The Granger causality of income on health

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Abstract

Socio-economic status and health status are positively related. However, one must be careful in considering the causal impact of income on health, since the reverse causality might be at play. Income inequalities are an important factor in health inequality such that policy makers who aim at improving general health or narrowing health inequalities using public policies, need to understand the sources and the true direction of the causality between income and health. We thus implement a linear probability model in order to assess the Granger causality of income on self-perceived health status. Moreover, we also apply an instrumental variables strategy in order to correct endogeneity issues coming from both income and phenomenon of persistence in the health status due to data generating process. Using the Survey of Health, Aging and Retirement in Europe (SHARE), we exploit the dynamic dimension of the data. We find evidence of a strong positive and significant effect of income on self-assessed health, implying the Granger causality of income on health. Thus, public policies such as redistribution, are efficient to reduce income-related health inequalities.

Keywords: Granger causality; income; endogeneity; instrumental variables; self-assessed health; Europe.
JEL Classification: C23; C26; D31; I10; J14.

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1 Introduction

A topic at the center of health economics is the relationship between health and individual income, with the consensus view among researchers being that higher socioeconomic status is associated with better health (Preston [1975]). This relationship has been reviewed using many health outcomes in different countries (e.g. Van Doorslaer et al. [1997] using self-assessed health). While this relationship appears to be well-known, this is not the case concerning its causal interpretation. There are many possible pathways through which earnings can impact health. Indeed, there is a causal relationship between socioeconomic status, or more specifically income, and health of the former on the latter (Frijters et al. [2005]; Apouey and Clark [2015]). However, we can also think of the reverse association, for instance stating that poor health status may influence income, by reducing the ability to work (Michaud and Van Soest [2008]). This lack of a clear understanding of causality is an important omission, and the direction of the causal effect of income on health does not seem obvious. Since income inequalities are an important factor in health inequalities (e.g. Carrieri and Jones [2016]), policy makers who aim at improving general health or narrowing health inequalities in a society, need to understand the sources and the true direction of the causality between income and health. The difficulty in disentangling cause and effect is due to endogeneity, more specifically whenever health and income mutually determine one another, there are simultaneity issues. Since simultaneous causality in both directions may exist, testing the causal impact of income on health requires assessing the exogeneity of income. In this context, different econometric methods have been used to fix this issue such as instrumental variables method or exogenous income shocks, but without finding a common consensus about the direction of the causality (from income to health according to Halliday [2016] or from health to wealth according to Michaud and Van Soest [2008]). While these studies disagree about the direction of the causality between health and income, they provide interesting insights. However, majority of these studies do not adequately consider heterogeneity due to individual fixed-effects that may be associated with both income and health. The two previous cited studies address this temporal concerns by both employing dynamic panel techniques to investigate causality. Nevertheless, our paper deepens the link between health and income and is different from these since we will explicitly bring to the forefront the Granger causality while taking into account other information and concerns. Indeed, on one hand, Halliday [2016]'s study differ from ours in two points. First, he uses data from the Panel Study of Income Dynamics which considers individuals aged 25 to 60 whereas we will use a panel data of individuals aged 50 and older, and second, our database contains more information so that we can investigate more covariates and control variables in the estimates, to make a robust link. On the other hand, Michaud and Van Soest [2008] work on the Health and Retirement Study, a population of U.S. couples aged 50 and older, a similar population than ours, but focus on wealth. However, instead of using further lags to instrument the phenomenon of persistence of health, we will make use of condition of moments' hypothesis concerning morbidity indicators to find appropriate instruments.

We choose to focus on self-perceived health, a subjective measurement of health status but considered to be a strong predictor of an individual's health (Benitez-Silva et al. [2004]). Indeed, individuals take into account several elements of their health when assessing their subjective measure of health. Diseases, diagnosed health problems, as well as interactions with health professionals are factors which influence self-rated health (Tubeuf et al. [2008]). Thus, it incorporates factors which are not always observed by health professionals because it integrates personal expectation of the level of health.

This paper contributes to these subjects by bringing the Granger causality of income on health to the forefront. We use European dynamic micro data, where the temporal dimension of the data is employed to evaluate and predict changes in self-perceived health status according to income. Linear probability model with control of endogeneity as well as, exogenous income shocks are used to get rid of the endogeneity issues related to income and persistence in health status. With these methods, we ensure the direction of the causality from income to health.

In section 2 we present the theoretical framework of the causal relationship between income and health. Section 3 describes the Survey of Health, Ageing and Retirement in Europe. In section 4 we detail the econometric framework, as well as the results. Section 5 concludes the paper.

2 The causal relationship

The relationship between self-perceived health status and individual income is heavily documented in health economics. Self-perceived health status assesses the general perceived health of an individual. In order to collect this information, individuals are asked: "Would you say your health in general is..." and they have to choose between five answer categories ("excellent", "very good", "good", "fair" or "poor"). Self-perceived health status is an important predictor of an individual's health since it combines different elements that an individual knows about his own health. This subjective measure also integrates factors which are not always considered by health professionals such as individuals' beliefs and attitudes towards health commodity for instance. Thus, this indicator, despite its subjective nature, is a good predictor of people's actual health status (Benitez-Silva et al. [2004]; DeSalvo et al. [2005] ;

Bond et al. [2006]). Recent studies modeling the dynamics of health-income relationship question the existence of a causal effect of income or other socioeconomic status on health (see, for instance, recent studies by Kim and Ruhm [2012]; Apouey and Clark [2015] or Halliday [2016]). The direction of causality is considered to be an important issue much debated among economists, since the lack of a clear and true understanding constitutes a major shortcoming for policy makers, who aim to narrow health inequalities and improve health. In this paper, we want to investigate the direction of the causality by tackling the question of what happens to a person's health when they experience a variation in their income. In the literature, some papers have already used instrumental variables methods or exogenous income shocks to investigate a causal link between health and income. Concerning instrumental variables method, authors investigate different kind of instruments and the majority find that income has a positive and significant effect on health (Ettner [1996]; Economou and Theodossiou [2011]; Halliday [2016]). Indeed, Ettner [1996] examines the effect of income on different health proxies, such as self-assessed health, daily activity limitations, proxies for alcohol abuse and others. She uses cross-sectional data from a number of US surveys collected in the 1980's. Depending on the health outcome, she uses ordered probit, probit or two-part models. The problem of reverse causality is addressed via an instrumental variables method, using parental education, work experience, spousal characteristics and unemployment rate as instruments. In each case, Ettner finds that income still has a significant impact on health. Economou and Theodossiou [2011] use European data to investigate the socioeconomic status-health relationship, and control for income endogeneity using inheritance, children's education and art collection as instruments. Results indicate a strong and positive relationship between household income and health. However, the use of cross-sectional data weakens the causal statement. More recently, Halliday [2016] employs data from the Panel Study of Income and Dynamics (US) to investigate the causal link of income on health. He implements a GMM procedure on a model in first-differences, and uses further lag variables as instruments. His results establish a causal link running from income to health in the case of married individuals. However, Michaud and Van Soest [2008] do not find a significant impact of wealth on health. They investigate the pathways of the health-wealth gradient using six waves of the Health and Retirement Study (US equivalent of SHARE database), implemented in a GMM framework. They instrument wealth using inheritances but do not find any causality from wealth to health. They also investigate the causality from health to wealth and the results are significant.[1] On the other hand, exogenous increases in income are investigated to identify a causal

[1]We will consider individual income since our database contains precise and complete information about the latter. We will also do our analysis using wealth for robustness and comparability. This will reduce our sample due to missing information.

effect of wealth or income on health. These exogenous shocks result from lottery winnings (Lindahl [2005]; Gardner and Oswald [2007]; Apouey and Clark [2015]), inheritances (Meer et al. [2003]; Kim and Ruhm [2012]) or other economic changes (Frijters et al. [2005]; Adda et al. [2009]; McInerney et al. [2013]). Findings from these studies suggest that lottery wins have a positive effect on mental health. Indeed, Lindahl [2005] uses Swedish longitudinal data to account for the health-income relationship. In this paper, lottery prizes are used to provide exogenous variations in income. However, the identification of lottery winners is not ideal since it is not possible to establish when the individual wins in his lifetime. Lindahl runs the estimation on different aspects of health and the results are varied. He finds that lottery winnings have a positive impact on mental health and imply lower body mass index. However, lottery winnings have no effect on other physical health problems. Gardner and Oswald [2007] explore the causality issue using medium-sized lottery wins (£1000+) as their instrument. They use medium-sized lottery wins because individuals who get no win are almost indistinguishable in their responses from individuals with a small win. They find that mental health is positively affected by income. Apouey and Clark [2015] determine the exogenous impact of income on different health outcomes with English data, using lottery winnings to make causal statements. They find that positive income shocks do not have a significant effect on general health, but do have an effect on mental health. Nonetheless, inheritances do not have a significant effect on health. Meer et al. [2003], on American data, use the amount of inheritances and gifts received over the last five years (amounts larger than US $10,000). In the econometric estimation, wealth does not have a significant effect on health. Moreover, the validity of inheritance information is also open to debate, as noted by the authors. Kim and Ruhm [2012], using eight waves of the Health and Retirement Survey, find that bequests (larger or equal to US $10,000) do not have a significant impact on health. Finally, variations in income due to changes in the economic environment suggest that health is positively impacted by exogenous income shocks. Frijters et al. [2005] analyze the association between self-assessed health and income using German data. Their instrumental method is to use an exogenous change in income due to the fall of the Berlin wall. In other words, they investigate whether there was a causal effect of income changes on the health satisfaction of East and West Germans in the years following reunification. Results show a positive impact of income on health. Adda et al. [2009] model income and health as a stochastic process evolving over the life cycle, created using a synthetic cohort dataset which is based on successive years of micro data from several English cross-sectional surveys. They exploit the fact that, at the cohort level, over the eighties and nighties, there were sizable changes in income, mainly due to changes in the macroeconomic environment. Their results imply that income variations have little effect on health, but do affect health behaviors and mortality.

McInerney et al. [2013] use exogenous variation in the interview dates of the 2008 Health and Retirement Survey to assess wealth losses's impacts on mental health. They find that feeling of depression and use of antidepressant drugs increase after the 2008 stock market crash.

Moreover, we should be aware that in the causal relationship between health and income, there are likely to be effects which need to be controlled. In graph 1, we

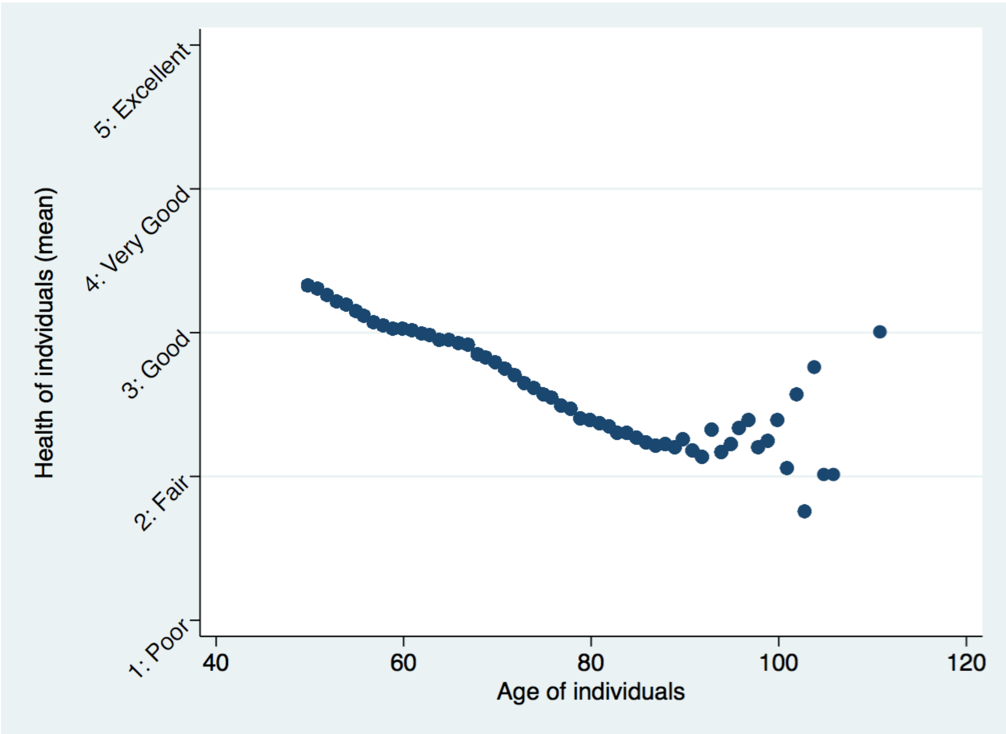

Figure 1: Health of individuals - SHARE survey

notice that health status is a decreasing function of age.[2] When people get older, they tend to consider themselves as being less healthy. Changes in health status are thus partly due to the age. As a result, researchers need to control for this factor if they want to establish a causal link between income and health. This could be due to changes in behaviors on the one hand or changes in morbidity or technological progress, on the other. Indeed, self-rated health assimilates morbidity, which in turn depends on diagnosed health problems, interactions with health professionals, as well as diseases (Tubeuf et al. [2008]). Traditional measures of morbidity provide important information about levels of health. Morbidity corresponds to the incidence of diseases. It seems that morbidity is a good predictor of the self-assessment of health status, and this is why we will control for its effect in the health-income relationship. We model for morbidity thanks to indicators characterized by chronic

[2]Graph 1 comes from data of the Survey of Health Ageing and Retirement in Europe, which contains five waves (each two years, from 2004 to 2015). See section 4.1 for further information.

illnesses and disability. The last impact we need to be careful about is technological progress. Examining trends and patterns in mortality helps to explain changes and differences in health status, permitting evaluation of health strategies. In the sixth edition of the "Public Health Status and Foresight Report: A Healthier Netherlands" (Hoeymans et al. [2014]), the authors argue that technological applications arise in prevention, treatment and care. The benefits range from improved diagnostic skills to regenerative medicine facilitating the independent living. For example, research enables more targeted prescription of medicines, and sensor technology enables instruments that monitor health status and home automation devices. As a result, one anticipates that self-perceived health status will increase across the board in the future, thanks to technological and societal trends allowing an improvement in medical care. Empirically, technological trends can be modeled in two ways: using longevity as a proxy (since this informs us on the improvement of medicine); and using any variable which is homogeneous across individuals in a given year. Concerning the latter way to model technological trends, we suppose that everybody is affected in the same way by these trends.

In order to establish a causal relationship between health and income, the goal of this paper is to take into account all the previously enumerated effects. One should notice that when talking about causality in social sciences, experimental studies might be useful. However, in this research we do not make use of such methods because we think that it refers to a different approach and thus story, and we do not have the means necessary to develop these methods. However, since we have access to a rich panel database, we can investigate the causal impact of income on health.

3 Data

The dynamic interaction of changing humans in changing environments is not thought to be captured adequately by simple relationships among variables at a point in time and this is why we want to explore the panel dimension of the database.

3.1 SHARE Survey

The Survey of Health, Ageing and Retirement in Europe (SHARE) is a multidisciplinary and cross-national panel database of micro data on health, socio-economic status and social and family networks of more than 123 000 individuals aged 50 and over from many European countries and Israel. Since 2004, SHARE asks questions to a sample of households throughout Europe with at least one member who is 50 and older. These households are re-interviewed every two years in the panel.

The first wave (2004-2005, around 27,000 individuals) and the second one (2006-2007, around 34,000 individuals) were used to collect data on health status, medical consumption, socio-economic status, and living conditions. The 2008-2009 survey (Wave 3) “SHARELIFE” was extended to life stories by collecting information on the history of the respondents. Since it does not contain the required information for our research, this wave is not taken into account in the pooled database used. The number of participants increased from 12 countries in wave 1 (Börsch-Supan [2016a]), to 15 (adding Ireland, Israel, Poland and Czech Republic) in wave 2 (Börsch-Supan [2016b]), while the third wave contains information about 13 countries. Wave 4 (2010-2011), is a return to the initial questionnaire of waves 1 and 2 (Börsch-Supan [2016c]). It collects data from 56 533 individuals in 16 European countries. The fieldwork of the fifth wave (Börsch-Supan [2017d]) was completed in November 2013. The following countries are included in the scientific release of 2015: Austria, Belgium, Switzerland, the Czech Republic, Germany, Denmark, Estonia, Spain, France, Israel, Italy, Luxembourg, Netherlands, Sweden, and Slovenia. This wave contains the responses of 63 626 individuals. Finally, the sixth wave is available since 2016 and contains information on 67 346 individuals from 18 countries (Börsch-Supan [2017e]). As a result, the pooled database contains almost 250 000 observations, and individuals are present on average 2.1 years in the panel. However, researchers should also be aware of the potential disadvantage of this database. Indeed, Börsch-Supan et al. [2013] explain that in some waves there are relative low response rates and moderate levels of attrition (even though the overall response rate is high compared to other European and US surveys with an average retention rate over the year of 81 %) which are presumably due to the economic crises faced by some of the countries implying a decrease in the participation rates. We choose to focus on this survey since it has all the information needed to carry out this research. Indeed, the dependent variable in our study is the self-perceived health status where individuals are asked to classify their health from “poor” to “excellent” (see figure 2). Concerning, the covariates, we use quadratic age, education (following the International Standard Classification of Education), marital status and wave and country specific Gini coefficient[3] to have more variability in this measurement (see table 2 in appendix part for further information). We also use dummies for group of countries to capture regional effects.[4] Then, technical progress, which allows an improvement in medicine, will have an ameliorating effect on the self-perceived health status in the future. On one hand, it can be modeled using longevity as a proxy, but this information is not easily obtainable in the dataset.

[3]The Gini coefficient goes from 0 to 1, with 0 representing the situation of perfect equality where incomes in a population are distributed completely equally.

[4]Dummies for countries are not included because of quasi-multicollinearity which can arise with the Gini coefficient.

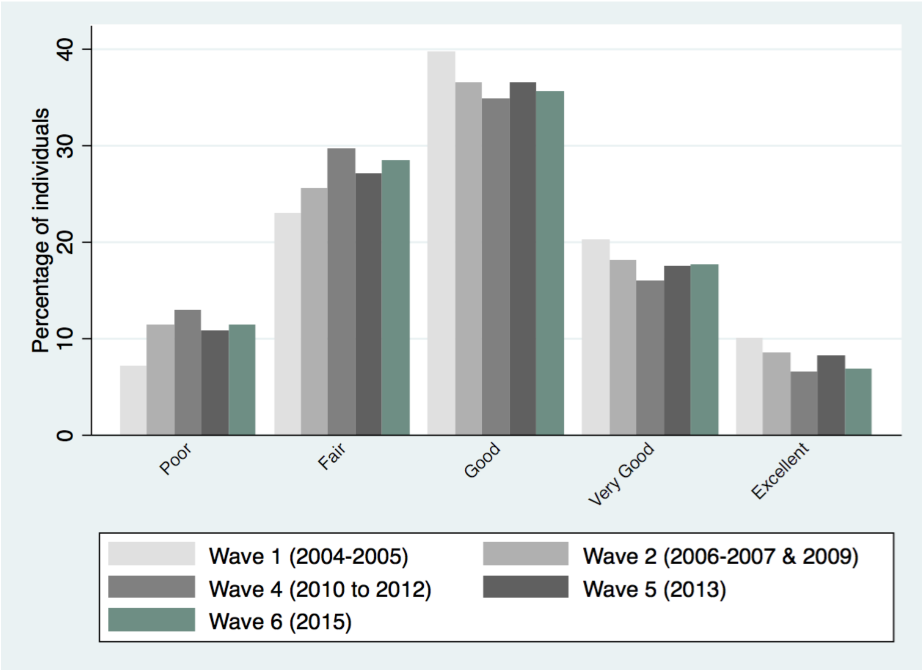

Figure 2: Distribution of self-perceived health status - SHARE

However, similar information is provided by life expectancy. The OECD gives information for Europeans countries about the life expectancy at 65 years of age. We distinguish the women's life expectancy from that of men in each country, in order to have the most accurate information. Technological progress can also be viewed as a variable which is homogeneous for all individuals for a given year. As a result, we also add time dummy variables to the specification. Since, life expectancy is not completely collinear to time dummy variables, both variables are added into the specification, in order to capture the real trend implied by the technical progress.

3.2 Income variable

As explained earlier in this paper, we have to control for income. In this database, income corresponds to the sum of individual imputed income for all household components. We use the logarithm of income to reduce the impact of outliers. We intend to apply two methods to make sure of the robustness of the causal link. First, we chose to apply an instrumental variables method to get rid of the endogeneity issue. A good instrument has to be correlated with income but not with the health of individuals. Due to data availability, we decided to introduce into the econometric analysis, two variables. The first variable is a microeconomic instrument corresponding to the location of the main residence. This is a categorical variable in which individuals say whether they live in a big city, the suburbs or outskirts of a big city, a large town, a small town or a rural area. We thus create dummy variables and take as a reference category "living in a rural area". The second variable is the unemployment rate[5] and can be considered as a macroeconomic instrument, since it is computed for each country at each year of the survey (Meer et al. [2003]). Second, we would like to know what are the changes in the health status following positive income shock. The use of data on financial gifts creates a setting as close as possible to the idealized laboratory experiments. One piece of information given in the survey is whether an individual has received an unexpected gift or inheritance (worth 5 000€ or more). One can ask whether a financial gift is a good instrumental variable. We are mindful of the possible concerns with our instrumentation strategy. One can support that inheritance does not satisfy all the exclusion restrictions such that this is not a very strong income shock (a family member dying might signal something about the individual's health or other unobserved variables might drive both heath and inheritance using the idea of "privileged backgrounds").

3.3 Morbidity indicators

It is important to measure health status in terms of non-fatal health outcomes since these are important for the burden of a disease. Morbidity indicators can be broadly defined by the prevalence or incidence of diseases, but also by the degree of disability and the risky behaviors of individuals, which can cause diseases. Morbidity is strongly correlated with the self-perceived health status (Manor et al. [2001]; Latham and P. [2013]; Chan et al. [2015]). As a result, it has to be taken into account when one studies self-perceived health status. Dormont et al. [2006] use a French microeconomic dataset (Santé Protection Sociale, conducted by IRDES) in order to construct morbidity indicators. We will base our construction of indicators on their method, since they produce these indicators with the help of general practitioners who assure their validity. As regards morbidity, we consider the last two indicators of the Mini European Health Module (MEHM), which represents three concepts of health.[6] The first one concerns the self-perceived health status which assesses general perceived health rather than the present state of health. This indicator, first recommended by the World Health Organization in 1988, seeks to incorporate different dimensions of health (i.e. physical, social, and emotional, as well as functional signs and symptoms). Despite its subjective nature, indicators of perceived general health have been found to be a good predictor of people's future health care use and mortality (DeSalvo et al. [2006]; Cox et al. [2009]). The second indicator is the morbidity and it assesses the incidence or prevalence of a disease or of all diseases. This indicator gives information about people having long-standing illness or health problems. The last indicator is about activity limitation and dis-

[5]Source: OECD website.

[6]The MEHM is included in several European survey programs (EU-SILC, SHARE, EHIS and Eurobarometer).

ability, which assess self-perceived long-standing limitations in usual activities due to health problems. Thus we will use a vector of chronic illnesses and disability indicators for morbidity. Indeed, a variety of lifestyle factors and health-related behaviors, such as alcohol consumption, physical activity and dietary habits, can affect a person's health. An unhealthy lifestyle often results in a higher risk of chronic diseases. SHARE database has the advantage of providing information about many morbidity indicators which can be divided into three main parts.[7] The first part concerns the degree of invalidity of individuals and is represented using the following indicators: Activities of Daily Living (ADLs), Instrumental Activities of Daily Living (IADLs), the Global Activity Limitation Indicator (GALI) and an indicator about mobility limitation. The second indicator is about chronic diseases and gives the number of chronic diseases of an individual. Finally, the third category of morbidity indicators concerns the risky behaviors of individuals.[8] We choose the alcohol consumption variable which informs us on the drinking habits.

4 Econometric framework and results

4.1 Identification strategy

In order to assess the real impact of income on health, we focus on the concept of Granger causality, which takes into account the temporal dynamic of the relationship. The definition of causality by Granger [1969] distinguishes lag causality from instantaneous one. As a result, we investigate the causal impact of past income on current health status. This approach includes the phenomenon of persistence of health status in the relationship. We intend to estimate the following health equation to highlight a permanent causality from income to health:

$$h_{it} = \alpha_0 + \lambda h_{i,t-1} + \delta linc_{i,t-1} + X_{it}\beta + c_{jt} + \epsilon_{it} \qquad \forall i = 1...N \quad \& \quad \forall t = 1...T_i \tag{1}$$

$$\epsilon_{it} = \eta_i + \zeta_{it} \tag{2}$$

where T_i corresponds to the number of observations for an individual i; h_{it} is a binary variable equals to 1 when individual i reports being in good, very good or

[7]See the appendix part in order to have detailed statistics and definitions on the indicators.

[8]We do not include information about smoking since this variable contains a lot of missing information such that it would considerably reduce the number of observations. However, we did the entire microsimulation method with the inclusion of this variable and find similar results. The results are not reported here but available upon request.

excellent health[9] at date t; $linc_{it}$ denotes the log income[10] of individual i at date t; c_{jt} represents the technological trend of country j at date t, thus corresponding to cross-country and time fixed effects; X_{it} is a set of observed variables representing age, gender, marital status, schooling, a country-specific indicator of income inequality (Gini coefficient) and dummies for group of countries; and ϵ_{it} is an error term which can be decomposed into two terms (equation 2) including individual fixed effects which account for individual unobserved heterogeneity. To be sure of correctly assessing the true impact of income on health, we also add an exogenous income shock (included in X_{it}) to the equation. Exogenous income shocks are useful to set up a causal link between health and income. Thanks to data availability, we follow the intuition first introduced by Meer et al. [2003] using information about the amount of gift or inheritance (worth 5 000€ or more). This variable is defined as unexpected gifts or inheritances and is assumed not to be endogenous. This information will be included as dummy variable. We first specify a model explaining the relationship between self-perceived health status and income, using a probit model by using a binary dependent variable. With the self-perceived health status outcome being denoted as h_{it}, the latent variable specification of the model can be stated that we estimate corresponds to equation 1:

$$h^*_{it} = \alpha_0 + \lambda h^*_{i,t-1} + \delta linc_{i,t-1} + X_{it}\beta + c_{jt} + \epsilon_{it} \tag{3}$$

where h^*_{it} is the latent variable which underlies self-reported health status. The other variables are the ones of equation 1. Hereafter, we detail our approach concerning the endogeneity status of the different variables.

First of all, in the estimation of equation 1, we consider the exogeneity of what we are calling, hereafter, the covariates (i.e. X_{it} corresponding to exogenous income shock, age, gender, marital status, schooling and an indicator of income inequality by country and wave):

$$E(X'_{it}.\epsilon_{it}) = 0 \quad \forall t$$

Concerning gender, this is fixed across waves. Then, for the other variables, each component provides different resources and displays different relationships to health. As a result, concerning schooling, a higher level will allow an individual to have better access to health systems and therefore one's subjective health should improve. Education shapes future occupational opportunities and earning potential. Thus, it also provides knowledge that allows better-educated persons to readily gain more

[9] This binary variable is derived from self-perceived health status. An individual reporting their health as being excellent, very good, or good were categorized as 'healthy", h_{it} equals 1; in contrast, individuals reporting their health as fair or poor were categorized as "unhealthy", h_{it} equals 0.

[10] We will use log transformation of income to reduce the effect of outliers, as done by Michaud and Van Soest [2008] or Halliday [2016].

access to information, which in turn promotes health. Grossman [1972] proposes, in addition, that variables such as age and education will influence the optimum level of health. As a result, if one decides to control for age, then we should also control for education. Then, since we are focusing on the health-income gradient, we need to consider an indicator for income inequality in a country since this also plays a role and has an impact on individual current health status (Adeline and Delattre [2017]).

Then, we need to focus on the income variable. The Granger causality involves a delayed causality of income on health in a manner that income creates disparities throughout time. In other words, lagged income has an impact on current health so that a permanent variation in individuals income will have a permanent impact on health. Moreover, income affects health and might also affect other unobservable variables (such as lifestyle or food expenditures) which in turn might influence health status.In health economics literature concerning causality, due to endogeneity issues, the difficulty is to distinguish causes and effects. From an early stage in the debate, it was argued that higher income causes better health (Preston [1975]). Smith [1999] explains that this positive relationship leads to a number of interpretations: causality may go from income to health (high economic resources lead to better health status for many reasons such as: more resources devoted to health or better knowledge about what improves health), from health to income (poor health may restrict a family's capacity to earn income or to accumulate assets by limiting work or by raising medical expenses), or both may be determined by other common factors. For instance, η_i (equation 2) might contain common factors to both h^*_{it} and $linc_{i,t-1}$, implying:

$$E(\epsilon_{it}|linc_{i,t-1}) \neq 0$$

Similarly, Wooldridge [2002] brings two issues to the forefront which need to be taken into account in solving the endogeneity problem:

1. The issue of reverse-causality is a concern when one studies income-related health relationship: a positive income shock can lead to an improvement in health status through, for example, better access to medical services. However, we can also think of the reverse relationship where people in good health are likely to be more economically productive and thus have higher incomes.
2. Some individual characteristics which are not identified by the researcher may determine both income and self-assessed health status. A biased estimation between income and health results from a failure to control for these effects.

In the literature, authors use instrumental variables methods to solve endogeneity issues (see section 2 for a review of such studies). To deal with this problem, the principle of instrumental variables is to find a variable Z_{it} which is correlated to the endogenous variable $linc_{i,t-1}$, but which is not correlated with the error term ϵ_{it}. We may think of two instruments thanks to data availability. From a macroeconomic point of view, we can use the unemployment rate of each country and each wave since this is correlated to the amount earned each month. Whether the individual has an income also depends on whether he is working. However, this will be a valid instrument only if the changes in health are due solely to differences in income. At the microeconomic level, we can use the location of the main residence of individuals. Indeed income is correlated with where individuals live. We assume that the location of the main residence is correlated to the employment regions, and thus to the income of individuals.

Finally, equation 1 is an auto-regressive form, which is due to the data generating process underlying by Granger causality of income on health. This auto-regressive form implies a biased estimation if we have:

$$E(h^*_{i,t-1}.\epsilon_{it}) \neq 0 \quad \forall t$$

As a result, in order to solve this endogeneity issue, we will implement an instrumental variables strategy using lagged values of a morbidity indicator. More specifically, we will use moment conditions of an indicator about activities of daily living (ADL) which is related to morbidity. Cabrero-García and Juliá-Sanchis [2014] explain that "the greater the reported morbidities, the more limited is the subject's activity and the poorer his health". This example supports the idea of an instantaneous correlation between self-perceived health status and activities of daily living. Since both are self-reported, when individuals rate their health, they also take into account their limitations which are included in morbidity indicators. We think that activities of daily living only have an instantaneous endogeneity effect on self-perceived health, implying that, with lagged values, we no longer face an endogeneity issue. Because our framework is based on the concept of Granger causality such that our regressor is past health, we thus consider double lagged of this morbidity indicator, such that we have the following:

$$E(ADL_{i,t-2}.h^*_{i,t-1}) \neq 0 \tag{4}$$

As a result, the error term remaining will no longer be corrupted.

4.2 Results

We examine the Granger causality of income to evaluate its effect on self-perceived health status. To do so, we adopt a strategy similar to that used by Halliday [2016]. Indeed, we implement a linear probability model which allows us to overcome issues with endogeneity in a dynamic dimension with discrete dependent variable. Since we want to highlight the Granger causality of income on health, we include lagged variables for income and health (phenomenon of persistence). We lose observations due to these delayed variables, because all individuals are not always interviewed during the five waves of the panel.[11] We first estimate the health equation 1 in order to get an idea about correlations of each factor to the health status. Results in column one of table 1 display a strong phenomenon of persistence in health status. Past income is positively related to the feelings of individuals concerning their current health. This result is significant and has the intuitive sign according to the literature, where it is said that a higher income is positively associated to health status. Concerning morbidity indicators, which represent the prevalence or incidence of a disease, results imply that being affected by a disease, or by limitations, is negatively correlated to self-rated health status. One exception is for variable representing instrumental activities of daily living (IADL), which is not statistically significant. For technical progress, we include both life expectancy and cohort fixed effects (wave 1 is not included since the analysis has been performed using lagged variables). Individuals feel better when life expectancy increases. We include an indicator of income inequalities in a country (Gini coefficient) which is negatively related to current health status, meaning that when inequalities increase, health status decreases.[12] Finally, we also include dummies for group of countries to capture specific country effects. It seems that these dummies are negatively related to health status when compared to individuals who live in western Europe.

[11]Thus, this analysis (equ. 1) gives us access to 92,196 observations corresponding to 55,300 individuals. Indeed, in the panel we have 116,388 individuals, including 42,986 individuals who are present only once in the panel, 33,912 present twice, 25,955 present during three waves, 7,384 individuals are interviewed during four waves, and only 6,151 individuals are followed during all five waves.

[12]A zero-value represents an egalitarian state whereas 1 implies full income inequalities in a country.

Table 1: Results of linear probability model

Variables	**Coefficients**	
	Without IVs	With IVs
Dependent variable:	Health_t	
Granger causality		
Health_{t-1}	0.200*** (0.003)	0.099*** (0.031)
Log of income_{t-1}	0.024*** (0.001)	0.102*** (0.010)
Exogenous income shocks		
Financial gift (5000€ or more)	−0.002 (0.001)	0.002 (0.002)
Morbidity Indicators		
IADL	0.002 (0.001)	0.001 (0.001)
GALI	−0.235*** (0.003)	−0.245*** (0.006)
Mobility indicator	−0.039*** (0.001)	−0.041*** (0.002)
Chronic diseases	−0.043*** (0.001)	−0.047*** (0.002)
Drinking	−0.010*** (0.003)	−0.006* (0.003)
Technical progress		
Wave 2	0.014*** (0.004)	
Wave 4	0.004 (0.004)	−0.008* (0.004)
Wave 5	0.005 (0.003)	−0.009** (0.004)
Wave 6	*Reference*	
Life Expectancy	0.009*** (0.002)	0.008*** (0.003)
Co-variables		
Age	−0.009*** (0.002)	−0.009*** (0.002)
Age squared	0.0001*** (0.0001)	0.0001*** (0.0001)
Gender (=1 if women)	−0.016** (0.007)	0.054*** (0.011)
Gini	−0.019* (0.025)	0.057 (0.045)
Education	0.018*** (0.001)	0.009*** (0.002)
Married	*Reference*	
Living with partner	0.001 (0.011)	−0.022** (0.011)
Living as a single	0.002 (0.006)	0.017*** (0.006)
Never married	−0.019*** (0.006)	0.022** (0.009)
Divorced	0.009** (0.005)	0.042*** (0.007)
Widowed	0.006 (0.004)	0.036*** (0.006)
Western Europe	*Reference*	
Eastern Europe	−0.017** (0.007)	0.006 (0.009)

Table 1: Results of linear probability model (continued)

Variables	**Coefficients**	
	Without IVs	With IVs
Northern Europe	-0.081^{***} (0.004)	-0.113^{***} (0.006)
Southern Europe	-0.006 (0.004)	0.029^{***} (0.007)
α_0	0.725^{***} (0.073)	0.206^{*} (0.122)
Numb. of obs.	92,196	83,858
Numb. of groups	55,300	51,284
Instruments for income: location of the main residence (dummies) and unemployment rate.		
Instruments for health: ADL_{t-2}		
***: 1% significant; **: 5% significant; *: 10% significant.		
Standard deviations are into parentheses below coefficients.		

To have an accurate causal relationship between health and income, researchers need also to account for endogeneity. In second column of table 1, signs of coefficients do not change from estimates of equation 1, being a bit different in magnitude but qualitatively similar. Thus, previous conclusion about the positive relationship between income and self-perceived health still holds true, such that we can now state that past income has a positive impact on current health status. Moreover, we also add one income shock to the estimation (financial gift of 5,000€ or more). this shock is not significant, meaning that an expected amount of money does not have a perceptible effect on health. An explanation would be that this shock is not large enough to have a significant and permanent impact on self-perceived health status. We correct endogeneity issues of the income variable by using unemployment rate (by country and year) and location of the main resident as instruments. In this estimation, morbidity indicators all have a negative and significant impact on current health status, except for IADL. Morbidity has an overall negative impact on self-perceived health status because it corresponds to health issues or diseases. Concerning life expectancy, the effect is qualitatively the same as before, implying that technological trend improves life expectancy and thus current self-perceived health status. Once we get rid of the income endogeneity issues, we also need to instrument our lag health variable. We decide to use the condition of moments on a morbidity indicator (activities of daily living, see equation 4). The instrumented estimation shows that past health always has a positive and significant impact on current health.

5 Conclusion

A heavily researched topic in health economics is the relationship between income and health and more specifically the direction of causality between the two. This paper sheds light on the question of whether income implies health in a causal way. While it seems well-known that people with higher incomes enjoy better health, it is far more difficult to establish the direction of the causality of this relationship. The definition of causality chosen here is that of Granger which includes a persistence phenomenon in the relationship, as well as a permanent causal link thanks to lagged variables. Factors such as morbidity or technical progress are controlled in this paper, since they could influence the health-income relationship. We use a rich longitudinal database (SHARE survey) which covers a statistically representative sample of Europeans individuals aged 50 and over and reports detailed information on their income and health, as well as health behaviors.

We implement a linear probability model to highlight the Granger causality of income on health. This enables us to identify components of the health-income relationship and to control for endogeneity issues which can arise. With this approach, we get rid of the income and past health endogeneity issues.

Since researchers need a clear understanding of the direction of the causality in this relationship, the results presented here contribute to a central point in the analysis of health and income. Our dynamic method and results ensure the Granger causality of income on health. In other words, we show that income has a permanent effect on subjective health status. Since our results appear to be robust at each step, we have apparently rid ourselves of the possible reverse causation in this relationship. Among each step, the results vary quantitatively but they all tell essentially the same story in qualitative terms (the coefficients always have the same signs and significance). This paper contributes to the health-income relationship and allows a better understanding of the direction of the causality in this literature. This is important for policy makers who want to reduce health inequalities in which income is shown to be an important lever. Finally, to the best of our knowledge, this is the first study analyzing health-income relationship using SHARE database and establishing a strong and permanent causal impact of income on self-perceived health status using the concept of Granger causality.

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[13] See www.share-project.org

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A Descriptive Statistics

A.1 Variables of interest and covariates

Table 2: Descriptive statistics of the variables of interests and some covariates

Variables	Mean	Std. dev.	Min.	Max.	Nb. of obs.
Self perceived health	2.833	1.083	0	5	248,966
Binary health =1 (%)	61.49				
Log of income	9.9695	1.328	-6.389	16.122	247,731
Exogenous Shock:	%				
Financial gift 5000€ or more	13.83				171,027
Instrumental variables:					
Unemployment rate	9.010	5.065	3.2	26.1	248,966
Big city (%)	15.41				183,425
Suburbs of a big city (%)	12.91				183,425
Large Town (%)	17.13				183,425
Small town (%)	24.65				183,425
Rural area (%)	29.90	*Reference*			183,425
Age	66.637	10.108	50	111	248,966
Gini	0.392	0.069	0.273	0.772	248,966
Education:	%				248,736
Without diploma	4.78				
Primary	19.97				
Lower secondary	18.17				
Upper secondary	35.90	*Reference*			
First Stage of tertiary	20.33				
Second stage of tertiary	0.75				
Marital Status:	%				246,547
Married living with spouse	68.18	*Reference*			
Married living single	7.03				
Registered partnership	2.04				
Never married	4.15				
Divorced	6.47				
Widowed	11.15				
Missing	1.35				

A.2 Morbidity indicators

As explained earlier, the morbidity indicators have been chosen following the selection of Dormont et al. [2006]. Our morbidity indicators are divided into three main parts corresponding to the indicators of the Minimum European Health Module (MEHM). The first category concerns the degree of invalidity of individuals and contains information on four health aspects. ADLs consist of "basic activities that are necessary to independent living (e.g. walking, bathing, dressing, toileting, brushing teeth and eating)", according to the World Health Organization (WHO). This concept determines an individual's ability to perform the activity with or without assistance. IADLs, according to the World Health Organization, are "activities with aspects of cognitive and social functioning, including shopping, cooking, doing housework, managing money and medication, and using the telephone or the computer". These tasks support an independent lifestyle. GALI belongs to the family of disability indicators, targeting situations in which health disorders and conditions have impacted people's usual activities (number of limitations with mobility, arm function and fine motor skills). It is a single-item survey instrument where individuals are asked: " For at least the last 6 months, have you been limited because of a health problem in activities people usually do?" and they have to answer: "1) Yes, strongly limited, 2) Yes, limited, or 3) No, not limited". Moreover, in the SHARE survey, individuals are asked to give the number of their limitations concerning mobility (from 0 to 10). The second category of indicators, corresponding to the chronic disease, gives the number of chronic diseases an individual suffer from (heart problem, high blood pressure/high blood cholesterol, stroke or cerebral vascular disease, diabetes, cancer...). Finally, we also take into account the risky behavior with a drinking variable. The World Health Organization recommendations for a reasonable consumption is a maximum of two glasses of alcohol per day.[14]

Table 3: Morbidity Indicators

Variables	**Mean**	**Std. dev.**	**Min.**	**Max.**	**Nb. of obs.**
ADLs	0.257	0.882	0	6	248,966
IADLs	0.407	1.243	0	9	248,966
GALI	0.462	0.499	0	1	248,966
Mobility	1.657	2.371	0	10	248,679
Chronic diseases	1.746	1.572	0	14	248,653
Drinking	0.289	0.453	0	1	248,035

[14]However, the WHO also states to abstain from alcohol at least one day in the week, and not to consume more than four drinks on an one-time opportunity.

A.3 Technical progress

Table 4: Life expectancy at 65 years old for all waves and individuals (females and males)

Country	Mean	Std. dev.	Min.	Max.	Nb. of obs.
Austria	20.003	1.689	17.3	21.7	15,344
Germany	18.622	2.683	11.9	21.2	16,954
Sweden	19.868	1.459	17.4	21.5	16,033
Netherlands	19.289	1.776	16.3	21.2	12,306
Spain	20.943	2.158	17.2	23.4	19,880
Italy	20.436	1.879	17.3	22.6	18,365
France	21.374	2.258	17.7	23.8	19,757
Denmark	18.769	1.538	15.9	20.7	14,091
Greece	19.379	1.546	16.9	21.3	10,449
Switzerland	20.745	1.547	18.2	22.6	11,767
Belgium	19.605	1.842	16.5	21.6	23,173
Israel	20.303	1.092	18.7	21.3	6,685
Czech Republic	17.674	1.803	14.3	19.3	18,453
Poland	17.608	2.226	14.5	20.1	5,918
Luxembourg	20.531	1.422	18.9	21.9	3,138
Hungary	16.547	1.985	14.3	18.3	2,974
Portugal	19.973	1.867	17.8	21.7	3,586
Slovenia	19.569	2.009	16.9	21.4	9,723
Estonia	18.217	2.573	14.3	20.7	17,923
Croatia	18.414	2.884	15.2	21	2,447
Total	19.565	2.276	11.9	23.8	248,966

A.4 Exogenous Shock

Table 5: Exogenous shock of income per country

Country	**Gift 5,000€ or more**		
	Yes (%)	No (%)	Nb. of obs.
Austria	11.38	88.62	11,062
Germany	17.51	82.49	11,382
Sweden	22.74	77.26	11,374
Netherlands	17.50	82.50	8,533
Spain	7.72	92.28	13,023
Italy	8.31	91.69	12,158
France	11.72	88.28	13,775
Denmark	21.56	78.44	9,818
Greece	14.68	85.32	7,185
Switzerland	19.73	80.27	8,466
Belgium	21.13	78.87	12,928
Israel	4.83	95.17	3,955
Czech Republic	9.73	90.27	12,560
Poland	8.41	91.57	4,008
Luxembourg	19.73	80.27	2,347
Hungary	15.32	84.68	1,952
Portugal	9.44	90.56	2,256
Slovenia	10.06	89.94	6,931
Estonia	6.12	93.88	12,262
Croatia	13.66	86.34	1,588
Total	13.83	86.17	171,027

A.5 Instrumental variables for income

Table 6: Unemployment rate (%)

Waves	Wave 1		Wave 2		Wave 4	Wave 5	Wave 6
Country	2004	2005	2006	2007	2011	2013	2015
Austria	5.49		5.25	4.86	4.6	5.3	5.7
Belgium	8.39	8.44	8.25	7.46	7.1	8.4	8.4
Czech Rep.			7.15	5.32	6.7	7	5
Croatia							15.1
Denmark	5.51		3.9	3.8	7.6	7	6.2
Estonia					12.3	8.6	6.2
France	8.47	8.49	8.45	7.66	8.8	9.9	10.4
Germany	9.79		10.25	8.66	5.8	5.2	4.6
Greece	10.59	9.99	9.01	8.4			24.9
Hungary					11		
Israel						6.2	5.2
Italy	8		6.78	6.08	8.4	12.1	11.9
Luxemb.			4.73	4.07		5.8	6.7
Netherl.	4.56		3.91	3.18	5	7.2	
Poland			13.85	9.61	9.6		7.5
Portugal					12.7		12.4
Slovenia					8.2	10.1	9
Spain	10.97		8.45	8.23	21.4	26.1	22.1
Sweden	6.53	7.48	7.07	6.16	7.8	8.1	7.4
Switzerl.	4.3		4	3.6	4	4.4	4.8
Total	11		14		16	15	18

Table 7: Location of the main residence (%)

	Big City	**Suburbs**	**Large town**	**Small town**	**Rural area**
Wave 1	13.97	18.34	18.65	25.47	23.58
Wave 2	16.25	15.71	19.65	22.41	25.98
Wave 4	14.99	10.47	16.47	23.94	34.13
Wave 5	14.37	11.92	16.91	25.74	31.05
Wave 6	17.01	10.32	14.96	25.47	32.24