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Impact distributif de la TVA sur le cycle de vie

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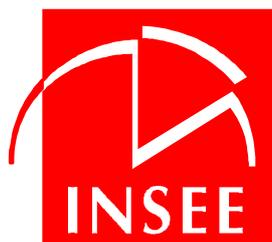
Direction des Études et Synthèses Économiques

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Simon GEORGES-KOT *

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Annual and lifetime incidence of the value-added tax in France

Abstract

Consumption taxes represent on average 30% of the total tax revenue and 10% of the GDP in OECD countries. In France, the value-added tax (VAT) makes up most of consumption taxes and constitutes 50% of the state's fiscal resources, yet progress still needs to be made to fully understand its distributional impact. In particular, since savings partly serve to finance future consumption, the incidence of consumption taxes should be measured over the entire life-cycle of individuals. This has proven difficult to do because appropriate data does not exist. Consumption surveys necessary to impute taxes paid by households are cumbersome and consequently bear no panel dimension. However, repeated cross-sections for such surveys are almost always available. In this paper, I take advantage of this feature to estimate a simple parametric model for the joint dynamics of income and VAT over the life of individuals. I then use simulation methods to recover the joint distribution of permanent income and VAT. According to the estimates, permanent VAT is half less regressive than annual VAT.

Keywords: consumption dynamics, income dynamics, value-added tax, life cycle

Impact distributif de la TVA sur le cycle de vie

Résumé

La TVA joue un rôle majeur dans la plupart des pays de l'OCDE. En France, elle représente la moitié des ressources budgétaires de l'État. Malgré son importance, ses effets distributifs sont encore mal connus. En particulier, comme l'épargne sert en partie à financer la consommation future d'un individu, l'impact de la TVA doit être évalué sur l'ensemble du cycle de vie. Le principal obstacle à cet exercice réside dans le manque de données appropriées. La TVA étant payée par les entreprises, il n'est pas directement possible de savoir combien un ménage dépense en TVA sur une année. La TVA payée doit être imputée à partir d'informations sur la consommation des ménages, mais les enquêtes de consommation ne permettent en général pas de suivre des individus sur plusieurs années. En France, l'enquête Budget de Famille est cependant effectuée à intervalle régulier. Cette étude tire parti de cette caractéristique pour estimer un modèle simple de dynamique jointe des revenus et de la TVA payée par un ménage sur le cycle de vie. L'étude utilise ensuite des techniques de simulation pour reconstituer la distribution jointe du revenu permanent et de la TVA permanente des ménages. Selon ces estimations, la TVA serait moitié moins régressive sur l'ensemble de la vie qu'en coupe.

Mots-clés : Dynamique de la consommation, dynamique des revenus, taxe sur la valeur ajoutée, cycle de vie

Classification JEL : E21, D91, H22

1 Introduction

Consumption taxes play a major role in most OECD countries. They represent on average 30% of the tax revenue and 10% of the GDP (OECD [2014]). In France, the value-added tax (VAT) makes up most of consumption taxes, and it constitutes about 50% of the state's fiscal resources. Despite the quantitative importance of VAT in France, and despite a few existing studies (e.g. Trannoy and Ruiz [2008], Meslin [2012]), progress still needs to be made to fully understand its distributional effects. In particular, no estimation of its lifetime incidence has been undertaken to this day, even though it is now widely recognized that annual and lifetime perspectives offer useful complementary insights into the overall impact of a tax (see e.g. Fullerton and Rogers [1991]). Moreover, in the case of consumption taxes, a lifetime perspective is arguably better suited since savings serve partly to finance future consumption. A general lack of appropriate data has prevented progress in the evaluation of the lifetime incidence of consumption taxes. There exists no administrative record at the household level for those taxes, and panel data recording both consumption and income is limited to non-existent.¹ On the other hand, it is well known that using annual income as a proxy of lifetime income can lead to important life-cycle biases (see e.g. Black and Devereux [2011], Haider and Solon [2006]). In this paper, I present a method to explore the differences between annual and lifetime VAT incidence using repeated cross-section data on income and consumption, as is available in many countries.

As noted by Lyon and Schwab [1995], there are several reasons why annual and lifetime VAT incidence are expected to differ. First, annual income can be subject to important fluctuations, such as those created by bonuses or periods of unemployment. The permanent income hypothesis (PIH) stipulates that consumption (and therefore VAT paid) adjusts very little to those transitory shocks, and this has been verified in multiple empirical studies (see among many others Blundell et al. [2008]). This implies for example that a lifetime rich who experiences a bad year maintains the same consumption level, and the same is true for a lifetime poor who just happens to have a good year. When conducting a distributional analysis from annual quantities, the first individual is placed lower in the distribution of income than what permanent quantities dictate, and is assigned a relatively high amount of VAT paid, whereas the second individual is ranked higher and is assigned a relatively small amount of VAT paid. Using annual quantities therefore leads to an overestimation of the lifetime regressivity of the VAT. A second reason why this is

¹In most countries, expenditure surveys bear no panel dimension at all. Even though there are some exceptions such as the American Consumer Expenditure Survey where individuals are re-interrogated, those surveys lack the time depth necessary for lifetime analyses (see e.g. Blundell [2014]).

the case is that income varies importantly over the life-cycle of individuals, but the tie between consumption and income is relatively loose (see e.g. Attanasio et al. [1999]). This is generally interpreted in the framework of the life-cycle theory as reflecting the fact that individuals choose their consumption level with respect to their expected future income rather than to their present income. As a result, an individual consumes a higher proportion of his income and pays relatively higher VAT whenever his income is lower than its permanent level. As before, this implies that VAT looks more regressive in cross-section than it is over a lifetime, simply because individuals are observed at different stages of their lives. One last reason why annual and lifetime VAT incidence might differ is that the structure of consumption evolves throughout life (see e.g. Aguiar and Hurst [2013]). Variations in consumption composition could lead to variations in VAT paid if tax rates vary across products. This can be the case even if consumption adjusts entirely to contemporary income.

I first study the average age trajectories of income, consumption and VAT paid by households. The shape of the income profile crucially depends on the treatment of homeowners via the inclusion of imputed rents in the resources of households. I find that income from imputed rents steadily increases over life both because the proportion of homeowners and the value of houses increase with age. For consumption, the age profile replicates the standard finding that expenditure is only loosely connected to income, even after controlling for family size (see among many others Gourinchas and Parker [2002], Fernández-Villaverde and Krueger [2007]). However, value-added tax paid by households decreases much more than consumption at older ages. I find that this is mainly driven by the fact that work-related expenditure is taxed on average at higher rates than the consumption of more essential products.² This divergence of consumption and VAT profiles, coupled with the surprisingly small decrease of income after retirement, is likely to create important disparities between annual and lifetime VAT incidence.

To go one step further, I build on the literature on income dynamics to estimate a simple model for the joint process of the unpredictable components of income and VAT over life (see Meghir and Pistaferri [2011] for a survey). The estimation relies on using second-order moments computed on a pseudo-panel, as first proposed by Deaton and Paxson [1994].³ I use the estimated parameters to simulate individual lifetime trajectories of income and VAT for all households in my sample. From these trajectories, it is possible to compute lifetime VAT incidence. Overall I

²See Aguiar and Hurst [2013] for a complete analysis of the heterogeneity of life cycle profiles of the components of consumption.

³See Blundell and Preston [1998], Bourguignon et al. [2004], Blundell et al. [2008] for related uses of this idea. The paper closest to mine is Bourguignon et al. [2004] which uses first-order autoregressive models to study vulnerability to poverty with pseudo-panel data.

find that VAT is about 50% less regressive in a lifetime perspective than in a cross-sectional one.

Several papers have attempted to estimate the lifetime distributional impact of consumption taxes. Some earlier studies have essentially proposed using annual consumption as a proxy for permanent income (Davies [1960], Poterba [1989]), assuming that the PIH is verified.⁴ Other studies have relied on simulations based on theoretical models, such as Davies et al. [1984] who simulate a lifecycle model derived from utility maximization for a number of taxes in Canada. Caspersen and Metcalf [1994] have employed a two-step procedure, based on the joint use of the American Panel Study of Income Dynamics (PSID) and of the Consumer Expenditure Survey (CEX), estimating permanent income in the PSID on the basis of observables that are common to both datasets, and then using these estimates to impute permanent income in the CEX. The paper closest to mine in spirit is probably Lyon and Schwab [1995], who restrict their analysis to taxes on alcohol and tobacco, the consumption of which is reported directly in the PSID, which enables them to simply estimate a panel model to predict income, consumption, and tax profiles with age. All those studies generally report that consumption taxes measured over the lifecycle are less regressive than when measured annually, an exception being cigarette taxes in Lyon and Schwab [1995] which have the same lifetime and annual level of regressivity.

This paper improves on those studies in a number of ways. I do not need to assume that individuals behave entirely according to a lifecycle model such as in some of the earliest studies in this field. By using the same dataset for income and consumption, I am able to explore the link between consumption and income even when it is not explained by observables. As observables typically explain only a small part of the income distribution, I obtain much more reliable estimates. Finally, unlike Lyon and Schwab [1995], I am able to provide estimates for the most important taxes on consumption, not only for those on tobacco and alcohol. The rest of this paper is organized as follows. Section 2 presents the main features of the French value-added tax, section 3 presents the data used in this study, section 4 introduces the method used in the paper in more details, sections 5 and 6 present my results, and section 7 concludes.

2 The value-added tax in France

From the point of view of the end consumer, a value-added tax (VAT) is very similar to a regular sales tax. As of 2015, the normal VAT rate applicable to most goods and services in France is

⁴On the other hand, Blundell and Preston [1998] have given a number of reasons why annual consumption might be a poor indicator of lifetime welfare.

20%, but there also exists 3 lower rates and some exemptions which are summed-up in Table 1.⁵ VAT exemptions are mostly comprised of rents and health services. The lowest rate is the so-called super-reduced rate, which is set at 2.1%. It concerns a very small fraction of expenditure, composed mainly of newspapers and drugs covered by the social security. Next is the reduced rate set at 5.5%, which is quite important since it primarily concerns food consumption which makes up almost 20% of total expenditure. Finally, the intermediate rate set at 10% covers a wide range of products, including domestic services, hotels and restaurants, and cultural goods and services (books, concerts, theater or cinema tickets,...). Which product falls in which tax category can be very specific. For example in the case of restaurants, eat-in meals are taxed at the intermediate 10% rate whereas take-out food is taxed at the 5.5% reduced rate. Other very fine distinctions include vegetable fats such as margarine (normal rate) vs. animal fats such as butter (reduced rate), or candy (normal rate) vs. chocolate-based candy (reduced rate).

In this paper, I impute VAT paid by households using consumption data for the period 1984-2011. The value-added tax underwent substantial changes over this period, which are reported in Appendix Table 3. The most important modification was the suppression in 1992 of the increased rate applied to luxury products (including cars, musical instruments, perfumes,...). I abstract from these changes by imputing VAT using a unique tax structure, namely that applicable in 2015. Using variable rates would create year-specific fluctuations in VAT that would induce a bias in our estimation of lifetime trajectories. The limit to this approach is that it ignores demand shifts due to changes in VAT rates.

3 Data

There exists no data recording VAT paid by households, because in practice the value-added tax is paid directly by firms. VAT paid can however be imputed to households from sufficiently detailed consumption data. To do so, I use the Enquête Budget de Famille (BDF), the French consumer expenditure survey. The BDF is conducted by the French statistical institute every 5 or 6 years since 1979 on a representative sample of about 10,000 households. All individuals in the interrogated households fill-in a consumption diary over one or two weeks,⁶ from which the statistical institute computes consumption of non-durable goods and services over the year. Two interviews are also carried out to infer annual durables expenditure. Overall, the survey

⁵Corsica and French overseas departments are subject to specific rules. They are excluded from this study.

⁶The period over which individuals have to fill-in their consumption diaries lasted 14 days prior to 2000 and has been shortened to 7 days since 2000.

Table 1: Budget shares of main consumption items

	Budget share
No VAT	5.2
<i>Health services</i>	45.5
<i>Education</i>	21.7
<i>Gambling</i>	17.7
<i>FISIM</i>	10.2
Super-reduced rate	1.7
<i>Newspapers and magazines</i>	62.9
<i>Drugs</i>	37.1
Reduced rate	20.0
<i>Food at home or take-away</i>	97.2
<i>Medical equipement</i>	2.8
Intermediate rate	16.1
<i>Domestic services</i>	20.1
<i>Food in restaurants</i>	19.7
<i>Rereational and cultural services ; books</i>	18.6
<i>House maintenance</i>	12.8
<i>Transportation services</i>	12.7
<i>Hotels</i>	12.0
<i>Utilities (i)</i>	4.1
Normal rate	53.2
<i>Vehicle maintenance and fuel</i>	22.0
<i>Clothing</i>	11.8
<i>Utilities (ii)</i>	10.1
<i>Vehicules</i>	10.1
<i>Non-durable household equipement</i>	6.2
<i>Durable household equipement</i>	5.2
<i>Personal care</i>	4.8
<i>Durable leisure equipement</i>	7.1

Note: the table reports the average share of consumption devoted to each tax category. For each tax category, the table then reports the main products comprising expenditure devoted to this tax category along with the associated budget share in that category.

provides annual consumption for interviewed households at a very detailed level, with 300 to 900 expenditure categories depending on the survey wave. In addition, the data contains detailed information on the financial resources of households, including their annual earnings, income from social transfers, taxes paid and imputed rents for homeowners.⁷ I use the six waves of the survey that took place between 1984 and 2011.⁸ I adjust all amounts relating to income to 2011 euros using the GDP deflator. For consumption, it is necessary to account for relative

⁷The information on imputed rents is not available before the year 2000. For previous waves, I impute rents to households who own their house using the simulated residuals method. This is the method used by the statistical office for later waves.

⁸These six waves correspond to the years 1984, 1989, 1995, 2000, 2006 and 2011.

changes in the price of different products. Relative price changes could lead to artificial VAT fluctuations that would be a source of bias later on. I use the product-specific deflators available in the household consumption accounts to adjust expenditure to 2011 prices. French national accounts report household consumption and price deflators for about 100 expenditure categories which correspond to the United Nations' Classification of Individual Consumption According to Purpose (COICOP).⁹ The BDF expenditure classes can generally be matched to a COICOP category unambiguously.

As many expenditure surveys, the BDF suffers from significant measurement error.¹⁰ On average, BDF consumption only covers about 75% of national accounts consumption. This coverage rate varies by product and by year, which could be problematic for the rest of the analysis. Differential trends in measurement error by product category could lead to spurious trends in VAT paid by households. To avoid this, I calibrate BDF expenditure on national accounts expenditure for each product. I then match every expenditure category in the BDF data to the corresponding VAT rate and compute annual VAT paid for each household. I also calibrate the income data on household income accounts for consistency,¹¹ and define the disposable income of a household as the sum of earnings, social transfers and imputed rents for homeowners, minus the income and housing taxes. Finally, I restrict the final sample by keeping households whose head is aged 26 to 70 at the date of the interview. I also impose that each cohort should be observed at least in two different survey waves.¹² The final sample contains 44,636 households.

4 Methodology

Individual income and VAT age trajectories are not easily recovered from the available data since households are only observed once, and since most of the evolution of income, consumption and VAT over life cannot be predicted from the observable characteristics of individuals. I proceed in two steps. First, I study the average age trajectories of income, consumption and VAT for households in my sample. I then compute the individual deviations from these average trajectories, which constitute the parts of income, consumption and VAT that cannot be predicted

⁹See <http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=5> for details.

¹⁰See Carroll et al. [2015] for a comprehensive treatment of the question of misreporting in expenditure surveys.

¹¹This is easily doable for social transfers income and imputed rents which have equivalents in households accounts. Earnings in BDF income do not have a direct counterpart in households' income accounts, because the Contribution Sociale Généralisée (CSG), an important tax in France, is considered a social contribution in household surveys, but an income tax in national accounts. Instead, I calibrate net of tax earnings in BDF on net of tax earnings in national accounts.

¹²Cohorts are formed of individuals born the same year.

from observables. I estimate a simple model for the dynamics of these unpredictable components to recover the key parameters governing their evolution. I simulate these evolutions over the life of all households in the sample in order to infer the joint distribution of lifetime income and VAT.

In the initial data, average age effects are mixed with cohort and year effects. In addition, since all quantities are measured at the level of the household, age effects are also interlaced with household size and composition effects. In order to single out the effects attributable to age, I estimate the following model:

$$y_{it} = \beta_0^y + \beta_1^y \text{cohort}_i + \beta_2^y \text{age}_{it} + \beta_3^y \text{year}_t + \beta_4^y \text{family}_{it} + \epsilon_{it}^y \quad (1)$$

where y_{it} denotes the logarithm of the outcome of interest (income, consumption or VAT paid) for household i at period t , cohort_i is a vector of 50 year of birth dummies for cohorts born from 1920 to 1980, age_{it} is a vector of 44 age dummies for ages 27 to 70, year_{it} is a set of 5 year of observation dummies, and family_{it} is a full set of controls for household composition. Specifically, family controls include the number of adults in the households (not counting the primary earner), and the number of children aged below 18, below 14, below 6 and below 2. It is well known that model (1) cannot be identified without further assumptions, because there exists a linear relationship between cohort, age and year dummies. This is because the age of a cohort can be inferred from its year of birth and the year of observation. However, identification can be achieved by imposing a proper normalization of year effects. As suggested by Deaton [1997], I do so by requiring that year effects sum to zero and be orthogonal to a time trend, which mechanically attributes the time trend to cohort effects. This constraint can be directly embedded in (1) by replacing the year dummies by normalized year dummies (see Appendix A for details).

The second step towards the estimation of lifetime incidence of the VAT is to go beyond average age trajectories and estimate individual trajectories for income and VAT. This is not directly possible given the limitations inherent to the available data on income and consumption. For example, since panel data is unavailable, it is not possible to estimate household fixed effects. Instead, I model the dynamics of the residual from the estimation of (1), which constitutes the unpredictable component of income (or VAT). I estimate the parameters of the unpredictable components' processes, and then rely on simulations of these processes to recover the joint distribution of income and VAT over the life-cycle. As noted by Deaton and Paxson [1994], inference

on the dynamics of the residuals can be made using repeated cross-section data by relying on moments computed over fixed-membership groups. Because income shocks are correlated to VAT shocks through consumption, both processes need to be modeled jointly. I assume the following VAR(1) model:

$$\begin{cases} r_{ijt} &= \beta_0^r + \beta_1^r \text{cohort}_{ij} + \beta_2^r \text{age}_{ijt} + \beta_3^r \text{year}_t + \beta_4^r \text{family}_{ijt} + \epsilon_{ijt}^r \\ c_{ijt} &= \beta_0^c + \beta_1^c \text{cohort}_{ij} + \beta_2^c \text{age}_{ijt} + \beta_3^c \text{year}_t + \beta_4^c \text{family}_{ijt} + \epsilon_{ijt}^c \end{cases} \quad (2)$$

$$\begin{pmatrix} \epsilon_{ijt}^r \\ \epsilon_{ijt}^c \end{pmatrix} = \begin{pmatrix} \rho_{jt}^r \epsilon_{ijt-1}^r \\ \rho_{jt}^c \epsilon_{ijt-1}^c \end{pmatrix} + u_{ijt} \quad (3)$$

$$u_{ijt} = \begin{pmatrix} u_{ijt}^r \\ u_{ijt}^c \end{pmatrix} \sim \mathcal{N}(0, \Sigma_{jt}) \text{ with } \Sigma_{jt} = \begin{pmatrix} v_{jt}^{u_r} & v_{jt}^{u_r u_c} \\ v_{jt}^{u_r u_c} & v_{jt}^{u_c} \end{pmatrix} \quad (4)$$

where j denotes the fixed-membership group comprising household i . In practice I use the household head's year of birth to define such groups. ϵ_{ijt}^r (resp. ϵ_{ijt}^c) are the residuals from the estimation of (1) for income (resp. VAT). The set of parameters to be estimated is $\{\rho_{jt}^r, \rho_{jt}^c, v_{jt}^{u_r}, v_{jt}^{u_c}, v_{jt}^{u_r u_c}\}_{jt}$. In the absence of panel data, model (3)-(4) cannot be estimated as such, because the lags of the residuals for household i are unknown. However, taking the variance and covariance of (3) among all households belonging to cohort j on year t , we get:

$$\begin{cases} v_{jt}^{\epsilon_r} = \rho_{jt}^r{}^2 v_{jt-1}^{\epsilon_r} + v_{jt}^{u_r} \\ v_{jt}^{\epsilon_c} = \rho_{jt}^c{}^2 v_{jt-1}^{\epsilon_c} + v_{jt}^{u_c} \\ v_{jt}^{\epsilon_r \epsilon_c} = \rho_{jt}^r \rho_{jt}^c v_{jt-1}^{\epsilon_r \epsilon_c} + v_{jt}^{u_r u_c} \end{cases} \quad (5)$$

where $v_{jt}^{\epsilon_r \epsilon_c}$ denotes the covariance of ϵ_{ijt}^r and ϵ_{ijt}^c . Not all equations defined by (5) correspond to observable moment conditions, because the BDF data is only available every 5 or 6 years. Instead, (5) provides us with recurrence relations that can be used to compute predicted moments at any observation year (excluding the first one) from parameter inputs. This means that finding an acceptable set of parameters using (5) is possible in practice, through numerical optimization. (5) is strongly under-identified since it defines 5 new parameters every year, whereas we can only write 3 moment conditions every 5 or 6 years, for each cohort. With 61 cohorts over 27 years (with only 5 usable data years), this would require the estimation of 8,235 parameters from 594 moment conditions.¹³ The age-dependency of these parameters is our main interest here, so a way

¹³This is less than $5 \times 61 \times 3 = 915$, because not all cohorts are observed at all years. I only impose that a cohort be observed for at least two years to include it in the sample.

to reduce dimensionality is to impose that $\rho_{jt}^r = \rho_{a_{jt}}^r$ (and similarly for the other 4 parameters), where a_{jt} is the age of cohort j at time t . With ages spanning from 26 to 70, this reduces the number of parameters to 220. Although theoretically the model becomes highly over-identified, solutions are hard to reach in practice because of the high dimensionality and nonlinearity of the problem. Restricting the number of parameters further produces more reliable estimates, while at the same time providing coarser descriptions of the unpredictable components' processes. Empirically I find that an acceptable compromise is to allow for 5 different parameter sets (25 parameters), imposing that age parameters be constant over ages 26-34, 35-43, 44-52, 53-61 and 62-70. I provide evidence below that this restricted version of the model can still account for the important evolutions of income and VAT variances over life.

Finally, it should be noted that all the parameters in (5) are subject to some constraints. Specifically, (i) the autoregressive coefficients ρ_{jt}^r and ρ_{jt}^c have to be between 0 and 1, (ii) the variances $v_{jt}^{u_r}$ and $v_{jt}^{u_c}$ should be positive, and (iii) the correlation between u_r and u_c must be between -1 and 1, so that $|v_{jt}^{u_r u_c}| \leq \sqrt{v_{jt}^{u_r} v_{jt}^{u_c}}$. The estimation of (5) yields a set of parameters $\{\hat{\rho}_a^r, \hat{\rho}_a^c, \hat{v}_a^{u_r}, \hat{v}_a^{u_c}, \hat{v}_a^{u_r u_c}\}_{a \in [26, 70]}$ from which it becomes possible to simulate lifetime trajectories of income and VAT for each household in the sample. To do so, I constitute a database with one line for each household and each age between 26 and 70. For each household i at each age a , I draw a random shock to income and VAT $(\tilde{u}_{ia}^r, \tilde{u}_{ia}^c)'$ in a multivariate normal distribution with covariance matrix $\hat{\Sigma}_a$, with:

$$\hat{\Sigma}_a = \begin{pmatrix} \hat{v}_a^{u_r} & \hat{v}_a^{u_r u_c} \\ \hat{v}_a^{u_r u_c} & \hat{v}_a^{u_c} \end{pmatrix}$$

I then calculate the full trajectory of the unpredictable components of income and VAT $(\tilde{\epsilon}_{ia}^r, \tilde{\epsilon}_{ia}^c)_{a \in [26, 70]}$:

$$\begin{cases} \tilde{\epsilon}_{i26}^{r,c} = \tilde{u}_{i26} \\ \tilde{\epsilon}_{ia}^{r,c} = \hat{\rho}_a^{r,c} \tilde{\epsilon}_{ia-1}^{r,c} + \tilde{u}_{ia}^{y,c} \text{ for } a \geq 27 \end{cases}$$

I also compute the predicted values of income and VAT from the estimation of (1). Since each household is only observed once, its composition at every age is not known. Some assumption has to be made regarding the evolution of the structure of households with age. For each age a , I attribute to each household the average demographic characteristics of households whose head is aged a in the original sample. Under this assumption, it becomes possible to compute the predicted component of income and VAT for all observations, and to recover total simulated income for each household at each age as the sum of the predicted and simulated unpredictable

component. This database is the one I use for the analysis of lifetime VAT incidence conducted in section 6.

In a related paper, Bourguignon et al. [2004] model the unpredictable component of income as an AR(1) process to study the dynamics of poverty using repeated cross-sections. They are able to compare their findings with results obtained from panel data, and conclude that the simple AR(1) form captures most of the important dynamics of income. At this stage, it is still unclear whether model (3)-(4) can account for the main evolutions of the unpredictable components of income and VAT. A way to gain some insight into this question is to compare the empirical and simulated age trajectories of the variance and covariance of income and VAT. To do so, I compute the variance of ϵ_{it}^r , ϵ_{it}^c and the covariance between both residuals within each age group in the original data. I proceed similarly for the simulated quantities $\tilde{\epsilon}_{ia}^{r,c}$, and then plot these quantities by age in Figure 1. As it turns out, observed and simulated variance age trajectories are quite close to each other in all three panels, which indicates that the model seems to perform quite well. This suggests that even if income and VAT residuals did not behave according to model (3)-(4), it might be hard to discriminate between this model and a better one solely on the basis of available information.

5 Income, consumption and VAT age trajectories

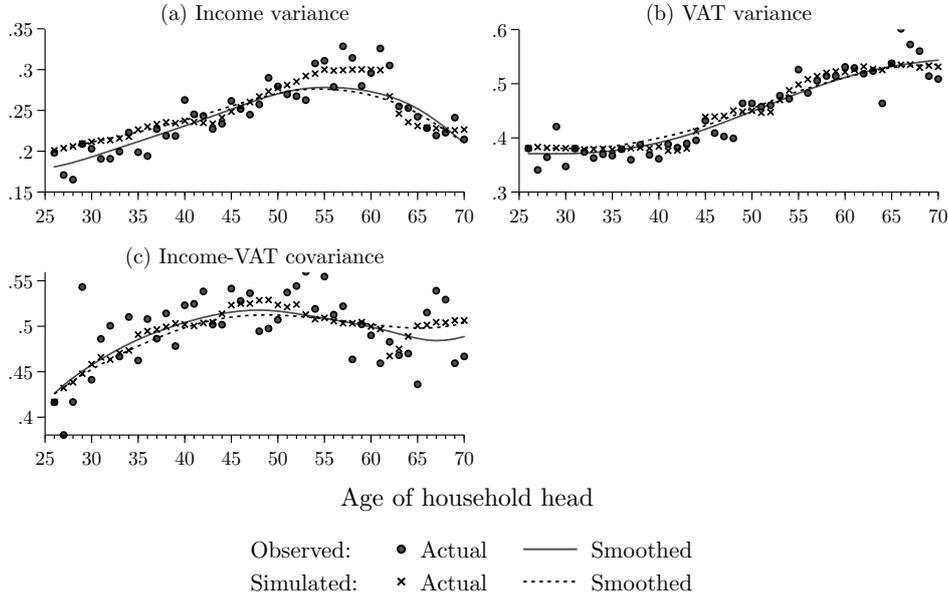
In this section, I explore the average trajectories of income, consumption and VAT over the life of individuals derived from model (1).¹⁴ Doing so provides preliminary insights into what the potential differences between annual and lifetime VAT incidence might be. In particular, how much the evolutions of consumption and VAT over life are connected to that of income will be one of the key driving forces of those differences. The objective of this section is to investigate the extent to which this is the case.

5.1 Income age profiles

To begin with, Figure 2 plots the value of the coefficients on each age indicator obtained from the estimation of model (1) for income. The figure first reveals that income rises sharply by about .22 log points (25%) between ages 26 and 40. It is then fairly stable until age 60 when it starts to rise again, increasing steadily by .1 log points until age 70. It is well documented that income

¹⁴As family composition effects are filtered away, this analysis considers the case of a household comprised of a single individual under the assumption that age trajectories do not depend on household composition.

Figure 1: Observed and simulated variance-covariance of the unpredictable components



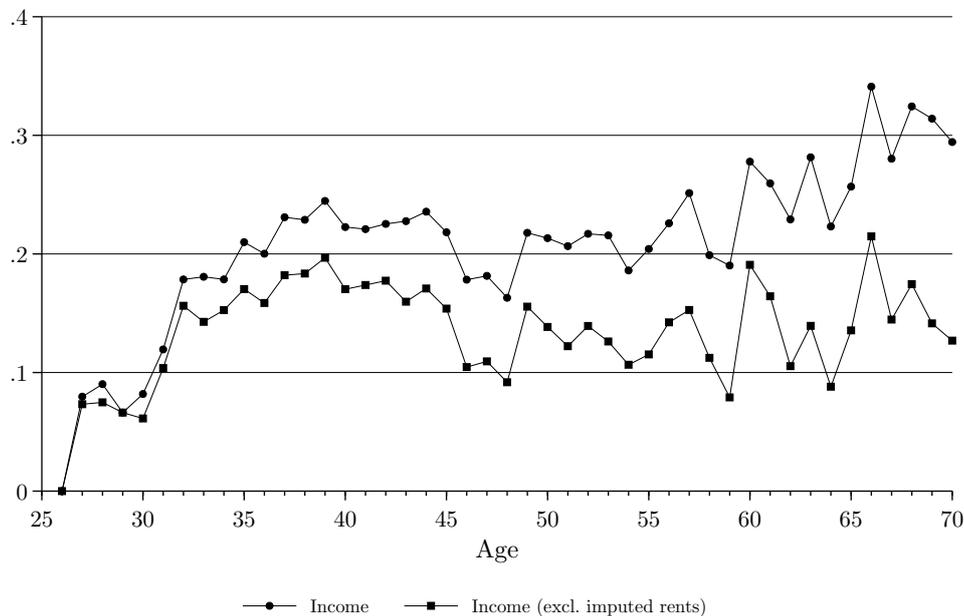
Note: for each age, the dots in panel (a) (resp. (b)) plot the variance of the residuals of a model regressing log-income (resp. log-VAT) on a full set of controls for age, cohort, year of observation and family composition, for households observed at that age. The solid line is a lowess smoother of the dots. Panel (c) plots the covariance between the income and VAT residuals for each age. The x plot the same variance-covariances but for households in the simulated data, where income and VAT age trajectories are simulated using the parameters estimated with model (5). The dotted line is the lowess smoother for the x.

rises over the first 20 to 25 years of an individual's work life, and then starts to decrease after individuals retire (see e.g. Carroll and Summers [1991]). The pattern revealed by Figure 2 until age 60 is in line with this, but what we observe after 60 is quite unexpected. In France, 60 is the age at which individuals can start to cash out their public pensions, and consequently it is the age at which most workers retire.¹⁵ French public pensions provide individuals with on average 75% of their pre-retirement income (COR [2013]). We would therefore expect to see a decrease in disposable income after retirement, even though this decrease could be less than 25% since it may be partly absorbed by a reduced income tax. To understand what might be at the bottom of this unexpected result, Figure 3 reproduces this analysis separately for the different income sources, namely earnings (net of contributions and income tax), social transfers, and imputed

¹⁵Individuals receive a pension that is proportional both to the duration of their contribution to the system and to their earnings. In addition, individuals who have not yet attained a statutory minimum contribution length receive a discounted amount. The discount is canceled if individuals wait until age 65 to retire. Consequently, a second retirement peak takes place at 65.

rents.

Figure 2: Average income age profile

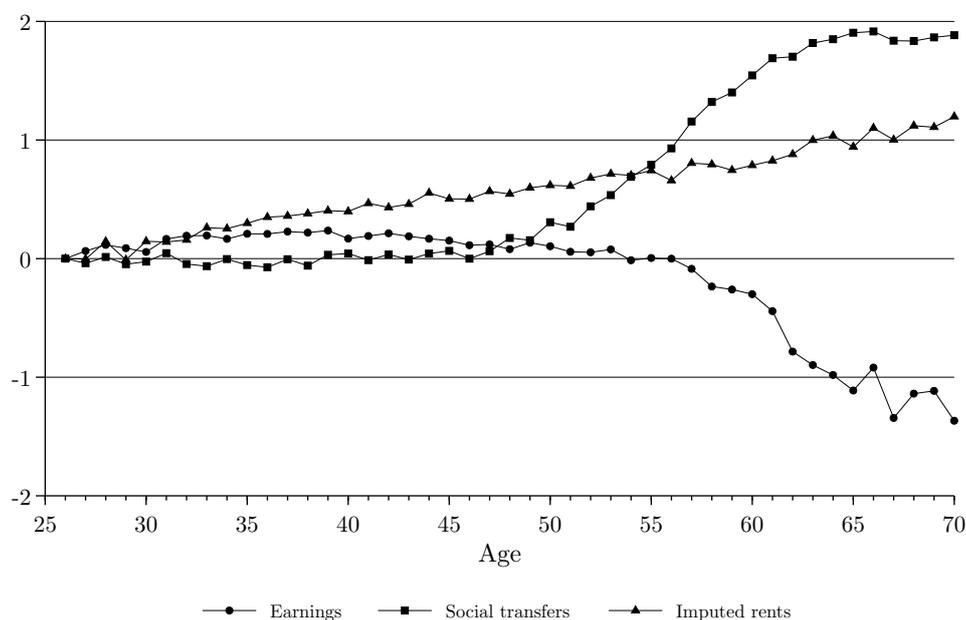


Note: the figure plots the age dummies' coefficients obtained when regressing the logarithm of (i) household disposable income and (ii) disposable income excluding imputed rents, on a set of age dummies, controlling for cohort, year of observation, and household composition effect, such as in model (1). Source: BDF, 1984-2011, Insee.

Figure 3 first reveals that average net of tax earnings rise regularly by about .2 log points (22%) over ages 26 to 40, and then decrease slowly until age 55. At 55, average earnings are back at their initial level and start to decrease more rapidly, by -1 log points (65%) up to age 70. Meanwhile, income from social transfers is roughly consistent up to age 50, when it starts to rise rapidly by 2 log points until age 65, and then stabilizes at 7.4 times its initial level. A number of professions are allowed to retire earlier than 60,¹⁶ causing average earnings to decrease and average social income to increase from 50 onwards. Figure 3 also shows the average age-profile of imputed rents for homeowners. Income from this source increases steadily over life, by about 1.1 log points between ages 26 and 70, which corresponds to a multiplication by 3. This continuous rise of imputed rents could be driving the increase of average income after age 60 observed in Figure 2. To be sure, Figure 2 also plots the average age trajectory obtained when

¹⁶This is most notably the case for military personnel, national railways employees, workers in the energy sector, and workers with disabilities. Special cases also exist for some public sector employees (for jobs belonging to the so called active categories).

Figure 3: Average age profiles for various income components



Note: the figure shows the age dummies' coefficients obtained when regressing the logarithm of (i) household earnings, (ii) social transfers income, and (iii) imputed rents, on a set of age dummies, controlling for cohort, year of observation, and household composition effect, such as in model (1). Source: BDF, 1984-2011, Insee.

we exclude imputed rents from our definition of disposable income. Disposable income with this new definition rises sharply between ages 26 and 40 by about .2 log points, and then decreases slightly to stabilize at around .15 log points above its initial value. Excluding imputed rents from the definition of disposable income largely eliminates the unexpected rise in income witnessed after age 60.

Different mechanisms might entail the increase in average imputed rents with age. It could be that the likelihood of becoming a homeowner increases over the life of individuals, but another explanation may be that individuals tend to live in more expensive houses as they age. A basic mechanism through which this would operate is if couples move to bigger homes when they start having children, but are reluctant to move back to smaller homes when their children leave the family residence. To test this, Figure 9 in Appendix B plots the age dummies coefficients obtained from the estimation of (1) when considering as outcomes (i) a dummy indicating that household i owns its house and (ii) the log of the surface of its dwelling. The figure confirms that the proportion of homeowners increases with age, by about .7 log points. The proportion

of homeowners doubles over the life of individuals. As it turns out, the surface of the residence also tends to increase steadily over life by about 80% even when controlling for family size.¹⁷

5.2 Consumption and VAT profiles

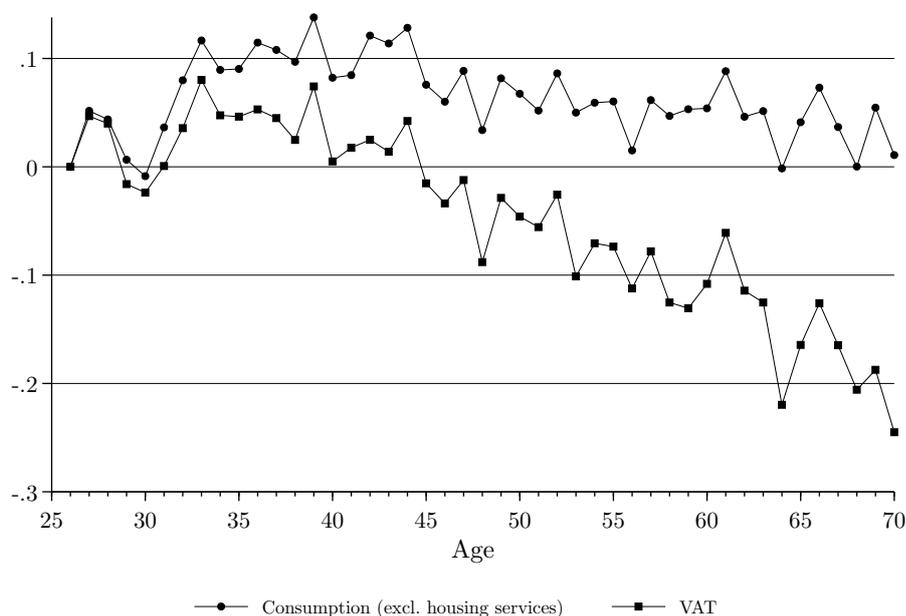
Disposable income decreases little after retirement. The next question becomes whether the same pattern is observed for consumption and VAT. To do so, Figure 4 plots the value of the coefficients on each age indicator obtained from the estimation of model (1) for consumption and VAT successively. Figure 4 first reveals that consumption follows a profile that is quite similar to that of income over the life of individuals. It first rises by about .1 log points (11%) over ages 26 to 45, and then decreases slowly by .05 log points (5 percentage points) until age 70. This is in line with the well-documented fact that consumption is slightly hump-shaped over life. This bump is about half the size of that of income in relative terms. The next question then becomes whether we observe the same pattern for VAT. As it turns out, Figure 4 shows that VAT also increases slightly by about .05 log points over the first 15 years of an individual's work-life. However, unlike consumption, it then decreases steadily by .25 log points until age 70. If all consumption was taxed at the same rate, any relative increase in consumption would lead to the same relative increase in VAT, and as a result VAT and consumption profiles would mechanically coincide. In other words, the differences between consumption and VAT profiles can be fully attributed to changes in budget shares devoted to products taxed at different rates. To investigate this further, Figure 5 replicates the analysis for consumption directed towards products in each VAT category separately.

Figure 5 reveals important disparities in the evolution of consumption. On the one hand, the consumption of products taxed at the normal and intermediate rates is largely decreasing over life, by about -.3 log points (23%) and -1.3 log points (76%) respectively over ages 26-70. On the other hand, the consumption of products taxed at reduced or super-reduced rates, or not taxed at all, increases regularly over life. Respectively, consumption of these products increases by 1 log point, .3 log points, and .8 log points. To understand what is causing these evolutions, Table 1 reports which products make up most of consumption in each tax category, along with the associated average budget shares.¹⁸ For the three tax categories associated with increasing consumption over life, the most important item by far is food at home or away, which is taxed at the reduced rate. Consumption of health services (not taxed) and newspapers and magazines

¹⁷See e.g. Ménard and Volat [2012] for a short analysis of housing conditions in France.

¹⁸Housing services are excluded from this analysis. Rents or imputed rents are not subject to VAT.

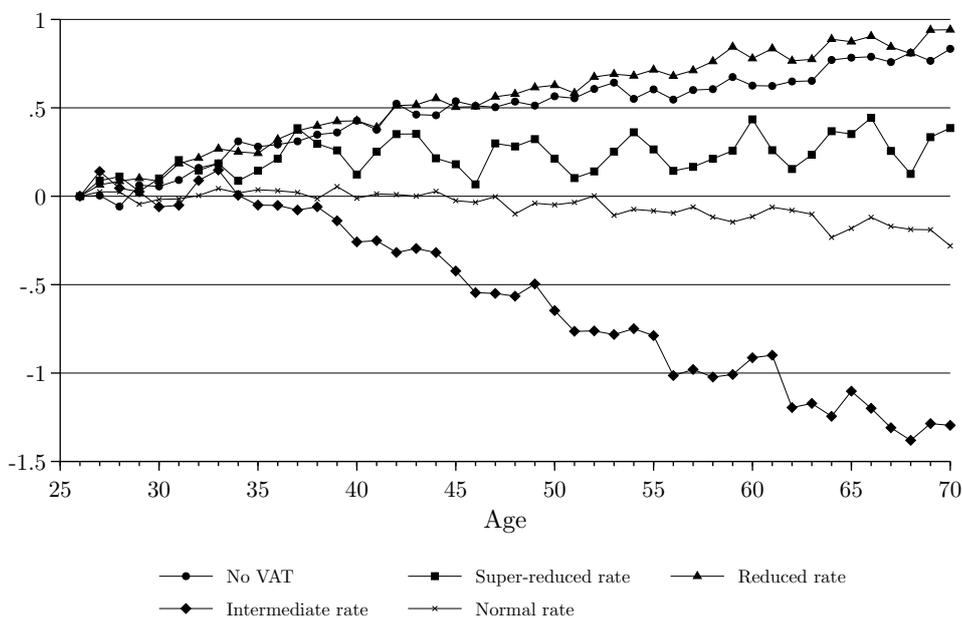
Figure 4: Average consumption and VAT age profiles



Note: the figure plots the age dummies' coefficients obtained when regressing the logarithm of (i) household consumption and (ii) VAT paid, on a set of age dummies, controlling for cohort, year of observation, and household composition effect, such as in model (1). Source: BDF, 1984-2011, Insee.

(taxed at the super-reduced rate) make up most of the rest of expenditure devoted to these tax categories. The evolution of food consumption is therefore key in understanding the increase in consumption of low taxed products over life. To be sure, Figure 6 plots the age profiles of food, health services, and newspapers consumption. The figure first shows that as individuals age, their consumption of medical services increases steadily, by about 1.2 log points. This is largely expected, and is the main explanatory factor of the increase in the consumption of zero-taxed products put forward by Figure 5. Figure 6 also shows that food consumption increases regularly over life, by about .8 log points. This is clearly the explanation behind the evolution of reduced-rate consumption described by Figure 5, but at this stage it is unclear why consumption of food at home or to take away should more than double over life. Further investigation actually shows that consumption of take-away food decreases over life, but that this is more than compensated by an increase of food consumed at home (not reported). A potential explanation for these trends is that there might be a substitution of food at home for food consumed in restaurants. This could be partly driven by the fact that individuals who work are likely to take their lunch in a restaurant, whereas individuals who do not work are likely to take their lunch at home.

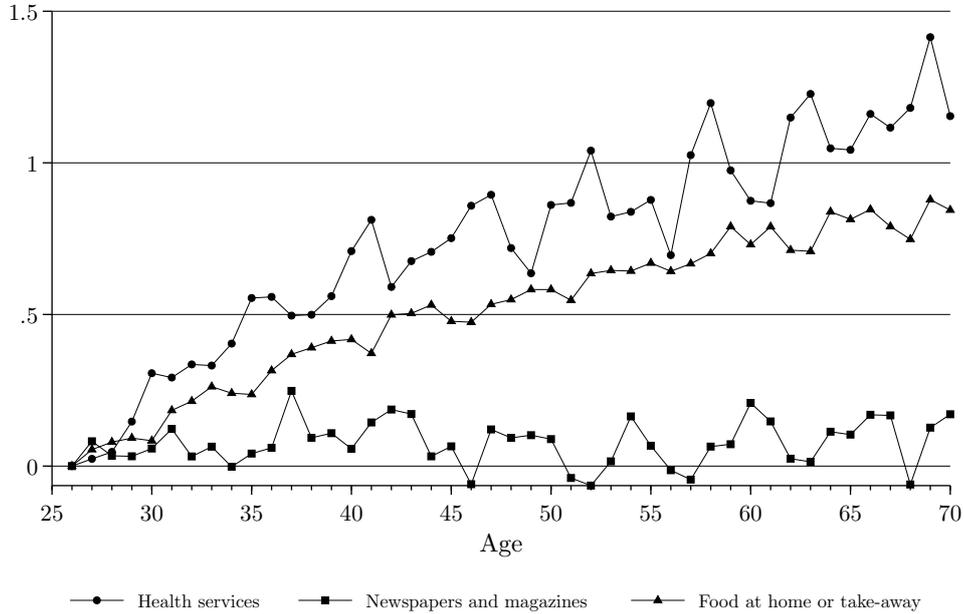
Figure 5: Average age profiles for consumption by VAT categories



Note: the figure plots the age dummies' coefficients obtained when regressing the logarithm of consumption devoted to each VAT category, on a set of age dummies, controlling for cohort, year of observation, and household composition effect, such as in model (1). Source: BDF, 1984-2011, Insee.

To test this, Figure 7 plots the evolution of the consumption of food in restaurants, which is taxed at the intermediate rate. To go one step further, it also reports the evolution of the two other top product categories comprising intermediate rate consumption, namely domestic services and recreational or cultural services. Figure 7 first reveals that consumption of food in restaurants decreases significantly by about -2.5 log points (90%) over life. As hypothesized earlier, individuals take less of their meals outside and more of their meals at home as they age. Consumption of domestic services also decreases sharply over life, by about -3.5 log points. This is somewhat surprising as older people typically require more assistance or personal care. However, further investigation shows that 70% of domestic services expenditure is actually related to child care. The analysis conducted here controls for family size, but assumes that age trajectories are independent of family composition. The fact that the consumption of child care services decreases even for a household comprised of a single individual reflects this assumption, and the limit of this econometric model. The last important item in intermediate rate expenditure is recreational and cultural services, the consumption of which stays roughly constant over life. Overall, the decrease in intermediate rate consumption witnessed in Figure 5 can be mainly attributed to a

Figure 6: Age profiles for the main components of consumption by VAT category: zero to reduced rates

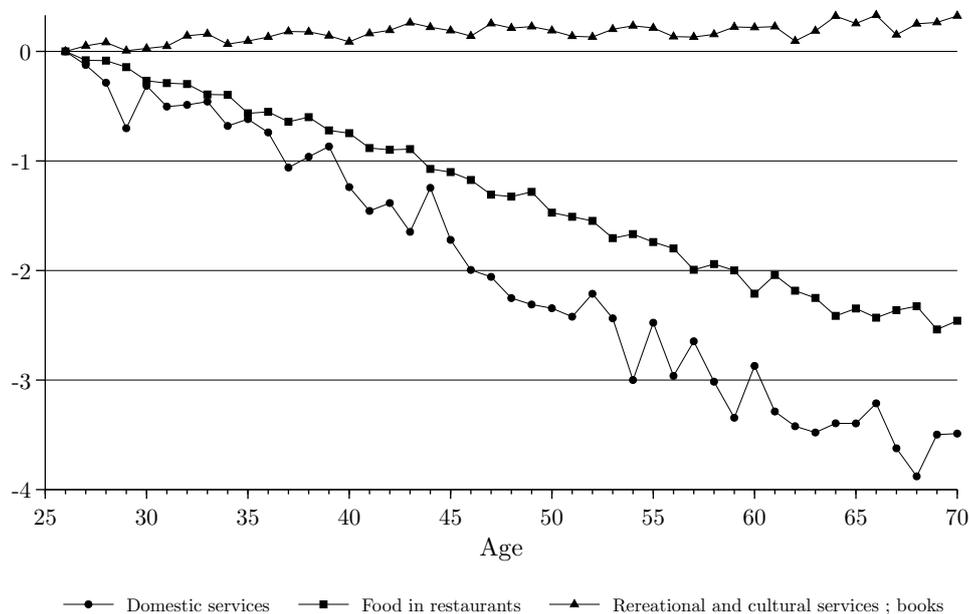


Note: the figure plots the age dummies' coefficients obtained when regressing the logarithm of consumption devoted to (i) health services, (ii) newspapers and magazines, and (iii) food at home or to take-away, on a set of age dummies, controlling for cohort, year of observation, and household composition effect, such as in model (1). Source: BDF, 1984-2011, Insee.

decrease in food taken in restaurants, which is substituted by food at home. By operating this substitution, households effectively replace the consumption of an intermediate rate product by a reduced rate product.

So far we have concentrated on explaining the evolutions of the consumption of products taxed lower than the normal rate. However, products taxed at the normal rate make up most of consumption, and namely constitute 53.2% of the budget of households on average. Understanding the slight decrease in normal rate consumption is therefore also important in interpreting the discrepancy between consumption and VAT profiles. To do so, Figure 8 plots the evolution of the three main product categories taxed at a normal rate, namely vehicle maintenance and gas, clothing, and some utilities. The figure first shows that the amount spent by individuals to service and run their car is roughly constant until age 50 and then decreases slightly by -0.4 log points over ages 50-70. Money spent on clothes follows a similar pattern, decreasing by around -0.8 log points over ages 45-70. By contrast, utility consumption increases steadily over life, by about 0.5 log points. As Aguiar and Hurst [2013] point out, an interpretation for these trends

Figure 7: Age profiles for the main components of consumption by VAT category: intermediate rate



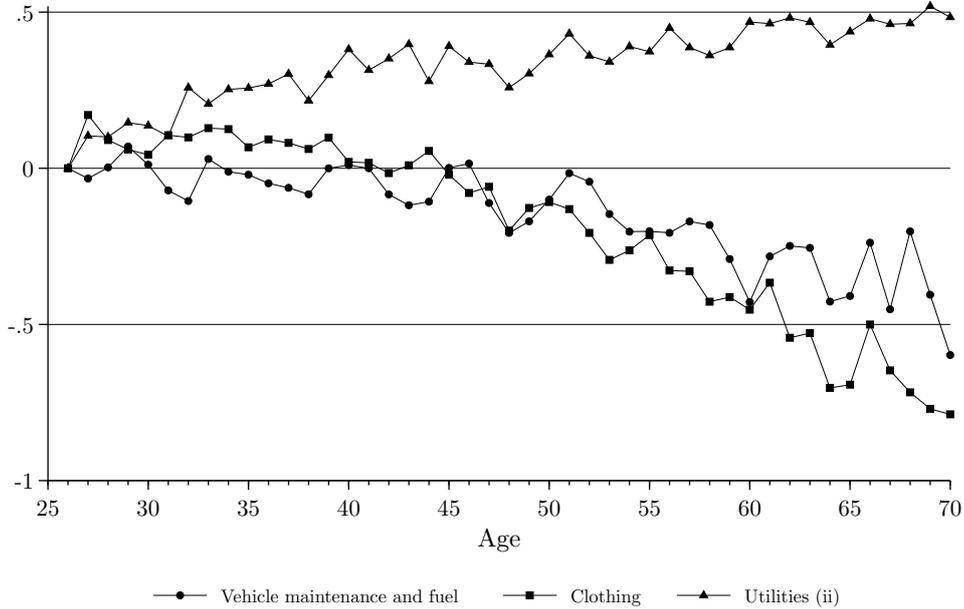
Note: the figure plots the age dummies' coefficients obtained when regressing the logarithm of consumption devoted to (i) domestic services, (ii) food in restaurants, and (iii) recreational or cultural services and books, on a set of age dummies, controlling for cohort, year of observation, and household composition effect, such as in model (1). Source: BDF, 1984-2011, Insee.

could be that owning a car and renewing a wardrobe are essentially work-related expenditures. As individuals age and start to retire, work-related consumption begins to decrease. Because work-related products such as clothing and restaurant lunches are more taxed on average than essential products such as food or medical services, VAT paid decreases more rapidly than expenditure after retirement, as shown by Figure 4. This trend is important, because it reveals a significant divergence between income and VAT paid at the end of the life. This could be the source of an important lifecycle bias in cross-sectional VAT incidence.

6 Incidence of the VAT

The previous section explored the average life-cycle trajectories of income and VAT. Because VAT paid decreases more substantially than income after individuals retire, older individuals benefit from an income level that is roughly comparable to the average income level they enjoy over their life, while at the same time paying much less VAT. In this scenario, a substantial part

Figure 8: Age profiles for the main components of consumption by VAT category: normal rate



Note: the figure plots the age dummies' coefficients obtained when regressing the logarithm of consumption devoted to (i) vehicle maintenance and fuel, (ii) clothing, and (iii) some utilities, on a set of age dummies, controlling for cohort, year of observation, and household composition effect, such as in model (1). Source: BDF, 1984-2011, Insee.

of the regressivity of VAT in cross-section could be linked to life-cycle dynamics. In this section, I build on the method presented in section 4 to investigate the extent to which VAT incidence in a cross-section and on the life-cycle differ.

To do so, Table 2 reports the cumulative income and VAT shares supported by individuals in each income quintile, as well as the corresponding Suits index for VAT. The Suits index (see Suits [1977]) is obtained by comparing the generalized Lorenz curves formed by income and VAT, when individuals are ordered by income. The index takes value -1 in the case of extreme tax regressivity, when a group of individuals in the economy earns 0% of the income and pays 100% of the tax, and takes value 1 in the opposite case where the single richest individual pays 100% of the tax. The Suits index is 0 when every individual contributes to the tax burden exactly in proportion of their resources. This is the situation where, if a group of individuals receives $x\%$ of the total income in the economy, then they pay $x\%$ of the total tax burden.

Columns (1)-(2) report these statistics obtained for the original sample. The rest of the table reports statistics computed using the simulated sample constructed as described in section 4.

Standard errors are obtained by bootstrap. For each iteration, I proceed as follows. I first draw a sample with replacement from the original data, stratified by year of birth and year of observation. I compute the set of statistics in columns (1)-(2) for this bootstrap sample. I then follow the method described in section 4 in order to simulate income and VAT at each age for all household in the bootstrap sample. Finally I compute the statistics reported in columns (3)-(5) using this simulated sample.

Table 2: Cumulative shares of income and VAT by income quintile, and Suits index

	Original sample		Simulated cross-section		Simulated lifetime	
	Income	VAT	Income	VAT	Income	VAT
1	9.0 (0.0)	12.4 (0.1)	8.9 (0.1)	12.0 (0.2)	14.3 (0.7)	16.3 (0.4)
2	22.8 (0.1)	27.8 (0.2)	22.4 (0.2)	27.9 (0.4)	31.6 (1.2)	34.9 (0.6)
3	40.8 (0.1)	46.5 (0.2)	39.9 (0.2)	46.8 (0.5)	51.1 (1.3)	54.8 (0.7)
4	63.6 (0.1)	69.1 (0.2)	63.0 (0.2)	69.3 (0.4)	73.1 (1.1)	76.2 (0.6)
5	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)
Suits index	-0.0874 (0.0026)		-0.0980 (0.0080)		-0.0523 (0.0187)	

Note: for each income quintile, the table shows the cumulative share of income received and VAT paid by households belonging to this quintile. The table also reports the Suits index for VAT. Columns (1)-(2) are obtained from the original data, columns (3)-(4) shows statistics obtained with the simulated data, but keeping households only at the age of the head when they are actually observed in the data, and columns (5)-(6) report statistics computed for lifetime quantities in the simulated data.

In the cross-sectional data, column (1) first reveals some inequality in the distribution of disposable income. The 20% poorest individuals receive only 9% of the total disposable income in the economy. In turn, column (2) shows that VAT is paid somewhat unequally. The 20% poorest individuals, earning 9% of total income, actually bear 12.4% of the total VAT burden. More generally, the cumulative share of VAT by income quintile is systematically above the cumulative share of income. In other words, poorer individuals contribute more to the tax burden in proportion of their income than richer individuals. The extent to which this is the case can be apprehended synthetically by computing the Suits index. In cross-section, the value-added

tax exhibits a Suits index of -0.087, which indicates mild regressivity.¹⁹

A first question of interest is whether the simulation method presented in section 4 can reproduce these results accurately. To investigate this, columns (3) and (4) of Table 2 report the cumulative shares and the suits index computed from the simulated data, but only keeping observations that correspond to the age of the household head for which each household was actually observed in the original data. A way to apprehend how well the method performs in cross-section is then to evaluate how close the numbers in columns (3)-(4) are to those in columns (1)-(2). As it turns out, simulated and actual cross-section cumulative income shares by income quintiles are quite similar. The difference is greatest for the third income quintile, when the simulated income share is .9 percentage points lower than the actual income share of 40.8%, corresponding to a 2.2% deviation. Similarly, cumulative VAT shares by income quintiles are very close in the simulated and actual cross-sections. The greatest deviation is for the first income quintile, where the simulated VAT share is 3% below the actual cross-section figure. Overall, the numbers in columns (1)-(2) and (3)-(4) are rarely significantly different. The Suits index is -.098 in the simulated cross-section, very close and not statistically different from the Suits index computed on the original data.

Altogether, these observations suggest that the method proposed here produces very consistent results, and can thus be used to investigate how much simulated lifetime VAT incidence differs from cross-section incidence. To explore this, columns (5) and (6) of Table 2 report the cumulative VAT and income shares by income quintiles obtained for lifetime income and VAT. I compute lifetime quantities for each household as the discounted sum of annual quantities over ages 26 to 70.²⁰ Column (5) first reveals that permanent income is distributed significantly more equally than cross-section income. When looking at permanent quantities, the first income quintile receives 14.3% of total income, instead of just 8.9% in cross-section.²¹ In the cross-section data, individuals are observed at very different stages of their lives. Since income tends to increase with age, younger individuals are mechanically pushed lower in the distribution of income than what their actual lifetime standard of living is. In other words, even in a population in which everyone would have the same lifetime income, observing individuals at different stages of their lives would create some inequality. Considering permanent income eliminates the part of income inequality that is due to this lifecycle effect. Turning to the distribution of the VAT

¹⁹In comparison, Suits [1977] finds that sales and excise taxes in the US have an index of -.15 in 1970. For the same year, he finds that the individual income tax corresponds to an index of .19.

²⁰I use a 4% discount rate as in Lyon and Schwab [1995].

²¹For the USA, Lyon and Schwab [1995] find that the first income quintile receives 6.1% of income in cross-section data, but 9.9% in permanent quantities. Our results highlight the same pattern.

burden, column (6) then reveals that VAT is still paid for quite unequally in a lifetime perspective. The 20% poorest individuals according to lifetime income pay 16.3% of lifetime VAT but only receive 14.3% of total lifetime income. More generally, cumulative lifetime VAT shares are always greater than cumulative income shares, which indicates that VAT is still regressive in a lifetime perspective. However, further inspection reveals that it is somewhat less regressive than in cross-section. The deviation between cumulative VAT shares and cumulative income shares is much smaller for lifetime quantities than for cross-sectional ones. Simulated cross-section data indicates that the 20% poorest individuals pay 35% more VAT than what they would be paying if the tax were proportional, whereas with lifetime quantities this deviation drops to 14%. Overall, the Suits index for lifetime VAT is -0.052 , significantly lower than -0.098 . This suggests that VAT is about 50% less regressive on the life-cycle than in cross-section.

7 Conclusion

Taxes on consumption account for an important part of fiscal resources in most countries. In France, the value-added tax has become the most important source of revenue for the State. Because collecting consumption taxes is easy and inexpensive, they may play an increasingly important role for many countries in the future. Since savings are partly used to finance future consumption, the distributional effect of such taxes should arguably be measured over the life-cycle of individuals. However, important data limitations have impaired progress in this direction.

In this paper, I propose a way to evaluate lifetime incidence of taxes on consumption, using only repeated cross-section data on consumption and income that is available in many countries. The method relies on estimating a simple parametric model for the joint process of income and VAT, using a pseudo-panel of empirical moments computed among fixed-membership groups. The joint distribution of lifetime income and VAT can then be recovered by simulating their individual life-cycle trajectories. Overall, I find that the value-added tax in France is about 50% less regressive over the life-cycle than in a cross-section.

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A Data appendix

Normalized year dummies

Following Deaton [1997], I impose that year effects sum to zero and that they be orthogonal to a time trend in model 1. Those constraints can be directly embedded in model 1 by replacing year dummies with properly normalized year dummies. This procedure is explained in Deaton [1997] for the case where data is available for consecutive years. However, in this paper we use repeated cross section that are spaced irregularly over time. I explain here how to recover normalized year dummies in this setting. We can write the full vector of year controls as:

$$\gamma_{1984}d_{1984} + \gamma_{1989}d_{1989} + \gamma_{1995}d_{1995} + \gamma_{2000}d_{2000} + \gamma_{2006}d_{2006} + \gamma_{2011}d_{2011} \quad (6)$$

where the γ_t 's are to be estimated and the d_t 's denote the vectors of zeros and ones associated with each year indicator. Normally, we would for example set γ_{1984} equal to zero to normalize the year effects. Here, we are trying instead to find a new linear combinations of the d_t 's (denote them \tilde{d}_t) such that imposing $\tilde{\gamma}_{1984} = 0$ and $\tilde{\gamma}_{1989} = 0$ mechanically imposes our two restrictions that year effects sum to zero and be orthogonal to a time trend. In other words, we need that:

$$\begin{cases} \tilde{\gamma}_{1984} = \gamma_{1984} + \gamma_{1989} + \gamma_{1995} + \gamma_{2000} + \gamma_{2006} + \gamma_{2011} \\ \tilde{\gamma}_{1989} = 5\gamma_{1989} + 11\gamma_{1995} + 16\gamma_{2000} + 22\gamma_{2006} + 27\gamma_{2011} \\ \tilde{\gamma}_t = \gamma_t \text{ for } t \geq 1995 \end{cases} \quad (7)$$

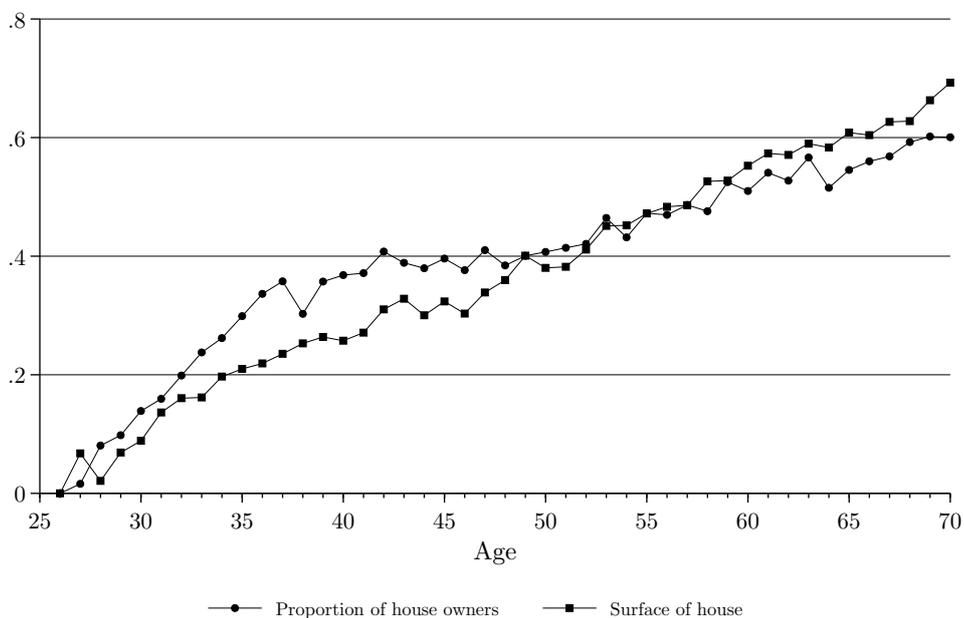
Collecting terms associated with each vector of year indicators d_t , this imposes:

$$\begin{cases} d_{1984} = \tilde{d}_{1984} \\ d_{1989} = \tilde{d}_{1984} + 5\tilde{d}_{1989} \\ d_t = \tilde{d}_t + \tilde{d}_{1984} + (t - 1984)\tilde{d}_{1989} \text{ for } t \geq 1995 \end{cases} \quad (8)$$

The normalized year dummies are therefore given by $\tilde{d}_t = d_t - d_{1984} - \frac{(t-1984)}{5}(d_{1984} - d_{1989})$ for $t \geq 1995$, with \tilde{d}_{1984} and \tilde{d}_{1989} being excluded from the estimation.

B Further results

Figure 9: Factors explaining the evolution of imputed rents over life



Note: the figure plots the age dummies' coefficients obtained when regressing (i) a dummy indicating homeownership and (ii) the log of the surface of the dwelling of households, on a set of age dummies, controlling for cohort, year of observation, and household composition effect, such as in model (1). Source: BDF, 1984-2011, Insee.

Table 3: Changes in VAT structure

	1982	1988	1989	1990	1992	1995	2000	2012	2014
Super-reduced rate	5.5	5.5	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Reduced rate	7.0	7.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Intermediate rate								7.0	10.0
Normal rate	18.6	18.6	18.6	18.6	18.6	20.6	19.6	19.6	20.0
Increased rate	33.33	28.0	25.0	22.0	18.6				

Note: the table reports the main changes that occurred from 1982 to 2014 concerning the existing VAT rates. Numbers reported are the percentage at which products falling in the corresponding tax category were taxed.