Obesity an Unintended Consequence of Taxes and the Gender Wage Gap?∗

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Abstract
We perform a dynamic general equilibrium analysis of the observed increase in the weight of the average American adult over the 1960-2005 period. Existing evidence suggests that this fifteen pound increase in weight can be attributed to the dramatic rise in the consumption of foods prepared away from home, which resulted in higher caloric intake. We evaluate the impact of the observed trends in taxes and in the gender wage gap on the caloric intake, food composition and time use of American adults, by gender and marital status. Surprisingly, we find that lower taxes and gender wage gap can account for more than two thirds of the changes in calories consumed and food composition observed in the data. Our general equilibrium analysis can also account for some of the observed movements in time devoted to market and food preparation activities, and reconciles the simultaneous increase in price and consumption of foods prepared away from home.

JEL Classification: E2, I1.
Keywords: Taxes, Gender Wage Gap, Female Labor Participation, Obesity.

1 Introduction

It is widely known that obesity has increased all throughout the 20th Century. However, the steepness of the rate of obesity over the past forty years is what seems to be surprising. According to the National Health Examination and the National Health and Nutrition

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Examination surveys, the average weight of an adult American female has increased by 14 pounds since the early 1960s, from 140 to 154 pounds. Similarly, the average weight of an adult male has increased by 16 pounds, from 166 to 182. As a matter of fact, the whole weight distribution has shifted to the right since the early 1960s. During the same time period, the average height of a female and male adult has only increased by one inch, which cannot account for the observed increase in weights. The highest increase in weight has been among married individuals, particularly among married women. Coincident with these trends, there has been a growing consensus about the health risks of obesity and physical inactivity, such as increasing the chances of suffering cancer, heart disease, and diabetes.¹

This accelerating increase in obesity rates in the United States has been labeled as an “epidemic” by public health officials. In March 2004, the director of the Centers for Disease Control and Prevention, Julie Gerberding, predicted that obesity will overtake smoking as the leading cause of preventable deaths in the United States by next year if current trends continue.² Understanding the underlying forces explaining this rapid increase over the last 30 years is of paramount importance.

From an accounting point of view, people gain weight if calories consumed are greater than calories expended. A recent study by Cutler, Glaeser and Shapiro (2003) shows that increased caloric intake is far more important than reduced caloric expenditure in explaining recent increases in obesity. Daily calories consumed by the average American adult have increased by 236, from 1996 during 1971-74 to 2247 in 2000. Most importantly, Lin, Guthrie, and Frazao (2002) show that all of the changes in calories consumed can be explained by the dramatic rise in the consumption of food away from home. When eating out people either eat more, or eat higher-calorie foods, or both.

But, what does obesity have to do with economics? Decisions about what to eat are inherently economic since they depend on time allocation and food choices. Thus, in spite

¹See the National Heart, Lung, and Blood Institute, National Institutes of Health (2000) report for more on this issue.

²Obesity is defined as a BMI (body mass index which is weight divided by height squared) over 30 kg/m². 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. According to the Center for Disease Control and Prevention the average BMI in the 1960s for adult females and males was 24.9 and 25.1; respectively. On the other hand, the average BMI in the 1990s for adult females and males was 28.1 and 27.8, respectively.
of the fact that agents face the same price of the goods that are inputs into what to eat, they might choose different combinations of goods and time to generate the same amount of “eating”. As a result, changes in the economic environment that influence the value of time are going to have crucial implications for what agents are going to eat. In this paper, we examine the role of taxes and the gender wage gap in accounting for changes in the composition of food consumption, time use and increased caloric intake of American households over the last thirty years. The transmission mechanism we evaluate is as follows: A decline in the personal income or corporate tax rate increases the after tax wage. Thus, it increases the opportunity cost of using time to cook food at home for both men and women. Similarly, a decline in the relative gender wage gap only increases the average wage of women, and hence her cost of cooking food at home. Data shows that eating at home and eating away from home are close substitutes. Hence, a decline in either the personal income tax rate, the corporate tax rate, or in the gender wage gap has the unintended consequence of raising the consumption of food away from home. Thus, increased weights may be an optimal household response to the observed changes in the economic environment.

This paper presents a quantitative analysis of the role of taxes and the gender wage gap on obesity based on a dynamic general equilibrium model of the macroeconomy. This model includes the explicit distinction between men and women, either single or in a partnership. All representative agents care about food items (prepared at home or purchased away from home), non-food items and leisure. Eating at home demands cooking time, groceries and capital specific for cooking activities (like microwaves, etc.). Market goods require quality adjusted work to be produced. Agents in this economy are price takers and interact in markets for labor, capital, investment and market consumption. Surprisingly, our main finding shows that the simple channel proposed in this paper, actual changes in income tax rates and in the gender wage gap, can account for most of the increase in the caloric intake from the consumption of food away from home. The model suggests that, in equilibrium, the increased opportunity cost of time should translate into a higher relative price, expenditure and consumption of food away from home, just as seen in the data. Our theory is also consistent with the observed patterns of time use, and capital specific for cooking activities. To the best of our knowledge this is the first paper to examine the relation between taxes,

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3This line of reasoning follows the tradition of Becker (1965) and Gronau (1977) of time allocation in home production.
the gender wage gap and the higher weight of the average American adult in a general equilibrium framework.

2 Additional Explanations

In the literature there have been several theories for the increase in obesity in the United States over the past decades. Researchers have shown that obesity has a large genetic component, and this plays an important role in explaining why a given individual is obese. However, genetic characteristics in the population change very slowly, and so they clearly cannot explain why obesity in the U.S. has increased so rapidly in recent decades.\(^4\) Researchers in the social sciences have instead sought to explain obesity by looking at technological developments, changes in taste and consumer habits, and the social environment.

Posner and Philipson (2003) use a partial-equilibrium model to study the hypothesis that changes in technology have lowered the cost of intake calories and raised the cost of expending calories, hence contributing in two ways to the rise in obesity. According to their hypothesis, technological change in food production has lowered the cost of producing calories, lowering its price. Technological change has also transformed the type of work people perform. In modern societies working requires far less physical activity than before. The increase in obesity may coincide with some of the changes pointed out by the authors; however, their study is only qualitative in nature. It is then difficult to conclude whether the economic forces pointed out by Posner and Philipson can account for the recent trends in obesity at a quantitative level.

Similarly, Lakdawalla and Philipson (2002) argue that declines in the real prices of grocery food items caused a surge in caloric intake that can, according to their regression analysis, account for as much as 40 percent of the increase in the body mass index (BMI) of adults since 1980. Technological advances in agriculture caused grocery prices to fall and these declines caused consumers to demand more groceries.\(^5\) Figure 1 illustrates the price of groceries (labeled food for off-premise consumption in the U.S. NIPA) relative to the GDP deflator.

\(^4\)See for example Chagnon, Rankinen, Snyder, Weisnagel, Perusse, and Bouchard (2003) for more on this issue.

\(^5\)Within this spirit, Burke and Heiland (2005) consider how a decrease in prices of certain foods may affect the social norms regarding obesity.
Figure 1: **Price of food relative to the GDP deflator.**

The relative price of groceries has not always declined over the last fifty years. Furthermore, the fact that most of the increase in weight can be attributed to higher consumption of food away from home (labeled purchased meals and beverages in the U.S. NIPA), and not to higher consumption of groceries, is troubling for the relative price hypothesis. Particularly because of the fact that both, the relative price and the consumption of food away from home have increased quite smoothly during the last 50 years. In summary, it seems that an explanation of obesity based on a negative correlation with relative food prices will be hard to reconcile with the data.

Important technological changes in the home seem to have fostered more caloric intake, too. Cutler, Glaeser, and Shapiro (2003), present evidence suggesting that the tools responsible for reductions in the time we spend preparing meals at home have contributed to an increase in caloric consumption. Microwaveable meals and other foods are easy to cook and

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*In particular, the relative price of groceries did go down from 1979 to 1985 but has not changed much since. Most of the observed increase in weights, nevertheless, has occurred over a period much longer than the 6 years of declining food prices. Moreover, the relative price of groceries increased quite strongly from 1973 to 1979. Yet, average weights did not go down as any hypothesis based on the behavior of the relative price of food would conclude.*
quicker to prepare, making them more desirable when households face high opportunity costs of their time. In this paper we also explore the role of kitchen capital. According to our model, it is the higher opportunity cost of time, generated by lower taxes and gender wage gap, that has driven households to accumulate a higher, better, stock of kitchen capital and to lower cooking times.

Finally, there is a growing body of empirical studies in the nutrition literature that emphasize the role of the change in the composition of food Americans consume as one of the main factors behind the weight status of the population. Young and Nestle (2002) suggest that increased portion sizes are one of the key elements in explaining the increased obesity epidemics in the United States. In their study they sample foods sold for immediate consumption in the most popular take-out establishments, fast-food outlets, and family-type restaurants. The data indicate that the sizes of current marketplace foods almost universally exceed the sizes of those offered in the 1970s. Moreover, Prentice and Jebb (2003) find that the highest correlation between calories consumed per unit volume (energy density) and fat content is found in fast foods closely followed by prepared meals. Moreover, they find that people spontaneously ingest more energy on high energy density (high fat) than low energy density diets—a phenomenon known as “high fat hyperphagia”. Furthermore, Lin, Guthrie and Frazao (2002) have shown that food away from home are higher in fat and saturated fat, and lower in fiber and calcium than foods cooked at home. These studies then suggest that it does not take a disproportionate amount of food to ingest more calories when eating away from home.

It is important to note that the actual price of food away from home may have actually decreased once increased portion sizes are take into account. However, since there is no estimate of the average increase in portion sizes for the average meal prepared away from home, we decided to abstract from this feature into our model.

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7When foods such as beer and chocolate bars were introduced, they generally appeared in just 1 size, which was smaller than or equal to the smallest size currently available. This observation also holds for french fries, hamburgers, and soda, for which current sizes are 2 to 5 times larger than the originals.

8Lower food away from home prices would clearly strengthen our predictive power for average weights.
3 Background Data

In this section we document facts about: (i) food expenditures and calories by gender and type of food that we consider in this study, (ii) time use (including labor supply and cooking and clean up times), (iii) the gender wage gap, marginal income tax rates on labor and capital incomes, by gender and marital status, as well as the tax rate on corporate output, and (iv) technological change in the capital goods employed to cook food at home.

With respect to the different consumption patterns among the different food choices considered in this paper, Table 1A reports real per capita annual expenditures, relative to the average growth rate of the economy, of the different types of food for the two periods considered in the model; see the Appendix for the data sources and computations involved in this and all of our data tables.

<table>
<thead>
<tr>
<th>Aggregate economy</th>
<th>Exp. Groceries</th>
<th>Exp. Food Away from Home</th>
</tr>
</thead>
<tbody>
<tr>
<td>∆%</td>
<td>-46%</td>
<td>40%</td>
</tr>
</tbody>
</table>

Table 1A: Per capita real annual expenditures for the different types of food relative to a 2% trend.

As we can see from Table 1A, per capita real expenditures on groceries has decreased by 46% relative to trend. On the other hand, expenditures on food away from home have increased by 40% relative to trend. Given the observed prices and the per capita annual expenditures we can infer a significant shift in the consumption patterns of American households over the last 30 years. Table 1B reports the per capita daily calories of the different types of foods by gender for the periods considered in this model.

<table>
<thead>
<tr>
<th>Aggregate economy</th>
<th>1965</th>
<th>1995</th>
<th>∆%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total calories</td>
<td>1996</td>
<td>2232</td>
<td>12%</td>
</tr>
<tr>
<td>From Groceries</td>
<td>1557</td>
<td>1496</td>
<td>-4%</td>
</tr>
<tr>
<td>From Food Away from Home</td>
<td>439</td>
<td>736</td>
<td>67%</td>
</tr>
<tr>
<td>For Males</td>
<td>2450</td>
<td>2666</td>
<td>9%</td>
</tr>
<tr>
<td>For Females</td>
<td>1542</td>
<td>1798</td>
<td>18%</td>
</tr>
</tbody>
</table>

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

As we can see from Table 1B, the increase in calories are driven by the increase of calories consumed from food away from home. Moreover, the group of the population that has seen a larger increase in the number of calories consumed have been females which is also the group that has experienced the highest increase in their opportunity cost of time.
Changes in the levels and composition of hours allocated to market and home production by gender and marital status since the 1960s are notable. Table 2A reports a summary of the hours worked by marital status and gender. Similarly, Table 2B reports the time devoted to food preparation and clean up also by gender and marital status.

<table>
<thead>
<tr>
<th>Households</th>
<th>1960</th>
<th>1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Married couples</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours worked (female)</td>
<td>10.7</td>
<td>22.2</td>
</tr>
<tr>
<td>Hours worked (male)</td>
<td>39.4</td>
<td>38.9</td>
</tr>
<tr>
<td>Single females</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours worked</td>
<td>22.4</td>
<td>24.7</td>
</tr>
<tr>
<td>Single males</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours worked</td>
<td>27.9</td>
<td>27.8</td>
</tr>
</tbody>
</table>

Table 2A: Average number of weekly working hours by Gender and Marital Status.

The most striking features from Table 2A are, first, that the average number of hours worked by married women has more than doubled with an increase of 108%. Secondly, single women work more now than during the 1960s with an increase of 10%. 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.

<table>
<thead>
<tr>
<th>Households</th>
<th>1965</th>
<th>1995</th>
</tr>
</thead>
<tbody>
<tr>
<td>Married couples</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours food prep. (female)</td>
<td>13.0</td>
<td>6.4</td>
</tr>
<tr>
<td>Hours food prep. (male)</td>
<td>1.2</td>
<td>1.7</td>
</tr>
<tr>
<td>Single females</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours food prep.</td>
<td>7.0</td>
<td>3.8</td>
</tr>
<tr>
<td>Single males</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours food prep.</td>
<td>2.1</td>
<td>2.1</td>
</tr>
</tbody>
</table>

Table 2B: 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 2B 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. On the other hand, married men devote 35% more time to home food preparation and clean up while single males devote basically the same time to it.

The data reported on Tables 2A and 2B play an important role in our analysis. The 1960s data is used to calibrate some of the parameters of the model. Moreover, Tables 2A and 2B
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 et. al. (2003).

One of the key mechanisms driving the shift in consumption and the increased obesity rates of all households in our model is due to the increased opportunity cost of cooking at home. Changes in taxes by gender and marital status are going to be important and will be directly incorporated into the model as reported in Table 3; see the Appendix for more details.
Taxes 1955-65 1995-04

<table>
<thead>
<tr>
<th>Households</th>
<th>1955-65</th>
<th>1995-04</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor income for married couples</td>
<td>22%</td>
<td>15%</td>
</tr>
<tr>
<td>Labor income for single females</td>
<td>22%</td>
<td>15%</td>
</tr>
<tr>
<td>Labor income for single males</td>
<td>22%</td>
<td>15%</td>
</tr>
<tr>
<td>Capital income</td>
<td>22%</td>
<td>15%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Firms</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Corporate output</td>
<td>10%</td>
<td>8%</td>
</tr>
<tr>
<td>Social security contributions</td>
<td>1%</td>
<td>4%</td>
</tr>
</tbody>
</table>

Table 3: Marginal Corporate and Personal Income Tax rates by Gender and Marital Status.

The tax reform 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 tax rates been reduced the most. Finally, corporations have seen their corporate taxes decrease, which in our model results in higher equilibrium wages. All of these changes are going to have important implications on the opportunity cost of cooking at home for the different households.

In order to detect changes in the speed of technological advances in the food production sector we follow the approach of Greenwood, Hercowitz and Krusell (1997). Whenever a certain sector in the economy experiences a rate of technical advance faster than that of total factor productivity in the economy then the price of the output of that sector will tend to decrease relative to the GDP deflator. Following this procedure, we find that there has been extremely fast growth in the production of capital specific for home cooking activities (kitchen and other household appliances in the U.S. NIPA). The price of this type of investment good has declined by more than 5-fold over the last 40 years, see Figure 2. It is important to emphasize, however, that the rate of decline in the relative price of cooking capital has been basically constant during our whole sample period, see Figure 2.\(^9\) Regarding the production of groceries (food purchased for off-premise consumption), the detailed tables of personal consumption expenditures show that its 1955-65 average relative price is basically equal to its 1995-2004 one.

\(^9\)This feature of the data is important since allow us to compare two different balance growth paths with the same price growth rates.
4 The Model

Given the previous facts we are now going to present a model for the different types of households where agents face different labor and consumption choices so that we can determine the total number of calories resulting from their food choices. Our model makes the simplifying assumption that agents choose over the types of meals the consume (prepared at home or away) but not on the calories they will consume.

We first start by laying out the different type of households and activities that they perform in this economy. Our model is an extension to that of Jones et. al. (2003) where we incorporate food preparation and consumption decisions. 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 outside the home and on other non-food items. Households invest in capital goods used in cooking and in market activities. Home food production requires the use of both labor inputs and capital goods. 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 tax wedges which differ by gender.

Married Households

We present now 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 and leisure streams can be represented by the following expression:

\[
\sum_t \frac{\beta^t}{1-\sigma} \left\{ \lambda_f \left( \alpha (C_{pF,t}^{pf})^{1-\sigma} + \nu (C_{pF,t}^{pm})^{1-\sigma} + (1 - \alpha - \nu) \left( \hat{L} - L_{h,t}^{pf} - L_{m,t}^{pf} \right)^{1-\sigma} \right) + (1 - \lambda_f) \left( \alpha (C_{pF,t}^{pm})^{1-\sigma} + \nu (C_{pF,t}^{pm})^{1-\sigma} + (1 - \alpha - \nu) \left( \hat{L} - L_{h,t}^{pm} - L_{m,t}^{pm} \right)^{1-\sigma} \right) \right\};
\]

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 \( m, h \) stand for market and household activities respectively and the subscript \( t \) represents time. Agents in this economy have an endowment of \( \hat{L} \) hours.\(^{10}\) The relative weight of the woman’s utility in a partnership is \( \lambda_f \), \( \beta \) is the discount factor, \( n \) denotes the population growth rate and \( \sigma, \alpha \) and \( \nu \) 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, \( C_{pF,t} \), can be obtained through foods eaten away from home (\( F^p \)) and home meals (\( HF^p \)); which is given by:

\[
C_{pF,t} = C_{pF,t}^{pf} + C_{pF,t}^{pm} = (\mu_1 (F^p)^\gamma + (1 - \mu_1) (HF^p)^\gamma)^{1/\gamma};
\]

where \( \gamma \) denotes the degree of substitution between foods eaten away from home and home meals, and \( \mu_1 \) represents the relative importance of food away from home. Home meals are produced using capital specific for cooking activities, \( k_{h}^p \), together with groceries, \( I^p \), and female and male cooking labor, \( L_{h}^{pf} \) and \( L_{h}^{pm} \), respectively. In particular, we have:

\[
HF^p = \left( \zeta_2 (k_{h}^p)^{\zeta_3} + (1 - \zeta_2) \left( \min \left[ P, \zeta_0 (L_{h}^{pf})^{\zeta_1} (L_{h}^{pm})^{1-\zeta_1} \right] \right)^{\zeta_3} \right)^{1/\zeta_3};
\]

where \( \zeta_3 \) determines the elasticity of substitution between cooking capital and the composite ingredients-cooking time. \( \zeta_2 \) is the relative importance of cooking capital, \( \zeta_1 \) is the share of female cooking hours and \( \zeta_0 \) is a conversion factor between groceries and labor cooking hours.

Households enjoy consumption goods other than food, \( NF \). These goods are acquired in the market and total consumption of non food items are given by:

\[
C_{NF,t}^p = C_{NF,t}^{pf} + C_{NF,t}^{pm} = NF^p.
\]

\(^{10}\)Time-use studies show that Americans sleep 8 hours per day [8]. 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.
Households can also invest in the capital stock used in market activities, in capital specific for cooking activities as well as in capital specific for the food away from home sector. These capitals evolve over time according to:

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

\[ k_{p,h,t}^{t+1} = q_{h,t}X_{p,h,t} + (1 - \delta)k_{p,h,t} \tag{6} \]

\[ k_{p,f,t}^{t+1} = X_{p,f,t} + (1 - \delta)k_{p,f,t} \tag{7} \]

where \( X \) represents investment, \( \delta \) denotes the depreciation rate. We model technological advances in the production of investment goods as in Greenwood et. al. (1997) so that \( 1/q \) is the relative price of an investment good. Finally, households face the typical budget constraint given by:

\[ P_{F,t}F_t^p + N_{F,t}^p + I_t^p + X_{p,m,t} + X_{p,f,t} + X_{p,h,t} + R_t b_t^p \leq \]

\[ (1 - \tau^p) \left( w \left((1 - \tau_d) L_{m,t}^{p,f} + L_{m,t}^{p,m}\right) + ((1 - \tau_k)(r_{t+1} - \delta)) (k_{p,m,t} + k_{p,f,t}) + \pi_m + \pi_f + b_{t+1}^p + T_t^p \right) \]

where \( L_{m,j}^p \) denotes hours devoted to market activities by the members in the partnership for \( j = f, m; b^p \) are bond holdings, \( \tau^p \) denotes the tax on labor income, \( \tau_k \) denotes the tax on capital income, \( (1 - \tau_d) \) denotes the gender wage gap tax, \( P_F \) corresponds to the price of food away from home relative to the GDP deflator; \( w \) is the wage rate, \( r \) corresponds to the rental rate on capital, \( R \) is the return on bonds, \( T^p \) are taxes rebated to households as lump sum transfers. Finally, \( \pi \) denotes the profits of the firms described below.

This economy is also populated by representative single male and female households whose preferences and optimization problems are analogous to the partnership’s problem.

**Technological Constraints and Aggregate Feasibility**

Our economy also has two representative competitive firms. One produces food away from home and the other one all non-food goods and services. Both of these firms maximize after tax profits. Namely,

\[ \pi_f = (1 - \tau_c)K_f^{\theta_f} \left(A_f L_f\right)^{1-\theta_f} - rK_f - w(1 + \tau_{ss})L_f \]

for the food away from home industry, and

\[ \pi_m = (1 - \tau_c)K_m^{\theta_m} \left(A_m L_m\right)^{1-\theta_m} - rK_m - w(1 + \tau_{ss})L_m \]
for the non-food and services sector; where \( K_i, A_i, L_i \) and \( \theta_i \) denote the capital, productivity, labor and capital share in sector \( i=m,f \). Finally, \( \tau_c \) is the tax rate on corporate output and \( \tau_{ss} \) denotes the contributions to social security paid by firms.

Feasibility in the food away from home sector requires

\[
F = K_f^{\theta_f} (A_f L_f^{1-\theta_f})
\]

while feasibility in the non-food goods and services sector implies

\[
NF + I + X_m + X_f + X_h = K_m^{\theta_m} (A_m L_m)^{1-\theta_m}.
\]

In the previous feasibility constraints, capital letters with no super-index denote the aggregate (weighted by the fraction of the population) consumption of each type of good.

A competitive equilibrium for this economy is a sequence of prices and allocations for the partnership and single households that solve the corresponding optimization problems, taking prices as given. For it to be an equilibrium all of the aggregate resource constraints and market clearing conditions must also be satisfied.

### 4.1 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:

\[
L_{pm}^{p} - L_{pf}^{p} = \left( \frac{(1 - \hat{\tau_d}(1 - \zeta_1))}{\zeta_1} \right) L_{pf}^{p} \tag{9}
\]

\[
\left( \frac{\hat{L} - L_{pf}^{p} - L_{pf}^{m}}{\zeta_1} \right) = \frac{\lambda_f}{(1 - \lambda_f)(1 - \tau_d)} \tag{10}
\]

\[
\frac{\partial C_p^{E}}{\partial F} = \frac{\partial C_p^{F}}{\partial L_{pf}^{m}} \frac{1}{(1 - \tau)(1 - \tau_d)w + P_L \zeta_0 f(\tau_d)} \tag{11}
\]

where \( f(\tau_d) = \left( \frac{(1 - \hat{\tau})(1 - \zeta_1)}{\zeta_1} \right)^{1-\zeta_1} \).
From Proposition 1 we can then derive some partial equilibrium corollaries for partnership households. In particular, we have the following results:

1. **Lower taxes and/or gender gap tends to increase the consumption of food away from home and tends to lower female cooking time.**

   Notice first that the denominator of the right hand side of equation (11) is the economic cost of cooking time. The first term in the 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 (11). To restore the equality, and given that the partial derivatives of $C_pF$ are decreasing in both, $F$ and $L_{pf}h$, either $L_{pf}h$ has to go down, or $F$ has to increase, or both.

2. **Lower taxes translate into lower cooking times for both, males and females**

   Holding the gender gap constant, equation (9) shows that cooking times are proportional to each other and, as argued in our first corollary, lower taxes lower cooking times for females.

3. **A lower gender gap has an indeterminate effect on the male’s cooking time. The total impact is approximated by**

   \[
   \Delta\%L_{pm}h \approx \Delta\%L_{pf}h + \Delta%(1 - \tau_d)
   \]

   A higher opportunity cost of female cooking time, via lower gender gap, motivates households into substituting female time by male cooking time. However, equation (9) also shows that lower female cooking pushes male cooking down (as times are proportional). The result in corollary 3 is a straightforward implication of equation (9).

4. **A lower gender gap increases female market hours**

   As previously discussed, a lower gender gap lowers female cooking times. Moreover, equation (10) shows that a lower gender gap translates into lower female leisure. Hence, a lower gender gap pushes female market hours up.

   As we can see, changes in taxes and the gender wage gap are key elements in explaining the increased opportunity cost of cooking at home. The two main channels considered in
this paper 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 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 the general equilibrium effects are considered.

4.2 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. Then, we feed into the model the observed changes in the U.S. tax system as well as the gender wage gap between male and female workers to represent the 1990s. A new balanced growth equilibrium emerges and our quantitative analysis compares this new balanced growth equilibrium time series to its corresponding U.S. data counterpart for the period 1995-04.

Estimates of the intertemporal elasticity of substitution found in the literature imply values for $\sigma$ within the interval $[1,2]$. In our baseline experiment we pick a value $\sigma = 1.5$. Some parameters of the model are straightforward to calibrate. We set the depreciation rate for capital at 6%, the discount factor $\beta$ so that the interest rate matches the average 4% of the data, and the parameters of the aggregate production function for the market good $\theta_m$ such that the share of income going to labor matches its data counterpart, $\theta_m=0.34$ and $\theta_f$ such that it matches the capital-labor ratio in the restaurant industry, $\theta_f=0.08$. The growth factor of the exogenous technology parameters $A_m, A_f$ are set at 1.02 so that the model matches the 2% average growth rate of per-capita GDP of the U.S. economy. The relative prices of investment goods in general and those used for preparing food at home (kitchen and other household appliances in the U.S. NIPA) have declined at a relatively steady rate during the last 40 years. We set the model’s parameters to match the observed average rates in the data, $\eta_{qh}=1.028$.

Preference parameter $\gamma$ determines the model’s price elasticity of demand for restaurant meals, which has been estimated in the range $[2,3]$ by Anderson, McLellan, Overton and
Wolfram (1997). We set $\gamma = 0.65$, which implies a value of 2.8 for such elasticity. In the base line experiment, we set the parameter that determines the substituibility between kitchen capital and the time-ingredients composite in the home-food production function, $\zeta_3 = 0.85$, so that the model matches the change in the investment in kitchen capital to GDP ratio observed during the 1960-1995 period.\footnote{We measure investment in kitchen capital as the total expenditure in kitchen and other household appliances reported in the detailed personal consumption expenditures tables of the BEA.}

Regarding married households, there are seven parameters to be calibrated. First, the weights in the utility of food and non-food consumption goods, which are given by $\alpha, \nu$, respectively. Secondly, the weight of the female in the total household utility, given by $\lambda_f$. Finally, a set of food technology parameters $\mu, \zeta_0, \zeta_1, \zeta_2$. The values of these seven parameters are jointly determined from steady state equations so that the model matches the U.S. averages for 1955-65 on: 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\footnote{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).} to food away from home equal to 18, a ratio of aggregate expenditure in ingredients\footnote{Ingredients correspond to food purchased for off premise consumption in the detailed personal consumption expenditure tables of the BEA.} to food away from home of 3, and a ratio of aggregate investment in kitchen capital to food away from home equal to 0.24.\footnote{Investment in kitchen capital equals from the NIPA fixed asset tables, Table 8.} The five parameters associated to the single households ($\alpha, \nu, \mu, \zeta_0, \zeta_2$)\footnote{The five parameters associated to the single households ($\alpha, \nu, \mu, \zeta_0, \zeta_2$) s,i are calibrated to match hours worked and preparing food of single adults (two observations each) and the three ratios of aggregate data used for the married households.} are calibrated to match hours worked and preparing food of single adults (two observations each) and the three ratios of aggregate data used for the married households.

### 4.3 Results

We assume the 1960s 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 5 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 $\tau_d$ in Table 5 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 taxes only reports the predictions from the model when taxes change as in the data keeping the gender wage gap at its 1960s level (i.e. $\tau_d=0.43$).

<table>
<thead>
<tr>
<th>Expenditures</th>
<th>$\Delta%$ Data</th>
<th>$\Delta%$ Model taxes and $\tau_d$</th>
<th>$\Delta%$ Model only taxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exp. Groceries</td>
<td>-46%</td>
<td>-48%</td>
<td>-15%</td>
</tr>
<tr>
<td>Exp. Food Away from Home</td>
<td>40%</td>
<td>23%</td>
<td>8%</td>
</tr>
<tr>
<td>Rel. Price of Food Away from Home</td>
<td>23%</td>
<td>2%</td>
<td>2%</td>
</tr>
</tbody>
</table>

Table 5: Data and model implications for food expenditures and calorie consumption (expenditures are relative to a 2% trend).

The predictions of the model with respect to the consumption of food away from home, and home cooked meals are qualitatively consistent at the aggregate level. In particular, the model slightly over predicts the decrease in expenditures of groceries and can explain two-thirds of of the increase in the expenditures of food away from home. It is also worth noting that our model predicts an increase in the relative price of food prepared away from home as observed in the data. In equilibrium, our model suggests that the increased opportunity cost of time should translate into a higher relative price, expenditure and consumption of food away from home, just as seen in the data.

Taxes alone can not fully account the patterns in expenditures observed in the data. Taxes alone can only account 33% of the decreased expenditures in groceries and 20% of the increase in expenditures of food away from home. The fact that women both married and single face different opportunity costs than men has important consequences on the food choices that households make.

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 for each type of food. This transformation factor is such that the observed change in expenditures

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15We compute the aggregate economy as the weighted sum of the total expenditures for each type of household 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 are married, 15% are single females and 7% are single males.
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.

With respect to increased calorie consumption, changes in taxes and the gender wage gap slightly over predict the decrease in calories from groceries and explain more than two thirds of caloric increase due to food away from home. The predictions of the model with respect to groceries and food away from home are qualitatively consistent with previous empirical findings, which highlights consumption of food away from home as one of the major factors explaining the increased obesity in the U.S.

Changes in taxes alone over predict the number of calories resulting from groceries and account for less than half of the increased calorie consumption from food eaten away from home.

Table 6 reports the data and the model’s implications for time use for the benchmark experiment (where both, taxes and the gender gap are changed as in the data) and for the case where only taxes are changed.

<table>
<thead>
<tr>
<th>Households</th>
<th>∆% Data</th>
<th>∆% Model taxes and τ_d</th>
<th>∆% Model only taxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Married couples</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours worked (female)</td>
<td>108%</td>
<td>114%</td>
<td>15%</td>
</tr>
<tr>
<td>Hours worked (male)</td>
<td>-1%</td>
<td>-21%</td>
<td>-1%</td>
</tr>
<tr>
<td>Hours food prep. (female)</td>
<td>-50%</td>
<td>-58%</td>
<td>-18%</td>
</tr>
<tr>
<td>Hours food prep. (male)</td>
<td>35%</td>
<td>-44%</td>
<td>-18%</td>
</tr>
<tr>
<td>Single females</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours worked</td>
<td>10%</td>
<td>24%</td>
<td>5%</td>
</tr>
<tr>
<td>Hours food prep.</td>
<td>-46%</td>
<td>-7%</td>
<td>0%</td>
</tr>
<tr>
<td>Single males</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours worked</td>
<td>0%</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>Hours food prep.</td>
<td>0%</td>
<td>3%</td>
<td>4%</td>
</tr>
</tbody>
</table>

Table 6: Data and Model Implications for Time Use.

Qualitatively speaking, the predictions of the model with respect to time use for the different types of households are consistent with the data, except for the number of hours devoted to food preparation and clean up of married males. Quantitatively the model over predicts the decrease in the number of hours worked by married males, over predicts the number of hours worked by married females as well as the increase in the number of hours worked by both single households and under predicts the number of hours devoted to food preparation and clean up.
As we can see, from Table 6 taxes alone cannot fully account for the time use patterns observed in the data. In particular, it can only explain 12% of the increased number of working hours and 36% of the reduction in the number of hours devoted to cooking and food preparation by married females. Taxes alone do not predict the type of specialization observed in the data.

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 30 years in the United States. 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.

5 Supporting Evidence

It is beyond the scope of the present paper to consider additional heterogeneity within each household, although it would be an interesting exercise. In this section we suggest 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. In order to do so, we present some additional evidence supporting the mechanism presented in this paper. In particular, the mechanism that we propose is as follows: A decline in the personal income tax rate increases the after tax wage. Thus, it increases the opportunity cost of using time to prepare food at home for both men and women. Similarly, a decline in the gender wage gap increases the average wage of women, and hence her cost of preparing food at home. Since eating at home and eating away from home are substitutes, a decline in either the personal income tax rate or in the gender wage gap will increase the consumption of food away from home.

With respect to the channel examined in this paper, Hamermesh (2005) examines how incomes and time prices affect time and goods inputs into the household-produced commodity. He shows that there is a large decrease over time in the time inputs into eating and a rise in its goods-intensity, even relative to other commodities. Moreover, he demonstrates that both inputs increase with income, and that higher time prices at a given level of income reduce time inputs. This would suggest that the highest increase in calories would be ob-
served with the highest income groups which is also the group with the highest opportunity cost. This is exactly what is observed in the data and is consistent with channel presented in this paper.

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

If we consider obesity within different income groups, 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 level both for men and women, see Table 11.\(^{16}\)

<table>
<thead>
<tr>
<th>Females</th>
<th>1970s</th>
<th>1990s</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low education</td>
<td>24.9</td>
<td>37.8</td>
<td>52%</td>
</tr>
<tr>
<td>Medium education</td>
<td>14.8</td>
<td>34.5</td>
<td>133%</td>
</tr>
<tr>
<td>High education</td>
<td>7.3</td>
<td>29.9</td>
<td>309%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Males</th>
<th>1970s</th>
<th>1990s</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low education</td>
<td>12</td>
<td>26.7</td>
<td>123%</td>
</tr>
<tr>
<td>Medium education</td>
<td>14.4</td>
<td>29.4</td>
<td>104%</td>
</tr>
<tr>
<td>High education</td>
<td>7.4</td>
<td>24</td>
<td>219%</td>
</tr>
</tbody>
</table>

Table 11: Obesity rates among U.S. adults by gender and education level.

As we can see from Table 11, the different groups that have increased obesity the most have been the groups that have seen their opportunity cost increased the most too. These findings are also consistent with the mechanism suggested in this model.

One of the main factors causing the increased weight of American adults according to 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

\(^{16}\)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.
wage gap has declined the most are also the groups where obesity rates have increased the most. These observations are also consistent with the increased opportunity cost of cooking at home, explaining the increase in obesity in the U.S. over the last thirty years.

At a national level, Sanz-de-Galdeano (2005) uses longitudinal micro-evidence from the European Community Household Panel to investigate the obesity phenomenon in nine EU countries from 1998 to 2001. She finds that, on average, obesity levels rose by 8.5% for both men and women for sample of countries between 1998 and 2001. Moreover, Joumard (2001) finds that the tax-to-GDP ratio rose steadily in most EU countries up to the late 1990s, largely reflecting a sustained expansion of public sector commitments to welfare provision. Since the late 1990s, many EU countries have cut tax rates. Coincident with these tax cuts there has been a narrowing of the gender wage gap in most EU countries since the 1990s. It seems then that there has been a simultaneous decrease in taxes and the gender wage gap as well as an increase in the obesity rates in most EU countries. It is not too surprising then that Cutler, Glaeser and Shapiro (2003) find some international evidence showing that the percentage of the population that is obese is positively related to income per capita and percentage of female labor force participation. These empirical findings also suggest the importance of considering the opportunity cost of women when studying the increased obesity world wide. This is then consistent with the increased opportunity cost of cooking in these countries. As a result, households are more likely to switch to purchases of food away from home contributing then to the rise in obesity.

Finally, Foreman-Peck, Humphries, Morris, Offer and Stead (1998) find that increased obesity rates in Great Britain tend to coincide 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.

6 Conclusions

It is widely known that obesity has increased all throughout the 20th Century. However, the steepness of the rate of obesity over the past decades is what seems to be surprising. Moreover, increased obesity of the American population is now a problem of public health. Understanding the underlying forces explaining this rapid increase over the last 30 years is
becoming increasingly important.

Our analysis suggests that the observed increase in average weight is, to a major extent, a natural consequence of important changes in the economic environment that have risen the value of time. In particular, we have found that the observed trends in taxes and the lowering of the gender wage gap have resulted in dramatic changes in time use and food composition chosen by the average household. Lower income taxes and gender gap have raised the opportunity of time. Hence, 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 gender gap by choosing to eat more foods prepared away from home. Dietary studies find foods prepared away from home have a higher calorie density (calories per meal) than meals cooked at home from scratch. Therefore, the observed trends in taxes and in the gender wage gap have had the unintended consequence of increasing the caloric intake of the average American household.

We do not claim that taxes and the gender wage gap are the unique cause of obesity in the United States. Many other factors suggested by the literature, like increased portion sizes, self-control problems, etc., are likely to be relevant. We have, however, derived the quantitative implications of a complementary hypothesis. We found that the increased opportunity cost of time driven by tax trends, and by the lowering of the gender wage gap, can account for a large fraction of the observed increase in the average weight of American adults and must then be part of any successful explanation of the rise in obesity in the United States.

One of the policy implications of this research is that providing information to households about how to eat healthy when consuming food prepared away from home may prove useful in controlling the obesity epidemic. Increased weights are, at least partially, an optimal household response to the observed changes in the economic environment. Hence, although introducing taxes to foods prepared away from home may result in lower consumption of such type of meals it may also result in lower economic welfare. Providing agents with more information about the consequences of their food choices, however, may result in lower obesity together with increased economic welfare.
7 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.

• The data corresponding to the relative price of food relative to the GDP deflator was computed by authors. In particular, 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, relative to the GDP.

• The total caloric intake for each type of food is computed by the authors. In particular, 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), Figure 2, which reports the fraction of calories due to food away from home and to home meals.

• The personal marginal income tax rates are computed by authors. In particular, we used the Individual Income Tax Returns, Table R, for the 1960 to determine household composition according to marital status. From the U.S. Census Bureau IDB Data Access Table 0.47 we can determine the fraction of single males and females in 1960
and from Bar and Leukhina (2005) we can find the married composition regarding labor employment. We then use Table 13 and Table 4 part 2 of the Individual Income Tax Returns for the 1960 according to marital status to determine the fraction of total income due to salaries and wages so we can compute the average salary per person as well as 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. Once the average wage salary is known, using Table 4 part 2 of the Individual Income Tax Returns for the 1960 we can compute the average income. Finally, we computed the appropriate marginal tax rates according to marital status by examining the relevant tax brackets. Identical procedures and data sources were used to compute the tax rates for the year 2000.

The capital tax is computed as the weighted average of the different marginal income tax rates by gender and marital status. Finally, we used Table 1.13 from NIPA to compute the corporate tax which corresponds to the average taxes of production as the fraction of total output. Identical procedures and data sources were used to compute the tax rates for the year 2000.

- The price of kitchen and other household appliances is taken from NIPA from Table 2.3.4U relative to the GDP deflator.

References


