sector by introducing a sequence of productivity parameters, A_F, that grows faster than the overall growth rate of total factor productivity during our sample period.[21] An increase in the productivity of the food prepared away from home sector increases its supply, which results in a lower price. Lower prices for foods prepared

[20] Consumption other than food is measured from the NIPA as Nondurable consumption expenditure + Government expenditure + Net exports – Food expenditure (the latter from the detailed personal consumption expenditure tables of the BEA). Ingredients correspond to food purchased for off premise consumption in the detailed personal consumption expenditure tables of the BEA.

[21] Data on the capital stock, hours worked, and value added for the food away from home sector is available in the U.S. NIPA from 1987 to the present. A measure for A_F based on such data, and on the corresponding production function of our model, shows productivity in this sector growing slightly below 2% per year. Measured output in the food away from home sector is subject to biases from changes in portion size and quality. Thus, we have chosen values of A_F based on existing hypotheses and to explore its quantitative implications.

away from home cause households to consume more of these goods and, via a substitution effect, less meals prepared at home from scratch. The latter implies lower cooking times and grocery expenditure. Table 5 below reports the quantitative implications of three possible values for the productivity of the food away from home sector as suggested by Cutler, Glaeser and Shapiro (2003).[22] The first set of A_F in 2004 matches the observed change in aggregate cooking hours, the second matches the observed change in expenditure in groceries, finally, we choose a value of A_F so that the model matches the observed changes in expenditure in food away from home.[23]

Aggregates	**Δ% Data**	**Δ% Model Target L_h**	**Δ% Model Target I**	**Δ % Model Target $P_F F$**
$\frac{A_F}{A_m}$		1.07	1.10	1.40
GDP	13%	-1%	-2%	-3%
Investment	38%	-2%	-3%	-7%
Exp. Non Food	19%	5%	5%	9%
Exp. Groceries	**-40%**	-35%	**-40%**	-84%
Exp. Food Away from Home	**41%**	10%	12%	**41%**
Calories consumed				
From Groceries	**-4%**	15%	**-4%**	-71%
From Food Away from Home	**67%**	30%	32%	**67%**

Table 5: Data and model implications for different values of A_F. Per-capita expenditures are relative to a 2% trend.

An increase in technology that makes the model match the observed drop in aggregate cooking times delivers very similar implications for consumption expenditures to the experiment where change in groceries is the target. This occurs because of the high complementarity between groceries and cooking times. In both cases, however, the model is only capable of accounting for about one-fourth of the increase in expenditure in food prepared away from home. Productivity in the food away from home sector can also be set so that the model matches the U.S. trends in expenditure on food away from home, but this implies a decline in grocery expenditure twice as big as what is observed in the data. Thus, technological improvements in the food prepared away from home sector are qualitatively consistent with food expenditure trends in the United States. However, they fall short of accounting for the magnitude of these changes.

The increase in output that results from higher productivity in the food away from home sector may not compensate for the decline in its relative price and GDP may fall. This is exactly what

[22]It has been suggested by these authors that changes in technology are behind the observed increase in expenditure of foods prepared away from home, behind the decline in cooking times, and also behind the drop in meals prepared at home from scratch.

[23]of the total expenditures for each type of households in the economy. The weights are the average fraction of households of each type, taken from the current population survey from 1962 to 2000. In particular, we have that for the period considered the composition of the U.S. is such that 78% of the households is married, 15% are single females and 7% are single males.

happens in the quantitative experiments reported in Table 5 where GDP declines by at least 1%, and investment by at least 3% relative to a 2% trend. These two predictions are not consistent with U.S. data where per capita GDP increased by 13%, and investment by 38% relative to a 2% trend. In all of the experiments we consider, changes in technology fall short of accounting for the observed increase in aggregate expenditure on non-food consumption items.

In order to obtain the implications of the model regarding calorie consumption we perform the following procedure. First, we derive from the U.S. data a transformation factor mapping dollars spent into calories consumed for each type of food. This transformation factor is such that the observed change in real per capita expenditures is compatible with the observed change in calorie consumption from the data. Finally, we apply the same transformation factor to the expenditures obtained in the model and derive the calories consumed implied by the theory. Using this procedure, Table 5 shows that technological advancements in the production of foods prepared away from home when we target aggregate hours predict more than half of the caloric increase due to food away from home and is qualitatively inconsistent with the observed decrease in calories from home cooked meals. When the target is expenditures on ingredients the model can only account for half of the calories of food away from home and by construction all of the caloric decrease in home cooked meals. Finally, when the target are the expenditures of food away from home, the model over states the decrease in calories from home cooked meals by almost a factor of two, and by construction matches all of the caloric increase from food away from home. Note that we have divided total calorie consumption by source of preparation (at home from scratch vs. prepared away from home). Cutler, Glaeser and Shapiro (2003) divide calorie consumption by the different meals and snacks of a given day, and find that most of the increase in calorie consumption can be attributed to snacks, which according to the authors, are largely pre-prepared. Thus, these two breakdowns are consistent with each other.

Table 6 below documents the implications of the model for time use under the three different parameter values chosen for A_F.

Households	**Δ % Data**	**Δ % Model Target L_h**	**Δ% Model Target I**	**Δ% Model Target $P_F F$**
Married couples				
Work (female)	108%	14%	15%	28%
Work (male)	-1%	-8%	-8%	-15%
Food prep. (female)	-50%	-44%	-48%	-86%
Food prep. (male)	35%	-44%	-48%	-86%
Single females				
Work	10%	5%	6%	12%
Food prep.	-46%	-23%	-30%	-66%
Single males				
Work	0%	2%	3%	7%
Food prep.	0%	-25%	-30%	-71%

Table 6: Data and model implications for time use.

The model is capable of matching the qualitative patterns of time use in the U.S., except for the time devoted to food preparation and cleaning of married males. As previously discussed, lower food prices make households demand less food prepared at home. Thus, households demand fewer groceries and lower their cooking times. Time formerly devoted to cooking is optimally allocated between leisure and an increase in market hours, which allow households to increase their incomes.

Quantitatively, changes in technology can account for the decline in cooking times of married females, and for two thirds of the decline in cooking times of single females. The model, however, falls very short of explaining the increase in market hours of married females (which is the most important change observed in the data), and predicts strong declines in market hours and cooking times of single and married males not present in the data.

In summary, technological improvements in the food away from home are qualitatively consistent with food expenditure trends, but fall short of accounting for the magnitude of the observed changes.

3.3.2 Changes in income taxes and gender wage gap

We now evaluate the idea that lower income taxes and gender wage gap alone increased the opportunity cost of cooking at home from scratch. The latter, in turn, lowered the relative cost of food prepared away from home. Households responded by substituting home made meals for foods prepared away from home. In particular, we assume the 1955-65 period constituted a balanced growth path of the U.S. economy and compare it to a different balanced growth equilibrium reached towards the end of the 1990s, which is characterized by lower values of the personal income tax rate and the gender wage gap. Table 7 reports the data together with the quantitative implications from the model for aggregate food expenditures, the relative price of food away from home, and caloric consumption. The column labeled taxes and τ_d in Table 7 considers the joint implications of the observed changes in taxes and in the gender wage gap. To separate the role of taxes from the gender wage gap, the column labeled only taxes reports the predictions from the model when taxes change as in the data keeping the gender wage gap at its 1960s level (i.e. τ_d=0.43).

Aggregates	**Δ% Data**	**Δ% Model taxes and τ_d**	**Δ% Model only taxes**
GDP	13%	17%	11%
Investment	38%	40%	34%
Exp. Non Food	19%	24%	9%
Exp. Groceries	-40%	-37%	8%
Exp. Food Away from Home	41%	32%	8%
Calories consumed			
From Groceries	-4%	0%	72%
From Food Away from Home	67%	56%	10%

Table 7: Data and model implications for food expenditures and calorie consumption. Per-capita expenditures are relative to a 2% trend.

The predictions of the model with respect to GDP, investment, expenditure of non food, the expenditure of food away from home, and expenditures in groceries are qualitatively consistent at the aggregate level. With respect to its quantitative implications, the model slightly over predicts the increase in expenditures of non food, GDP and investment. The model can account for 93% of the observed changes in groceries. The joint trends of taxes and gender wage gap can also account for 78% of the actual increases in expenditure in food away from home.

As we can see from Table 7, changes in taxes alone has predictions of the model with respect to GDP, investment, expenditures of non food, and food away from home that are qualitatively consistent at the aggregate level. Quantitatively speaking, just taxes can only account for a fifth of the increase in expenditures of food away from home. Lower taxes have a positive income effect and expenditures in all goods, including groceries, go up. Thus, the fact that women, both married and single, face different opportunity costs than men have important consequences on the food choices that households make.

With respect to increased calorie consumption, changes in taxes and the gender wage gap are qualitatively consistent with the decrease in calories from ingredients and can explain almost all of the caloric increase resulting from food away from home. This finding emphasizes the importance of the gender wage gap in accounting the observed number of calories.

Based on the previous results, we conclude that the increased opportunity cost of cooking at home is important in accounting the food expenditures and calorie consumption of the representative American household. Both of the two channels (changes in tax rates and in the gender gap) studied in this section of the paper, which drive the increased opportunity cost of time, seem to be quantitatively and qualitatively relevant.

Table 8 reports the data and the model's implications for time use for the case where taxes and the gender gap are changed as in the data and for the case where only taxes are changed.

Households	Δ% Data	Δ% Model taxes and τ_d	Δ% Model only taxes
Married couples			
Hours worked (female)	108%	107%	2%
Hours worked (male)	-1%	-19%	2%
Hours food prep. (female)	-50%	-46%	8%
Hours food prep. (male)	35%	-28%	8%
Single females			
Hours worked	10%	19%	-3%
Hours food prep.	-46%	-3%	9%
Single males			
Hours worked	0%	11%	-3%
Hours food prep.	0%	-4%	12%

Table 8: Data and model implications for time use.

Changes in tax rates and in the gender gap seems to match the qualitative patterns of time use in the U.S. except for the time devoted to food preparation and cleaning of males, which is small in absolute terms anyway. Quantitatively, the model does a good job in predicting changes in time use of married females. However, it predicts a large decline in hours worked of married males that is not present in the data. In our model, the distribution of resources within married households is determined by maximization of a weighted utility. The failure of this type of models in accounting fully for the observed trends in hours worked as the gender wage gap drops has been studied recently by Knowles (2007). This author develops a theory where the distribution of resources within married households is determined in a bargaining game. Such a model results in a much better fit for the time use of husbands and wives as a result of changes in the gender wage gap. We do not expect the total demand of goods of the married household to change much under such bargaining specification. Thus, to keep our presentation simple, we decided to abstract from bargaining issues in our analysis.

The transmission mechanism of our model, relating increased opportunity cost of time to food choices, implies that single males should be the group least affected by changes in taxes and the gender wage gap. Notice, however, that lower taxes and gender gap have an important general equilibrium effects on income. Thus, our theory is consistent with a modest increase in food consumption, caloric intake, and BMI for single males as a result of their higher income.[24] Similarly, partnership households, and particularly married females should be the group with the highest increase in BMI. The previous implications of our model are consistent with BMI data by marital status and gender reported by Cutler, Glaeser and Shapiro (2003).[25]

[24]Higher income is translated in higher food consumption thus more calories.

[25]The BMI of single men increased among adults (4.5 percentage points, as opposed to that of married men which increased by 6.22 percentage points) during our sample period. Married females constituted the group with the largest increase in BMI equal to 12 percentage points during our sample period.

We can conclude then that lower taxes and the narrowing of the gender wage gap between male and female workers are important elements when accounting for the increased calorie consumption over the last 40 years in the U.S. In particular, the asymmetric nature of the gender wage gap is a necessary component when explaining the observed specialization in home production within married households as well as the different consumption and leisure patterns observed between single male and female households.

3.3.3 Further discussion

American households have substituted food prepared from scratch at home for food prepared away from home. Moreover, according to dietary studies people end up consuming more calories when eating food prepared away from home. An interesting question is why, in equilibrium, food prepared away from home has not become more similar to food prepared at home from scratch. Certain observations suggest that changes in technology in the food away from home sector have favored the production of calorie-intensive foods relative to healthier foods (or at least higher prices for foods prepared away from home that are also healthier). First, technical change in the preparation of mass produced foods has contributed to widen the gap between the price of healthier foods and calorie dense foods over time.[26] The widespread use of hydrogenated oils constitutes one of the examples of technological advancements that favored high calorie food.[27] The greater the degree of hydrogenation, the more saturated the fat becomes. Benefits of hydrogenating plant-based fats for food manufacturers include an increased product shelf life and decreased refrigeration requirement. Plant-based hydrogenated vegetable oils are much less expensive than the animal fats traditionally favored by bakers, such as butter or lard, and may be more readily available than semi-solid plant fats such as palm oil. Finally, partially hydrogenated oils spoil and break down less easily under conditions of high temperature heating. This is why they are used in restaurants for deep frying, to reduce how often the oil must be changed.

Certainly, many factors have to be included in a theory that fully accounts for the observed changes in time use of the average American household, and its implications for obesity trends in the United States. For instance, our analysis has abstracted from self-control problems and changes in social weight norms, which according to Heiland and Burke (2007) may help us better understand the observed changes in the weight distribution of American adults. We also abstracted from changes the bargaining power of married women that result from a lower gender gap, as considered by Knowles (2007). Changes in bargaining power may help accounting for the fact that the amount of time married men devote to cooking activities has increased substantially since the 1960s (although it is very small in absolute numbers). Our analysis has all agents working. Thus, our framework is not designed to address the fact that cooking times of non-working married women have declined since the 1960s. The latter observation may seem first at odds with the increased opportunity cost of time

[26] A typical example is the dramatic increase in the production of trans fats since the 1960s.

[27] "Hydrogenate" means to add hydrogen or, in the case of fatty acids, to saturate. The process changes liquid oil, naturally high in unsaturated fatty acids, to a more solid and more saturated form.

channel explored in this paper. It is important to note, nevertheless, that the characteristics of non-working married women have also changed dramatically through time, and that such changes may account for the observed decline in cooking times. In particular, relative to the 1960s, the average non-working married women of today is out of the labor force only for a short period of time.[28] Thus, non-working married women today have lower experience associated with household activities, including cooking. Furthermore, non-working married women today also devote larger amount of time to childcare activities, leaving less time for cooking.[29] Finally, changes in the relative wage of women may substantially alter the division of labor within the household, as suggested by Albanesi and Olivetti (2006), which may translate into lower cooking times.

According to our mechanism, obesity should increase the most among groups for whom the costs of food production fell the most. Thus, the theory predicts that obesity should increase the most among groups who formerly made most of their food in the house and should have increased the least among groups that already ate out more. It is beyond the scope of the present paper to consider additional heterogeneity within each household, although it would be an interesting exercise. Available evidence suggests that an extended version of the current model with heterogeneous agents within each household would have the potential to explain some other features of the data for various subgroups of the U.S. population. The data is particularly suggestive for the hypothesis that explains higher weights through changes in the opportunity cost of time. Zhang and Wang (2004) find that during 1971 to 2000 the group of U.S. adults that has increased obesity rates the most have been the ones with the highest education levels (see Table 9).[30]

	1970s	**1990s**	**% Change**
Females			
Low education	24.9	37.8	52%
Medium education	14.8	34.5	133%
High education	7.3	29.9	309%
Males			
Low education	12	26.7	123%
Medium education	14.4	29.4	104%
High education	7.4	24	219%

Table 9: Obesity rates among U.S. adults by gender and education level, taken from Zhang and Wang (2004).

Thus, if higher education is correlated with higher opportunity cost of time, then groups that have increased obesity the most have been the groups that have seen their opportunity cost increased the

[28]See Lombard (1999).

[29]According to the time-use data reported by Aguiar and Hurst (2007), the increase in time devoted to childcare activities by non-working married women is roughly equal to the corresponding decline in food preparation and clean up.

[30]The data for this study is taken from the National Health and Nutrition Examination Surveys. The authors define low education as less than high school, medium education as high school education, and college or above as high education.

most too. Furthermore, one of the main factors causing the increased weight of American adults suggested by our theory is the observed decline in the gender wage gap. Blau (1998) finds that the relative gender wage gap for adults with low education levels has declined less than that of adults with high education levels. The gender wage gap over 1969-1994 for individuals with less than 12 years of education declined by 19.67%, while the one for more than 12 years of education declined by 25%. Thus, the groups of individuals for which the gender wage gap has declined the most are also the groups where obesity rates have increased the most. These observations are consistent with the hypothesis that the increased opportunity cost of cooking at home is an important factor driving the increase in obesity in the U.S. over the last forty years.

A puzzling observation that emerges from Table 9 is that, at the cross-sectional level, the groups of people with higher education, income, and thus higher opportunity cost of time, are less likely to be obese at a given point in time. It seems then important to discuss how this observation can be reconciled with the transmission mechanism linking higher opportunity cost of time to higher consumption of food prepared away from home, and to higher consumption of calories. The evidence in Andrieu, Darmon, and Drewnowski (2006) as well as in Drewnowski and Darmon (2005) illustrate that, at a given point in time, the price of foods with higher fat and calorie content is cheaper than that of foods with lower calorie content and higher nutritional value. Thus, if low nutritional value/high calorie foods are inferior while high quality foods are normal goods, then people with high opportunity costs of time (and thus higher income) should be less likely to be obese at a given point in time.[31] Notice, however, that people with the highest opportunity cost of time have gained the most weight over time. The latter fact suggests that the lower price of high calorie food brought by technological change in the mass preparation of foods has dominated the income effect in determining the caloric composition of food away from home consumed by American household.

Regarding childhood obesity, Anderson, Butcher and Levine (2003) find that a child is more likely to be overweight if her mother worked more intensively (more hours per week) over the child's life. This effect is particularly evident for children of white mothers, of mothers of high education, and of mothers with a high income level. This evidence is consistent with one of the mechanisms we have evaluated since this increase in obesity may be due to the higher opportunity cost of cooking by their mothers.

Finally, at the international level, Foreman-Peck, Humphries, Morris, Offer and Stead (1998) find that increased obesity rates in Great Britain are correlated with the lowering of the gender gap and substantial reduction in taxes. The British experience parallels that of the U.S. emphasizing the importance of the increased opportunity cost of cooking at home when studying increased obesity rates.

[31] A possible example of inferiority of certain foods would be to consider fast food restaurants versus sit in restaurants, canned fruits and vegetables versus fresh fruits and vegetables or spam versus prime steak.

4 Conclusions

Obesity is one of the greatest public health challenges of the 21st century. According to the World Health Organization its prevalence has tripled in many European and North American countries since the 1980s, and the numbers of those affected continue to rise at an alarming rate. Understanding the underlying causes of the rapid increase in obesity rates is paramount to the debate over policies meant to reserve it.

In this paper, we use dynamic general equilibrium theory to derive the quantitative implications of a decline in the relative monetary and time costs of food prepared away from home on the caloric intake by American households. Motivated by the empirical literature, we consider two channels that lower the relative costs of food prepared away from home. One is productivity improvements in the production of processed foods. The second is actual declines in income taxes and in the gender wage gap, which increases the opportunity cost of cooking at home from scratch. Households respond optimally to this decline in relative costs by consuming more food prepared away from home.

Our analysis suggests that the observed increase in the average weight of American adults may be, at least in part, a natural consequence of changes in the opportunity cost of time. In particular, we have found that the observed trends in taxes and the lowering of the gender wage gap alone have increased the opportunity cost of time, which lower the relative cost of food prepared away from home. The average household has responded optimally to this change by dramatically altering its time use and food composition choices. The time households wish to spend in home production activities, including cooking, has substantially decreased. Instead of cooking at home, households have responded to lower taxes and the lowering of the gender wage gap by choosing to eat more foods prepared away from home. The latter resulted in higher caloric intake for the average American household.

When taxes and the gender wage gap are held constant, technological advancements in the food away from home sector are qualitatively consistent with expenditure trends in food items. Quantitatively, the model can match either the observed drop in aggregate cooking times, or the higher expenditure in food away from home, or the observed decline in expenditures on groceries. What the model cannot do is to account jointly for the magnitude of changes in expenditure on food items and cooking times. This suggests that technological advancements in the food prepared away from the home sector are qualitatively consistent with food expenditure trends, but fall short of accounting for the magnitude of the observed changes.

Data Appendix

- In this model we consider a balanced growth path for the period 1955-65 as well as a new balanced growth equilibrium for the period 1995-04 which incorporates the observed changes in the U.S. tax system and the gender wage gap between male and female workers.

- To compute the data corresponding to the relative price of food relative to the GDP deflator, we considered the price indexes and the personal consumption expenditures by type of expenditure,

Table 2.5.4 and 2.5.5, as well as the price indexes for the gross domestic product, Table 1.1.4, from NIPA.

- The data on hours worked are taken as the middle point of interval hours from the integrated public use micro-data series version 3.0 from University of Minnesota for 1960 and 1990 and for individuals between the ages of 18 and 65.

- The data on the average number of weekly hours devoted to food preparation and clean up is taken from Cutler, Glaeser and Shapiro (2003).

- The per capita expenditures are obtained from the NIPA detailed personal consumption expenditures by type of product, Table 2.4.5.

- To compute the total caloric intake for each type of food, we use NHANES data which reports the number of calories by gender for the 1971-74 and 1989-94 periods. Total calories reported in the paper are the average from males and females. For the 1965 period we assumed that the total and the composition of calories are equal to the one in the 1971-74 period which is an upper bound estimate for the calories consumed in that period. In order to determine the number of calories from groceries and from food away from home, we use the data taken from Lin, Guthrie, and Frazao (2002) in Figure 2, which reports the fraction of calories due to food away from home and to home meals.

- **Computation of income tax rates:** Existence of a balanced growth path were all households hold a positive stock of capital in this model requires a common capital tax rate for capital income across households. We, nevertheless, want to capture a basic feature of the data: Wage income is taxed at different rates for different households. The statistics of income report income sources and taxes paid by marital status, but it does not decompose single households by gender. The statistics of income do not divide married households into two wage earners or one wage earner either. Gender and female labor participation are key features of our model. Hence, we had to approximate incomes and marginal tax rates.

  To obtain the tax rate on marginal income by gender and marital status we proceed as follows. First, we derive an average hourly wage. Then, using the information on hours worked by marital status and gender we compute total labor income for each type of household. Finally, from the statistics of income we can compute the total taxable income that corresponds, on average, to each different level of labor income, as well as the associated tax bracket. The details involved in each one of these steps follow.

  We start by deriving the composition of households. From the Statistics of Income Individual Income Tax Returns, Table R, we determine household composition according to marital status. The U.S. Census Bureau IDB Data Access, Table 0.47, allows us to split single households into single males and females. The data reported by Bar and Leukhina (2005) helps us split married households into two wage earners and one wage earners. To derive the average hourly wage, we use Table 13 and Table 4 part 2 of the Individual Income Tax Returns and determine the fraction of total income due to salaries and wages. From this, we compute the average salary per person. We also compute the average hourly wage taking into account the average number of working hours reported by Table 1A of our paper as well as the observed wage gap between male and female. Hence, we can approximate total labor compensation by gender, marital status, and female labor participation status in married households. Finally, from Table 4, part 2, we compute the ratio labor compensation income to taxable income, and extrapolate from this the taxable income for each type of household. Finally, we obtain the marginal tax rates by examining the tax brackets that correspond to each taxable income for each type of household. In this computation we take into account the fact that for one-wage-earner married households, the relevant marginal tax rate corresponds to switching from one worker to two.

Tax rates on profits are taken from McGrattan and Prescott (2005). Finally, the tax rate on individual's capital income is computed as the weighted average of the different marginal income tax rates by gender and marital status.

References

[1] Aguiar, M. and E. Hurst (2007): "Measuring Trends in Leisure," *Quarterly Journal of Economics,* Forthcoming.

[2] Albanesi, S. and C. Olivetti (2006): "Home Production, Market Production, and the Gender Wage Gap: Incentives and Expectations," NBER working paper No. 12212.

[3] Anderson, P., K. Butcher and P. Levine (2003): "Maternal Employment and Overweight Children," *Journal of Health Economics*, 22, 477-504.

[4] Andrieu, E., N. Darmon, and A. Drewnowski (2006): "Low-Cost Diets: More Energy, Fewer Nutrients," *European Journal of Clinical Nutrition*, 60, 434-436.

[5] Bar, M. and O. Leukhina (2005): "To Work or Not to Work: Did Tax Reforms Affect Labor Force Participation of Secondary Earners?," *manuscript.*

[6] Becker, G. (1965): "A Theory of the Allocation of Time," *Economic Journal*, 75, 493-517.

[7] Binkley, J.K., J. Eales, and M. Jekanowski: "The Relation between Dietary Change and Rising US Obesity," *International Journal of Obesity*, 24, 1032-1039.

[8] Blau, F. (1998): "Trends in the Well-Being of American Women, 1970-1995," *Journal of Economic Literature*, 36, 112-165.

[9] Bleich, S., D. Cutler, C. Murray, and A. Adams (2007): "Why is the Developed World Obese," NBER working paper # 12954.

[10] Bowan, S. and B. Vinyard (2004): "Fast Food Consumption of U.S. Adults: Impact on Energy and Nutrient Intakes and Overweight Status," *Journal of the American College of Nutrition*, 23 (2), 163-168.

[11] Burke, M., and F. Heiland (2006): "Social Dynamics of Obesity," *Economic Inquiry*, Forthcoming.

[12] Byrne, P., O. Capps, and A. Saha (1996): "Analysis of Food-Away-from-Home Expenditure Patterns for U.S. Households, 1982-89," *American Journal of Agricultural Economics*, 78: 614-627.

[13] Chagnon Y., T. Rankinen, E. Snyder, S. Weisnagel, L. Perusse, C. Bouchard (2003): "The Human Obesity Gene Map: the 2002 Update," *Obesity Research*, 11(3), 313-67

[14] Cutler, D., E. Glaeser, and J. Shapiro (2003): "Why Have Americans Become More Obese?," *Journal of Economic Perspectives*, 17(3), 93-118.

[15] Dong, D., P.J. Byrne, A. Saha and O. Capps (2000): "Determinants of Food-Away-From-Home Visit Frequency: A Count-Data Approach," *Journal of Restaurant and Foodservice Marketing*, 4, 31-46.

[16] Drewnowski, A. and N. Darmon (2005): "The Economics of Obesity: Dietary Energy Density and Energy Cost," *American Journal of Clinical Nutrition*, 82, 265S-273S.

[17] Drewnowski, A. and S. Specter (2004): "Poverty and Obesity: The Role of Energy Density and Energy Costs" *American Journal of Clinical Nutrition*, 79, 6-16.

[18] Foreman-Peck,J.,J. Humphries, S. Morris, A. Offer and D. Stead (1998): "Epidemics of Abundance: Overeating and Slimming in the USA and Britain Since the 1950s," University of Oxford Discussion Papers in Economic and Social History, Number 25.

[19] Foreyt, J.P., and W.S. Poston, "Consensus view on the Role of Dietary Fat and Obesity," *The American Journal of Medicine,* 113, 60-62.

[20] Golay, A. and E. Bobbioni (1997): "The Role of Dietary Fat in Obesity," *International Journal of Obesity,* 21, 2–11.

[21] Goldin, C. (1990): *Understanding the Gender Wage Gap*, Oxford University Press, New York, NY.

[22] Greenwood, J., A. Seshadri, and M. Yorukoglu (2005): "Engines of Liberation, " *Review of Economic Studies,* 72, 109-133.

[23] Hayashi, F. (1982): "Tobin's Marginal q and Average q: A Neoclassical Interpretation," *Econometrica*, 50: 213-224.

[24] Jensen, H. and S. Yen (1996): "Food Expenditures Away From Home by Type of Meal," *Canadian Journal of Agricultural Economics*, 44, 67-80.

[25] Jones, L., R. Manuelli and E. McGrattan (2003): "Why Are Married Women Working So Much?,"*Federal Reserve Bank of Minneapolis Staff Report*, 317.

[26] Knowles, J. (2007): "Why are Married Men Working So Much? The Macroeconomics of Bargaining Between Spouses," *Working Paper,* University of Pennsylvania.

[27] Lin, H., J. Guthrie, and E. Frazao (2002): "Role of Food Prepared Away from Home in the American Diet 1977-78 versus 1994-98: Changes and Consequences," *Journal of Nutrition Education and Behavior,* 34, 140-150.

[28] Lombar, K. (1999): "Women's Rising Market Opportunities and Increased Labor Force Participation," *Economic Inquiry*, 37, 195-212.

[29] McGrattan, E. and E. C. Prescott, "Taxes, Regulations, and the Value of U.S. and U.K. Corporations," *Review of Economic Studies* 72 (2005), 767-796.

[30] Mela, D. (1999): "Food Choice and Intake: The Human Factor," *Proceedings of the Nutrition Society,* 58(3), 513-521.

[31] Mutlua, S. and A. Gracia (2006): "Spanish Food Expenditure Away from Home (FAFH): by type of meal," *Applied Economics*, 38, 1037-1047.

[32] National Heart, Lung, and Blood Institute, National Institutes of Health (2000): "The Practical Guide: Identification, Evaluation, and Treatment of Overweight and Obesity in Adults," *NIH Publication* No. 00-4084.

[33] Nielsen, S. and B. Popkin (2003): "Patterns and Trends in Food Portion Sizes, 1977-1998," *Journal of the American Medical Association,* 289 (4), 450-453.

[34] Nielsen, S., A. Siega-Riz, and B. Popkin (2002): "Trends in Energy Intake in U.S. between 1977 and 1996: Similar Shifts Seen Across Age Groups," *Obesity Research,* 10, 370-378.

[35] Paeratakul, S., D. Ferdinand, C. Champagne, D. Ryan, and G. Bray (2003): "Fast-food Consumption Among U.S. Adults and Children: Dietary and Nutrient Intake Profile," *Journal of the American Dietetic Association*, 103 (10), 1332-1338.

[36] Piggot, N. (2003): "The Nested PIGLOG Model: An Application to U.S. Food Demand," *American Journal of Agricultural Economics*, 85, 1-15.

[37] Prentice, M., and A. Jebb (2003): "Fast Foods, Energy Density and Obesity: A Possible Mechanistic Link," *Obesity Reviews* 4, 187-194.

[38] Prochaska, F.J. and R.A. Schrimper (1973): "Opportunity Cost of Time and Other Socioeconomic Effects on Away-From-Home Food Consumption," *American Journal of Agricultural Economics*, 55, 595-603.

[39] Rolls, B. (1995): "Carbohydrates, Fats, and Satiety," *American Journal of Clinical Nutrition,* 61, 960–967.

[40] Rolls, B., E. Bell, and M. Thorwart (1999): "Water Incorporated Into a Food but Not Served with a Food Decreases Energy Intake in Lean Women," *American Journal of Clinical Nutrition,* 70, 448–455.

[41] Rolls, B., E. Bell, V. Castellanos, M. Chow, C. Pelkman, and M. Thorwart (1999): "Energy Density but Not Fat Content of Foods Affected Energy Intake in Lean and Obese Women," *American Journal of Clinical Nutrition,* 69, 863–871.

[42] Sanz-de-Galdeano, A. (2005): "The Obesity Epidemic in Europe," IZA Discussion Paper No. 1814.

[43] Smith, T. (2002): "Obesity and Nature's Thumbprint: How Modern Waistlines can Inform Economic Theory," Working paper, University of California, Santa Barbara.

[44] Young, L., and M. Nestle (2002): "The Contribution of Expanding Portion Sizes to the U.S. Obesity Epidemic," *American Journal of Public Health*, 92, 246-249.

[45] Zhang, Q. and Y. Wang (2004): "Trends in the Association between Obesity and Socioeconomic Status in U.S. Adults: 1971 to 2000," *Obesity Research,* 12, 1622-1632.