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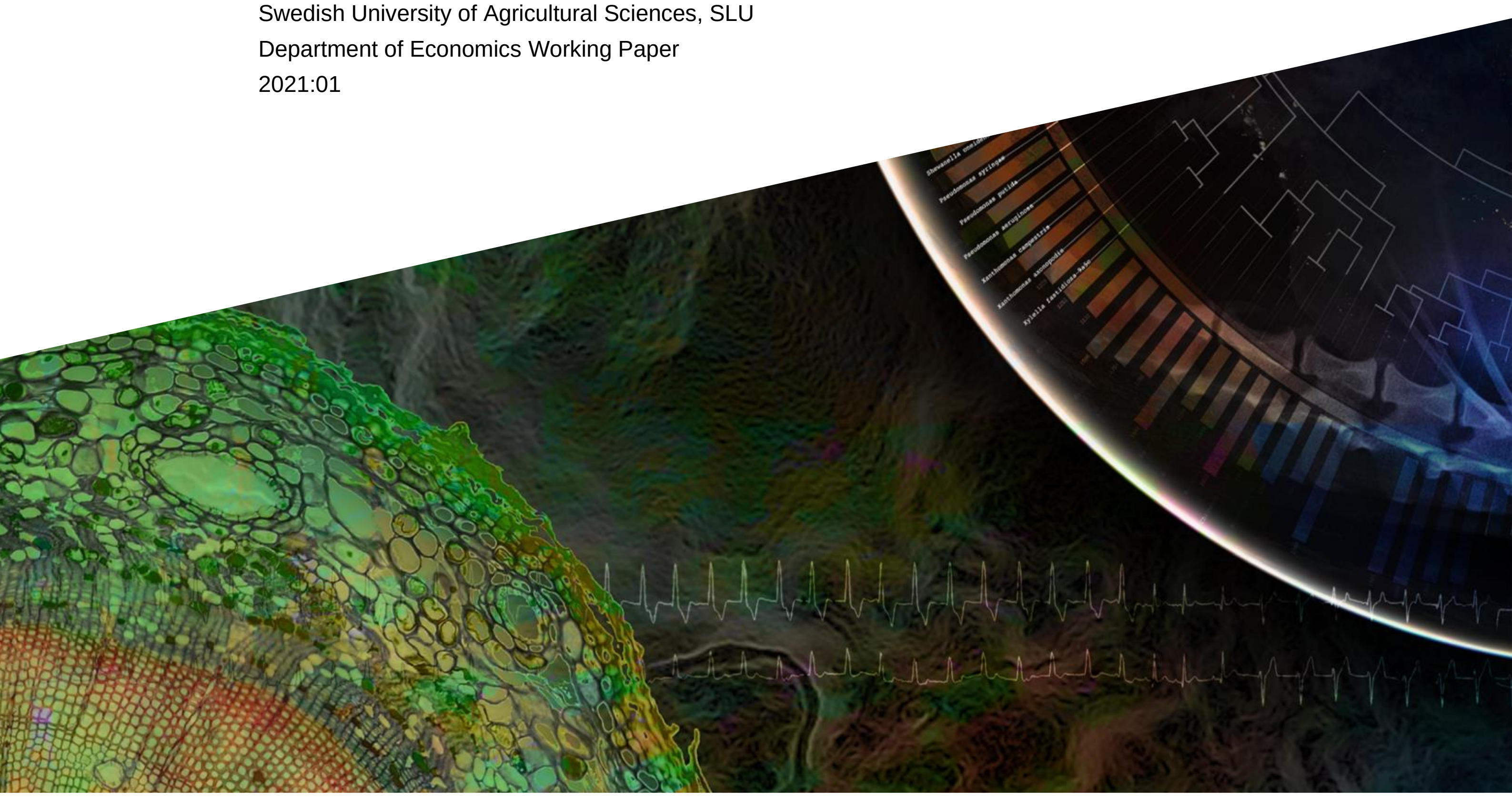

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Working hours, status consumption, and optimal taxation[☆]

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Abstract

We build a growth model focusing exclusively on household choices, including both pollution and consumption externalities. The consumption of status goods helps to motivate labour supply, and the importance of this effect increases as productivity increases. This accounts for two stylized facts: firstly, although labour supply declines with income at low incomes (both for time series and cross-sectional country data, and for cross-sectional individual data), the decline levels off at high incomes; and secondly, that expenditure tends to shift towards energy- and resource-intensive goods with rising income. To achieve first best—with a long-run increase in leisure and decline in pollution—taxes on both emissions and status goods should increase with productivity. When we parameterize the model to match patterns of labour supply across leading economies, the shift of taxation to status goods causes a significant drop in labour supply, and an even larger drop in polluting emissions.

1. Introduction

> [We are] being persuaded to spend money we don't have, on things we don't need,
> to create impressions that won't last, on people we don't care about.

The words—from a TED talk by Tim Jackson (2010)—are part of an argument questioning the pursuit of consumption growth. Are we choosing unsustainable consumption patterns driven by competition for status? As productivity grows, our choice set increases. We can choose what to consume, and also *whether* to consume; there is a trade-off between consumtpion and leisure. When the choices of individuals impinge on others' utility, laissez faire implies non-optimal allocations. Most obviously, consumption of pollution-intensive goods is excessive, a problem which grows in importance as productivity grows, as Hart (2020) shows. Furthermore, we argue that consumption of goods which give the buyer status is also excessive, and that this problem grows in importance with increasing productivity.

The key to our model is the utility function. Households must consume a minimum quantity of a subsistence good to survive, and when productivity is sufficiently low this is their sole focus, as in Ohanian et al. (2008). However, as productivity increases they must choose between a standard consumption good, a status good, and leisure, which are poor substitutes (elasticity of substitution less than 1). The status good has two crucial features. Firstly, although its consumption gives utility directly, its consumption *relative to other households* is also an argument of the utility function. The second crucial feature is that, following Fraja (2009)—who argues that evolutionary selection pressure gives rise to a 'conspicuous consumption gene' favouring demonstration of status through showing control over resources—we assume that the status good is also resource-intensive and hence also pollution-intensive.

Initially, as productivity grows, both ordinary consumption and leisure are close to zero. On the other hand, since we assume symmetric equilibrium, relative consumption of the status good is always equal to 1 in equilibrium. The result is that households focus on raising the former two, and not the latter, when productivity is low but increasing; both consumption and leisure grow whereas status consumption takes a back seat. But as productivity grows further, ordinary consumption rises without bound and thus becomes much larger than both leisure (which is bounded by the number of waking hours in the day) and relative status consumption

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(which is locked at 1). Hence when productivity is high the focus of households switches to the balance between leisure and status consumption, and the purchase of status goods becomes the main motivation behind labour supply. In the long run the laissez faire economy approaches a balanced growth path with constant labour supply, exponentially increasing consumption of status goods, and constant (high) emissions of pollution. However, under optimal regulation—which involves a Pigovian pollution tax and a consumption tax on the status good—labour supply approaches zero, ordinary consumption grows without bound, and pollution approaches zero.

The paper picks up on the well-known paper of Keynes (1930), who argued that technological progress must render work—motivated by the satisfaction of absolute needs—largely unnecessary in the long run, but that we would continue to work nonetheless, motivated by competition for status. Labour supply has indeed levelled off in the richest countries, but at a much higher level than that predicted by Keynes. This levelling of can be seen most clearly in Ohanian et al. (2008), who focus on time-series analysis of leading economies, and allow for the effects of changing tax rates. Furthermore, Bick et al. (2018) present cross-sectional within country data which also clearly shows the same effect: at low incomes, labour supply declines with the hourly wage, but at high incomes there is, if anything, a rise in labour supply with the wage.[1]

The paper that comes closest to formalizing Keynes' argument is Ohanian et al. (2008). They postulate a generalized Stone–Geary utility function with arguments leisure and net consumption $C+G-\overline{C}$, where $\overline{C}$ is subsistence consumption. Thus when productivity is low labour supply is largely determined by the need to achieve the subsistence minimum, but as productivity increases the subsistence minimum becomes less and less relevant, and labour supply decreases. When productivity is very high, the subsistence minimum is irrelevant and the balance between labour supply and leisure depends on the balance between the income and substitution effects of increasing productivity: if the income effect dominates, labour supply will approach zero, whereas if the substitution effect dominates then we will go back to very long working hours as we get even richer. And if they exactly cancel out (the knife-edge condition assumed by Ohanian et al. (2008)) then labour supply will approach an intermediate level, and differences in long-run labour supply between countries will depend on differences in the tax wedge.[2]

However, Keynes's prediction of a flattening out of labour supply was not due to a knife-edge balance between substitution and income effects, but rather to a balance between leisure and the desire for status goods.[3] For Keynes it is obvious that the elasticity of substitution between leisure and consumption should be less than 1, implying that in the absence of other factors (such as status effects) the long run must involve leisure increasing towards the limit (i.e. zero labour) while consumption also increases without bound. Ohanian et al.'s work contributes to the debate about the effect of taxes on long-run labour supply triggered by Prescott (2004), who argued that differential trends in tax rates between countries can explain different trends in labour supply, in particular the rise in US labour supply relative to many European countries. The question is controversial, as Keane and Rogerson (2012, p.464) explain: '[R]esearchers who look at micro data typically estimate relatively small labor supply elasticities. But researchers who use representative agent models to study aggregate outcomes typically employ parameterizations that imply relatively large aggregate labor supply elasticities.' We show that consumption externalities can explain the discrepancy.

The inclusion of consumption externalities links not just to the literature on long-run labour supply, but also to the literature on the importance of consumption externalities and the need for taxes on status goods; see for instance Frank (2005). One of the central results from models in which relative consumption enters the utility function is that labour is oversupplied in laissez faire compared to first best: see for instance Persson (1995) and Wendner and Goulder (2008) for theory, and Neumark and Postlewaite (1998) and Bowles and Park (2005) for empirical

[1]Note however that both Bick et al. (2018) and Boppart and Krusell (2020) argue that the country-level data is consistent with steadily falling labour supply with income, Bick et al. on the basis of cross-sectional data, and Boppart and Krusell using time series. Using the same data we argue, in the next section, that there is a clear levelling off at high incomes.

[2]Ohanian et al. as allow the ratio of GDP to consumption to affect labour supply, but since this is almost constant over time this has little effect.

[3]Note that Keynes also puts forward an alternative explanation for continued labour supply, our urge 'to strive and not to enjoy'.

evidence that consumption externalities really do raise labour supply.[4] However, there is little work linking consumption externalities to the dynamics of labour supply in the context of a growing economy, and in the modern macroeconomic literature on long-run labour supply consumption externalities are rarely mentioned. Our contribution in relation to this literature is to specify, analyse and simulate a dynamic model, showing both how the importance of consumption externalities increases with growth, and how the inclusion of such externalities can explain observed patterns such as the levelling-off of labour supply and the shift into conspicuous—and resource-intensive—goods.

Finally, the paper contributes to the debate about growth, consumption patterns, and environmental policy. In addition to predicting a strictly positive limit to long-run aggregate labour supply, our model also predicts a shift in the composition of consumption towards status goods. It is well known, at least since Engel (1857), that economic growth goes hand-in-hand with systematic shifts in patterns of consumption: as income increases, the share of necessities such as food declines while luxury goods increase their share.[5] But luxury is a relative concept, and Matsuyama (2002) argues that as productivity improves, more goods become affordable, and households expand the range of goods they consume. Hart (2018) argues that the 'frontier' goods—such as private cars in the post-war period, passenger flight during the last 30 years, perhaps private (or space) flight in the next 30—tend to be more energy-intensive than the established goods, hence there is an overall shift in composition towards increasingly energy-intensive goods, which counterbalances the technique effect of increasing energy efficiency and hence explains why aggregate energy efficiency increases so slowly. For heuristic evidence that purchase of increasing quantities of energy-intensive and conspicuous goods drives labour supply, consider vehicles and housing: Knittel (2011) and Hart (2018) provide evidence of dramatic shifts to heavier and more powerful vehicles in the US, while census bureau data[6] shows that (based on the average new house and the average household) living space per person rose from 551 to 1051 square feet between 1973 and 2015, matching GDP growth, whereas building costs per square foot were approximately constant.[7] Some evidence for such shifts can also be seen on the production side of the economy, where for instance Brunel (2017) notes shifts in composition towards pollution-intensive goods. Could these patterns be explained by a shift towards status goods?

Fraja (2009) argues that a link between status and the energy and resource intensity of consumption is a logical result of evolutionary selection pressure giving rise to a 'conspicuous consumption gene', since such consumption demonstrates control over resources. In line with this hypothesis, many papers show a very high degree of positionality for housing and cars; see for instance the hypothetical choice experiments of Alpizar et al. (2005), and the econometric analysis of Charles et al. (2009) which shows that households which have a particular need to demonstrate status (because they have other observable attributes that signal low status) spend more on positional goods including cars. Finally, Jorgenson et al. (2017) show that at state level in the US there is a positive correlation between carbon emissions and the income share of the top 10 percent. They argue that in unequal societies the need to signal status is greater (see for instance Persson, 1995), and that status is signalled through consumption of carbon-intensive goods.

The remainder of the paper is structured as follows. In Section 2 we discuss existing data on long-run labour supply. We present the model in Section 3, solve it in the presence of an optimal consumption tax in Section 4, and solve without a consumption tax in Section 5. In Section 6 we take the model to the data. Section 7 concludes.

2. Data on labour supply and productivity

The aim of our data analysis is to get an approximate picture of the changes over time in labour supply per capita as labour productivity increases. We plot both time series and cross-sectional data, and also cross-sectional within-country data.In the time-series plot, Figure 1(a), we plot annual hours against GDP per capita over the period 1956–2019. Since countries

[4] Neumark and Postlewaite show that a woman who's sister's husband earns more than her own husband is significantly more likely to work herself, apparently trying to make up the shortfall in relative income, and Bowles and Park estimate a structural model in which consumption externalities raise labour supply.

[5] See Houthakker (1957) for a discussion of Engel's law.

[6] Historical household tables, and 2015 Characteristics of new housing.

[7] Conspicuous goods are of course not all energy- and resource-intensive. According to data from FashionUnited Business Intelligence, the fashion industry accounts for a remarkable 10 percent of the UK economy.

differ greatly in population we aggregate across our sample to get a single curve. We wish to see if the data support our hypothesis that the pattern changes with productivity (at low productivity the curve should be steeper than at high productivity), hence we cannot aggregate across countries at different stages of development; therefore we select countries which have been at or close to the global technology frontier throughout the period (and thus can be assumed to have broadly comparable labour productivities throughout): the G7.[8] In the cross-sectional plot, Figure 1(b), we take the data of Bick et al. (2018), order the countries by labour productivity (GDP per capita divided by hours worked per capita) then divide the countries into population deciles. We then calculate average hours and plot against average productivity in each decile, giving us (in each case) 10 points each representing equal populations at different productivity levels.

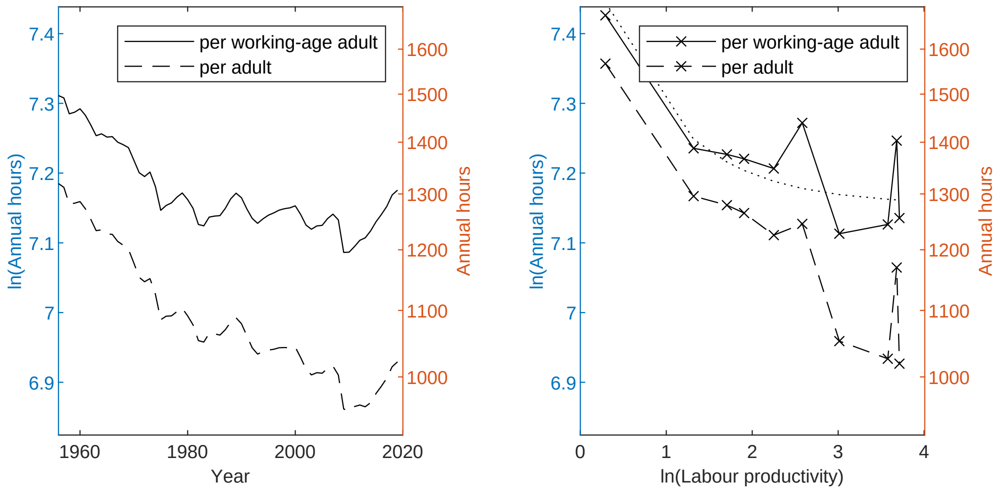

Figure 1: Data over aggregate annual hours. (a) Time-series data for the G7. (b) Cross-sectional data for 81 countries divided into population deciles according to productivity. Sources: (a) OECD and GGDC Total Economy Database; (b) Bick et al. (2018) and World Bank population data. Note: In (b) the US is split across the last two deciles.

Note that Boppart and Krusell (2020) show data for hours per working-age adult, whereas Bick et al. show data for all adults, not just working age. We plot both, in both panels. The plots per adult (i.e. including over-65s) show a steeper decline in hours, especially for the richer countries where the number of over-65s increases steeply with income (and hence also with time). However, it seems likely that a large proportion of these extra adults are not capable of full-time work, hence we suggest that the plots per working-age adult are most relevant when analysing household choices between labour and leisure, although the 'true' picture is likely to lie between the two curves.

In the time-series plot we show the log of hours, so the slope shows the percentage drop in hours per year. In the cross-section plot we use log–log, so the slope shows the percentage drop in hours for a 1 percent increase in productivity. Both of the curves showing hours per working-age adult show a clear association between higher income and a slower rate of decline in hours; indeed, the decline in hours slows dramatically at high incomes. The effect is less marked for hours per adult, where the increase in the proportion of retirees with productivity (and over time) pulls the curves down. Three other notable features are (i) the big dip in hours in 2008/9, caused by the financial crisis, (ii) the high hours in the sixth decile of the cross-sectional data, primarily driven by the high labour supply in Russia, whose population dominates this decile, and (iii) the high hours in the ninth decile, which is dominated by the US.

In Figure 2 we show the relationship between wages and labour supply within 16 high-income countries. Taking data from Bick et al. (2018), we focus on the richest countries in the dataset, and all workers (including self-employed). We see that the deciles with the lowest income tend to work longer hours, whereas for the high-income deciles there is no

[8] We follow Boppart and Krusell (2020) by taking data on total population from the OECD, and on total hours worked from the GGDC Total Economy Database. We complement the population data for Germany with data for the form DDR from `http://www.populstat.info/Europe/germanec.htm`. Furthermore, population data is missing from 2015 but since changes are very slow over the large period for which we have data, we assume constant population over the five missing years.

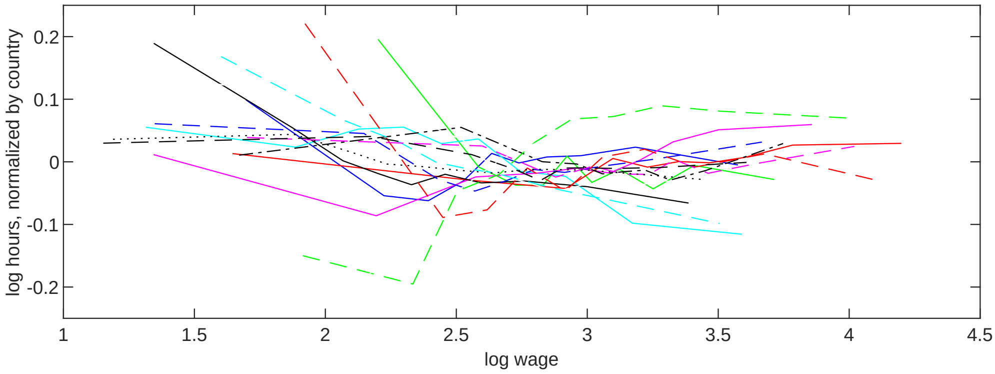

Figure 2: Hours per worker by wage deciles by country, for the richest 16 countries in Bick et al.'s sample. Note that we plot log–log, so a straight line indicates a constant rate of decline. Countries AUT, BEL, CHE, CYP, DEU, DNK, ESP, FIN, FRA, GBR, IRL, ITA, NLD, SVN, SWE, USA.

clear relationship between wages and hours.

3. The baseline model

Recall that we focus exclusively on household choices. The heart of the model is therefore the utility function of household i:

$$u_i = \left[\beta_c {c_i}^{(\varepsilon-1)/\varepsilon} + \beta_y (y_i/\overline{y})^{(\varepsilon-1)/\varepsilon} + l_i^{(\varepsilon-1)/\varepsilon} + \beta_q q^{(\varepsilon-1)/\varepsilon}\right]^{\varepsilon/(\varepsilon-1)}. \tag{1}$$

The four arguments of the function are non-essential consumption c_i, consumption of status goods y_i relative to average consumption of such goods $\overline{y}$, leisure is l_i, and household i's environmental quality is q_i. The parameter ε is the elasticity of substitution between the inputs, which is less than 1, and β_c, β_y, and β_q are positive parameters. For a well-defined utility function leisure, non-essential consumption and environmental quality must be strictly positive. Aggregate quantities are denoted without a subscript. We assume a representative consumer, so these are equivalent to the quantities of the representative consumer.

The arguments of the utility function are of course linked. For household i, non-essential consumption

$$c_i = \min\left\{\frac{x_i - \overline{s}}{1-\alpha}, \frac{y_i}{\alpha}\right\}, \tag{2}$$

where x and y are the two produced goods, $\overline{s}$ is essential consumption, and $\alpha \in (0,1)$. So c_i is a Leontief function of consumption of $x_i - \overline{s}$ and y_i, and we have two constraints, $c_i \leq (x_i - \overline{s})/(1-\alpha)$ and $c_i \leq y_i/\alpha$. The first of these will always bind, but the second may not since y is in demand for status as well as the intrinsic utility of its consumption. Hence

$$c_i = (x_i - \overline{s})/(1-\alpha) \quad \text{and} \quad y_i/\alpha \geq c_i \tag{3}$$

are necessary conditions for an optimal allocation of household resources.

Total time allocation is 1, so labour (which is non-negative) is $h_i = 1 - l_i$. Given exogenous productivity A the aggregate resource constraint is

$$x + y = Ah$$

so the unit production costs of both x and y are normalized to 1 (without loss of generality). Returning to the necessary conditions (3), we can now see that when the restriction binds, unit production costs of c are 1, and the share of y in these costs is α.

Production of x does not lead to any pollution flows, whereas production of y is polluting, and pollution flow p reduces environmental quality q. The pollution flow depends on production and an efficiency parameter A_p, and the effect on q depends on the positive parameter ψ:

$$p = y/A_p;$$
$$q = 1 - \psi p.$$

A regulator may impose an emissions tax τ per unit of polluting emissions, and a consumption tax σ per unit of the conspicuous good y, and define the optimal levels of these taxes τ^* and σ^*, where τ^* is denoted a Pigovian tax. In addition, the regulator can impose a an income tax ω, to generate revenue to finance public services (modelled as lump-sum transfers). Finally, we define w_c:

$$w_c = 1 + \alpha\tau/A_p,$$

with a corresponding definition for w_c^*. Thus household i's total expenditure on x and y is $x_i + (1 + \tau/A_p + \sigma)y_i$. Furthermore, the household may buy environmental quality at price w_q through trade with other households (we can think of rich households paying to live in areas with high environmental quality), given an initial endowment $e_i q$ where e_i is the household's initial share. Hence household i's resource constraint is

$$A_i(1-l_i)(1-\omega) = x_i + \left(1 + \frac{\tau}{A_p} + \sigma\right) y_i + w_q(q_i - e_i Q) - L$$

where L represents lump-sum transfers from the regulator to the (representative) household.

The model is essentially static: there are no endogenous state variables. However, we are interested in the dynamics of the solution over time—and the dynamics of the optimal policy instruments—as the productivity factors grow. We assume that

$$\dot{A}/A = \dot{A}_p/A_p = g,$$

hence the two productivity factors grow at equal rates. Furthermore, we consider a market economy starting in year $t = 0$ when productivity is marginally above the minimum survival level $A = \overline{s}$.

In the next two sections we focus on an economy with no need for public funds, hence the optimal labour tax ω is zero, while a Pigovian emissions tax and a 'consumption tax' on the status good y are needed to achieve first best. In the following two Lemmas we find the optimal levels of these taxes.

Lemma 1. *When $y = \alpha c$ the* Pigovian tax *is given by*

$$\tau^* = \frac{\psi}{\frac{\beta_c}{\beta_q}\left(\frac{1}{c} - \frac{\alpha\psi}{A_p}\right)^{1/\varepsilon} - \frac{\alpha\psi}{A_p}} \tag{4}$$

and

$$w_c^* = \frac{\frac{\beta_c}{\beta_q}\left(\frac{1}{c} - \frac{\alpha\psi}{A_p}\right)^{1/\varepsilon}}{\frac{\beta_c}{\beta_q}\left(\frac{1}{c} - \frac{\alpha\psi}{A_p}\right)^{1/\varepsilon} - \frac{\alpha\psi}{A_p}}. \tag{5}$$

And when $y > \alpha c$ we have

$$\tau^* = \psi\frac{\beta_q}{\beta_c}\left(\frac{c}{1 - \psi y/A_p}\right)^{1/\varepsilon}. \tag{6}$$

Proof. The Pigovian tax τ, applied per unit of emissions, is by definition equal to the monetary value of marginal damages. When $y = \alpha c$ we can take equation (1) and set τ equal to the social cost of the marginal increase in c (price w_c) that would compensate for a marginal increase in p, i.e. $\tau = (1 + \alpha\tau/A_p)(-\partial u_i/\partial p_i)/(\partial u_i/\partial c_i)$ (noting that q is a function of p_i). And when $y > \alpha c$ we can substitute $c_i = (x_i - \overline{s})/(1-\alpha)$ into equation (1), then $\tau = (-\partial u_i/\partial p_i)/(\partial u_i/\partial x_i)$; note that the price of the input x is simply 1. □

Lemma 2. *The* optimal consumption tax *is given by*

$$\sigma = (1/\alpha + \tau/A_p)(\chi/\gamma)^{(1-\varepsilon)/\varepsilon} c^{(1-\varepsilon)/\varepsilon}.$$

Proof. When the optimal consumption tax applies then $y = \alpha c$, hence we can take equation (1) and find $\sigma = (1 + \alpha\tau/A_p)(-\partial u_i/\partial\overline{y})/(\partial u_i/\partial c_i)$. □

4. Solution with a consumption tax σ

To solve the model we set up Lagrangians and take first-order conditions. As long as we focus on symmetric equilibria there will be no trade in the environmental good, hence we can simplify slightly by dropping such trade. And we can simplify further using the following Lemma.

Lemma 3. *In the presence of an optimal consumption tax σ^* household i's problem is identical to the problem facing a household which gains no utility from relative consumption. Hence we can solve the household's problem by setting up and solving the simpler problem without relative consumption.*

Proof. Follows since the optimal tax fully corrects the consumption externality. □

So in the presence of the consumption tax we can focus purely on the trade-off between c_i and l_i, and write household i's Lagrangian as follows:

$$\mathcal{L}_i = \left[\beta_c c_i^{(\varepsilon-1)/\varepsilon} + l_i^{(\varepsilon-1)/\varepsilon}\right]^{\varepsilon/(\varepsilon-1)} + \mu_i \left[A_i(1-l_i)(1-\omega) - \bar{s} - \left(1+\frac{\alpha\tau}{A_p}\right)c_i + L\right].$$

FOCs yield Proposition 1.

Proposition 1. *Under an* optimal consumption tax σ^*, *when productivity is sufficiently low increasing productivity leads to a monotonic rise in non-essential consumption, leisure, and pollution—starting from a lower limit of zero when productivity is at the minimum level necessary for survival—driven by the decreasing salience of the subsistence minimum. However, the long-run growth path depends on whether $\varepsilon < 1, = 1$, and > 1. The limiting growth rate of c (as $A \to \infty$) is equal to $\min\{\varepsilon g, g\}$, so consumption always grows without bound. However, the behaviour of the other variables in the limit differs in the three cases:*

(i) When $\varepsilon < 1$, $\{\dot{h}/h\}_{\lim} = \{\dot{p}/p\}_{\lim} = -(1-\varepsilon)g$ *and* $l \to 1$;

(ii) When $\varepsilon = 1$, $l \to w_c^*/(w_c^* + \beta_c)$, $h \to \beta_c/(w_c^* + \beta_c)$, *and* $p \to \alpha(A/A_p)\beta_c/(w_c^* + \beta_c)$;

(iii) When $\varepsilon > 1$, $\{\dot{l}/l\}_{\lim} = -(\varepsilon-1)g$, $h \to 1$, *and* $p \to \alpha A/A_p$,

where $\gamma_c = \beta_c(1-\omega)$, and the subscript 'lim' indicates the limiting value as $A \to \infty$. So in (i) labour and pollution approach zero, and leisure approaches its upper limit; in (ii) h, l and p all approach strictly positive limits, with the balance between labour and leisure determined by the parameter β_c; and in (iii) labour and pollution approach zero, and leisure approaches its upper limit. Finally, note that if we shift from $\tau = 0$ to $\tau = \tau^*$ the limiting growth rates are all identical, but labour supply, consumption, and pollution are all lower—at all times—given the Pigovian tax.

Proof. Take FOCs in l_i and c_i and eliminate μ_i to yield, for the representative household,

$$l/c = (w_c/A)^\varepsilon / [\beta_c(1-\omega)]^\varepsilon. \tag{7}$$

And given the aggregate resource constraint,

$$A(1-l) = \bar{s} + c, \tag{8}$$

we have

$$l = \frac{(A-\bar{s})\left(\frac{w_c}{A}\right)^\varepsilon}{\beta_c^\varepsilon(1-\omega)^\varepsilon + A\left(\frac{w_c}{A}\right)^\varepsilon} \tag{9}$$

and

$$c = \frac{(A-\bar{s})\beta_c^\varepsilon(1-\omega)^\varepsilon}{\beta_c^\varepsilon(1-\omega)^\varepsilon + A\left(\frac{w_c}{A}\right)^\varepsilon}. \tag{10}$$

The results then follow straightforwardly, using in addition equations 4 and 5.[9] □

[9] To prove (i), assume first that c is not increasing despite $g > 0$. Then from the proof of Lemma 1, τ and w_c must be declining. Therefore (from 10) c must be increasing, a contradiction. So c must rise monotonically. Now note that w_c/A is declining (from Lemma 1), so equation (9) shows that l is increasing. Turning to (ii), this follows by construction: production of x is pollution-free, but this is not so for y. Part (iii) can be shown by letting A and A_p approach infinity in equations (10) and (4) to show that w_c approaches a limit. The limiting growth rates of c and l then follow straightforwardly from (9) and (10); note that $c/A^\varepsilon \to 1/[w_c^\varepsilon \gamma^{(1-\varepsilon)}]$. For the growth rates of h and p note that in the limit there is no structural change, $\dot{h}/h$ is $-g$ plus the growth rate of c, and $\dot{p}/p = \dot{h}/h$. Finally, under Pigovian taxation $w_c > 1$ for any strictly positive consumption rate c.

The results are illustrated in Figures 3, 4, and 5. In Figure 3 we see how average labour hours per capita change with increasing productivity, in each of the three cases ($\varepsilon < 1$, $= 1$, and > 1); note the initial decline in each case, and the different long-run limits; note also the effect of the Pigovian tax. In Figure 4 we see how consumption of the non-essential good c changes over time in each case: we use a log scale to show changing growth rates clearly.[10] Note the initial rapid growth, which stabilizes at εg when A is high; note the level effects of the different choices of ε, and the effect of the Pigovian emissions tax. The growth rate of pollution is equal to the growth rate of production minus g, hence when $\varepsilon < 1$ pollution approaches zero, but when $\varepsilon \geq 1$ it approaches a strictly positive limit, as we see in Figure 5.

Crucially, Proposition 1 shows that at low productivities the pattern of labour supply is dominated by the diminishing salience of the subsistence minimum, causing labour hours to fall as productivity increases. But at high productivities labour supply is determined by ε, the elasticity of substitution between consumption and leisure: if this elasticity is less than 1, increasing productivity leads to increases in both consumption and leisure, and labour supply approaches zero. If on the other hand it is greater than 1 then leisure is willingly sacrificed for consumption at high productivities, and leisure approaches zero. Finally, in the knife-edge case of $\varepsilon = 1$, both labour and leisure approach strictly positive limits which are determined by preferences and the rate of income taxation ω. These three cases are illustrated in Figure 3.[11]

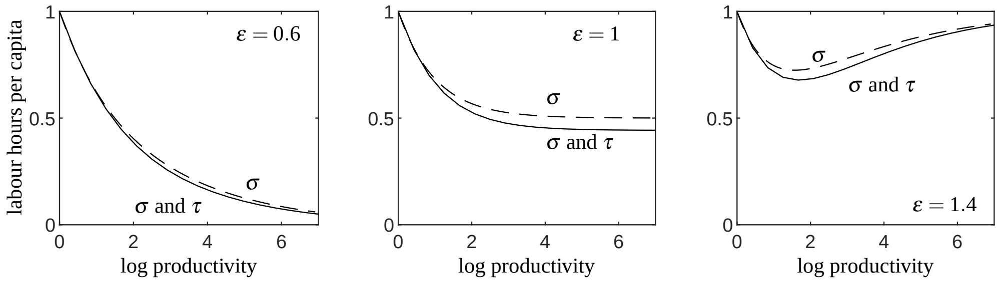

Figure 3: Simulations of the increase in average hours with productivity. When $\varepsilon < 1$, hours approach zero; when $\varepsilon > 1$ they approach the upper limit (leisure approaches zero), and when $\varepsilon = 1$ we have the knife-edge case.

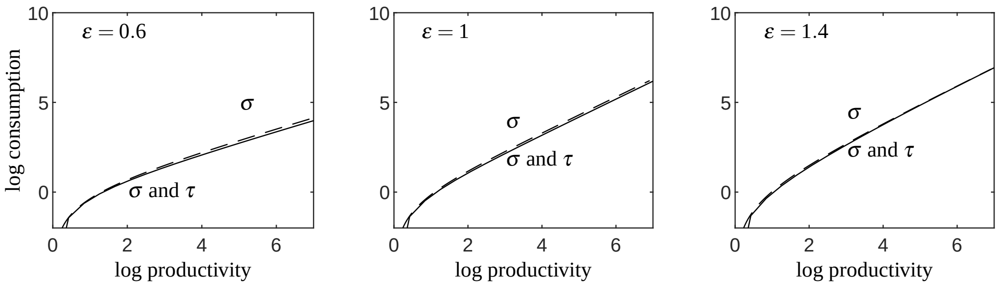

Figure 4: Simulations of the increase in non-essential consumption c with productivity. In all cases, $\log c$ increases from the limit of $-\infty$ at the minimum level of productivity, and then approaches a constant growth rate of εg when $\varepsilon \leq 1$, and g when $\varepsilon > 1$.

In Figures 4 and 5 we see non-essential consumption and pollution. Consumption cannot grow faster than g in the long run; when $\varepsilon < 1$ then the long-run decline in labour hours (approaching zero) pulls down the long-run growth rate of consumption: both leisure and consumption grow in the limit. And when consumption grows more slowly than productivity, polluting emissions decline. Note that in all cases the additional effect of the Pigovian emissions tax is modest. The fundamental reason is that the tax can only affect emissions by pushing down labour supply: households are already consuming the most environmentally friendly good possible (i.e. the non-essential consumption good c) and by construction there is no possibility to reduce emissions through green technology.

These results are identical to the results we would obtain from a model in which there were no consumption externalities, as Lemma 3 makes clear. Thus we have a candidate explanation

[10] We do not show y, since c and y track each other in each case, since $c = \alpha y$.

[11] Parameters in all three figures: $\psi = 1$; $\alpha = .33$; $\beta_c = \beta_y = \beta_q = 1$; $\bar{s} = 1$; $A_0 = 1.01$; $A_p = A$; $g = 0.023$. Note that the key equations for the programs for the figures based on theory are to be found in Appendix B.

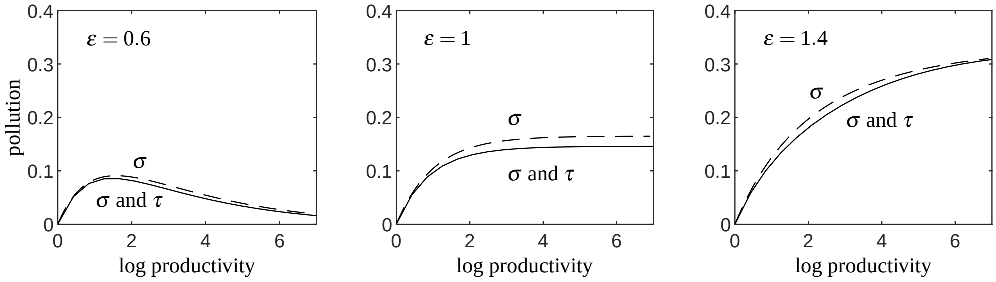

Figure 5: Simulations of the increase in pollution with productivity. When, in the limit, labour approaches zero and consumption grows at a rate less than g, then pollution approaches zero. Otherwise it approaches a strictly positive limit.

for the levelling off in labour supply at high incomes. (Recall that this levelling off is observed at country level over time, at country level cross-section, and within countries cross-section; see Figure 1.) This explanation has nothing to do with consumption externalities: it is simply that the elasticity of substitution between leisure and non-essential consumption is 1, but that at low income non-essential consumption does not grow linearly with income because a fixed portion of income must be spent on subsistence consumption. This is precisely the explanation of Ohanian et al. (2008), who set the relevant elasticity equal to 1 by construction.

Note that, just as in Ohanian et al. (2008), when $\varepsilon = 1$ in our model the long-run level of labour supply depends on preference parameters and the tax wedge $(1-\omega)/(1+\alpha\tau/A_p)$: higher taxes drive down labour supply. In Section 6 we compare the ability of the alternative models—without consumption externalities and with $\varepsilon = 1$, à la Ohanian et al. and with consumption externalities and $\varepsilon < 1$, our base case. Note however that apart from the ability to fit the data, there are at least three potential advantages to our approach. Firstly, the Ohanian result relies on a knife-edge condition, that it that long-run labour supply levels off because the elasticity of substitution between leisure and consumption happens to be exactly 1. Secondly, the 'consumption externalities' explanation coheres with a lot of data and analysis showing that the desire to signal status is an increasingly important driver of our choices, including with regard to labour supply. And thirdly, consumption externalities offer a natural explanation for the observed difference between the (high) 'macroeconomic' elasticity of labour supply to taxation, as opposed to the (low) 'microeconomic' elasticity of labour supply to income shocks.

5. Solution without a consumption tax

We now turn to the cases in which the consumption externality is not corrected, i.e. when $\sigma = 0$. A crucial fact to bear in mind in these cases is that relative consumption of conspicuous goods is always equal to 1 in symmetric equilibrium. When A is low, relative consumption $(= 1)$ is large relative to non-essential consumption, and restriction (3) binds. That is, consumers buy good y as a complement to their purchases of good x, rather than to boost relative consumption; if this complementarity were weaker, they would buy less y. However, when A is high, relative consumption is small relative to non-essential consumption, and they buy more y than is needed to complement x, motivated by their desire to boost relative consumption. So in each case there is some critical value of A at which the restriction ceases to bind.

To solve the model we set up the Lagrangian and take first-order conditions. Again, we simplify the presentation by dropping trade in the environmental good from the start. However, by contrast to the case with a consumption tax, we now consider the variables x_i, y_i, and l_i rather than c_i and l_i, and the Lagrangian for the household i is as follows:

$$\mathcal{L}_i = \left[\beta_c\left(\frac{x_i - \bar{s}}{1-\alpha}\right)^{(\varepsilon-1)/\varepsilon} + \beta_y\left(\frac{y_i}{\bar{y}}\right)^{(\varepsilon-1)/\varepsilon} + l_i^{(\varepsilon-1)/\varepsilon} + \beta_q q_i^{(\varepsilon-1)/\varepsilon}\right]^{\varepsilon/(\varepsilon-1)}$$
$$+\mu_i\left[A(1-l_i)(1-\omega) - x_i - \left(1+\frac{\tau}{A_p}\right)y_i + L\right] + \nu_i\left(\frac{y_i}{\alpha} - \frac{x_i - \bar{s}}{1-\alpha}\right),$$

where the multiplier ν_i is non-zero when the restriction $y_i/\alpha \geq c_i$ binds. We solve for $\tau = 0$ and $\tau = \tau^*$.

Lemma 4. *Under both laissez faire and Pigovian taxation the solution can be divided into two phases, an initial phase during which $\nu_i > 0$, and a later phase when $\nu_i = 0$. During the initial phase the allocation is given by the unique solution to*

$$\left(1+\frac{\alpha\tau}{A_p}\right)cA^{(1-\varepsilon)/\varepsilon} = [A-(\bar{s}+c)]^{1/\varepsilon}(1-\omega)\left(\frac{\beta_c}{c^{(1-\varepsilon)/\varepsilon}}+\beta_y\right) \tag{11}$$

given either that $\tau = 0$ or that $\tau = \tau^*$ (equation 4). During the final phase the allocation is given by the unique solution to

$$1+\frac{\tau}{A_p} = \frac{c^{1/\varepsilon}}{\frac{A-\bar{s}}{1-\alpha} - c\{1+[A/(1-\alpha)]^{1-\varepsilon}[(1-\omega)\beta_c]^{-\varepsilon}\}}\frac{\beta_y}{\beta_c}. \tag{12}$$

Again, insert the appropriate values of τ (either $\tau = 0$ or τ^* as defined in equation 6) to find the allocation in the respective cases. Note also that during the final phase

$$y = A-\bar{s}-(1-\alpha)c\left(1+\frac{[A/(1-\alpha)]^{1-\varepsilon}}{[(1-\omega)\beta_c]^{\varepsilon}}\right). \tag{13}$$

Proof. First take FOCs in x_i, y_i, and l_i to yield—after substituting for x using $c = (x-\bar{s})/(1-\alpha)$, and assuming symmetric equilibrium—the following three equations:

$$(u/c)^{1/\varepsilon}\beta_c = (1-\alpha)\mu+\nu;$$
$$\left(u^{1/\varepsilon}/y\right)\beta_y = (1+\tau/A_p)\mu-\nu/\alpha;$$
$$(u/l)^{1/\varepsilon} = A\mu(1-\omega).$$

To solve for the initial phase, when $\nu > 0$, substitute for y using $y_i = \alpha c_i$, and note that equation (8) describes the resource constraint when the restriction binds. Use these four equations to obtain (11). And to solve for the final phase, take the same FOCs, set $\nu = 0$, and note that the resource constraint is now $A(1-l) = (1-\alpha)c+\bar{s}+y$. For proof of uniqueness, see Appendix A. □

We now look in more detail at the dynamics of the solution as A and A_p increase over time. By contrast to the previous cases—the prologue model, and the full model with a consumption tax—labour supply no longer approaches zero as productivity grows without bound. The reason is that labour supply is motivated by each household's need to maintain levels of conspicuous consumption relative to the other households in the economy. The results are summarized in Proposition 2 (compare to Proposition 1 for the equivalent results for the prologue model). Note that we restrict attention to the case that we argue is empirically reasonable, namely $\varepsilon < 1$.

Proposition 2. Absent a consumption tax, *the dynamics are similar at low productivity: increasing productivity leads to a monotonic rise in non-essential consumption, leisure, and pollution—starting from a lower limit of zero when productivity is at the minimum level necessary for survival—driven by the decreasing salience of the subsistence minimum. When $\varepsilon < 1$, limiting growth rates of the variables are as follows:*

$$\{\dot{c}/c\}_{\lim} = \varepsilon g,\ \{\dot{y}/y\}_{\lim} = g,\ \{\dot{l}/l\}_{\lim} = \{\dot{p}/p\}_{\lim} = 0,$$

and labour, leisure, and pollution all approach strictly positive limits. Finally, note that if we shift from $\tau = 0$ to $\tau = \tau^*$ the limiting growth rates are all identical, but labour supply, consumption, and pollution are all lower—at all times—given the Pigovian tax.

Proof. The results follow straightforwardly from Lemma 4. For the limiting case (when $A \to \infty$) assume a b.g.p. exists, and show then show what properties it must have. To see the effect of the Pigovian tax, consider the proof of uniqueness in Lemma 4, and note that when ψ increases from zero (equivalent to a tax being imposed), c increases and y decreases. Since in the limit all labour is devoted to production of y, this implies that h decreases and l increases. □

Proposition 2 shows that in the limit $y/c \to \infty$, so production of status goods dominates non-essential consumption goods. Recall that in the presence of the optimal consumption tax (Proposition 1) when $\varepsilon < 1$ then labour approaches zero in the long run while c grows at the rate εg; here labour approaches a positive limit, c still grows at εg, but y grows at the rate g. So the desire for status consumption motivates excessive labour supply which gives no benefit, since no households actually gain higher status. (And if we extended to allow for heterogeneity, some households might benefit but others would suffer.)

Production of the status good also causes pollution. Since polluting emissions per unit produced decline at the rate g, if $\dot{y}/y < g$, then emissions decline. This is the case in the long run when consumption externalities are corrected, as shown in Proposition 1. But when consumption externalities are not corrected then $\dot{y}/y = g$ in the limit, and pollution flows approach a strictly positive limit, where the limiting value is a linear function of limiting labour supply.

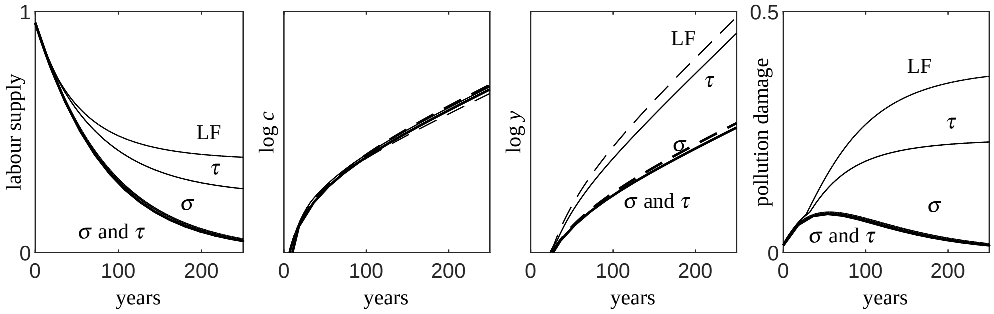

Figure 6: Simulation results for all four scenarios for our baseline parameterization in which $\varepsilon < 1$. Productivity starts at the minimum level necessary for survival, and then increases at a constant rate. The scenarios are laissez faire (LF), a Pigovian tax alone (τ), and consumption tax alone (σ), and a first-best combination of Pigovian and consumption taxes (σ and τ).

The results of both Propositions 1 and 2 are illustrated in Figure 6. In the first panel we see how labour supply always approaches a constant limit, which is zero when σ^* is applied. When the consumption tax—applied to the polluting good y—is in place, the addition of the Pigovian tax makes little difference. However, in the absence of the consumption tax the Pigovian tax makes a large difference, as we can see from the differences in labour supply and pollution damage between the scenarios labelled τ (Pigovian tax alone) and LF (laissez faire). In the second panel we see the effect on non-essential consumption c, which grows at εg in the long run, in all scenarios, but at slightly different levels. In the third panel we see that the long-run growth rate of status consumption y is higher (at rate g) in the absence of the consumption tax σ than in its presence. In the latter case y is consumed as a complement to x in non-essential consumption, and the growth rate is εg. Finally we see that when y grows at rate εg in the long run, pollution flows approach zero, whereas when y grows at rate g pollution approaches a strictly positive limit.

Based on the above analysis we have a reasonable understanding of the properties of the model, both under laissez faire and under regulation with one or both of a Pigovian tax and a consumption tax on the status good y. We have seen that in an optimally managed economy the need for a consumption tax increases over time, and that the tax opens up a large difference between the optimal allocation—with both labour supply and pollution flows approaching zero—and the laissez faire allocation with high long-run labour supply and pollution damages. In the introduction we argued that the model can shed light on actual trends in labour supply and pollution, as well as the difference between 'macroeconomic' and 'microeconomic' estimates of the elasticity of labour supply to taxation and wages. In the next section we put the model to the test on these tasks.

6. Taking the model to the data

The first thing to point out when taking the model to the data is that in real economies most takes are levied—either directly or indirectly—on labour income generally, rather than on a specific good or set of goods. (But note the significant tax revenues from fuel taxes in Europe.) And these revenues are required to finance government spending on public goods such as national defence and the police and courts. Furthermore, in most rich countries health care and education are provided largely for free 'at the point of use' by the state. So taxes to correct distortions are not collected in a vacuum, and are not simply returned 'lump sum' to households. Our main task in this section is thus to look at observed patterns of taxation, and observed outcomes with regard to labour supply, and test how well the model can explain these observations. Having parameterized the model on this basis, we can turn to the effects of optimal policy, and also the analysis of polluting emissions.

6.1. Labour supply and taxation

To test the model's ability to explain long-run labour supply we take a similar approach to Ohanian et al. (2008). That is, we take data on the tax wedge over the interval 1950–2015 in the 15 countries in the database of McDaniel (2007), combine it with data on labour productivity over the same period in these countries, and feed this data into a parameterized model to predict the paths of labour supply.[12] The paths predicted by the model are then compared to observations: Figure 7.

In Figure 7 we see that the model does a remarkably good job of matching trends in labour supply, based solely on the productivity trends in each country, and trends in taxation. Countries which start at a high level of productivity, and which have a relatively stable tax wedge (the prime example being the US) have stable labour supply, both as predicted by the model and according to observations. And where productivity increases from a relatively low level, at the same time as taxes increase—exemplified by Sweden between 1950 and 1980—see steep falls in labour supply both according to the model and the data. The model fails to match overall trends in just 2 of the 15 countries, namely France and Germany. In both cases we observe much steeper falls in labour supply than are predicted by the model, indicating that other factors were at play here, in addition to the effects of growth and taxes captured by the model.

6.2. Policy implications

The model does a good job of accounting for data on labour supply. With regard to polluting emissions, it is far too simplified to take to the data: we cannot explain polluting emissions by country based only on productivity and taxation in a model where firms cannot choose alternative production technologies, only alternative products. Furthermore, the implications of the model as currently formulated for labour supply are drastic: optimal policy would lead to large reductions in labour supply even in high-tax countries such as Sweden, due to the shift in focus to conspicuous goods, which motivate labour supply. And there would be an even greater reduction in polluting emissions, due to a combination of lower production in total, and the shift out of conspicuous goods.

The above implications would be revolutionary if they were built on a credible description of the economy. However, careful study of the characteristics of the model shows that a better model would lead to more conservative results, albeit going in the same direction, i.e. an optimal management of the economy with taxation of status goods, lower labour supply, and much lower polluting emissions. One important addition to the model is to include Keynes' idea that we work because we have evolved 'to strive and not to enjoy'. That is, our optimal degree of labour supply is not zero, all else equal. There is a lot of evidence that more leisure increases utility when labour supply is high, but it seems reasonable to suppose that above a certain level —measured over our lifetimes—further leisure (and less work) would actually reduce utility, even if we coordinated our choices, and even holding consumption unchanged. Work helps us to feel a sense of purpose in our lives, as well as giving us status and consumption goods. By adding to the model a 'baseline' rate of labour supply greater than zero we could explain observed labour supply with weaker preferences for status goods, hence the effects of optimal policy would be less radical.

7. Conclusions

We have shown that in an economy with both pollution and consumption externalities, the consumption of status goods takes over as the main motivation behind labour supply as productivity increases. This accounts for two stylized facts: firstly, although labour supply declines with income at low incomes (both for time series and cross-sectional country data, and for cross-sectional individual data), the decline levels off at high incomes; and secondly, that expenditure tends to shift towards energy- and resource-intensive goods with rising income.

[12] We drop the period 1950 to 1959 for the four countries in the sample that were defeated in the Second World War (Austria, Germany, Italy, and Japan) as their labour supply is anomalously low in that period. And we drop all points for 2008, '09, and '10.

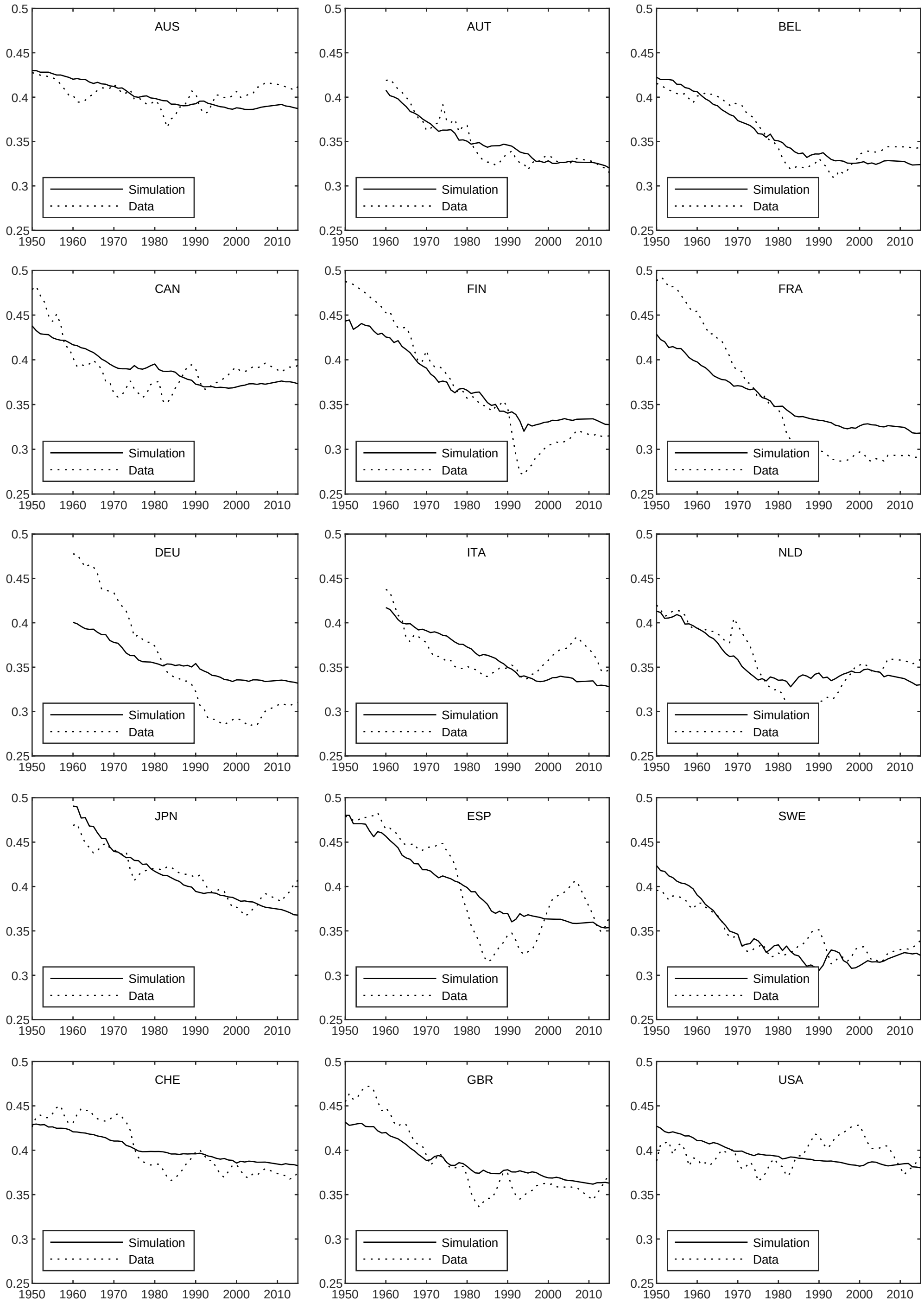

Figure 7: Labour supply (hours per working age adult) as a fraction of our assumed maximum, 3300 hours per year. Observed supply compared to simulation results for the 15 countries, with baseline parameters and correction for country fixed effects. Parameters: $\psi = 1$; $\varepsilon = 0.4$; $\alpha = .33$; $\beta_c = 2$; $\beta_y = 1.5$; $\beta_q = 1$; $A_p = A$; $\bar{s} = 0.356$. We take data on taxation from McDaniel (2007), updated with data up to 2015; data on hours per working-age adult is put together using total hours and total population from the Conference Board Total Economy Database, and the proportion of the population that is working-age from the OECD. Labour productivity is taken directly from the Conference Board.

The policy implication of the model as it stands is that taxes should be shifted to status goods, which would cause both an increase in leisure and a radical drop in polluting emissions. However, more research is needed in order to strengthen the model's ability to explain historical data, and to make credible recommendations for policies that would improve social welfare.

Appendix A. Proof of Lemma 4: uniqueness

For low values of A uniqueness is straightforward to demonstrate for both $\tau = 0$ and Pigovian taxation. Set $\tau = 0$ in equation (11), and let c increase from 0 to $A - \bar{s}$. The LHS increases monotonically (linearly) from 0 to $(A-\bar{s})A^{(1-\varepsilon)/\varepsilon}$, whereas the RHS declines monotonically from a limit of +infinity to a limit of zero. And when τ is given by equation (4), let c increase instead from 0 towards $A_p/(\alpha\psi)$ (at which point environmentally quality is zero). Then τ rises monotonically from 0, approaching infinity at a value of c strictly below $A_p/(\alpha\psi)$. Hence the LHS of (11) increases monotonically from zero and approaches infinity at finite c, whereas the RHS declines monotonically from an infinite limit, approaching zero at finite c. And whichever of the limits is binding, the curves must cross exactly once: there is a unique solution.

For high values of A, uniqueness is again straightforward. When $\tau = 0$ then when we let c increase from 0 in equation (12) we see that the LHS is constant (= 1) whereas the RHS increases monotonically from zero approaching infinity at finite c. Under Pigovian taxation substitute the expression for τ^* (6) into (12). Together with (13) we have two equations in c and y and it is straightforward to show that they have a unique crossing point, and that this crossing point has allowed values of y and c: (13) is linear, of negative slope ($\mathrm{d}y/\mathrm{d}c < 0$), and crosses the y axis at $y = A-\bar{s}$; the other curve passes through the origin and has positive slope.

Appendix B. Programs

Appendix B.1. Figures 3–5

Rearrange equation 5 to yield
$$\frac{1}{c} = \left(\frac{\beta_q}{\beta_c}\frac{w_c}{w_c-1}\frac{\alpha\psi}{A_p}\right)^{\varepsilon} + \frac{\alpha\psi}{A_p}.$$

and from 10 we have
$$\frac{1}{c} = \frac{\beta_c^{\varepsilon}(1-\omega)^{\varepsilon} + A\left(\frac{w_c}{A}\right)^{\varepsilon}}{(A-\bar{s})\beta_c^{\varepsilon}(1-\omega)^{\varepsilon}}.$$

So we have two equations in two unknowns and can solve for c and w_c given an optimal tax τ^*. The case of $\tau^* = 0$ is trivial.

Appendix B.2. Figure 6

When $y = \alpha c$ we can rearrange equation (11) to yield

$$w_c = [A-(\bar{s}+c)]^{1/\varepsilon}(1-\omega)\left(\frac{\beta_c}{c^{(1-\varepsilon)/\varepsilon}} + \beta_y\right)/[cA^{(1-\varepsilon)/\varepsilon}].$$

For laissez faire we have $w_c = 1$ (hence a single equation for c), and given Pigovian taxation we have equation 5,

$$w_c^* = \frac{\beta_c}{\beta_q}\left(\frac{1}{c} - \frac{\alpha\psi}{A_p}\right)^{1/\varepsilon}\left[\frac{\beta_c}{\beta_q}\left(\frac{1}{c} - \frac{\alpha\psi}{A_p}\right)^{1/\varepsilon} - \frac{\alpha\psi}{A_p}\right]^{-1},$$

so two equations and two unknowns, w_c and c.

When $y > \alpha c$ we have, from equation (12),

$$w_c = \frac{\alpha c^{1/\varepsilon}}{\frac{A-\bar{s}}{1-\alpha} - c\left\{1+[A/(1-\alpha)]^{1-\varepsilon}[(1-\omega)\beta_c]^{-\varepsilon}\right\}}\frac{\beta_y}{\beta_c} + 1 - \alpha,$$

and, from equations (6) and (13),

$$w_c^* = 1 + \frac{\alpha\psi}{A_p}\frac{\beta_q}{\beta_c}c^{1/\varepsilon}\left\{1-\psi\left[A-\bar{s}-(1-\alpha)c\left(1+\frac{[A/(1-\alpha)]^{1-\varepsilon}}{[(1-\omega)\beta_c]^{\varepsilon}}\right)\right]/A_p\right\}^{-1/\varepsilon}.$$

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