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On Habit and the Socially Efficient Level of Consumption and Work Effort*

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Abstract

We study relative preferences in a general equilibrium model where households make social comparisons and/or get habituated to levels of labour-effort they supply and goods they consume. Bayesian estimations for the US support the existence of a society based on such preferences. In particular, there is evidence that households a) make social comparisons and form habituation patterns in consumption and b) face peer-pressure when supplying labour and are aversely affected by it. Using our empirical estimates we provide numerical results for the optimal tax levels that correct for inefficiencies generated by relative preferences and distortions in product and labour markets. Owing to the latter, we find weak support for 'corrective' taxation as a way of mitigating the inefficiencies generated by such preferences.
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In quite a few years ... we may be able to perform all the operations of agriculture, mining, and manufacture with a quarter of the human effort to which we have been accustomed. ... Now it is true that the needs of human beings may seem to be insatiable. But they fall into two classes – those needs which are absolute in the sense that we feel them whatever the situation of our fellow human beings may be, and those which are relative in the sense that [they] makes us feel superior to, our fellows. Needs of the second class ... may indeed be insatiable .... But this is not so true of the absolute needs - a point may soon be reached ... when these needs are satisfied in the sense that we prefer to devote our further energies to non-economic purposes.
"Economic Possibilities for our Grandchildren", collected in Keynes (1963).

1 Introduction

In a famous contribution, Prescott (2004) examined the persistent differences between hours worked in the US and Europe. Using a small calibrated model of capital and labour supply he argued that higher taxes and entitlements, by distorting the labour-leisure trade off, were a key component explaining cross-country differences.

This sparked an intense debate about institutions versus preferences as potential explanations of labour utilization. In contrast, Blanchard (2004) suggested that preferences for leisure were an important determinant of the observed downward trend in hours worked in general and an important difference between countries. In a similar vein, Alesina et al. (2006) emphasized the influence of trade unions from the 1970s onward (partly reflecting preferences for social cohesion) and widespread labour-market regulations.

Naturally, such explanations have weakness of one sort or another. For example, the elasticity of labour supply to tax changes would need to be relatively high (relative to comparable micro studies) to induce the responses envisaged by Prescott. Moreover, if cultural factors were important, it is unclear why they impacted hours worked in the 1970s and not before. Likewise, with declining unionization across the developed world, insider and regulatory type arguments should be less important over time.

The question of "appropriate" work effort thus remains unsolved. And yet it remains a fundamental one – both in economics and other disciplines. As the opening quotation from the 1930s shows, Keynes speculated that future labour effort might fall considerably. However, whilst hours worked have generally fallen across the developed world, they have not done so for the reasons Keynes addressed or fell to the extent envisaged. And yet, as we shall see, his basic insight (namely, that relative preferences matter[1]) can in

[1] Although the idea that agents make relative comparisons in consumption and use it as a way to gain and project social status has a long heritage in economics, perhaps the most famous early example being Veblen (1899).

combination with these other studies offer an insight as to whether work effort at any particular time is appropriate.

We contribute to this debate in a quite distinct way. And our starting point is the following. Whether Americans work more or less than others is only one part of the story. After all, as **Tables 1** and **2** make clear, many other countries do work or have worked more hours than America (e.g., Korea and Greece). Some tend to work fewer hours but have enjoyed higher output growth (e.g., Germany). Indeed, some countries have radically altered their average work effort in recent decades but still enjoy high living standards (e.g., Germany, the Netherlands).

Moreover seen in a historical perspective, the ranking of hours worked across countries has varied considerably. For instance Huberman (2002) looks at historical trends in annual hours worked in six major economies since 1870. From this, we learn that it was only until the late 1970s that annual hours worked in the US began to systematically rise above those of peer nations. Germany, the Netherlands, and France typically worked annual hours in excess of those of the US and the UK until the late 1960s.

Given this uncertainty (i.e., which historical period; which national benchmark), perhaps the fundamental question is whether Americans work *too* much. To answer this, though, requires that we know what "too much" means. Like Prescott, we study this issue in a general-equilibrium, micro-founded setting. First, in a small calibrated model similar in spirit to his. Thereafter, in an extended model better reconciled with the US data (but with the same motivation). It turns out that we can provide a much richer answer than Prescott and can also, to some degree, encompass the differing explanations for patterns in activity and participation discussed above.

In both of our modeling frameworks, the economy is characterized by several dynamic and steady-state "frictions". These serve two purposes. First, they bring realism to the model. This gives us confidence that it is close to the data and can be taken seriously for policy purposes. Second, such frictions drive a wedge between the private and socially optimum level of activity, and hence introduce the possibility of a corrective role for policy. That wedge could be positive or negative depending on the net effect of these various frictions.

For instance, if economic activity in the decentralized optimum falls short of the social optimum then there is sub-optimal labour utilization (i.e., agents work too little). This requires a subsidy to encourage extra hours worked and economic activity. Otherwise, a tax is required. Such a "corrective tax" would discourage consumption and labour effort, thus guiding activity towards its lower socially optimum level [2]. The numerical

[2] These ideas are often associated with work by Richard Layard (Layard (1980, 2006))

size of that tax or subsidy can then be compared to the actual tax burden, to judge whether labour utilization (through the lens of our model) is excessive or insufficient.

Table 1: Average Annual Hours Worked per worker, US=100

	1950	1960	1970	1980	1990	2000-12
France	110.8	107.4	101.1	92.5	87.4	82.8
West Germany			96.4	91.9	82.4	78.5
Germany					83.2	79.3
Greece				116.9	115.8	114.7
Italy				102.6	101.7	100.6
Japan			116.5	114.9	104.0	98.6
Korea				157.1	142.3	130.0
Netherlands			90.3	82.4	78.8	77.7
Spain			106.1	98.8	94.6	94.2
Sweden	100.1	94.0	87.1	84.2	88.1	89.8
United Kingdom			100.6	95.8	94.5	92.8

Note: The US level figures are, for the respective years, 1975, 1954, 1861, 1826, 1835, 1798.
Source: OECD.

Table 2: Real GDP per hour worked, annual growth rate, US=100

	1970	1980	1990	2000-12
France	244.7	224.2	109.5	60.8
Germany	233.3	161.7	132.7	68.8
Greece		141.9	75.6	92.4
Italy	245.9	147.7	81.0	12.2
Japan	255.3	296.1	145.2	77.6
Korea		574.7	358.9	213.9
Netherlands	234.0	135.9	76.8	51.1
Spain	267.3	268.8	63.7	62.0
Sweden	95.6	93.0	121.4	97.9
United Kingdom	167.9	157.8	157.1	78.5

Note: The US level figures are, for the respective years, 1.8, 1.3, 1.7, 1.8.
Source: OECD.

What do we mean by "frictions"? The presence of monopolistically competitive firms and downward sloping demand curves are a familiar source of friction in models. Typically viewed, such firms restrict output. This restriction, possibly combined with monopoly labour unions, implies sub-optimal labour utilization and sub-optimal consumption and activity. Such frictions are relatively well known.

One other friction (though rarely considered as such) is habit formation. Habit formation is often included in business-cycle and growth models to reconcile their features to various inertial aspects of the data (e.g., “hump-shaped” consumption responses to demand shocks etc.), see Fuhrer (2000). However, in our case habit formation becomes a key channel upon which we assess the social efficiency of the model economy.

In terms of consumption, there are broadly speaking two variants. A consumer’s utility may depend not only on her consumption level but also how that level compares to her own past consumption levels (the *habit-formation* variety of relative preferences). Alternatively, she may compare her consumption level with those in her peer group (*catching-up-with-the-Joneses’* variety). These mechanisms have been utilized in many economic and behavioral literatures to illuminate several distinct phenomena.[3,4]

The tendency of an agent to evaluate her position according to standards set either by herself and/or her peer group naturally lends itself to policy considerations. Consider a world of relative preferences where agents consume more, by force of habit, leading to excessive consumption. This interesting possibility is raised in Arrow and Dasgupta (2009). Moreover, in so far as widening differences in relative income affect reported well being (e.g., Easterlin (1974), Kahneman et al. (1999)), their underlying causes (and possible remedies) becomes a legitimate matter of public policy. For example, as in the use of fiscal measures to correct for inefficiencies or excesses. Indeed, sharp income differences may impel status-conscious consumers to leverage their way up the social ladder. Political pressures may then perversely build to compensate the middle class for flat or declining incomes by erratic redistributive policies, or the imprudent promotion of easy credit and house ownership, e.g., Rajan (2010).

As in the macro literature, relativity in this literature takes two forms (but only named differently):

1. **Social Comparison** (or *external habit*), and

2. **Habituation** (or *internal habit*).

[3]For instance, in explaining the equity-premium puzzle, e.g., Abel (1990), Galí (1994); the savings-growth relation (e.g., Carroll et al. (2000), Tsoukis (2007)); and monetary/ business-cycle interactions (Christiano et al. (2005)).

[4]Tsoukis (2007) provides an excellent discussion of the taxonomy of different habit forms.

Social comparison implies that an agent is aversely affected by the relative income or consumption levels of others. As a result, even though I am getting richer, the fact that my peers are also getting wealthier makes me appreciate less of what I have (see Blanchflower and Oswald (2004), Clark and Oswald (1996), Stutzer (2004) for empirical evidence).

Habituation, or internal habit, by contrast, refers to the fact that the personal joy from higher income and consumption is short-lived and requires, over time, a further income boost to sustain felicity (Clark (1999), Di Tella et al. (2003) and Van Praag and Frijters (1999)).

However, the phenomenon does not or need not rest solely with consumption decisions. We also examine relativity comparisons in *labour* supply. Such an approach is for example consistent with studies on work addiction (Oates (1971)), but also with a broader, more diverse literature. Woittiez and Kepteyn (1998) and Kubin and Prinz (2002), for instance, find a significant empirical role for social interaction and habit formation in explaining labour supply; and Vendrik (2002) uses it to explain unemployment hysteresis. Faria and León-Ledesma (2004) investigate the interaction between labour supply, work ethics and technical progress. Lettau and Uhlig (2000) introduce relative comparisons in labour supply in business-cycle models to better replicate high-frequency moments in the data.

To assess the quantitative importance of the different habit forms, we utilize recent advances in micro-founded dynamic stochastic general equilibrium (DSGE) model suitable for quantitative policy analysis, e.g., Christiano et al. (2005), Smets and Wouters (2007), Christoffel et al. (2008). For our purposes emphasis is given to quantifying the habituation and social aspect of relativity in consumption and labour supply choice. To repeat, although the former is relatively well researched, there is sparse evidence on the latter despite the well-known "workaholism" phenomenon.

Therefore we consider several model variants incorporating different forms of relativity as well as more generally a rich set of real and nominal frictions to better represent the data. Our choice of modeling framework turns out to be important along two dimensions: (1) it is micro-founded and therefore captures the optimizing decisions of agents in an explicit general-equilibrium setting; (2) since DSGE models provide a multivariate stochastic process representation of the data they are suitable for estimation. Bayesian estimation, in particular, allows us to integrate *a priori* information on parameters and uncertainty about this information in a formally stringent way. Moreover, the approach is suitable for formal model comparison by means of their posterior odds.

We therefore extend the literature in four main ways:

1. Situations in which the agent pins down her choice of consumption *and* labour-supply on the basis of relative preferences have received little attention but are appropriate and worth quantifying;

2. We delineate the various channels by which macroeconomic product and labour frictions, as well as behavioral ones may imply deviations of the decentralized economy from the socially efficient outcome. This allows us to nest the various existing literatures regarding the extent of labour effort in a general-equilibrium setting;

3. We provide empirical estimates on the marginal likelihood and point-estimates of a variety of relative preferences models we consider for the U.S.;

4. Using our empirical estimates we provide numerical results for the optimal tax levels that [may or may not] correct for inefficiencies in the form of output generated by relative preferences and other distortions.

The paper is organized as follows. The main ideas of the paper are set out in Section 2 using a simple flex-price general equilibrium macro-model that incorporates variants of the relativity-approach in consumption and labour supply. Such a model is far too simple to be reconciled with data, so Section 3 turns to a more general dynamic stochastic general equilibrium model along the line of Smets and Wouters (2003, 2007) and Christiano et al. (2005). In both of these sections, for the small and larger model, we present the decentralized and planner's optimum and derive the optimal tax rate (or subsidy) which would align the two. Section 4 provides Bayesian estimates for twelve variants of the second, empirically more relevant model, each with variants of habit forms and relativity comparisons embedded within them. Section 5 calculates the optimal tax rates and transfers in each case. Section 6 concludes.

2 Optimal Taxes and Habit: An Illustration

What are the welfare consequences of incorporating social habit and habituation? Does habit imply a case for corrective taxes? To address these questions we first utilize a simple model in which consumers display this behavior.

labour is the only factor of production. There are three sources of inefficiency: market power in the product market from the existence of differentiated goods; market power in the labour market from the existence of differentiated labour; and external habit in both consumption and labour supply.

The welfare of representative household r at time 0 is given by,[5]

$$\underset{\{C_{t,r}\},\{L_{t,r}\}}{Max}\ \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_{t,r} - H_{C,t})^{1-\sigma}}{1-\sigma} - \frac{(L_{t,r} - H_{L,t})^{1+\phi}}{1+\phi} + u(G_t) \right] \tag{1}$$

where $\mathbb{E}_t$ is the expectations operator; β is the household's discount factor; $\sigma > 0$ and $\phi \geq 0$ reflect risk aversion and the real wage-labour supply (or the inverse Frisch) elasticity, respectively; $C_{t,r}$ is an index of consumption; $L_{t,r}$ are hours worked; and $u(G_t)$ represents utility from government spending G_t (this is held fixed until we consider optimal taxes in section 2.2).

$H_{C,t}$ represents the habit in consumption, thus the desire not to differ too much from other households. For the "social comparisons" variant of habit formation, we have that,

$$H_{C,t} = h_C C_{t-i},\ h_C \in [0,1),\ i \geq 0 \tag{2}$$

where $C_t = [\int_0^1 C_{t,r}^{\frac{\zeta-1}{\zeta}} dr]^{\frac{\zeta}{\zeta-1}}$ is aggregate consumption and $\zeta > 1$ determines the price elasticity of demand for individual goods. Similarly

$$H_{L,t} = h_L L_{t-j}\ j \geq 0, h_L \in (-1,1) \tag{3}$$

represents social comparisons in labour supply, where $L_t = [\int_0^1 L_{t,r}^{\frac{\eta-1}{\eta}} dr]^{\frac{\eta}{\eta-1}}$ is an aggregate of differentiated household labour.

Note, in contrast to consumption, we assume habit in labour supply may be positive *or negative*: in other words, when the agent sees his peers working more he may feel less discontent about himself working as much (a positive externality), or instead he may feel pressure to join them (a negative one).[6] Note, the fact that $i, j \geq 0$, means the formulation is consistent with both keeping-up-with-the-Joneses ($i = j = 0$) and catching-up-with-the-Joneses ($i, j \geq 0$).

If instead of the Social Comparisons variant, the household's utility were based on "habituation" (alternatively, internal habit) then $H_{C,t} = h_C C_{t-1,r}$ and $H_{L,t} = h_L L_{t-1,r}$, i.e. households compare their *own* past levels of consumption and labour supply.

[5]Habit here is in *difference form*, but we also considered a second formulation with *habit in ratio* form:

$$\frac{(C_{t,r}/H_{C,t})^{1-\sigma}}{1-\sigma} - \frac{(L_{t,r}/H_{L,t})^{1+\phi}}{1+\phi}$$

where $H_{C,t} = C_{t-1}^{h_C}$ and $H_{L,t} = L_{t-1}^{h_L}$. Results for this case are touched upon in section 4.3. Households could exhibit a weighted average of ratio and difference habit forms but, given identification issues, we confine our analysis to these more straightforward cases.

[6]See for example the case of academia in Faria and Monteiro (2008).

The household maximizes (1) subject to the budget constraint,

$$P_tC_{t,r} + \mathbb{E}_t\left[P_{D,t+1}D_{t+1,r}\right] = (1-\tau_{Y,T})P_tY_{t,r} + D_{t,r} + TR_t, \tag{4}$$

where P_t is an aggregate Dixit-Stiglitz price index, $D_{t+1,r}$ is a stochastic discount factor denoting the payoff of the portfolio $D_{t,r}$, acquired at time t, and $P_{D,t+1}$ is the period-t price of an asset that pays one unit of currency in a particular state of period $t+1$ divided by the probability of an occurrence of that state given information at time t. The nominal rate of return on bonds, R_t, is determined by $\mathbb{E}_t\left[P_{D,t+1}\right] = 1/(1+R_t)$. TR_t denotes lump-sum transfers to households by the government net of lump-sum taxes. $\tau_{Y,t}$ is an income tax rate on total nominal income which is given by,

$$P_tY_{t,r} = W_{t,r}L_{t,r} + \Xi_{t,r}, \tag{5}$$

where $W_t = [\int_0^1 W_{t,r}^{1-\eta}dr]^{\frac{1}{1-\eta}}$ is the aggregate wage index and $\Xi_{t,r}$ is the dividend derived from the monopolistically competitive intermediate firms plus the net inflow from state-contingent assets. The labour demand schedule is,

$$L_{t,r} = \left(\frac{W_{t,r}}{W_t}\right)^{-\eta} L_t. \tag{6}$$

The first-order conditions are:

$$\frac{1}{\beta(1+R_t)} = \mathbb{E}_t\left[\frac{\Lambda^C_{t+1,r}}{\Lambda^C_{t,r}}\frac{P_t}{P_{t+1}}\right] \tag{7}$$

$$\frac{W_{t,r}}{P_t}\frac{1-\tau_{Y,t}}{1+\tau_{C,t}} = -\mu_w\frac{\Lambda^L_{t,r}}{\Lambda^C_{t,r}} \tag{8}$$

where Λ^C and Λ^L respectively denote the marginal utilities of consumption and labour, and $\tau_{C,t}$ is the consumption tax rate. Equation (7) is the familiar Keynes-Ramsey condition. Condition (8) equates the marginal rate of substitution with the real disposable wage where mark-up $\mu_w = \eta/(\eta-1)$ reflects the market power of the household in the labour market.

In (7) and (8), the marginal utilities are written in general form, but these will take different forms depending on the specific habit mechanism considered. For **social-comparison (external habit)** we have,

$$\Lambda^C_{t,r} = \left[C_{t,r} - h_C C_{t-1}\right]^{-\sigma} \tag{9}$$

$$\Lambda^L_{t,r} = -[L_{t,r} - h_L L_{t-1}]^{\phi} \tag{10}$$

For **habituation (internal habit)** the marginal utilities are,

$$\Lambda^C_{t,r} = \quad [C_{t,r} - h_C C_{t-1,r}]^{-\sigma} - \beta h_C [C_{t+1,r} - h_C C_{t,r}]^{-\sigma} \tag{11}$$

$$\Lambda^L_{t,r} = -[L_{t,r} - h_L L_{t-1,r}]^{\phi} \quad + \beta h_L [L_{t+1,r} - h_L L_{t,r}]^{\phi} \tag{12}$$

The inefficiency that arises from social comparisons, as we shall see, lies in the fact that households take aggregate behavior (namely, C_{t-1}, L_{t-1}) as *exogenous* in planning consumption and labour supply. In fact the internal habit case reduces to that with external habit if households fail to perceive the effect.[7]

Regarding the supply side of our illustrative model, the economy is populated by a continuum of monopolistically competitive firms each producing a differentiated good with the downward-sloping demand curve:

$$Y_{t,f} = \left(\frac{P_{t,f}}{P_t}\right)^{-\zeta} Y_t \tag{13}$$

Parameter ζ is the elasticity of substitution between the differentiated goods and determines the firm's desired mark-up, $\mu = \zeta/(\zeta - 1)$. Each good f is produced by a single monopolistically competitive firm f using differentiated labour,

$$Y_{t,f} = A_t L_{t,f} \tag{14}$$

where $L_{t,f}$ is the aggregate labour input across labour types used by firm f. A_t is aggregate technology. The intermediate firm $f's$ profit-maximizing price is,

$$P_{t,f} = \frac{1}{\mu}\frac{W_t}{A_t}. \tag{15}$$

The output aggregation and balanced government budget constraint (that assumes the consumption tax is paid on government services) completes the model:

$$Y_t = A_t L_t = C_t + G_t \tag{16}$$

$$TR_t + P_t G_t = (\tau_{Y,t} + \tau_{C,t}) P_t Y_t \tag{17}$$

Solving for steady-state output Y **Table 3** below displays the matrix of possi-

[7]This is the case of 'unforeseen habituation' discussed by Layard (2006).

ble outcomes.[8] To illustrate the use of the table, assume we have external habit in consumption and labour. Thus, the steady state output would be solved out from $\Gamma(Y) - \Upsilon = 0$. Likewise, if both habits were internal, Y would be the solution of the equation, $\Gamma(Y) - \Upsilon\frac{1-\beta h_C}{1-\beta h_L} = 0$. The output level that arises from the first case will in general differ from the second case.

Table 3: Equilibrium conditions in the Simple Model

	labour Supply	
	Internal habit	External habit
Consumption		
Internal habit	$\Gamma(Y) = \Upsilon(Y)\frac{1-\beta h_C}{1-\beta h_L}$	$\Gamma(Y) = \Upsilon(1-\beta h_C)$
External habit	$\Gamma(Y) = \Upsilon\frac{1}{1-\beta h_L}$	$\Gamma(Y) = \Upsilon(Y)$

where,

$$\Gamma(Y) = \left(1 - \frac{G}{Y}\right)^{\sigma + h_C(1-\sigma)} Y^{\phi+\sigma}$$

$$\Upsilon(Y) = \frac{1-\tau_Y}{1+\tau_C}\frac{\left(1-\frac{1}{\eta}\right)\left(1-\frac{1}{\zeta}\right)}{(1-h_L)^{\phi}(1-h_C)^{\sigma}}A^{1+\phi}$$

The expressions in the table moreover show how the steady state level of output is affected by its various components. For example, for a given government expenditure to output ratio, denoted g, the Ext-Ext element of the above matrix shows that output is positively related to technology; and negatively to mark-ups and taxes:

$$Y = \left[(1-g)^{-[\sigma+h_C(1-\sigma)]} \cdot \frac{1-\tau_Y}{1+\tau_C} \cdot \frac{\left(1-\frac{1}{\eta}\right)\left(1-\frac{1}{\zeta}\right)}{(1-h_C)^{\sigma}(1-h_L)^{\phi}}A^{1+\phi}\right]^{\frac{1}{\phi+\sigma}}$$

Our prior might be that habit in consumption increases steady state output. But the contribution of work habits depend on whether they constitute a positive or negative externality. Naturally, when *both* habits are present their net effect depends on whether they reinforce or offset one another (in addition to the size of the other distortions).

So far, though, we do not know whether the outcomes described by Table 3 represents

[8]See Appendix A for derivation.

socially optimal or sub-optimal outcomes. To determine that we must solve the central planner's maximization problem. This is the issue to which we now turn.

2.1 Inefficiency and the Social Optimum

The social planner's problem is,

$$\underset{\{C_t\},\{L_t\},\{G_t\}}{Max} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_t - h_C C_{t-1})^{1-\sigma}}{1-\sigma} - \frac{(L_t - h_L L_{t-1})^{1+\phi}}{1+\phi} + u(G_t) \right] \tag{18}$$

subject to resource constraint (16). Note, compared to the decentralized case, the planner naturally deals in economy-wide aggregates rather than $r-$indexed household decisions; in this way she internalizes the effect of the habit terms. In addition, compared to maximand (1) government spending is a control variable. For simplicity, let us define the utility derived from public consumption analogously with private consumption: $u(G_t) = G_t^{1-\sigma}/(1-\sigma)$.

The first-order conditions are,

$$(C_t - h_C C_{t-1})^{-\sigma} - \beta h_C (C_{t+1} - h_C C_t)^{-\sigma} - \nu_t = 0 \tag{19}$$

$$-(L_t - h_L L_{t-1})^{\phi} + \beta h_L (L_{t+1} - h_L L_t)^{\phi} + A_t \nu_t = 0 \tag{20}$$

$$G_t^{-\sigma} - \nu_t = 0 \tag{21}$$

where ν_t is the costate variable on the resource constraint. Solving in the same manner as for the decentralized market equilibrium yields,

$$(Y^*)^{\phi+\sigma} \left(1 - \frac{G^*}{Y^*}\right)^{\sigma} = \frac{A^{1+\phi}}{(1-h_L)^{\phi}(1-h_C)^{\sigma}} \frac{1-\beta h_C}{1-\beta h_L} \tag{22}$$

$$G^* = (1-h_C)\left(\frac{1}{1-\beta h_C}\right)^{\frac{1}{\sigma}} C^* \tag{23}$$

The *social optimum*, $\{C^*, L^*, Y^*, G^*\}$ is then characterized by conditions (19), (20), (22), (23). The inefficiency of the market equilibrium can now be found by comparing these results with the conditions in **Table 3**. If there are differences between the market efficient and socially efficient level of output, we can calculate the tax rate (or subsidy) that would enforce equality.

2.2 Optimal Taxation

Choosing the tax structure $\{TR, \tau_Y, \tau_C\}$ so as to equate output in the market equilibrium with the social optimum given by (22) leads to the following Proposition:

Proposition 1 *The steady state* ***social optimum*** *can be attained in the decentralized market equilibrium with the following structure of taxes:*

$$\frac{1-\tau_Y}{1+\tau_C} = \mu \cdot \mu_w \frac{1-\beta h_C \mathcal{I}_C}{1-\beta h_L \mathcal{I}_L}$$

Where indicator variable $\mathcal{I}_x$ equals 1 [0] if habit x is external [internal] and where $\{TR, \tau_Y, \tau_C\}$ satisfies the government budget constraint,

$$\tau_Y + \tau_C - \frac{TR}{PY} = \frac{G^*}{Y^*} \tag{24}$$

Proof: Set $Y = Y^*$ and $G/Y = G^*/Y^*$ then substitute (23) into (22) and compare and solve with the conditions in Table 3. ■

Note that Proposition 1 simplifies further if either habit form is internal. In that case we can, in the optimal tax condition, set its value to zero (or $\mathcal{I}_x = 0$), since internal habit does not constitute an externality. To illustrate, if consumption and labour habits were respectively internal ($\mathcal{I}_C = 0$) and external ($\mathcal{I}_L = 1$), the optimal tax expression would instead be, $\frac{1-\tau_Y}{1+\tau_C} = \frac{\kappa}{1-h_L\beta}$, where $\kappa = \mu \cdot \mu_w$.

To make matters tractable, let us assume a uniform tax schedule,

$$\tau_Y = \tau_C \Leftrightarrow \tau = \frac{1-\kappa\frac{1-h_C\beta}{1-h_L\beta}}{1+\kappa\frac{1-h_C\beta}{1-h_L\beta}}$$

This uniquely determines the optimal tax structure given G^*/Y^*.

2.3 A Simple Calibration Exercise

We can now directly use the conditions above to calculate under what circumstances the optimal tax is positive or negative as well as its quantitative value. We choose parameter values broadly consistent with the calibration and estimation of our later empirical model: $\beta = 0.99$, $\sigma = 1.4$, $\phi = \varphi = 2.0$, $\eta = 3$, $\zeta = 7.65$ (corresponding to a price mark-up of 15%), $h_C = 0.7$, $h_L \in \{-0.5, 0.5\}$ and $G/Y = G^*/Y^* = 0.2$. Based on this calibration we present the optimal tax burden for each case in **Table 4**.[9] In the model with no habit (or equivalently internal habit) the market equilibrium output level is below the social optimum, $\frac{Y}{Y^*} < 1$, owing to market distortions in the labour and output markets. This "standard distortions" case is well known in the literature (e.g., Woodford (2003)) and requires the policy maker to offset these inefficiencies by issuing a subsidy rate (of $\tau = -0.27$) financed by lump-sum taxation, which also finances government spending.

In the second row if habit in consumption and labour are both external with $h_L > 0$, then the market equilibrium output level is still below the social optimum, with market distortions in the labour and output markets and the positive externality of habit in labour supply outweighing the negative externality of habit in consumption. This case requires a subsidy (albeit a tiny one).

If $h_L < 0$ (third row), then both habit in consumption and labour supply constitute negative externalities. Now the market equilibrium output level is substantially *above* the social optimum (around three fold). A large corrective tax emerges that is sufficient to also finance a lump-sum transfer to households.

If habit in consumption is internal (or, equivalently, non-existent) then in rows four and five we see subsidies reappear financed by a lump-sum tax (albeit of distinct sizes). In the final row we have external habit in consumption only with the market equilibrium output level again above the social optimum. Optimal taxes again involve a corrective tax rate.

Our results demonstrate that the optimal tax structure may be corrective rather than distortionary, depending on the nature of utility habits, and their interaction with other frictions. Thus, the possibility that agents work and consume too much (in the sense of beyond the social optimum) can be found quite readily in a simple model using a relatively standard calibration (although with the new feature of labour habits).

[9] Note that our treatment discussed inefficiencies with respect to output rather than hours. The conclusions however from one variable map quite naturally to the other through the production function and Okun's Law. Only in the case where technology was non-neutral and specifically (and sufficiently) labour-saving would this mapping break down. However, we know that non-neutral technical progress is asymptotically incompatible with a balanced growth path (e.g., Acemoglu (2002), León-Ledesma et al. (2010)).

Table 4: Optimal Tax Structure

Cons	Lab. Supply	Y/Y^*	τ	TR/PY	Remarks	Net Outcome
int	int	0.58	-0.27	-0.74	Standard Distortions alone, $Y < Y^*$	Subsidy
ext	ext $h_L > 0$	0.95	-0.02	-0.24	-'ve Cons. Ext: $Y > Y^*$; +'ve labour ext $\Rightarrow Y < Y^* \Rightarrow$	Subsidy
ext	ext $h_L < 0$	2.82	**0.48**	0.76	2 -'ve ext's: $Y > Y^*$	**Tax**
int	ext $h_L > 0$	0.29	-0.55	-1.30	-'ve labour Ext: $Y > Y^*$	Subsidy
int	ext $h_L < 0$	0.87	-0.07	-0.34	+'ve labour Ext: $Y > Y^*$	Subsidy
ext	int	1.89	**0.31**	0.42	-'ve Cons. Ext: $Y > Y^*$	**Tax**

Note: Corrective tax rates are in boldface. "int" and "ext" respectively denote the internal and external habit forms.

However, these results are by no means definitive. The difficulty lies in the fact that we do not necessarily know the likely value of these key habit parameters. Nor do we know how likely each of these outcomes are.[10] Are internal consumption habits probabilistically more likely than external habits? Further, if a model with, say, labour habit attracts a very low probability, should policy makers ignore it. On the other hand if it attracts a high probability or even a low but non trivial one, it may yet influence policy design (in the manner of a tail event). To pursue these ends, we now turn to a specific empirical setting.

3 The Empirical Model

The empirical model is the workhorse New Keynesian one with capital, fixed costs, nominal and real inertia mechanisms, and a policy reaction function (Smets and Wouters (2003, 2007) and Christiano et al. (2005) are seminal contributions). It is listed in full in Appendix B. Here we sketch the salient parts.

Since the model includes capital, nominal output is now given by,

$$P_t Y_{t,r} = W_{t,r} L_{t,r} + \left[R_{K,t} Z_{t,r} - \Psi(Z_{t,r})\right] P_t K_{t-1,r} + \Xi_{t,r}, \tag{3'}$$

where $R_{K,t}$ is the real return on the beginning-of period capital stock K_{t-1} which the household owns, $Z_{t,r} \in [0,1]$ is the degree of capital utilization with $\Psi', \Psi'' > 0$. Capital accumulation is given by,

$$K_{t,r} = (1-\delta)K_{t-1,r} + \left[1 - S\left(\frac{I_{t,r}}{I_{t-1,r}}\right)\right] I_{t,r}, \tag{25}$$

where $S(\cdot)$ is the investment adjustment cost function with $S(1) = S'(1) = 0$.

In the intermediate goods sector each good f is produced by a single firm f using differentiated labour and capital with a Cobb-Douglas technology subject to fixed costs of production:

$$Y_{t,f} = A_t (Z_{t,f} K_{t-1,f})^{\alpha} L_{t,f}^{1-\alpha} - \mathbb{F} \tag{14'}$$

where $\mathbb{F}$ are fixed costs of production (pinned down as a share of output, $\phi_{\mathbb{F}} \equiv 1 + \frac{\mathbb{F}}{Y}$).

[10] To illustrate, if we assume that all models in Table 4 are equally likely then we could average the respective tax/subsidy rates and the aggregate net externality. However, in the simple model case, this is infeasible since the average actual-potential output ratio turns out to be above one $\mathbb{E}[Y/Y^*] = 1.23$ and yet the averaged tax rate involves a small subsidy, $\mathbb{E}[\tau] = -0.02$. This counter-intuitive results arises from the fact that the models are not meaningfully weighed. This in turn justifies taking such models to the data and meaningfully weigh them, e.g. by their model probability to derive appropriate tax rates.

Following Calvo (1983) there is a probability of $1-\xi_p$ in each period that the price of each good f is set optimally (i.e., to maximize discounted profits) at the value $P^0_{t,f}$. If not re-optimized, the price is indexed to lagged aggregate inflation with indexation parameter $\gamma_p \geq 0$. The solution to this is given by price index,

$$P_{t+1}^{1-\zeta} = \xi_p \left[P_t \left(\frac{P_t}{P_{t-1}} \right)^{\gamma_p} \right]^{1-\zeta} + (1-\xi_p)(P^0_{t+1,f})^{1-\zeta} \tag{26}$$

We assume the same staggered mechanism for wages:

$$W_{t+1}^{1-\eta} = \xi_w \left[W_t \left(\frac{P_t}{P_{t-1}} \right)^{\gamma_w} \right]^{1-\eta} + (1-\xi_w)(W^0_{t+1,r})^{1-\eta} \tag{27}$$

As before we examine the dynamic behavior in the vicinity of a steady state in which the government budget constraint is in balance and given by (17). We further assume that changes in government spending are financed by changes in lump-sum taxes with tax rates $\tau_{Y,t}$ and $\tau_{C,t}$ held constant at their steady-state values. In the estimation the model is closed with a Taylor-type rule (see Appendix B).

Following our previous analysis, we arrive at:

Proposition 2 *In the model with capital and fixed costs, the steady state social optimum can be reached in the decentralized equilibrium with the following structure of taxes:*

$$\frac{1-\tau_Y}{1+\tau_C} = \mu\mu_w^{1+\alpha\phi} \cdot \frac{1-h_C\beta\mathcal{I}_C}{1-h_L\beta\mathcal{I}_L} \cdot \Omega \tag{28}$$

Where indicator variable $\mathcal{I}_x$ *equals 1 [0] if habit* x *is external [internal] and where* $\{TR, \tau_Y, \tau_C\}$ *satisfies the government budget constraint (24), and where,*[11]

$$\Omega = \frac{\left(1-\delta\left[\left(1-\frac{1}{\zeta}\right)\frac{\alpha\beta}{1-\beta(1+\delta)}\right] - \frac{G+\frac{\delta\alpha\beta}{1-\beta(1+\delta)}\mathbb{F}}{Y}\right)^{\sigma}}{\left(1-\frac{\delta\alpha\beta}{1-\beta(1+\delta)} - \frac{G^*+\frac{\delta\alpha\beta}{1-\beta(1+\delta)}\mathbb{F}^*}{Y^*}\right)^{\sigma}} \frac{\left(1+\frac{\mathbb{F}}{Y}\right)^{\phi}}{\left(1+\frac{\mathbb{F}^*}{Y^*}\right)^{\phi}}$$

Proof: Appendix C ■

[11] Note, as to be expected, dynamic frictions such as those in price setting and investment adjustment costs do not enter these tax setting conditions because they do not affect the steady state solution of the model.

Straightforwardly, note, *Proposition 2* reduces to *Proposition 1* if there is no capital and no fixed costs: $K = \alpha = \mathbb{F} = 0$ and so $\Omega = 1$.[12]

Note that despite its cumbersome nature, condition (28) contains many familiar elements. The parameters, $\sigma, \beta, \delta,$ and α, reflect preferences for current versus future saving. As β and σ change this shifts consumers' risk aversion and consumption planning profiles, and thus their reaction to shocks such as technology improvements etc. Likewise, as δ and α change this reflects the incentives for capital accumulation and thus again the deferral of current consumption (see also de La Grandville (2012)). The parameter ϕ, the inverse Frisch elasticity, captures the response of labour supply decisions, and these in turn are influenced by tax rates, τ_Y, τ_C (both central components of Prescott's analysis). The parameters μ, μ_w and ζ reflect product and labour market rigidities and regulatory arrangements as emphasized by Alesina et al. (2006) and others. Finally, there are the habit parameters, h_C and h_L reflecting the keeping-up-with- and catching-up-with-the-Joneses phenomena, and the possibility of "workaholism". The condition therefore can be seen to encompass many of the key channels identified as important for labour effort, as well as - in the habit case - some perhaps less well-understood ones.

4 Bayesian Estimation of the Empirical Model

To assess the ultimate quantitative importance of the twelve model variants, that result from the possible combinations of external and internal habit in consumption and labour as well as the possibility of a positive and negative externality in labour supply, we resort to the Bayesian estimation methodology that has become a standard tool for quantitative analysis of general equilibrium models in academia and policy institutions in recent decades. An and Schorfheide (2007) provide an extensive overview.

We proceed in three steps. First, we calibrate a set of parameters that are difficult to estimate from the cyclical dynamics of the data and select independent prior densities for the remaining parameters, which will be estimated. Second, based on the log-linear state-space representation of the model, the Kalman filter is employed to compute the log-likelihood. Combining the log-likelihood with the log-prior we use Markov Chain Monte Carlo methods to estimate the posterior distribution, which is not known analytically. In the third and final step, we conduct model comparison based on the posterior probability that each model receives. These three steps are now discussed in turn.

[12] Naturally, S, I and δ similarly drop out.

4.1 Calibration, and the Specification of Priors

Our calibration reflects common practice, (e.g., Cantore et al. (2013)) and is common across the model variants. We fixed the discount factor to 0.99 (implying an annual steady state interest rate around 4 percent). The depreciation rate and capital share were respectively set to 0.025 and 0.36. The wage mark-up was set to 20%. The steady state shares of consumption, government and investment expenditures to output were, consistent with the US data over the sample considered, respectively, $c_y = 0.56$, $g_y = 0.20$, and $i_y = 0.24$.

Table A1 in Appendix D lists the priors and posteriors for the model variants. We use prior means that are very similar to previous studies but, importantly, allow for larger standard deviations, i.e. less informative priors, in particular for the habit parameters. Also, for these parameters we center the prior density in the unit interval. Regarding the habit in labour coefficient h_L we restrict the prior to the positive unit interval but multiply h_L by -1 in models 10-12 to account for the negative externality.[13] For the standard deviations of the shocks we select inverse gamma densities with finite but fairly large variance to express our degree of uncertainty about the size of the shocks.

4.2 Posterior Estimates

We estimate the models using seven macroeconomic time series: real GDP, real private consumption expenditure, real investment expenditure, hours worked, real wages, domestic consumer price inflation (proxied by the GDP-deflator) and the Federal Funds rate. These are the standard observables used in models of this class, and thus we retained them for comparability and continuity.

The data covers 1980Q1 to 2007Q4 and are retrieved from the FRED Database except for hours worked and hourly compensation which are from the Bureau of Labor Statistics. Real GDP, hours worked, real consumption and real investment expenditure are converted into per capita series using population from the U.S. Bureau of Economic Analysis.

Prior to estimation log-linear trends are removed from the log-transformed time series in order to obtain approximately stationary data. First, we estimate the posterior mode to initialize the Markov Chain Monte Carlo procedure that is implemented with the Metropolis-Hastings algorithm. Then we sample 250 000 draws from the posterior and retain 100 000 draws to compute the posterior means.

[13]In practice, we write equation (3) as $H_{L,t} = -h_L L_{t-1}$, $h_L \in [0, 1)$ in models 10-12.

The posterior means of all parameters and for each model are collected in Table A1 in the Appendix. Overall, the posterior means of the structural parameters are in the ballpark of earlier studies. In all models the habit coefficient estimates are sizeable showing that habit formation is an important model feature to attain a good data fit. The real shocks turn out to be rather persistent, a result that is often found in the estimation of general equilibrium models and that partly reflects the remaining persistence in the transformed data. In addition, we note that the log-marginal likelihood values for models featuring habit formation in consumption are relatively close to each other. In contrast, models where habit in consumption is assumed to be absent provide a distinctly worse data fit.[14] The row "Posterior Odds" works out the relative fit to data of each of the model variants. It is discussed below.

4.3 Model Comparison

Let $p_i(\theta|\mathbb{M}_i)$ represent the prior distribution of the parameter vector $\theta \in \Theta$ for model $\mathbb{M}_i \in M$ and let $\mathcal{L}(y|\theta, \mathbb{M}_i)$ denote the likelihood function for the observed data $y \in Y$ conditional on the model and the parameter vector. The joint posterior distribution of θ for model $\mathbb{M}_i$ combines the likelihood function with the prior distribution $p_i(\theta|y, \mathbb{M}_i) \propto L(y|\theta, \mathbb{M}_i)\, p_i(\theta|\mathbb{M}_i)$.

Importantly, Bayesian inference allows a framework for comparing models based on their marginal likelihood. For model $\mathbb{M}_i \in M$ and a common dataset of observable variables, the marginal likelihood is obtained by integrating out vector θ:

$$\mathcal{L}(y|\mathbb{M}_i) = \int_{\Theta} \mathcal{L}(y|\theta, \mathbb{M}_i)\, p(\theta|\mathbb{M}_i)\, d\theta.$$

To compare models (say, $\mathbb{M}_i$ and $\mathbb{M}_{j\neq i}$) we calculate the Posterior Odds ratio which is the ratio of the posterior model probabilities (or Bayes Factor when the prior model probabilities are equal, i.e. the prior odds ratio, $\frac{p(\mathbb{M}_i)}{p(\mathbb{M}_j)}$, is set to unity), in terms of the log-marginal likelihoods (LL) obtained from the estimation:

$$PO_{i,j} = \frac{p(\mathbb{M}_i|y)}{p(\mathbb{M}_j|y)} = \frac{\mathcal{L}(y|\mathbb{M}_i)p(\mathbb{M}_i)}{\mathcal{L}(y|\mathbb{M}_j)p(\mathbb{M}_j)} \tag{29}$$

$$BF_{i,j} = \frac{\mathcal{L}(y|\mathbb{M}_i)}{\mathcal{L}(y|\mathbb{M}_j)} = \frac{\text{Exp}(LL(y|\mathbb{M}_i))}{\text{Exp}(LL(y|\mathbb{M}_j))}. \tag{30}$$

Components (29) and (30) thus provide a framework for comparing alternative and

[14] For brevity, we have suppressed the full results in terms of standard impulse responses and convergence diagnostics of the various model estimates. All such results are though available on request.

potentially mis-specified models based on their marginal likelihood.

The selection criteria is to choose the model with the highest posterior probability, as posterior odds has the desirable property of asymptotically favoring the model closest to the true data-generating process in the Kullback-Leibler sense (see An and Schorfheide (2007) for a discussion). This methodology is now applied to analyze the twelve model variants.

The Bayesian estimates for the models' probabilities are summarized in **Table 5**. Consistent with our earlier discussion, we define consumption habits as internal or external (equivalently, reflecting habituation or social comparison preferences). The same is true for labour habits, although with the additional remark that there the associated externality depends on $sgn\{h_L\}$.

Four key results stand out.[15] First, models that include some form of comparisons in consumption and labour supply receive a significant odds (for example model 2 with social comparisons in consumption and no labour habits attracts almost 30% of the probability mass, and model 11 where social comparisons are present in both consumption and labour attract around 15%). Second, models with social comparison in consumption receive higher model probabilities than models with habituation in consumption. This result is independent of whether social comparison or habituation in labour are included. Overall, models with social comparison in consumption have cumulated probabilities of about 70% and the cumulated probabilities of models with habituation in consumption make up around 30%. Third, models where the combination labour supply with negative externality as well as consumption decisions are referenced in some form or another (i.e. models 11 and 12) receive significant probabilities making up for just under 20% of the cumulative probability.[16] Finally, as might be expected, models without habit formation in consumption attract degenerate probability mass (irrespective of the presence or form of labour habits).

These results justify our approach of raising the possibility that labour and consumption choice are simultaneously subject to some form of relativity. Furthermore, our fourth result is in contrast to various literatures that argue that households do not

[15] A typical outcome of Bayesian selection criteria is degenerate models odds. That is to say, typically 1 of the M models absorbs the mass of posterior probability (e.g., Gelman et al. (2003)). This undermines the usefulness of the approach and, in so far as degenerate odds reflect weak model identification, it masks the uncertainty facing policy makers, when confronted with policy implementation. Here, however, it is worth noting that we have a fairly dispersed odds range.

[16] Note that although model 2 odds (ext/–) exceed those of model 11 (ext/ext), a Bayesian decision maker would not dismiss the information associated with the latter; since all models are deemed to be necessarily misspecified, there are gains to weighting outcomes in this way. Indeed, odds associated to models with external labour habits sum to 0.377 which exceeds the odds associated to the model with no labour habits and external consumption habits.

seem to realize making social comparisons or getting habituated (see for example Layard (2006)) to various aspects of life. Furthermore, taking our four key results together we can infer that an economy in which agents make relative comparisons in consumption and supply work on the basis of peer comparisons are highly likely.[17]

Table 5: Estimated Models Variants and Model Odds

$\mathbb{M}_i$	Consumption	labour supply	Habit Forms			Externality	Odds
2	Social Comparison	no	ext	:	–	0	0.247
9	Social Comparison	Habituation	ext	:	int	+	0.188
11	Social Comparison	Social Comparison	ext	:	ext	−	0.146
7	Social Comparison	Social Comparison	ext	:	ext	+	0.113
6	Habituation	Habituation	int	:	int	+	0.104
3	Habituation	no	int	:	–	0	0.084
12	Habituation	Social Comparison	int	:	ext	−	0.072
8	Habituation	Social Comparison	int	:	ext	+	0.046
10	no	Social Comparison	–	:	ext	−	0
1	no	no	–	:	–	0	0
4	no	Social Comparison	–	:	–	+	0
5	no	Habituation	–	:	int	+	0

Notes:
Social comparison ⇔ EXTernal habit
Habituation ⇔ INTernal habit
Positive externality in labour supply: $h_L > 0$
Negative externality in labour supply: $h_L < 0$
"–" denotes not applicable.

5 Optimal Tax Structure

Using the empirical model, we now turn to the computation of the optimal tax structure that aligns the efficient decentralized outcome with the socially efficient one. These computations mirror those for our illustrative model of Section 2, except that we now use the model odds in Table 5 to calculate an average tax rate spanning the candidate models (as well as use a considerably richer modelling framework).

[17] We also estimated the model with habit in *ratio* form as mentioned in footnote 3. We find that in a marginal-likelihood race across all the 12 model variants, the ratio form consistently gives a lower log-marginal likelihood and in many cases substantially so. Details are available upon request.

To undertake these calculations there is one remaining parameter to calibrate, namely the substitution elasticity between differentiated goods, ζ.[18] The mark-up of the price on the marginal cost is given by $\mu = \zeta/(\zeta - 1)$. In what follows we set this to typically-used values of 1.10, 1.15 and 1.20. **Table 6** shows the computed corresponding optimal tax rate conditional on the assumed price mark-ups for each of the $\mathbb{M}_i$ $i = 1, .., 12$ model variants, and key parameters associated to them. Then, using the estimated model probabilities, we report in the final row the expected optimal tax rate as,

$$\mathbb{E}[\tau^*] = \sum_{i=1}^{12} p(\mathbb{M}_i|y) \cdot \tau_i^* \tag{31}$$

for each μ.

In just over half the cases, ($\mathbb{M}_{1,4-9}$) a subsidy is required to align the (lower) decentralized optimum with the social optimum. The range of subsidy values (concentrating on the $\mu = 1.1$ column) spans from a subsidy marginally above zero ($\mathbb{M}_9$) to a relatively large value of around 0.25 ($\mathbb{M}_5$). These cases are straightforward to motivate. In all of them, we have the impact of the product and labour market distortions, lowering the output level. If there is (external) habit in consumption, this pushes the level of output (and thus labour hours) towards its social optimum. However, given the non-habit distortions, this is insufficient to fully offset matters, thus requiring the central planner to encourage activity by an aggregate subsidy. Even a positive externality in labour ($\mathbb{M}_{4,7,8}$ is an insufficient reversal mechanism. The highest subsidy ($\mathbb{M}_5$) naturally arises when there is no offsetting externality in labour and consumption. By similar argument, the lowest, $\mathbb{M}_{7,9}$, occurs when there is external habit in consumption, and possible external habit in labour (constituting a positive externality).

[18] An examination of the linearized form of the model in Appendix A reveals the fact that ζ does not appear and is therefore not identified.

Table 6: Optimal Tax Rates within and across Models

$\mathbb{M}_i$	$p(\mathbb{M}_i\|y)$	Habit Forms C	L	h_C	h_L	σ	ϕ	$\phi_{\mathbb{F}}$	τ_i^* μ=1.10	τ_i^* μ=1.15	τ_i^* μ=1.20
1	0.000	–	–	–	–	2.92	1.452	1.449	-0.148	-0.153	-0.159
2	0.247	ext	–	0.487	–	2.23	1.473	1.536	**0.168**	**0.159**	**0.149**
3	0.084	int	–	0.456	–	2.26	1.474	1.532	**0.140**	**0.131**	**0.121**
4	0.000	–	ext	–	0.173	2.98	1.357	1.462	-0.235	-0.240	-0.245
5	0.000	–	int	–	0.196	3.00	1.312	1.467	-0.246	-0.251	-0.256
6	0.104	int	int	0.524	0.456	2.21	1.311	1.550	-0.089	-0.098	-0.108
7	0.113	ext	ext	0.553	0.415	2.21	1.395	1.551	-0.025	-0.035	-0.045
8	0.046	int	ext	0.508	0.412	2.24	1.430	1.548	-0.070	-0.080	-0.090
9	0.188	ext	int	0.556	0.421	2.22	1.302	1.554	-0.024	-0.034	-0.044
10	0.000	–	ext	–	-0.628	2.80	1.716	1.420	**0.083**	**0.077**	**0.070**
11	0.146	ext	ext	0.449	-0.504	2.25	1.479	1.523	**0.325**	**0.316**	**0.308**
12	0.072	int	ext	0.432	-0.506	2.25	1.471	1.520	**0.313**	**0.304**	**0.295**
$\mathbb{E}[\tau^*]$	–	–	–	–	–		–	–	**0.104**	**0.094**	**0.085**

Notes:
In column 2, we list the model posterior odds associated to each $\mathbb{M}_i$ model variant and habit form, and in columns 5 – 9 we show relevant estimated posterior parameter means. Then the optimal tax rates for an assumed mark-up are derived, following condition (28) in the last three columns.
The final row of the table, $E[\tau^*]$ calculates for each of the assumed mark-up cases the optimal tax as weighted average using the model probabilities as weights and condition (31).
A "–" entry indicates not applicable.
Bold indicates a corrective tax.

Aside from these cases, a corrective tax is required to align the decentralized with socially optimal economy ($\mathbb{M}_{2,3,10-12}$). Again the intuition is clear. In the last three models the negative labour externality in habit (the last three models) produce a surge of output which offset the product/labour market distortions and add to, where applicable, the consumption habit (i.e., $\mathbb{M}_{11}$).

Note, the delineation of these cases into those model economies requiring either a subsidy or a tax are robust across mark-up values. Although of course if we assumed higher mark-up values (i.e., higher product and labour market distortions) then these corrective taxes would necessarily tend towards subsidies (to raise decentralized activity).

However the expected (average) tax rate across all variants, found using the estimated model odds is in fact marginally positive (around 0.09 on average). Largely speaking this positive average is driven by the high probabilities associated to models 2 and 11.[19]

How does this compare with the data? The US average tax burden in 2012 was

[19]Notice, again, that cases of internal habit in consumption perform poorly in terms of model odds and so their tax outcomes have limited impact on the aggregate tax rate, reported in the final row.

around 9.9%.[20] This is identical to the one suggested by our table. The the total wedge (summing income tax, employee and employer social security contributions) was around 29.6%.[21]

Whilst it is tempting to declare this a vindication of the model, this is not an appropriate interpretation. This is for two reasons. First, whilst governments typically implement many subsidies and tax breaks (e.g., for physical and human capital investment) it is not obviously done for the purposes of adjusting equilibrium output levels. Second, nor is a net aggregate subsidy position a realistic fiscal stance for developed nations.[22]

Indeed, the tax burdens in the US tend to be small by international comparisons. Although taken as a whole, the OECD the average (11.9%) and total (35.6%) tax burdens were only marginally higher in the same year, many similar income countries had appreciably higher tax burdens, for example France and Germany. Thus, the question of whether the US is currently implementing a fiscal stance which broadly implies that the economy is near its social optimum, cannot be unambigously inferred from the data.

6 Conclusion

Do Americans work too much? Such matters have generated heated arguments, in and outside the economics literature. We have argued that we must first define what we mean by “too much”. Armed with a well-defined concept, we may be in a position to both assess the original question and determine the optimality of existing tax policy.

Like Prescott, we used a micro-founded, general equilibrium framework to investigate the topic. The larger, empirical model in particular contained a rich set of relevant features to address the question in a reasonable yet tractable manner. Bayesian estimations of our models empirically support the ideas of habituation and relative comparison in consumption and peer comparison in labour supply. We found some (albeit weak) support for taxation as a method for mitigating the inefficiencies that exist due to relative preferences.

There is here, however, no presumption of offering precise quantitative policy advice; the model and the exercises are too stylized in this respect. However what the paper achieved is to establish the conditions under which work effort (and thus consumption

[20] Expressed as a fraction of labour Costs in the OECD definition. Appendix E shows the dis-agregation for the same country set as Tables 1 and 2.

[21] It also appears relatively stable, the total wedge figure in 2000 was only marginally higher at 30.4%.

[22] A possible exception may be Oil-rich Arab states. Hydrocarbon windfalls, to some degrees, obviated the need for general taxation, see Nabli (2004), Schwarz (2013).

and activity) may be deemed excessive. And under what circumstances the average tax rate could be corrective or distortionary. This takes the various literatures in this field a significant step forward. We have also shown that many of the different arguments discussed in the Introduction (rationalizing patterns in hours worked) can be naturally nested within a general setting.

Our framework was kept relatively simple. It could be extended in several fruitful directions. For example, by examining a full set of taxes, rather than just some average measure. Note that we have only considered the unconstrained Ramsey problem where the policy maker has the full range of distortionary and non-distortionary taxes available to reach the social optimum, including that for government spending. It would be of interest to consider a constrained problem where only distortionary taxes are available.[23]

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[23] Then Ramsey-optimal government spending will not coincide with the social optimum and its optimal size will rise as taxes become less distortionary with the presence of social comparison (external habit) in consumption and peer pressure in labour supply. To assess this empirically one might like to add a habit parameter in government spending, h_G. With separable utility this parameter does not influence household behavior; but alternative functional forms for utility consistent with balanced growth would identify h_G.

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APPENDICES

A Derivation of results in Table 1

The deterministic zero-inflation zero-growth steady state with $Y_t = Y_{t-1} = Y$, etc., is given by,

$$
\begin{aligned}
1 &= \beta(1+R)\\
\frac{W(1-\tau_Y)}{P(1+\tau_C)} &= -\frac{1}{1-\frac{1}{\eta}}\frac{\Lambda^L}{\Lambda^C}\\
Y &= AL = C+G\\
\frac{W}{P} &= A\left(1-\frac{1}{\zeta}\right)\\
TR + PG &= (\tau_Y + \tau_C)PY
\end{aligned}
$$

where for internal habit (habituation)

$$
\begin{aligned}
\Lambda^C &= \quad (1-\beta h_C)[(1-h_C)C]^{-\sigma}\\
\Lambda^L &= -(1-\beta h_L)[(1-h_L)L]^{\phi}
\end{aligned}
$$

and for external habit (social comparison)

$$
\begin{aligned}
\Lambda^C &= \quad [(1-h_C)C]^{-\sigma}\\
\Lambda^L &= -[(1-h_L)L]^{\phi}
\end{aligned}
$$

This gives us six equations for R, $\frac{W}{P}$, L, C, Y and possible tax structures, $\{TR, \tau_Y, \tau_C\}$, given G. Solving for steady-state output Y gives us the required expression.

B Listing of Full Model

The full linearized form of our model is as follows (all lower case variables are defined as proportional deviations from the steady state except for rates of change which are absolute deviations):[24]

$$
\begin{aligned}
\Lambda^C_{t+1} &= \Lambda^C_t - (r_t - \pi_{t+1})\\
mrs_t &= \Lambda^L_t - \Lambda^C_t\\
q_t &= \beta(1-\delta)q_{t+1} - (r_t - \pi_{t+1}) + \beta Z r_{K,t+1} + \epsilon_{Q,t}
\end{aligned}
$$

[24] We suppress the expectations operator for notational convenience

$$
\begin{aligned}
z_t &= \frac{r_{K,t}}{Z\Psi''(Z)} = \frac{\psi}{R_K} r_{K,t}, \quad \text{where} \quad \psi = \frac{\Psi'(Z)}{Z\Psi''(Z)} \\
i_t &= \frac{1}{1+\beta} i_{t-1} + \frac{\beta}{1+\beta} i_{t+1} + \frac{1}{S''(1)(1+\beta)} q_t + \frac{\beta u_{I,t+1} - u_{I,t}}{1+\beta} \\
\pi_t &= \frac{\beta}{1+\beta\gamma_P} \pi_{t+1} + \frac{\gamma_P}{1+\beta\gamma_P} \pi_{t-1} + \frac{(1-\beta\xi_P)(1-\xi_P)}{(1+\beta\gamma_P)\xi_P} mc_t + \epsilon_{P,t} \\
k_t &= (1-\delta)k_{t-1} + \delta i_{t-1} \\
mc_t &= (1-\alpha)wr_t + \frac{\alpha}{R_K} r_{K,t} - a_t \\
wr_t &= \frac{\beta}{1+\beta} wr_{t+1} + \frac{1}{1+\beta} wr_{t-1} + \frac{\beta}{1+\beta} \pi_{t+1} - \frac{1+\beta\gamma_W}{1+\beta} \pi_t \\
&\quad + \frac{\gamma_W}{1+\beta} \pi_{t-1} + \frac{(1-\beta\xi_W)(1-\xi_W)}{(1+\beta)\,(1+\eta\phi)\xi_W} \left(mrs_t - wr_t\right) + \epsilon_{W,t} \\
l_t &= k_{t-1} + \frac{1}{R_K}(1+\psi) r_{K,t} - wr_t \\
y_t &= c_y c_t + g_y g_t + i_y i_t + k_y \psi r_{K,t} \\
y_t &= \phi_{\mathbb{F}} \left[a_t + \alpha\left(\frac{\psi}{R_K} r_{K,t} + k_{t-1}\right) + (1-\alpha) l_t \right], \quad \text{where} \quad \phi_{\mathbb{F}} = 1 + \frac{\mathbb{F}}{Y}
\end{aligned}
$$

Persistent shock processes are of the form, $\lambda_{t+1} = \rho_\lambda \lambda_t + \epsilon_{\lambda,t+1}$ where $\lambda \in [u_C, u_L, u_I, g, a]$ are preference, investment, government spending and technology processes respectively, and where "inefficient cost-push" shocks $\epsilon_{Q,t}$, $\epsilon_{P,t}$ and $\epsilon_{W,t}$ have been added to the value of capital, the marginal cost and marginal rate of substitution equations respectively. Variables y_t, c_t, mc_t, $u_{C,t}$, $u_{L,t}$, a_t, g_t are proportional deviations about the steady state. $[\epsilon_{C,t}, \epsilon_{L,t}, \epsilon_{g,t}, \epsilon_{a,t}]$ are iid. disturbances. π_t, $r_{K,t}$ and r_t are absolute deviations about the steady state.

In order to implement the monetary rule we require the *output gap* the difference between output for the sticky price model obtained above and output when prices and wages are flexible, $\hat{y}_t$ say. Following Smets and Wouters (2003) we also eliminate the inefficient shocks from this target level of output. The latter, obtained by setting $\xi_p = \xi_w = \epsilon_{Q,t} = \epsilon_{P,t} = \epsilon_{W,t} = 0$. The Taylor rule used is given by,

$$
r_t = \rho r_{t-1} + (1-\rho)[\bar{\pi}_t + \theta_\pi(\pi_{t+j} - \bar{\pi}_{t+j}) + \theta_y \tilde{y}_t] + \theta_{\Delta\pi}(\pi_t - \pi_{t-1}) + \theta_{\Delta y}(\tilde{y}_t - \tilde{y}_{t-1}) + \epsilon_t
$$

where $\tilde{y}_t$ is the output gap and $\bar{\pi}_t$ an exogenous inflation target assumed to follow an AR(1) process.

The model list above is written independent of the form of labour and consumption habit and thus independent of the specification of the marginal utilities. Their form is specified below:

External Habit

$$\Lambda_t^C = u_{C,t} - \frac{\sigma}{1-h_C}(c_t - h_C c_{t-1})$$
$$\Lambda_t^L = -\frac{\phi}{1-h_L}(l_t - h_L l_{t-1}) + u_{L,t} + u_{C,t}$$

Internal Habit

$$\Lambda_t^C = \frac{1}{1-\beta h_C}\left[u_{C,t} - \frac{\sigma}{1-h_C}(c_t - h_C c_{t-1}) - \beta h_C\left(u_{C,t+1} - \frac{\sigma}{1-h_C}(c_{t+1} - h_C c_t)\right)\right]$$
$$\Lambda_t^L = \frac{1}{1-\beta h_L}\left[-\frac{\phi}{1-h_L}(l_t - h_L l_{t-1}) + u_{L,t} + u_{C,t} - \beta h_L\left(-\frac{\phi}{(1-h_L)}(l_{t+1} - h_L l_t) + u_{L,t+1} + u_{C,t+1}\right)\right]$$

C Proof of Proposition 2

C.1 Steady state of the Empirical Model

The deterministic zero-inflation steady state of the empirical model, denoted by variables without the time subscripts, is given by

$$1 = \beta(1+R) \tag{C.1}$$
$$Q = \beta(Q(1-\delta) + R_K Z - \Psi(Z)) \tag{C.2}$$
$$R_K = \Psi'(Z) \tag{C.3}$$
$$Q = 1 \tag{C.4}$$
$$\frac{W(1-T_Y)}{P(1+T_C)} = \frac{(1-h)^\sigma}{1-\frac{1}{\eta}} L^\phi C^\sigma \tag{C.5}$$
$$Y = A(KZ)^\alpha L^{1-\alpha} - F \tag{C.6}$$
$$\frac{WL}{PZR_K K} = \frac{1-\alpha}{\alpha} \tag{C.7}$$
$$1 = \frac{P^0}{P} = \frac{MC}{1-\frac{1}{\zeta}} \tag{C.8}$$
$$MC = \frac{1}{A}\left(\frac{W}{P}\right)^{1-\alpha} R_K^\alpha \alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)} \tag{C.9}$$
$$Y = C + (\delta + \Psi(Z))K + G \tag{C.10}$$
$$TR + PG = (T_Y + T_C)PY + T_L WL \tag{C.11}$$

giving us 11 equations for R, Z, Q, $\frac{W}{P}$, L, K, R_K, MC, C, Y and possible tax structures, $\{TR, T_Y, T_C\}$, given G. In this cashless economy the price level is indeterminate.

The solution for steady-state values decomposes into a number of independent calculations. First from (C.1) the natural rate of interest is given by $R = \frac{1}{\beta} - 1$ which is therefore pinned down by the household's discount factor. Equations (C.2) to (C.4) give

$$1 = \beta[1 - \delta + Z\Psi'(Z) - \Psi(Z)] \tag{C.12}$$

which determines steady-state capacity utilization. As in Smets and Wouters (2003) we assume that $Z = 1$ and $\Psi(1) = 0$ so that (C.3) and (C.12) imply that

$$R_K = \Psi'(Z) = \frac{1}{\beta} - 1 + \delta = R + \delta \tag{C.13}$$

meaning that perfect capital market conditions apply in the deterministic steady state.[25]

Finally, it can be shown that capital deepening is given by:

$$\frac{K}{L} = \left[\alpha \frac{A}{\mu R_K}\right]^{\frac{1}{1-\alpha}}$$

This will be useful when comparing the decentralized and social optima. Following the same analysis as earlier, we can derive the equilibrium condition of the empirical model as below:

$$\Gamma = \left(1 + \frac{\mathbb{F}}{Y}\right)^{\phi} Y^{\phi+\sigma} \left(1 - \frac{\delta}{A}\left(\frac{K}{L}\right)^{1-\alpha} - \frac{G + \frac{\delta\alpha}{R_K}\mathbb{F}}{Y}\right)^{\sigma}$$

$$\Upsilon \equiv \frac{(1-\alpha)}{\alpha} \frac{1-\tau_Y}{1+\tau_C} \frac{A^{1+\phi}\left(\frac{K}{L}\right)^{\alpha(1+\phi)}}{(1-h_L)^{\phi}(1-h_C)^{\sigma}}$$

These clearly reduce to the earlier expressions if there is no capital and fixed costs ($K = \alpha = \mathbb{F} = 0$).

C.2 Inefficiency in the Empirical Model

The social planner's problem for the deterministic case is now obtained by maximizing

$$\Omega_0 = \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_t - h_C C_{t-1})^{1-\sigma}}{1-\sigma} - \frac{(L_t - h_L L_{t-1})^{1+\phi}}{1+\phi} + u(G_t)\right]$$

with respect to $\{C_t\}$, $\{K_t\}$, $\{L_t\}$ and $\{Z_t\}$ subject to the resource constraint:

$$Y_t = A_t(Z_t K_{t-1})^{\alpha} L_t^{1-\alpha} = C_t + G_t + K_t - (1-\delta)K_{t-1} + \Psi(Z_t)K_{t-1}$$

Solving this problem as for the model with no capital we arrive at

$$1 = \beta[1 - \delta + Z^*\Psi'(Z^*) - \Psi(Z^*)] \tag{C.1}$$

[25] As we shall see later Z is socially efficient thus justifying the assumption $Z = 1$.

Hence $Z^* = Z = 1$ and $R_K^* = R_K = R + \delta = \frac{1}{\beta} - 1 + \delta$. Thus the *market rate of capacity utilization is efficient.* However,

$$\frac{K^*}{L^*} = \left[\frac{A\alpha}{R_K}\right]^{\frac{1}{1-\alpha}} > \left[\left(1 - \frac{1}{\zeta}\right)\frac{A\alpha}{R_K}\right]^{\frac{1}{1-\alpha}} = \frac{K}{L} \tag{C.2}$$

and the *market capital-labour ratio is below the social optimum.* The socially optimal level of output can now be solved from

$$\begin{aligned} &\left(1 + \frac{F^*}{Y^*}\right)^{\phi} (Y^*)^{\phi+\sigma} \left[1 - \frac{\delta}{A}\left(\frac{K^*}{L^*}\right)^{1-\alpha} - \frac{G^* + \frac{\delta\alpha}{R_K}F^*}{Y^*}\right]^{\sigma} \\ = \;& \frac{(1-\alpha)A^{1+\phi}\left(\frac{K^*}{L^*}\right)^{\alpha(1+\phi)}(1 - \beta h_C)}{\alpha(1-h_L)^{\phi}(1-h_C)^{\sigma}(1-\beta h_L)} \end{aligned} \tag{C.3}$$

The inefficiency of the natural rate of output can now be found by comparing the equilibrium condition of the empirical model in C.1. Since $Y^{\phi+\delta}$ is an increasing function of Y, we arrive at Proposition 2.[26]

[26] This generalizes the result in Choudhary and Levine (2006) which considered the same model, but without capital.

D Full Model Estimation

Table A1: Posterior means 1980Q1 - 2007Q4

Habit consumption/labour		Prior(Mean, Std)	$\mathbb{M}_1$ -/-	$\mathbb{M}_2$ ext/-	$\mathbb{M}_3$ int/-	$\mathbb{M}_4$ -/ext	$\mathbb{M}_5$ -/int	$\mathbb{M}_6$ int/int	$\mathbb{M}_7$ ext/ext	$\mathbb{M}_8$ int/ext	$\mathbb{M}_9$ ext/int	$\mathbb{M}_{10}$ -/ext	$\mathbb{M}_{11}$ ext/ext	$\mathbb{M}_{12}$ int/ext
Marginal Likelihood			-727.959	-716.808	-717.883	-729.884	-729.945	-717.674	-717.591	-718.498	-717.082	-726.202	-717.338	-718.037
Posterior Odds			0.000	0.247	0.084	0.000	0.000	0.104	0.113	0.046	0.188	0.000	0.146	0.072
Invest adj. cost	$S''(1)$	$\mathcal{N}$(4.00,1.50)	3.941	4.289	4.258	3.950	3.958	4.224	4.159	4.102	4.307	3.729	4.357	4.277
Cons utility	σ	$\mathcal{N}$(2.00,0.50)	2.922	2.229	2.258	2.977	3.000	2.210	2.211	2.241	2.215	2.798	2.245	2.254
Cons habit	h_C	$\mathbf{B}$(0.50,0.25)		0.487	0.456			0.524	0.553	0.508	0.556		0.449	0.432
Labour habit	h_L	$\mathbf{B}$(0.50,0.25)				0.173	0.196	0.456	0.415	0.412	0.421	-0.628	-0.504	-0.506
Labour utility	ϕ	$\mathcal{N}$(1.20,0.50)	1.452	1.473	1.474	1.357	1.312	1.311	1.395	1.430	1.302	1.716	1.479	1.471
Fixed cost	ϕ_F	$\mathcal{N}$(1.45,0.13)	1.449	1.536	1.532	1.462	1.467	1.550	1.551	1.548	1.554	1.420	1.523	1.520
Capital utilisation	Ψ	$\mathcal{N}$(1.50,0.50)	2.593	2.481	2.479	2.582	2.579	2.463	2.472	2.462	2.476	2.527	2.497	2.477
Wage stickiness	ξ_W	$\mathbf{B}$(0.75,0.10)	0.815	0.783	0.773	0.809	0.804	0.787	0.782	0.773	0.780	0.846	0.782	0.775
Price stickiness	ξ_P	$\mathbf{B}$(0.75,0.10)	0.941	0.940	0.940	0.942	0.941	0.939	0.940	0.940	0.939	0.941	0.939	0.940
Wage indexation	γ_W	$\mathbf{B}$(0.50,0.15)	0.422	0.401	0.397	0.409	0.398	0.392	0.400	0.391	0.383	0.464	0.410	0.399
Price indexation	γ_P	$\mathbf{B}$(0.50,0.15)	0.675	0.666	0.663	0.669	0.655	0.656	0.664	0.659	0.657	0.706	0.667	0.663
R Inflation	θ_P	$\mathcal{N}$(2.00,0.50)	2.424	2.446	2.401	2.358	2.344	2.344	2.359	2.341	2.365	2.482	2.457	2.407
R ΔInflation	$\theta_{\Delta\pi}$	$\mathcal{N}$(0.20,0.10)	0.197	0.183	0.187	0.202	0.201	0.171	0.173	0.180	0.171	0.177	0.185	0.188
R lagged interest	ρ	$\mathbf{B}$(0.80,0.10)	0.822	0.847	0.846	0.818	0.821	0.861	0.853	0.852	0.861	0.829	0.844	0.843
R output	θ_Y	$\mathcal{N}$(0.25,0.25)	0.238	0.255	0.280	0.250	0.231	0.288	0.278	0.304	0.259	0.247	0.244	0.274
R ΔOutput	$\theta_{\Delta Y}$	$\mathcal{N}$(0.25,0.25)	0.418	0.330	0.367	0.423	0.399	0.310	0.312	0.347	0.277	0.377	0.333	0.367
Technology	ρ_a	$\mathbf{B}$(0.85,0.10)	0.941	0.945	0.945	0.941	0.941	0.943	0.944	0.944	0.944	0.938	0.945	0.945
Cons. preference	ρ_C	$\mathbf{B}$(0.85,0.10)	0.879	0.757	0.770	0.875	0.870	0.654	0.688	0.717	0.648	0.892	0.781	0.782
Government expend.	ρ_g	$\mathbf{B}$(0.85,0.10)	0.950	0.942	0.940	0.949	0.950	0.940	0.942	0.940	0.941	0.948	0.942	0.942
Labour supply	ρ_L	$\mathbf{B}$(0.85,0.10)	0.940	0.946	0.957	0.936	0.949	0.961	0.955	0.956	0.961	0.935	0.958	0.959
Investment	ρ_I	$\mathbf{B}$(0.85,0.10)	0.560	0.628	0.601	0.565	0.594	0.682	0.659	0.628	0.716	0.592	0.610	0.592
Standard Deviations														
Technology	ϵ_a	$\Gamma^{-1}(0.60, 4)$	0.396	0.389	0.390	0.397	0.396	0.389	0.388	0.389	0.389	0.402	0.389	0.390
Inflation target	$\epsilon_{\overline{\pi}}$	$\Gamma^{-1}(0.10, 4)$	0.151	0.137	0.148	0.171	0.161	0.157	0.151	0.164	0.147	0.152	0.135	0.148
Cons. preference	ϵ_C	$\Gamma^{-1}(2.00, 4)$	2.272	2.917	2.732	2.272	2.320	2.774	3.247	2.946	3.113	2.216	2.778	2.610
Government expend.	ϵ_g	$\Gamma^{-1}(2.00, 4)$	2.764	2.776	2.772	2.760	2.760	2.795	2.776	2.775	2.771	2.760	2.768	2.767
Labour supply	ϵ_L	$\Gamma^{-1}(3.00, 4)$	2.278	2.398	2.469	2.273	2.270	2.504	2.565	2.647	2.506	2.187	2.398	2.448
Investment	ϵ_I	$\Gamma^{-1}(6.00, 4)$	4.926	4.624	4.847	4.812	4.687	4.367	4.384	4.733	4.086	5.044	4.641	4.895
Monetary policy	ϵ_r	$\Gamma^{-1}(0.10, 4)$	0.081	0.133	0.136	0.098	0.100	0.164	0.160	0.165	0.160	0.069	0.116	0.120
Equity premium	ϵ_Q	$\Gamma^{-1}(0.50, 4)$	1.309	1.410	1.289	1.318	1.420	1.565	1.515	1.355	1.683	1.420	1.381	1.280
Price markup	ϵ_P	$\Gamma^{-1}(0.20, 4)$	0.142	0.143	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.141	0.142	0.142
Wage markup	ϵ_W	$\Gamma^{-1}(0.20, 4)$	0.330	0.330	0.328	0.329	0.328	0.328	0.329	0.330	0.329	0.331	0.329	0.328

Note: Distributions are Normal, $\mathcal{N}$ Beta, $\mathbf{B}$, and Γ^{-1} = Inverted gamma density with degrees of freedom instead of standard deviation.

E International Differences in Average and Total Tax Wedges.

Table 2A: Tax wedge as a % of labour Costs, 2012(1)

Country	Income tax	Employee SSC	Employer SSC	Total Wedge(2)	Av. Wedge
France	10.2	9.5	30.6	50.2	16.7
Germany	16.0	17.3	16.4	49.7	16.6
Greece	6.9	12.8	22.2	41.9	14.0
Italy	16.1	7.2	24.3	47.6	15.9
Japan	6.6	12.0	12.6	31.2	10.4
Korea	4.4	7.4	9.2	21.0	7.0
Netherlands	14.9	13.9	9.7	38.6	12.9
Spain	13.5	4.9	23.0	41.4	13.8
Sweden	13.6	5.3	23.9	42.8	14.3
United Kingdom	14.0	8.5	9.8	32.3	10.8
United States	15.6	5.1	8.9	29.6	9.9
Std. Dev	4.2	4.1	7.7	9.3	3.1
OECD Average	13.1	8.2	14.1	35.6	11.9

Note: (1): Single individual without children at the income level of the average worker.
(2) Column 5 is the summation of columns 2-4.
Source: OECD Economic Outlook Volume 2012 (No. 92).