HEDG
HEALTH, ECONOMETRICS AND DATA GROUP
THE UNIVERSITY of York

WP 16/04

Acute health shocks and labour market outcomes

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March 2016

http://www.york.ac.uk/economics/postgrad/herc/hedg/wps/

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15 March 2016

Abstract

We investigate the labour supply response to acute health shocks experienced in the post-crash labour market by individuals of working age, using data from Understanding Society. Identification exploits uncertainty in the timing of an acute health shock, defined by the incidence of cancer, stroke, or heart attack. Results, obtained through a combination of coarsened exact and propensity score matching, show acute health shocks significantly reduce participation, with younger workers displaying stronger labour market attachment. The impact on older, more educated, women suggests an important role for preferences, financial constraints, and intra-household division of labour determining labour supply decisions.

Keywords: health shocks, labour supply, panel data, matching methods

JEL codes: C14, I10, J22

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Acknowledgements: We are grateful to participants at the UK Causal Inference Meeting (Bristol, 2015); Health and the Labour Market Workshop (Aahrus, 2015); Understanding Society Scientific Conference (Colchester, 2015); Italian National Conference of Labour Economics (Cagliari, 2015); Italian Society of Public Economics (Ferrara, 2015); Italian Health Economics Association (Alghero, 2015) and seminars held in York, Venice, Adelaide, Melbourne (Monash University) and at the University of New South Wales for useful comments. The work was financially supported by the Centre for Health Economics at the University of York, through the Alan Williams Fellowship and by the Ca' Foscari University of Venice. Understanding Society data, collected by the Institute for Social and Economic Research at the University of Essex and NatCen Social Research, is available through the UK Data Archive, and accessed with permission. Responsibility for the analysis and interpretation of the data lies solely with the authors.

1 Introduction

Understanding the labour supply decisions of individuals following a major health shock is fundamental to informing policy around maintaining employment opportunities and contributing to reducing the employment gap between individuals with and without long-term health conditions. To this end, the relationship between health and labour supply has attracted a great deal of attention. Early empirical evidence, grounded in the theory of human capital investment, identified important associations between heath and labour market participation and wages, but was hampered by a reliance on cross-sectional data (for example, Grossman and Benham, 1973; Luft, 1975; Bartel and Taubman, 1979). More recently, the availability of rich longitudinal survey data enabling more reliable evidence on behavioural responses to changes in health, as well as greater understanding of the potential underlying explanatory mechanisms, has fuelled interest in this important relationship.

Estimating meaningful effects of the impact of health on labour supply is, however, complex: issues such as health and economic activity being jointly determined, unobserved preferences, justification bias in survey self-reports of health status, and health-related selection into employment are typically difficult to overcome. An additional challenge is that the design and operation of pension, social benefit and welfare systems, as well as the structure of the labour market and the organisation of health and social care services all contribute to shaping labour supply decisions in response to a significant change to health (Garcia Gomez, 2011, Cai *et al.*, 2014, Datta Gupta *et al.*, 2011). This is particularly pertinent given the profound impact the recent recession has imparted on the structure of labour markets (Immervol *et al.*, 2011, Jenkins *et al.*, 2012, Elsby *et al.*, 2011, 2016) and the fiscal policy response leading to significant changes in welfare provision. Up-to-date evidence on the causal impact of deteriorations in health on labour supply decisions in the post-recession period is sparse. This paper aims to address this important gap in the literature by providing evidence of the causal effects of exogenous shocks to health along both the extensive and intensive margins of labour supply, together with evidence on labour market and employer attachment, earnings, and job security of individuals remaining active in the labour market following a shock to health.

The majority of the literature on the interaction of the health and the labour market has been concerned with older workers approaching retirement, with little concern for younger workers. While older workers exhibit higher morbidity risks[1], they face wider labour market

[1] The incidence of acute health shocks increases sharply with age (Feign *et al.*, 2009; British Heart Foundation, 2012; Nichols *et al.,2013*; International Agency for Research on Cancer; 2012); for example, in the UK, more than half of cancer diagnoses relate to individuals aged between 50 and 74 years. However, non-trivial incidence rates are observed among younger adults.

exit options (i.e. in terms of eligibility for early retirement, and private and occupational pension schemes) and lower incentives to retrain for less demanding jobs. The consequences of early labour market exit for younger workers are likely to be more severe. Although survival rates have been generally improving for all ages, younger individuals exhibit lower case-fatality and mortality rates than older counterparts and have a greater number of potential years of working life remaining, making the study of their labour market outcomes of particular interest. Upon exit, younger workers typically transit into inactivity, rather than early retirement, possibly leading to income poverty. Beyond the immediate income loss, wider effects include foregone earnings increases, limited savings and asset accumulation and a poorer lifetime history of contributions, resulting in lower future pension entitlements. Adverse spillover effects on household members are likely to fall mainly on children rather than other adults, which may dampen intra-generational mobility. The few studies that have considered younger workers (e.g. Garcia Gomez *et al.*, 2010, 2011; Moran *et al.*, 2011; Halla *et al.*, 2013) found a non-negligible response to health deteriorations with only minor differences detected with respect to the response of older workers.

A potential reason for the paucity of research covering younger workers is the lack of adequate sources of data[2]. This paper builds on the recent availability of Understanding Society: the UK Household Longitudinal Study (UKHLS). The UKLHS data offer an unique combination of a large sample size, a longitudinal dimension and a broad range of coverage including rich data on labour market experience and dimensions of health across all adults of working age. The UK offers a uniform policy setting characterised by a publicly funded health care system free at the point of use, with a limited role for private health insurance. This contrasts starkly with the US context, to which the vast majority of existing studies refer.

To tackle the potential endogeneity of health and labour supply, our identification strategy exploits uncertainty in both the occurrence and timing of acute health shocks, defined by the incidence of cancer, stroke or myocardial infarction, which are arguably less prone to reporting bias and justification bias than other health measures. We observe labour market active individuals until they experience either a first occurrence of a health shock, or a re-occurrence, and compare their labour supply responses to that observed in a matched control group. Accordingly, the only restriction we place on age is through the minimum age at which we observe an acute health shock in the data. While such shocks exclude the very young, in our sample they occur from age 30 upwards.

[2]In contrast, there are a number of rich panel surveys of older people collecting information on health, labour market activity, and other domains, for example The Health and Retirement Study in the US; The English Longitudinal Study of Ageing in England; and The Survey of Health, Ageing and Retirement in Europe, in Europe.

The panel dimension of the data allows us to condition on unobserved individual heterogeneity through lagged outcomes. Through a combination of coarsened exact matching and propensity score matching, together with parametric regression, we treat the occurrence of an acute health shock as exogenous, conditional on observable characteristics and lagged outcomes. While the main outcome of interest is labour market participation, we also consider hours worked, earnings, perceived job security and work-related expectations and aspirations. Our identification strategy is shown to be robust to a set of checks using placebo outcomes and placebo treatments. In addition, we explore heterogeneity in labour market responses by demographic characteristics (age, gender, family composition), socio-economic status (education, income) and health shock severity in an attempt to understand the mechanisms behind the observed response.

The main estimate of an ATT of 0.07 implies a doubling of the baseline probability of labour market exit. This is shown to be robust to a broad range of approaches to estimation. Placebo tests based on pre-treatment outcomes and using future health shocks as a placebo treatment support our identification strategy. Our sub-group analyses show that in general younger workers of both genders display a stronger labour market attachment than older counterparts, conditional on a health shock. Older and more educated women exhibit the strongest reaction despite experiencing less disabling shocks than men. This suggests an important role for preferences, financial constraints and intra-household division of labour in explaining labour supply adjustments.

2 Acute health shocks and employment

The relevance of health for labour market outcomes is well established in the economic literature (Currie and Madrian, 1999; Bound and Burkhauser, 1999) with empirical evidence covering a variety of countries documenting the detrimental effect of poor health and health deterioration on labour market participation (for example, Bound *et al.*, 1999, Disney *et al.*, 2006, Jones *et al.*, 2010, Zucchelli *et al.*, 2010). There are a number of reasons to be concerned with the determinants of labour market participation. Most signicant is the possible substantial and enduring financial consequences of early labour market exit (Angelini *et al.*, 2009), and their spillover effects on other family members both in the short- (Smith, 2005, Garcia Gomez *et al.*, 2013) and long-run (Morrill *et al.*, 2013, Zwysen, 2015). Labour market attachment in itself brings wider benefits to individuals, by nurturing personal identity and self-esteem, and providing opportunities for social contacts. Beyond individuals' financial and non-financial wellbeing, prolonging working lives and fostering disabled individuals' inclusion in the labour market has become a policy priority in most developed countries

(OECD, 2003). This concern, which is even more pertinent in the light of population ageing and the need to limit the fiscal burden of social security provision, has led several European countries to adopt benefit reforms aimed at maintaining employment at the core of support for disabled people of working age. For example, in the UK, with the introduction of the Employment and Support Allowance in 2008, that replaced the previous Incapacity benefit scheme, placing more emphasis on identification of claimants deemed as capable of some working activity, and encouraging their employment.

Studying the effect of health on labour market behaviour requires dealing with the endogeneity of health with respect to labour supply (Haan and Myck, 2009, Cai, 2010). Previous studies have addressed this potential source of bias using a variety of approaches. Strategies have included modelling labour market outcomes by exploiting variation in self-assessed health (Au *et al.*, 2005) or satisfaction with health (Riphahn, 1999); the onset of health conditions (Garcia Gomez, 2011); acute hospitalization episodes (Garcia Gomez *et al.*, 2013); and car accidents (Dano, 2005; Halla *et al.*, 2013). We follow previous studies (Smith, 1999, 2005, Coile, 2004, Datta Gupta *et al.*, 2011, Trevisan and Zantomio, 2015) and exploit, as a source of exogenous variation, unanticipated health shocks measured by the incidence of a cancer, stroke or myocardial infarction. The focus on these particular health conditions is motivated by two reasons. First, they occur suddenly and largely unexpectedly - in the case of stroke and myocardial infarction due to the nature of the condition; in the case of cancer, due to its often asymptomatic nature it typically becomes known upon diagnosis. Indeed, these conditions can be regarded as unanticipated shocks with respect to the timing of onset, as risk factors that might inform an individual about her/his health risk are largely uninformative with respect to the timing of the event. Second, given their nature as major health conditions, they are arguably less exposed to the chance of misreporting and justification bias than milder conditions (Baker *et al.*, 2004; Bound, 1989, 1991; Benitez-Silva *et al.*, 2004).

Other studies that exploit acute health shocks often find a reduction in labour supply following the occurrence of a health event. The estimates of Smith (2005) and Coile (2004) are based on parametric modelling of Health and Retirement Study (HRS) data. Smith estimates a 15% immediate decline in labour market participation for older workers, following the onset of cancer, heart attack, stroke or lung diseases. Coile (2004) finds men to be 35% and women to be 23% more likely to exit the labour market after experiencing a major health shock (stroke, cancer or heart attack). Datta Gupta *et al.* (2011) adopt similar methods to compare older workers in the US and Denmark, and relate the stronger retraction in participation found for US workers (a counter-intuitive result when the institutional differences between the two countries are considered) to differential mortality and baseline health differences. Trevisan and Zantomio (2015) use propensity score matching and combine data from the Survey of Health, Ageing and Retirement in Europe (SHARE) and the English Longitudinal Study of Ageing (ELSA) to investigate the case of older workers in sixteen European countries and find a significant reduction in labour market participation (amounting to 12% on average), with the strongest effects found for highly educated women, and in countries providing more generous disability benefits.

The above studies have considered the labour supply responses of older workers only. A related strand of research, covering younger as well as older workers, has been evolving with respect to cancer (mostly breast cancer) survivors, generally using US data (Bradley *et al.*, 2002, 2005, 2013; Farley Short *et al.*, 2008, Moran *et al.*, 2011, Heinesen *et al.*, 2011). These studies have largely relied on administrative register data and have applied a number of approaches, including matching techniques, to select appropriate controls for cancer survivors observed within population surveys[3]. Focusing on breast cancer survivors in the US and using a number of alternative data sources, Bradley *et al.* (2002, 2005, 2013) find a negative impact on employment, but also a greater number of hours supplied and higher wages for survivors who remained in the labour market. These results point to a need for more detailed consideration of the selection mechanisms and heterogeneity in labour market responses to health shocks. Conditioning on a single specific health condition, such as breast cancer, might ensure stronger internal validity given the greater knowledge about condition-specific health effects and treatments. However this comes at the cost of sacrificing generalizability.

In what follows, we build on these strands of literature and apply a combination of nonparametric and semiparametric techniques to estimate the labour supply response of all working age individuals to the onset of a broader set of health conditions including cancer, myocardial infarction and stroke. A priori, such events might be expected to stimulate different labour market responses at different points in the lifecycle. At the time when the health shock occurs, younger workers have acquired less health-specific human capital than older workers (Charles, 2003), and in this respect leaving a current job might be less costly. Also, younger workers face a longer time horizon for earned labour income, which strengthens their incentive to invest in re-training towards more physically suited jobs or tasks. This would be reinforced, in tight labour markets, by the more favourable prospects of re-employment younger workers face, with respect to older workers, although this is less likely to be the case in times of adverse economic conditions, such as the period we are considering. In times of restrictions to job opportunities, the availability of replacement incomes is likely to play a major role in shaping workers' response to health shocks, as evidenced by the increase in disability benefits rolls typically registered during recessions (Pasini and Zantomio, 2013). The wider options that older workers face in this respect

[3] Health and Retirement Survey, Current Population Survey or the Panel Study of Income Dynamics.

would appear predictive of a higher exit from employment.

3 Data

The analysis is based on five waves of Understanding Society: the UK Household Longitudinal Study (UKHLS) that builds on the British Household Panel Study (BHPS). The BHPS has been widely used in the study of health and labour (e.g. Robone *et al.*, 2011; Bender and Theodossiou, 2014, Dawson *et al.*, 2015). The large sample size of UKHLS (circa 100,000 individuals) offers the opportunity to study sub-groups of the population capturing, for example, heterogeneity in labour market responses to health shocks at different points in the lifecycle, including younger age groups previously regarded as too small for analysis using population based surveys (Buck *et al.*, 2012). UKHLS currently offers five waves of annual data spanning 2009 to 2015, overlapping the recession employment dip visible in Figure 1.

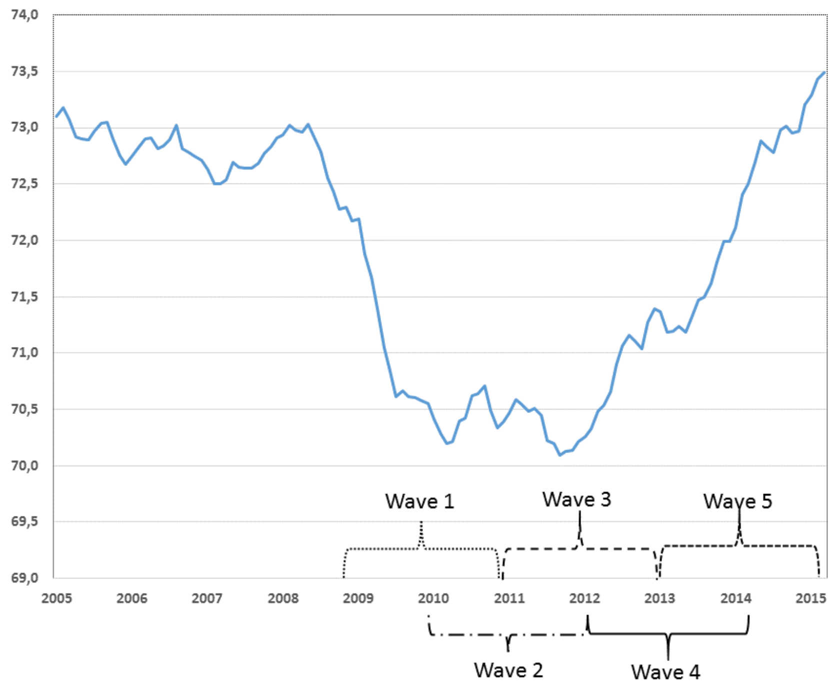

Figure 1: Employment rate (ages 16-64) seasonally adjusted (ONS) and UKHLS fieldwork

The fieldwork for each wave is undertaken over two calendar years, with CAPI interviews for each household held in each wave. Together with a household questionnaire, all adults aged 16 or older are given an individual questionnaire. These questionnaires cover a wide range of topics including demographic characteristics, educational background, health, disability, labour market activity, job characteristics, and incomes and their sources. This rich information combined with the longitudinal dimension and generous samples, makes UKHLS particularly well suited to this study.

The first time individuals are interviewed they are asked about past diagnoses of specific health conditions, including cancer, heart attack or myocardial infarction, and stroke [4]. This allows us to identify individuals who have already experienced the onset of an acute health shock. In subsequent waves individuals are asked whether, since the previous interview, they have been newly diagnosed as having any of the same list of conditions so that a full annual history of the onset of acute health shocks is observed. In addition information about health risk factors, such as diagnoses of coronary heart disease, angina, diabetes and high blood pressure, mostly relevant for CVD, is also collected[5].

Further information concerning health risk include parents' longevity (individuals are asked whether the mother and the father were alive when respondent was aged 14), indicative of genetic factors; a battery of standard health indicators, covering poor self-assessed health, the presence of a long-standing illness or disability, eleven types of limitations in activities of daily living (ADLs); and information about health habits and behavioural risk factors, via past and current[6] smoking participation and intensity, also indicative of time preferences.

We make use of demographic information including age, gender, race, marital status, number of children, and household size, together with socioeconomic characteristics including highest educational qualification, individual and household income from various sources, and housing tenure. With respect to labour market activity, at each wave respondents are asked about employment status (including self-employment), type of occupation, the number of hours worked (including overtime hours, both paid and unpaid), earnings, job satisfaction and other job and employer characteristics. At alternate waves an additional set of employment related questions are asked to employees about job conditions, covering their aspirations, expectations and perceived job security.[7]

[4] The full list includes: Asthma; Arthritis; Congestive heart failure; Coronary heart disease; Angina; Heart attack or myocardial infarction; Stroke; Emphysema; Hyperthyroidism or an over-active thyroid; Hypothyroidism or an under-active thyroid; Chronic bronchitis; Any kind of liver condition; Cancer or malignancy; Diabetes; Epilepsy; High blood pressure; Clinical depression.

[5] Congestive heart failure represents more of a consequence, than a risk factor, for infarction, but for this same reason it might capture unobserved factors correlated with CVD risk.

[6] More precisely, as of Wave 2 or 5.

[7] UKHLS contains additional potentially relevant variables, for example mental health as measured by the GHQ instrument, biomarkers, and alcohol consumption. We do not, however, include these as they impose a drastic reduction in sample size through a combination of being collected through the self-completion questionnaire (which registers significantly lower response rates); from a subset of respondents only (for example biomarkers); at a specific wave only.

4 Empirical Strategy

The sample for analysis is restricted to individuals who are observed for at least two points in time, labelled $t-1$ and t. In addition, the sample is restricted to individuals who are labour market active, either as employees or self-employed, as of $t-1$, and who would be aged less than the statutory retirement age as of time t. An additional lower bound to age reflects the adult questionnaire being administered only to household members aged 16 or over.

Our empirical approach exploits innovations in health induced by the onset of an acute health shock, occurring between $t-1$ and t, to identify the short run labour supply response, observed at time t. We compare individuals who experience an acute health shock with observationally identical (as of $t-1$) individuals, who do not experience an acute health shock. Pre-shock observational equivalence is defined by a wide set of potential confounders, including demographic and socioeconomic characteristics, underlying health risk factors, previous acute health shock history, as well as variables informative about labour market activity and labour market attachment. Observability of all potential confounders, that is variables potentially affecting both labour market behaviour and the risk of experiencing an acute health shock, is crucial to the success of the empirical strategy, which relies on a conditional independence assumption. The set of controls needs to be sufficiently comprehensive such that, conditional on these, variation in the occurrence or otherwise of an acute health shock can be regarded as random. As illustrated in Section 3, the broad topic coverage of the UKHLS questionnaire is appealing in this respect. All of the time-varying potential confounders are measured as of $t-1$; the longitudinal dimension of the data in this way allows us to control for time invariant unobservables through conditioning on some of the lagged outcomes.

A further requirement to ensure the success of our matching strategy is achieving common support and the availability of an adequate number of matched control individuals. Despite the large samples available in UKHLS, the number of individuals observed to experience a major acute health shock is limited to 428, which while small is not out of line with that of similar studies. The study does, however, offer a large pool of potential controls (approximately 60,220 individuals). Table 1 reports descriptive statistics for the set of health risk related conditioning covariates in the treated and potential control group. Striking differences in pre-shock health risks, including age, father's longevity, smoking status, general health and past conditions are clearly evident.

Table 1: Descriptive statistics: health risk variables

	Health shocked (n=428)		*Potential controls* (n=60,220)		
	mean	*sd*	*mean*	*sd*	*Pval (diff)*
age	50.2	9.7	42.2	11.5	0.0000
male	0.488	0.500	0.465	0.499	0.3403
father_dead_when_aged14	0.070	0.256	0.031	0.174	0.0000
mother_dead_when_aged14	0.009	0.096	0.012	0.107	0.6716
ever_smoker	0.591	0.492	0.539	0.498	0.0308
current_smoker	0.271	0.445	0.204	0.403	0.0006
regular_smoker_past	0.241	0.428	0.211	0.408	0.1369
heavy_smoker (current_or_past)	0.136	0.343	0.077	0.266	0.0000
self assessed poor health(t-1)	2.9	1.1	2.3	1.0	0.0000
number of limitations(t-1)	0.5	1.2	0.2	0.7	0.0000
has long stanbding illness/disability(t-1)	0.425	0.495	0.245	0.430	0.0000
sofar_acute_shock(t-1)	0.157	0.364	0.025	0.155	0.0000
sofar_high_blood_pressure(t-1)	0.243	0.429	0.123	0.329	0.0000
sofar_diabetis(t-1)	0.107	0.310	0.031	0.174	0.0000
sofar_congestive_heart_failure(t-1)	0.009	0.096	0.001	0.030	0.0000
sofar_coronary_heart_disease(t-1)	0.049	0.216	0.004	0.066	0.0000
sofar_angina(t-1)	0.044	0.206	0.006	0.078	0.0000

Source: UKHLS, waves 1-5.

Note: Variable in bold if t-test of equality of means between treated and controls rejected at the conventional 5% level.

Table 2: Descriptive statistics: other variables

	Health shocked (n=428)		*Potential controls* (n=60,220)		
	mean	*sd*	*mean*	*sd*	*Pval (diff)*
in_coohab_partnership(t-1)	0.722	0.449	0.714	0.452	0.7299
hh size(t-1)	2.9	1.3	3.083	1.365	0.0009
number of children(t-1)	2.0	2.0	1.410	1.293	0.0000
highest qual: degree	0.238	0.427	0.335	0.472	0.0000
highest_qual: other_higher	0.143	0.350	0.143	0.350	0.9850
highest_qual: a_level	0.194	0.396	0.214	0.410	0.3090
highest_qual: gcse	0.231	0.422	0.195	0.396	0.0579
highest_qual: other_qual	0.124	0.330	0.069	0.254	0.0000
highest_qual: none	0.070	0.256	0.044	0.205	0.0092
white	0.895	0.307	0.839	0.368	0.0016
eq. hh monthly income(t-1)	2230.0	1447.3	2326.8	1498.7	0.1831
social renter(t-1)	0.150	0.357	0.111	0.314	0.0118
home owner(t-1)	0.762	0.427	0.747	0.435	0.4731
usual hours per week, incl.overtime(t-1)	36.7	14.6	36.004	13.968	0.3356
job satisfaction(t-1)	5.3	1.4	5.288	1.453	0.4135
”permanent” job (non temporary)(t-1)	0.923	0.267	0.922	0.268	0.9432
management & professional(t-1)	0.409	0.492	0.425	0.494	0.4981
intermediate(t-1)	0.234	0.424	0.228	0.420	0.7871
routine(t-1)	0.353	0.478	0.341	0.474	0.6037
employee (vs self-employed)(t-1)	0.879	0.327	0.879	0.327	0.9963
net earnings (employees)(t-1)	1375.9	908.8	1454.6	1005.7	0.1617
year of interview	2011.9	1.3	2011.9	1.3	0.1786
elapsed months since previous interw.	12.9	3.1	12.4	2.4	0.0002

Source: UKHLS, waves 1-5.

Note: Variable in bold if t-test of equality of means between treated and controls rejected at the conventional 5% level.

Descriptive statistics for the set of other potential conditioning covariates are reported in Table 2. Again there are significant differences across the two groups with respect to household composition, education, race, and social renting. These point to a less advantaged pre-shock socioeconomic situation for those who are likely to experience the onset of a health shock. These individuals also exhibit a greater lapse of time between the two observational points, $t-1$ and t. This may reflect the occurrence of the health shock leading to postponement of the interview. It is notable and encouraging that no statistically significant differences emerge, however, with respect to pre-treatment labour market variables. This provides an indication that systematic selection according to labour market outcomes may not be problematic. The next section describes the selection of appropriate controls for each treated individual from the large pool of potential individuals.

4.1 Implementation of matching algorithm

Our identification strategy relies on the assumption that conditional on the set of confounding variables and lagged outcomes, the occurrence of a health shock can be treated as an exogenous shock. The approach to estimation of the treatment effect involves a combination of coarsened exact matching (CEM) and propensity score matching to ensure common support and adequate covariate balance, followed by parametric regression analysis on the balanced data. This follows the method for estimating the average treatment effect on the treated (ATT) set out in Ho *et al.* (2007).

While traditional matching methods typically imply a trade-off in the balance achieved across different conditioning variables, the CEM approach (Iacus *et al.*, 2011) allows - at the cost of a reduced sample size - to reduce the imbalance in any chosen confounder with no detrimental effect on the balancing of others. This monotonic imbalance bounding property is achieved by coarsening selected variables into meaningful groups and performing exact matching on the coarsened data, so that balance is achieved in the full joint distribution of coarsened variables, accounting for interactions and nonlinearities. Clearly, as the number of confounders increases, CEM may result in a progressively reduced sample size as exact matches with the set of potential controls become more difficult to locate. In our setting it is therefore employed to ensure that adequate balancing is achieved with respect to those confounders deemed most relevant for capturing endogenous selection into experiencing an acute health shock.

Accordingly, as a first preprocessing step we perform CEM on age (coarsened into 5 age groups, with thresholds set at 25, 35, 45 and 55), gender, being (or having been) a heavy smoker, lagged self-assessed health (uncoarsened), past experience of an acute health shock, and diagnosis of at least one of the following: high blood pressure, diabetes, congestive heart failure, coronary heart disease, angina. In practice, for the dummy variables (the majority of those considered here), and lagged self-assessed health, CEM corresponds to exact matching. This first step leads to a stratification of the sample into 193 strata. For 106 of these strata we observe individuals falling within the treatment group of those experiencing an acute health shock, as well as potential controls. Accordingly, to ensure common support the remaining 87 strata (for which only observations from the set of potential controls are observed) are omitted from further analysis. This first preprocessing step invokes common support and balancing in the joint distribution of the basic set of confounders without any loss of treated cases. While avoidable bias is generally reduced, it potentially remains with respect to other confounders (illustrated in Table A.1 in the Appendix).

To ensure adequate balance across these other covariates parametric propensity score estimation is used (Rosenbaum and Rubin, 1983). This involves estimating a probit model for the conditional probability of experiencing an acute health shock between $t-1$ and t, on the full set of conditioning variables measured at time $t-1$. Appropriate weights are used to account for the different size of treated and potential control observations in each CEM stratum as derived in the first preprocessing step. Estimation results, and summary statistics on the distribution of the estimated propensity score, are reported in the Appendix (Tables A.2 and A.3). There is wide overlap in the propensity score distribution across treated and controls, and hence a strong chance of observing adequate conterfactual observations for the individuals who experience an acute health shock.

Rather than proceeding, as is generally done, with a nearest neighbour or caliper matching on the estimated propensity score, we again exploit the properties of CEM and use it to match controls to treated individuals, using the estimated propensity score as an additional coarsening variable, with values collapsed into 10 groups and cut-offs chosen to minimize imbalance. With respect to nearest neighbour matching on the propensity score, this methodology allows maintaining the tight balance achieved in the basic set of most relevant - in terms of endogenous selection - confounders. This is because nearest neighbour matching on the propensity score entails trading-off the balancing of different covariates, while our methodology allows us to control and maintain the balance achieved in specific variables, possibly at the cost of a reduced sample size. In this second round of CEM, strata are again defined by the same set of basic confounders used in the first round, with the addition of the coarsened propensity score and also an uncoarsened wave indicator, to avoid matching individuals from different points in time. Out of the 774 defined strata, 206 are retained to ensure common support.

A summary of overall balancing achieved, for each confounder, in terms of equality of

Table 3: Overall balancing of covariates

	Pval		*Bias*	
	Unbalanced	*Balanced*	*Unbalanced*	*Balanced*
age	**0.000**	0.716	75.6	1.6
male	0.340	1.000	4.6	0
father_dead_when_aged14	**0.000**	0.512	17.8	3.6
mother_dead_when_aged14	0.672	0.274	-2.2	-4.2
ever_smoker	**0.031**	0.710	10.5	-1.8
current_smoker	**0.001**	0.400	15.9	4.4
regular_smoker_past	0.137	0.578	7	-2.8
heavy_smoker (current_or_past)	**0.000**	1.000	19.1	0
self assessed poor health	**0.000**	0.698	52	2
number of limitations	**0.000**	0.549	29.9	3.4
has long stanbding illness/disability	**0.000**	0.656	39	2.3
sofar_acute_shock	**0.000**	1.000	47.1	0
sofar_high_blood_pressure	**0.000**	0.974	31.3	-0.2
sofar_diabetis	**0.000**	0.850	30.4	-1.1
sofar_congestive_heart_failure	**0.000**	0.476	11.8	5
sofar_coronary_heart_disease	**0.000**	0.301	28	7.2
sofar_angina	**0.000**	0.672	24.6	2.7
in_coohab_partnership	0.730	0.652	1.7	2.2
hh size	**0.001**	0.705	-16.5	1.9
number of children	**0.000**	0.381	33.8	3.4
highest qual	**0.000**	0.865	25.1	0.9
white	**0.002**	0.466	16.6	3.2
eq. hh monthly income	0.183	0.412	-6.6	-4.3
social renter	**0.012**	0.979	11.4	0.1
home owner	0.473	0.972	3.5	0.2
usual hours per week, incl.overtime	0.336	0.647	4.6	2.3
job satisfaction	0.414	0.135	4	7.7
”permanent” job (non temporary)	0.943	0.864	0.3	0.8
management & professional	0.498	0.692	-3.3	2
intermediate	0.787	0.795	1.3	-1.3
routine	0.604	0.828	2.5	-1.1
year of interview	0.179	0.397	-6.5	4.1
elapsed months since previous interw.	**0.000**	0.072	15.7	8.4

Source: UKHLS, waves 1-5.
Notes: Pval - p values for tests of equality of means between treated and controls.
Bold signifies rejection at the conventional 5% level.
Bias: standardised percentage difference in means between treated and controls.

means and bias, measured as standardised percentage difference in means, is presented in Table 3. The null hypothesis of equality of means between treated and matched control observations is not rejected for any confounder; also, the imbalance remaining in the pre-processed data is always reassuringly below 10%. Quantile-quantile (QQ) plots provide a further useful tool to assess the balancing of the marginal distributions of the covariates.

Figure A.1 in the Appendix presents the QQ plot of the estimated propensity score, before and after this adjustment. Similar plots can be used to gauge the balance achieved in the distribution of specific confounders. QQ plots for the continuous conditioning variables (age, hours worked, earnings and equivalent household income) are also reported in Figure A.1.

To estimate the ATT of an acute health shock we estimate parametric models (via probit or OLS depending on the nature and distribution of the outcome) on the preprocessed data using appropriate weights obtained from the implementation of CEM. This approach, in contrast to a purely nonparametric comparison of weighted means in the preprocessed treated and control groups, allows us to condition further on the set of observable and time-invariant unobservable confounders, proxied by lagged outcomes, to account for any remaining imbalance.

Table 4: ATT after one year, overall sample

	n (treated)	ATT	Std. Err.	P val
Labour market participation	413	**-0.072**	0.022	0.001
Hours, cond. on LMP	357	-0.840	0.477	0.078
Limitations	413	**0.485**	0.040	0.000
Disability Benefit	413	**0.136**	0.026	0.000
Cond. on LMP:				
Job satisfaction	357	-0.058	0.069	0.398
Would like to give up paid work	182	**-0.068**	0.031	0.025
Would like to change employer and job	182	-0.043	0.025	0.089
Bad feelings about job	178	-0.608	0.328	0.064
Cond. on LMP, employees only:				
Perceived job security (1 to 4)	149	**-0.166**	0.064	0.009
Earnings	316	**-75.022**	31.763	0.018
Hourly earnings	316	-1.668	3.751	0.657

Source: UKHLS, waves 1-5.
Notes: ATT estimate in bold if significant at the conventional 5% level.

5 Results

5.1 Overall effects

Table 4 reports the overall ATT results for the various outcome measures we consider. As a preliminary consideration, the onset of an acute health shock significantly increases the number of ADLs (approximately doubled, with respect to the baseline value), as well as disability benefit receipt (more than tripled, with respect to the baseline value), confirming that the health conditions on which we focus do indeed capture non-trivial health deteriorations. On average, experiencing an acute health shock leads to a 7.2% reduction in labour market participation, while no significant adjustment in the number of hours worked, for those who keep on working, is observed. Although our point estimate for labour market participation reduction is lower than found in previous studies (which considered older workers only, and mostly before the onset of the recent economic crisis), it is by no means trivial. Compared to the baseline labour market exit probability, which is approximately 7.9%, experiencing an acute health shock doubles the risk of leaving the labour market.

In addition to labour market participation we estimate the impact of acute health shocks on job-related aspirations, a measure of 'feelings' about one's own job, and job satisfaction. As most of these indicators stem from questions administered at alternate waves only, the sample sizes available to estimate the ATTs are smaller than for labour supply. While no effect on job satisfaction is detected, estimated ATTs on the other outcomes often lack strong statistical significance; however, the consistently negative sign that emerges points at an increased post-shock employment attachment and employer attachment, compared to individuals who do not experience an acute health shock. This evidence relates to literature showing how individuals who remain working with the same employer following a health shock, are more likely to receive appropriate work-place support and display longer employment spells than those who change employer (Hogelund *et al.*, 2014). Further outcomes, measured for employees only (not the self-employed), include perceived job security (measured on a 1 to 4 scale) and earnings. While no effect on hourly earnings is detected, employees experiencing an acute health shock exhibit a significant reduction in perceived job security.

The ATTs estimated for outcomes conditional on remaining in employment (i.e. hours, earnings etc.) might be biased by selection. To assess the extent to which this might be the case, Table 5 presents ATTs computed separately for those who where working part- and full- time respectively, before the occurrence of a health shock. This distinction should proxy pre-shock labour market attachment. Hence evidence of a differential (higher) exit of part-time workers, with respect to those working full-time, might signal selection bias. This

Table 5: ATT, full- and part-timers

	Full-timers (t-1)		Part-timers(t-1)	
	ATT	P val	ATT	P val
Labour market participation	**-0.082**	0.003	-0.052	0.138
Hours, cond. on LMP	-0.704	0.226	-1.025	0.176
Cond. on LMP:				
Job satisfaction	-0.077	0.356	-0.016	0.892
Would like to give up paid work	**-0.076**	0.048	-0.058	0.226
Would like to change job (employer)	-0.035	0.302	-0.059	0.118
Bad feelings about job	**-0.811**	0.048	-0.201	0.705
Cond. on LMP, employees only:				
Perceived job security (1 to 4)	-0.091	0.263	**-0.292**	0.003
Earnings	11.840	0.765	**-111.8**	0.008
Hourly earnings	1.331	0.869	-2.816	0.480

Source: UKHLS, waves 1-5.

Notes: ATT estimate in bold if significant at the conventional 5% level.

appears not to be the case, as we observe a significant participation response for full-time workers only. Presumably due to greater flexibility in working hours arrangements, part-time workers maintain employment but reveal a reduction in perceived job security. Overall, the lack of evidence of significant exit from part-time employment appears to mitigate against selection bias favouring more labour attached workers among those who remain active[8].

The multiple waves of UKHLS allow us to assess dynamic patterns in labour supply response over time. With respect to individuals who experience an acute health shock between $t-1$ and t, ATTs for some of the outcomes can be estimated up to $t+1$ and $t+2$. Results, reported in Table 6, reveal that in both of the follow-up periods, the reduction in labour market participation is confirmed, while a significant decrease in the number of hours worked by those who remain active emerges in $t+1$. The ATT for hours worked loses significance in $t+2$, where we observe a larger point estimate for the participation ATT, suggesting that some workers might leave the labour market in the longer run, after an attempted adjustment along the intensive margin.

5.2 Robustness checks and placebo tests

To gauge the robustness of our results to alternative approaches to estimation, ATTs for labour market participation are estimated using a range of other conditioning proce-

[8]As part time work is more common among women, gender differences in response for part- and full-timers are further discussed in Section 6.1.

Table 6: ATT after two ($t+1$) or three years ($t=2$)

	t+1			t+2		
	n (treated)	ATT	P val	n (treated)	ATT	P val
Labour market participation	291	**-0.064**	0.012	196	**-0.092**	0.007
hours, cond. on LMP	237	**-2.493**	0.000	149	-1.081	0.194
Limitations	290	**0.379**	0.000	196	**0.312**	0.000
Disability Benefit	291	**0.089**	0.001	196	**0.056**	0.038
Cond. on LMP:						
Job satisfaction	237	0.035	0.685	149	-0.086	0.440
Cond. on LMP, employees only:						
Perceived job security (1 to 4)	68	-0.012	0.894	66	-0.042	0.645
Earnings	198	-43.842	0.308	127	-6.671	0.902
Hourly earnings	198	1.004	0.844	127	1.512	0.614

Source: UKHLS, waves 1-5.

Notes: ATT estimate in bold if significant at the conventional 5% level.

dures: nearest neighbour propensity score matching and Mahalanobis distance matching, with calipers set to obtain the same number of successfully matched treated individuals as in our four step procedure. In addition, we apply simple parametric estimation which is not preceded by any preprocessing adjustment. Finally, a simpler CEM approach where the propensity score is estimated on the full sample, and CEM is subsequently applied on the coarsened estimated propensity score and the usual set of key confounders. Results, reported in Table 7, appear remarkably robust to the different methods used, although the balancing of specific covariates (see Table A.4) worsens when these other approaches are used.[9]

Our identification approach relies on the assumption of conditional independence of treatment given our set of observed confounders, which include some lagged outcomes. To test for possible bias arising from additional unobserved confounders, we run two checks for robustness: one based on 'placebo outcomes', the other on 'placebo treatments'. The first consists in applying our four step conditioning process to estimate ATTs on outcomes measured at $t-1$ and $t-2$, that is, outcomes prior to the health shocks occurring. If our conditioning strategy had succeeded in removing all potential sources of bias, we would expect to detect no difference in the lagged outcomes of treated and matched controls. On the contrary, significant differences in lagged outcomes would likely signal that ATTs estimated in t or the following years could partly reflect pre-existing differences between treated and matched

[9]Also refer to QQ plots reported in Figure A.2 for balancing of continuous variables across the alternative methods of estimation.

Table 7: Estimated ATT for LMP - comparison with other matching methods

Method	n (treated)	ATT	Std. Err.	P val
4 step procedure	413	**-0.072**	0.022	0.001
NNPSM	411	**-0.063**	0.020	0.002
NNMDM	414	**-0.070**	0.020	0.000
Simple parametric	428	**-0.076**	0.022	0.001
Simple CEM	418	**-0.079**	0.022	0.000

Source: UKHLS, waves 1-5.
Notes: NNPSM - nearest neighbour propensity score matching.
NNMDM - nearest neighbour Mahalanobis distance matching.
ATT estimate in bold if significant at the conventional 5% level.

controls that our matching strategy failed to remove. Results from this first placebo exercise are reported in the top panel of Table 8. Because of conditoning on being labour market active in $t-1$, the labour market participation outcome can only be assessed at $t-2$, while other outcomes can be assessed at both $t-1$ and $t-2$. No statistically significant difference in the $t-1$ and $t-2$ outcomes of individuals who experience an acute health shock between $t-1$ and t is revealed, suggesting that our matching strategy has succeeded in controlling for endogenous selection into experiencing the acute health shock.

Table 8: Placebo tests

	Lagged outcomes			
	t-1		t-2	
	ATT	P val	ATT	P val
LMP	-	-	-0.013	0.389
Hours	0.430	0.513	0.070	0.934
Limitations	0.003	0.946	0.054	0.239
Disability Benefit	0.021	0.101	0.020	0.192
Earnings	-40.738	0.251	-23.171	0.603

	Current outcomes on later shocks	
	ATT	P val
LMP	-0.014	0.422
Hours	0.971	0.077
Limitations	0.088	0.054
Disability Benefit	0.025	0.149
Earnings	-33.597	0.451

Source: UKHLS, waves 1-5.
Notes: ATT estimate in bold if significant at the 5% level.

In a similar vein, the second placebo exercise consists of assessing current outcomes for individuals who will go on to experience a future health shock, using the same preprocessing strategy. This corresponds to matching individuals who will and will not experience an acute health shock between $t-1$ and t, with preprocessing based on their $t-2$ time-varying characteristics, and outcomes assessed as of $t-1$. Results, reported in the bottom panel of Table 8, point at a similarity in outcome trajectories before the health shock between those who experience it and those who do not. This is reassuring with respect to the effectiveness of our pre-processing adjustments.

A common concern when using panel data is that non-random attrition might bias estimates of interest. In our setting, for example, individuals experiencing more severe health shocks might be more likely to be lost to follow-up or die. If substantial, such attrition will result in an underestimation of the impact of an acute health shock. As a sensitivity exercise, we re-estimate ATTs applying attrition weights derived as the inverse of the estimated propensity of remaining in the sample.[10]. Results are substantially unchanged, as apparent from a comparison of Table A.8 (reported in the Appendix) with the corresponding unweighted results in Table 4.

Table 9: ATT by age group

	16-51			52-65		
	n (treated)	ATT	P val	n (treated)	ATT	P val
Labour market participation (LMP)	199	-0.005	0.788	213	**-0.146**	0.000
Hours, cond. on LMP	187	-0.355	0.589	170	-1.235	0.065
Limitations	200	**0.426**	0.000	213	**0.550**	0.000
Disability Benefit	195	**0.088**	0.008	212	**0.199**	0.000
Cond. on LMP:						
Would like to give up paid work	100	-0.059	0.132	82	-0.084	0.077
Would like to change job (employer)	99	-0.064	0.067	83	-0.036	0.302
Cond. on LMP, employees only:						
Perceived job security (1 to 4)	85	-0.150	0.068	64	-0.177	0.072
Earnings	170	-67.091	0.091	144	-75.588	0.123
Hourly Earnings	170	-0.811	0.898	144	-2.606	0.428

Source: UKHLS, waves 1-5.

Note: ATT estimate in bold is significant at the conventional 5% level.

[10]Propensities are estimated using a probit model of attrition as explained by the set of confounders controlled for in the main analysis.

6 Heterogeneous effects

6.1 Demographic gradients

We investigate heterogeneity in labour market adjustments with respect to individual's pre-shock characteristics, to explore potential mechanisms behind the observed response patterns. First we compute ATTs separately for younger and older workers[11], with the threshold set at the median age of 51 years. Estimates are reported in Table 9. Contrary to previous studies (but based on data from pre-economic crisis years), which found small or negligible differences between younger and older workers, we observe a substantial difference between the two age groups. No reduction in labour market participation is observed for younger aged workers, despite the significant increase in ADLs experienced following an acute health shock. Conversely, the 14.6% reduction in participation observed for older workers, which is comparable to the figure reported by Trevisan and Zantomio (2015) for older workers in England, represents a major decrease in labour market participation, with respect to the baseline 10% exit rate[12].

Table 10: ATT by gender

	Male			Female		
	n (treated)	ATT	P val	n (treated)	ATT	P val
Labour market participation (LMP)	199	**-0.064**	0.033	210	**-0.095**	0.004
Hours, cond. on LMP	172	-0.379	0.578	185	-1.098	0.094
Limitations	201	**0.552**	0.000	212	**0.439**	0.000
Disability Benefit	199	**0.190**	0.000	211	**0.106**	0.001
Cond. on LMP:						
Would like to give up paid work	85	-0.010	0.839	97	**-0.118**	0.000
Would like to change job (employer)	85	-0.015	0.726	97	**-0.069**	0.013
Cond. on LMP, employees only:						
Perceived job security (1 to 4)	67	**-0.268**	0.005	82	-0.086	0.307
Earnings	147	-62.284	0.243	167	**-91.379**	0.013
Hourly Earnings	147	-4.111	0.349	167	-0.186	0.974

Source: UKHLS, waves 1-5.
Note: ATT estimate in bold if significant at the conventional 5% level.

We further observe a substantial difference in age-related disability benefit uptake across

[11] This distinction is made in the final stage of parametric estimation.

[12] The strong age gradient in employment response is confirmed when part- and full- time workers are considered separately.

the two age-groups with the probability of uptake in the older group more than twice the rate observed in the younger group. This might result from older workers experiencing more severe health shocks, and/or conditional on shock severity, a greater propensity amongst older workers to claim benefits or encountering lower claim rejections rates (Zantomio, 2013). Taken as a whole, these results indicate a strong gradient in labour supply response to health shocks by age. The more limited re-employment prospects experienced by younger individuals, and in particular the lower educated, during the economic crisis, coupled with lower access to replacement incomes, may have induced individuals to retain existing employment.

Table 10 reports estimated ATTs by gender[13]. Previous literature has generally found either no major difference in the way men and women respond to health shocks, or a stronger response for women than men. This is also confirmed in our analysis. The 9.5% reduction in women labour market participation corresponds to 1.5 times their 6.6% baseline exit probability, while the 6.4% ATT estimated for men corresponds to 0.7 times their 9.5% baseline exit probability. This gender difference does not appear to be driven by shock-induced impairments, as women generally appear to experience less disabling shocks, compared to men. The significant gender difference with respect to the desire to give up paid work or change job/employer, with women increasing their 'attachment' after an acute health shock, is perhaps indicative of stronger positive selection of women in employment and of women who keep on working. This type of selection is also suggested by the significantly reduced labour market participation following a health shock of women who previously worked part-time, compared to those who previously worked full-time (for whom no change in participation is detected). For men the opposite trend is observed with labour market participation significantly reducing for full-time workes, but not for part-time workers.[14] Only men, however, register a sizeable reduction in perceived job security.

If we consider age and gender-related differences in together, the largest reduction in labour supply is attributable to older women (refer to Table A.5 in the Appendix). Not only do we observe a sizeable and significant response along the extensive margin, but conditional on remaining in the labour market, older women significantly reduce the number of hours worked by more than 2 hours per week. In contrast younger women do not significantly reduce participation, nor hours worked, and report increased labour market attachment (as measured by reductions in the desire to give up work or change employer). This differential response by age and gender suggests a strong role for preferences and intra-household division of labour. Indeed, among older workers, when comparing those who live with a partner and those who do not, a significant (and larger) adjustment in employment is registered only for

[13]Attrition weighted results for ATT by age and gender are also reported in the Appendix, Tables A.9 and A.10.

[14]Results available upon request from the authors.

those who live with a partner and might therefore rely on financial support.

Table 11: ATT by education

	High			Low		
	n (treated)	ATT	P val	n (treated)	ATT	P val
Labour market participation (LMP)	160	**-0.088**	0.017	252	**-0.058**	0.024
Hours, cond. on LMP	138	-0.14	0.857	219	**-1.25**	0.040
Limitations	160	**0.370**	0.000	253	**0.575**	0.000
Disability Benefit	157	**0.120**	0.002	-	-	-
Cond. on LMP:						
Would like to give up paid work	62	-0.003	0.961	120	**-0.095**	0.006
Would like to change job (employer)	62	-0.047	0.261	120	-0.038	0.242
Cond. on LMP, employees only						
Perceived job security (1 to 4)	49	-0.181	0.097	100	-0.138	0.074
Earnings	114	-17.82	0.782	200	**-94.30**	0.003
Hourly Earnings	114	-2.38893	0.590	200	-1.12205	0.836

Source: UKHLS, waves 1-5.

Note: ATT estimate in bold if significant at the conventional 5% level.

6.2 Socio-economic gradients

Previous studies that have investigated educational gradients in labour supply adjustments following a health shock report contrasting results. For example, Heinesen (2013) and Taskila-Abrandt (2004) found less educated workers in Denmark and Finland respectively more likely to exit the labour market, presumably due to experiencing more disabling health shocks while being employed in more physically demanding jobs compared to their more educated counterparts. A stronger impact of acute health shocks on the earnings of lower, as opposed to higher, educated workers is reported by Lundborg *et al.* (2015) for Sweden. Across different institutional settings, possibly characterised by less generous replacement incomes, the opposite gradient has also emerged. For example, Trevisan and Zantomio (2015) found higher exit rates for more educated older women in Europe; evidence that points at the explanatory role of financial constraints to labour market exit. When differentiated by educational status our results suggest a larger reduction in labour market participation for more educated workers, despite the fact that they appear to experience less severe disabilities compared to less educated individuals (refer to Table 11). The less educated appear to respond by reducing hours worked for those that remain active in the labour market. In addition, less educated workers report a significant increase in their desire to maintain paid work. Presumably these responses reflect greater financial constraints faced by low educated workers, but also lower opportunities for securing alternative or less physically demanding jobs.

We also consider heterogeneity in labour supply response with respect to equivalised household income, measured at time $t-1$. The sample is stratified into three tertiles, with thresholds corresponding to approximately 75% and 120% of the median value. Results are reported in Table A.6. Significant reductions in labour market participation are observed in the bottom and the top tertiles only. The significant ATT in the bottom income group supports the findings of Garcia-Gomez *et al.* (2013) using data from the Netherlands, with the financially worse-off affected the greatest. In the UK, where disability benefits are paid mostly at a flat rate, these workers enjoy relatively higher replacement rates upon labour market exit, given their presumably low level of wages. Workers in the top income tertile display a lower increase in the number of ADLs, but a sizeable point estimate for the reduction in labour market participation, presumably due to the availability of alternative financial means. Financial constraints may be tighter for workers in the middle tertile, who do not change their labour market participation, despite significant disablement.

Table 12: ATT by impairment severity

	No impairment			Induced impairment		
	n (treated)	ATT	P val	n (treated)	ATT	P val
Labour market participation (LMP)	297	-0.037	0.082	115	**-0.116**	0.009
Hours, cond. on LMP	267	-0.679	0.218	90	-0.865	0.346
Disability Benefit	294	**0.096**	0.001	116	**0.188**	0.000
Cond. on LMP:						
Would like to give up paid work	137	-0.057	0.121	45	**-0.114**	0.025
Would like to change job (employer)	138	-0.040	0.189	44	-0.013	0.787
Cond. on LMP, employees only						
Perceived job security (1 to 4)	115	-0.100	0.163	34	**-0.462**	0.001
Earnings	234	-56.163	0.131	80	**-120.994**	0.030
Hourly Earnings	234	-1.217	0.790	80	**-5.220**	0.038

Source: UKHLS, waves 1-5.
Note: ATT estimate in bold if significant at the conventional 5% level.

6.3 The role of impairment

Consistent with findings from Coile (2004), the level of shock-induced impairment plays a crucial role in explaining observed labour supply adjustments. Table 12 reports ATTs estimated separately for individuals who experience a wider set of limitations following a health shock, compared to individuals who do not. The reduction in participation is significant for those who experience an increase in ADL limitations only. This group of individuals also report a significant reduction in hourly earnings. The severity of a health shock is also associated with a dramatically reduced perceived level of job security for individuals who remain in the labour market.

We find additional acute health shocks to be more harmful to maintaining labour supply than an initial shock (Table 13). This finding is consistent with the findings of Moran *et al.* (2011) when considering cancer. Our earlier finding of a stronger response for older workers might reflect the fact that they experience greater severity and impairment following a health shock than younger workers. To assess this possibility we estimate ATTs by age and impairment (reported in Table A.7). A strong disability gradient arises for older workers with the ATT in labour market participation for individuals with impairment being 2.5 times that estimated for individuals without impairment (-0.204 versus -0.084). In contrast younger workers are not responsive to the severity of the health shock. This suggests that shock induced disability is not the only explanation for the age gradient we observe.

Table 13: ATT: first and recurrent shocks

	First ever shock			Additional shock		
	n (treated)	ATT	P val	n (treated)	ATT	P val
Labour market participation (LMP)	352	**-0.049**	0.02	61	**-0.233**	0.000
Hours, cond. on LMP	312	-0.76	0.13	45	-1.17	0.389
Limitations	352	**0.460**	0.000	61	**0.669**	0.000
Disability Benefit	348	**0.130**	0.000	59	**0.224**	0.000
Cond. on LMP:						
Would like to give up paid work	148	-0.048	0.173	34	**-0.178**	0.000
Would like to change job (employer)	148	-0.043	0.141	32	0.045	0.521
Cond. on LMP, employees only						
Perceived job security (1 to 4)	122	-0.134	0.052	27	**-0.307**	0.044
Earnings	277	**-84.20**	0.012	37	15.14	0.86
Hourly Earnings	277	-2.41	0.572	37	2.81	0.533

Source: UKHLS, waves 1-5.

Note: ATT estimate in bold if significant at the conventional 5% level.

7 Conclusions

The issue of labour market responses to acute health shocks, and of the mechanisms behind observed adjustments to these shocks, has remained relatively unexplored. The paucity of research covering all working age individuals can largely be attributed to a lack of adequate sources of data, given the relatively low incidence rates of health shocks of sufficient magnitude to stimulate labour supply adjustment in a younger age group. However, given the potential impact on lifetime income and wealth accumulation together with the spillover effects on household members that the withdrawal of labour at younger ages implies, the study of such individuals warrants consideration. Drawing on a recently available longitudinal survey of household in the UK (UKHLS), this paper offers new evidence on the labour supply responses to acute health shocks experienced by workers of all ages, including younger age groups. Inference is made with respect to workers observed after the onset of the 2008 financial crisis that profoundly changed European labour markets.

Our approach identifies causal impacts of the incidence of acute health shocks on labour supply decisions. Acute health shocks are defined by the onset of a cancer or stroke or myocardial infarction, three conditions that can be regarded as unanticipated in the timing of onset, as well as being arguably less exposed to measurement biase compared to conditions that develop gradually over time. We apply a combination of non-parametric coarsened exact and propensity score preprocessing methods, followed by parametric estimation of the average treatment effect for the treated, and consider a variety of labour market outcomes.

Results point to a significant reduction in labour market participation, with the average labour market exit risk doubling in response to an acute health shock, although among workers who remain active after the health deterioration, no adjustment in hours and earnings is detected, at least in the short run. However, labour market exit does not represent a temporary adjustment to an acute health shock; when a longer time span is considered, adjustment persists along the extensive margin, but it also involves the intensive margin of labour supply.

We find evidence of considerable heterogeneity in observed responses to health shocks. In particular, younger workers display stronger labour market attachment following a health shock than older workers. This is evidenced through no reduction in labour market participation for younger workers, coupled with an increase in their attachment to paid work, possibly motivated by a reduction in perceived job security. In contrast, older workers report higher shock-induced disablement than younger workers and more than double their labour market exit probability compared to their baseline exit rate. Important differences, however, emerge between men and women. Older and higher educated women exhibit the largest labour supply retraction. This would appear to indicate an important role for preferences and financial constraints that interact with shock-induced impairments to explain the observed adjustments.

Data constraints, stemming from a combination of a limited number of waves of data (currently five), together with survey attrition, restrict our ability to observe the labour supply effects to a relatively short period of time following a health shock. It is worth noting, however, that previous literature indicates that the bulk of supply adjustments happen in the short run with limited adjustment thereafter (e.g. Halla *et al.*, 2003, Smith, 2005). As additional waves of data become available increasing the sample of individuals experiencing an acute health shock, the scope for investigating causal pathways, and the relative importance of disablement, job characteristics, preferences for leisure and financial constraints, will become more profitable.

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A Appendix A: Supplementary results

Table A.1: First Preprocessing CEM, achieved balance

	Pval (diff)		*Bias (std. % diff. in means)*	
	Unbalanced	*Post CEM (1)*	*Unbalanced*	*Post CEM (1)*
age	**0.000**	0.690	75.6	1.7
male	0.340	1.000	4.6	0
father_dead_when_aged14	**0.000**	**0.024**	17.8	14.7
mother_dead_when_aged14	0.672	0.090	-2.2	-5.6
ever_smoker	**0.031**	0.421	10.5	3.9
current_smoker	**0.001**	**0.002**	15.9	16.5
regular_smoker_past	0.137	0.219	7	-5.9
heavy_smoker (current_or_past)	**0.000**	1.000	19.1	0
self assessed poor health	**0.000**	0.398	52	4.3
number of limitations	**0.000**	0.282	29.9	5.6
has long stanbding illness/disability	**0.000**	0.393	39	4.4
sofar_acute_shock	**0.000**	1.000	47.1	0
sofar_high_blood_pressure	**0.000**	0.095	31.3	-8.7
sofar_diabetis	**0.000**	0.125	30.4	9.9
sofar_congestive_heart_failure	**0.000**	0.378	11.8	6.9
sofar_coronary_heart_disease	**0.000**	**0.015**	28	19
sofar_angina	**0.000**	0.090	24.6	12.5
in_coohab_partnership	0.730	0.311	1.7	-5
hh size	**0.001**	0.997	-16.5	0
number of children	**0.000**	**0.004**	33.8	11.4
highest qual	**0.000**	0.065	25.1	9.4
white	**0.002**	0.086	16.6	6.9
eq. hh monthly income	0.183	0.195	-6.6	-6.6
social renter	**0.012**	0.053	11.4	10.7
home owner	0.473	0.280	3.5	-5.3
usual hours per week, incl.overtime	0.336	0.412	4.6	4
job satisfaction	0.414	0.111	4	8.1
”permanent” job (non temporary)	0.943	0.397	0.3	-4.3
management & professional	0.498	0.805	-3.3	-1.2
intermediate	0.787	0.923	1.3	-0.5
routine	0.604	0.750	2.5	1.6
year of interview	0.179	0.157	-6.5	-6.8
elapsed months since previous interw.	**0.000**	**0.000**	15.7	16.9

Source: UKHLS, waves 1-5.

Note: P values in bold if t-test of equality of means rejected at the conventional 5% level.

Table A.2: Propensity Score Estimates - Probit regression

Number of obs	54,971	Pseudo R2	0.0197
LR chi2(40)	98.48	Prob chi2	0.0000
	Coef.	*Std. Err.*	*P val.*
age	-0.001	0.002	0.766
male	-0.016	0.040	0.694
father_dead_when_aged14	0.240	0.075	0.001
mother_dead_when_aged14	-0.231	0.181	0.203
ever_smoker	-0.091	0.067	0.176
current_smoker	0.188	0.072	0.009
regular_smoker_past	0.031	0.081	0.701
heavy_smoker (current_or_past)	0.020	0.074	0.792
health (excellent)	-	-	
health very good	0.067	0.063	0.292
health good	0.023	0.065	0.721
health fair	-0.050	0.073	0.498
health poor	0.131	0.100	0.190
number of limitations	0.000	0.020	0.989
has long stanbding illness/disability	0.018	0.046	0.689
sofar_acute_shock	-0.051	0.051	0.322
sofar_high_blood_pressure	-0.085	0.043	0.050
sofar_diabetis	0.122	0.063	0.055
sofar_congestive_heart_failure	0.154	0.211	0.466
sofar_coronary_heart_disease	0.369	0.106	0.001
sofar_angina	0.072	0.108	0.507
in_coohab_partnership	-0.037	0.047	0.430
hh size	-0.005	0.018	0.774
number of children	0.030	0.013	0.018
Highest qualification (degree)	-	-	-
Other higher degree	0.021	0.060	0.730
A-level	0.034	0.058	0.560
GCSE	0.096	0.058	0.096
Other qualification	0.091	0.070	0.197
No qualification	0.030	0.085	0.721
white	0.099	0.060	0.099
eq. hh monthly income	0.000	0.000	0.521
social renter	0.144	0.077	0.062
home owner	0.078	0.065	0.235
usual hours per week, incl.overtime	0.002	0.001	0.226
job satisfaction	0.022	0.012	0.066
”permanent” job (non temporary)	-0.089	0.069	0.199
management & professional	0.017	0.270	0.950
intermediate	-0.020	0.271	0.941
routine	-0.044	0.271	0.870
year	-0.026	0.014	0.065
elap_months	0.027	0.006	0.000

Source: UKHLS, waves 1-5.

Note: Variables in bold if coefficient significant at the conventional 5% level.

Table A.3: Propensity score distribution

	Percentiles		*Smallest/Largest*				
	Treated	*Controls*	*Treated*	*Controls*		*Treated*	*Controls*
1%	0.0037	0.0028	0.0025	0.0009	*Mean*	0.0101	0.0077
5%	0.0044	0.0038	0.0030	0.0012	*Std. Dev.*	0.0078	0.0037
10%	0.0052	0.0043	0.0030	0.0012	*Variance*	0.0001	0.0000
25%	0.0064	0.0055	0.0034	0.0013	*Skewness*	5.8767	3.4051
50%	0.0081	0.0070			*Kurtosis*	54.3972	32.3456
			Largest	*Largest*			
75%	0.0116	0.0090	0.0335	0.0682			
90%	0.0159	0.0117	0.0622	0.0730			
95%	0.0226	0.0139	0.0772	0.0818			
99%	0.0317	0.0209	0.0972	0.0859			

Source: UKHLS, waves 1-5.

Table A.4: Balancing - comparison with other matching methods

	Bias (std. % diff. in means)				
	Unbalanced	*Balanced*	*PSM*	*MDM*	*Simpler CEM*
age	75.6	1.6	-5.9	*19.0*	1
male	4.6	0	5.4	*-1.9*	0
father_dead_when_aged14	17.8	3.6	-1.1	*3.3*	9.3
mother_dead_when_aged14	-2.2	-4.2	-7.2	0.0	-3.2
ever_smoker	10.5	-1.8	0	7.8	4.4
current_smoker	15.9	4.4	1.7	8.5	14.4
regular_smoker_past	7	-2.8	-3.5	0.0	-3.9
heavy_smoker (current_or_past)	19.1	0	-2.4	2.4	0
self assessed poor health	52	2	-0.5	0.5	3.1
number of limitations	29.9	3.4	3.9	1.7	3.7
has long stanbding illness/disability	39	2.3	5.2	0.5	3.2
sofar_acute_shock	47.1	0	7	0.0	0
sofar_high_blood_pressure	31.3	-0.2	0	3.8	-6.5
sofar_diabetis	30.4	-1.1	0	0.0	5.5
sofar_congestive_heart_failure	11.8	5	3.4	0.0	3.4
sofar_coronary_heart_disease	28	7.2	6.1	0.0	10.6
sofar_angina	24.6	2.7	0	0.0	9
in_coohab_partnership	1.7	2.2	8.6	-12.9	-3.6
hh size	-16.5	1.9	8.7	-2.5	-0.2
number of children	33.8	3.4	5.1	9.3	5
highest qual	25.1	0.9	-3.9	-0.1	5.6
white	16.6	3.2	-3.6	-6.4	4.7
eq. hh monthly income	-6.6	-4.3	6.6	-2.8	-5.1
social renter	11.4	0.1	-10.9	2.2	8.3
home owner	3.5	0.2	5.1	-5.6	-4.8
usual hours per week, incl.overtime	4.6	2.3	4.2	1.8	4.2
job satisfaction	4	7.7	-8.9	-1.2	7
”permanent” job (non temporary)	0.3	0.8	-5.5	-8.1	-2.4
management & professional	-3.3	2	5.9	0.0	-1.3
intermediate	1.3	-1.3	-10.4	2.9	-1.2
routine	2.5	-1.1	3.1	-2.5	2.3
year of interview	-6.5	4.1	6.2	3.0	2.8
elapsed months since previous interw.	15.7	8.4	2.5	9.0	16.7

Source: UKHLS, waves 1-5.

Note: * Propensity Score Matching; ** Mahalanobis Distance Matching; *** Simple CEM

Table A.5: ATT by gender and age

	Male					
	16-51			52-65		
	n (treated)	ATT	P val	n (treated)	ATT	P val
Labour market participation (LMP)	74	0.001	0.982	125	**-0.103**	0.018
Hours, cond. on LMP	70	-0.70	0.501	102	-0.66	0.452
Limitations	75	**0.555**	0.000	126	**0.551**	0.000
Disability Benefit	72	**0.136**	0.032	125	**0.237**	0.000
Cond. on LMP:						
Would like to give up paid work	38	0.055	0.476	47	-0.089	0.161
Would like to change job (employer)	37	-0.008	0.918	48	-0.045	0.307
Cond on LMP, employees only:						
Perceived job security	33	-0.192	0.136	34	**-0.340**	0.013
Earnings	64	-91.3658	0.253	83	-65.7447	0.334

	Female					
	16-51			52-65		
	n (treated)	ATT	P val	n (treated)	ATT	P val
Labour market participation (LMP)	123	-0.019	0.459	87	**-0.210**	0.001
Hours, cond. on LMP	117	0.21	0.80	68	**-2.34**	0.021
Limitations	125	**0.320**	0.000	87	**0.622**	0.000
Disability Benefit	123	0.076	0.053	85	**0.152**	0.005
Cond. on LMP:						
Would like to give up paid work	62	**-0.127**	0.000	35	-0.077	0.275
Would like to change job (employer)	62	**-0.094**	0.002	35	-0.023	0.676
Cond. on LMP, employees only:						
Perceived job security	52	-0.10	0.326	30	-0.03	0.822
Earnings	106	-63.51	0.12	61	-91.11	0.183

Source: UKHLS, waves 1-5.

Note: ATT estimate in bold if significant at the conventional 5% level.

Table A.6: ATT by equivalent household income tertile

	Bottom			Middle			Top		
	n (treated)	ATT	P val	n (treated)	ATT	P val	n (treated)	ATT	P val
Labour market participation (LMP)	137	**-0.127**	0.004	138	-0.020	0.455	137	**-0.109**	0.01
Hours, cond. on LMP	113	-0.61	0.51	125	-0.81	0.265	119	-1.16	0.145
Limitations	138	**0.548**	0.000	138	**0.574**	0.000	137	**0.341**	0.000
Disability Benefit	137	**0.145**	0.001	135	**0.155**	0.002	134	**0.130**	0.004
Cond. on LMP:									
Would like to give up paid work	57	-0.068	0.188	64	-0.059	0.262	61	-0.057	0.289
Would like to change job (employer)	57	-0.007	0.895	63	-0.040	0.333	62	-0.054	0.152
Cond. on LMP, employees only									
Perceived job security (1 to 4)	47	-0.118	0.297	52	-0.151	0.158	50	**-0.252**	0.017
Earnings	97	-25.27	0.518	115	**-132.47**	0.004	102	-41.07	0.551
Hourly Earnings	97	1.70753	0.469	115	-3.7715	0.548	102	-1.9118	0.822

Source: UKHLS, waves 1-5.

Note: ATT estimate in bold if significant at the conventional 5% level.

Table A.7: ATT on LMP: disability gradients by age

		n (treated)	ATT	P val
16-51	No impairment	148	0.001	0.976
	Impairment	48	0.006	0.862
52-65	No impairment	149	**-0.081**	0.029
	Impairment	64	**-0.204**	0.001

Source: UKHLS, waves 1-5.
Note: ATT estimate in bold if significant at the conventional 5% level.

Table A.8: ATTs, overall sample, using attrition weights

	ATT	Std. Err.	P val
Labour Market Participation (LMP)	**-0.070**	0.021	0.001
Hours, cond. on LMP	-0.847	0.458	0.065
Limitations	**0.489**	0.038	0.000
Disab Benefit	**0.130**	0.025	0.000
Cond on lmp:			
Job satisfaction	-0.052	0.067	0.435
Would like to give up paid work	**-0.067**	0.030	0.023
Would like to change employer and job	-0.045	0.025	0.068
Bad feelings about job	-0.615	0.319	0.054
Cond on lmp, employees only:			
Perceived job security (1 to 4)	**-0.164**	0.062	0.008
Earnings	**-75.919**	30.384	0.012
Hourly earnings	-1.6325	3.5972	0.65

Source: UKHLS, waves 1-5.
Note: ATT estimate in bold if significant at the conventional 5% level.

Table A.9: ATTs, by age group, using attrition weights

	16-51		52-65	
	ATT	P val	ATT	P val
Labour market participation (LMP)	-0.005	0.773	**-0.143**	0.000
Hours, cond. on LMP	-0.37	0.556	-1.284	0.05
Limitations	**0.431**	0.000	**0.558**	0.000
Disab Benefit	**0.089**	0.005	**0.192**	0.000
Cond on lmp:				
Would like to give up paid work	-0.059	0.118	-0.083	0.071
Would like to change job (employer)	**-0.066**	0.049	-0.036	0.282
Cond on lmp, employees only:				
Perceived job security (1 to 4)	-0.144	0.068	-0.179	0.063
Earnings	-69.00	0.067	-76.389	0.11

Source: UKHLS, waves 1-5.

Note: ATT estimate in bold if significant at the conventional 5% level.

Table A.10: ATTs, by gender, using attrition weights

	MALE		FEMALE	
	ATT	P val	ATT	P val
Labour market participation (LMP)	**-0.064**	0.025	**-0.091**	0.003
Hours, cond. on LMP	-0.377	0.565	**-1.118**	0.075
Limitations	**0.545**	0.000	**0.445**	0.000
Disab Benefit	**0.184**	0.000	-	-
Cond on lmp:				
Would like to give up paid work	-0.008	0.862	**-0.117**	0.000
Would like to change job (employer)	-0.014	0.738	**-0.074**	0.005
Cond on lmp, employees only:				
Perceived job security (1 to 4)	**-0.265**	0.005	-0.083	0.309
Earnings	-64.349	0.206	**-92.197**	0.009
Hourly Earnings	-3.8294	0.362	-0.2536	0.964

Source: UKHLS, waves 1-5.

Note: ATT estimate in bold if significant at the conventional 5% level.

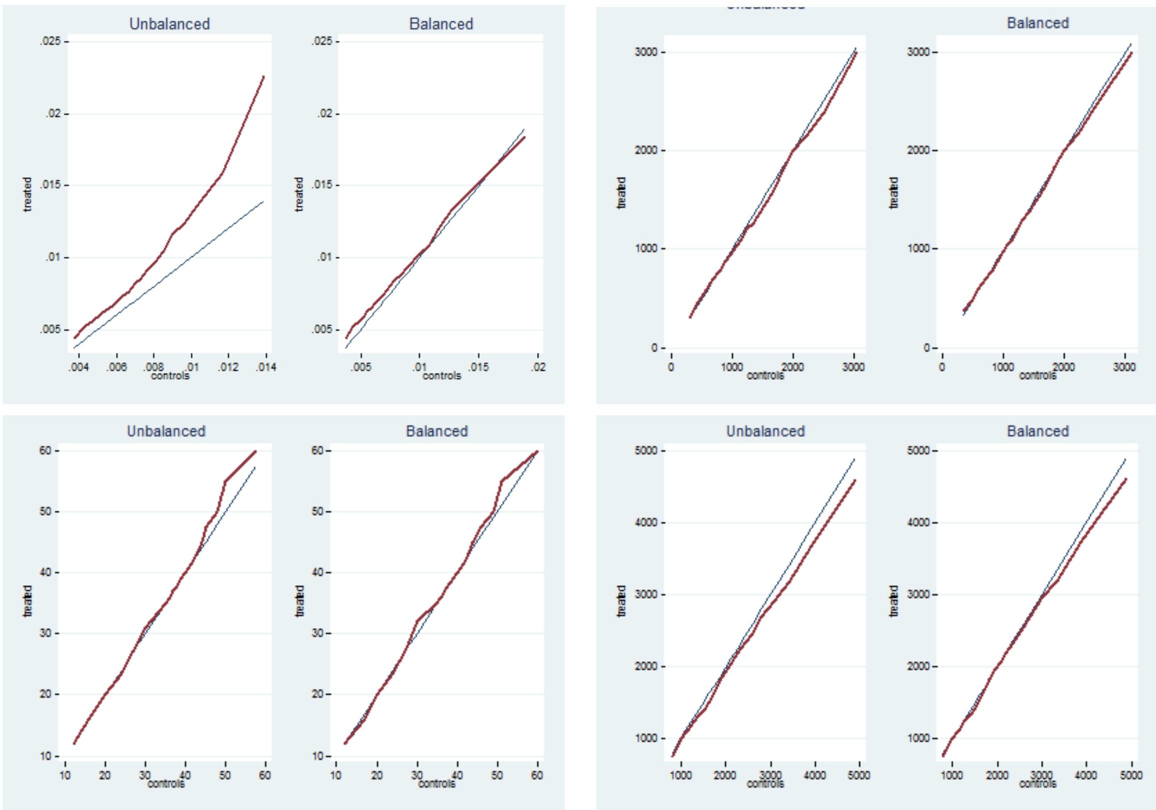

Figure A.1: Quantile-Quantile plots
Top Left: propensity score; Top right: earnings $(t-1)$
Bottom Left: hours worked $(t-1)$; Top right: equivalent household income $(t-1)$

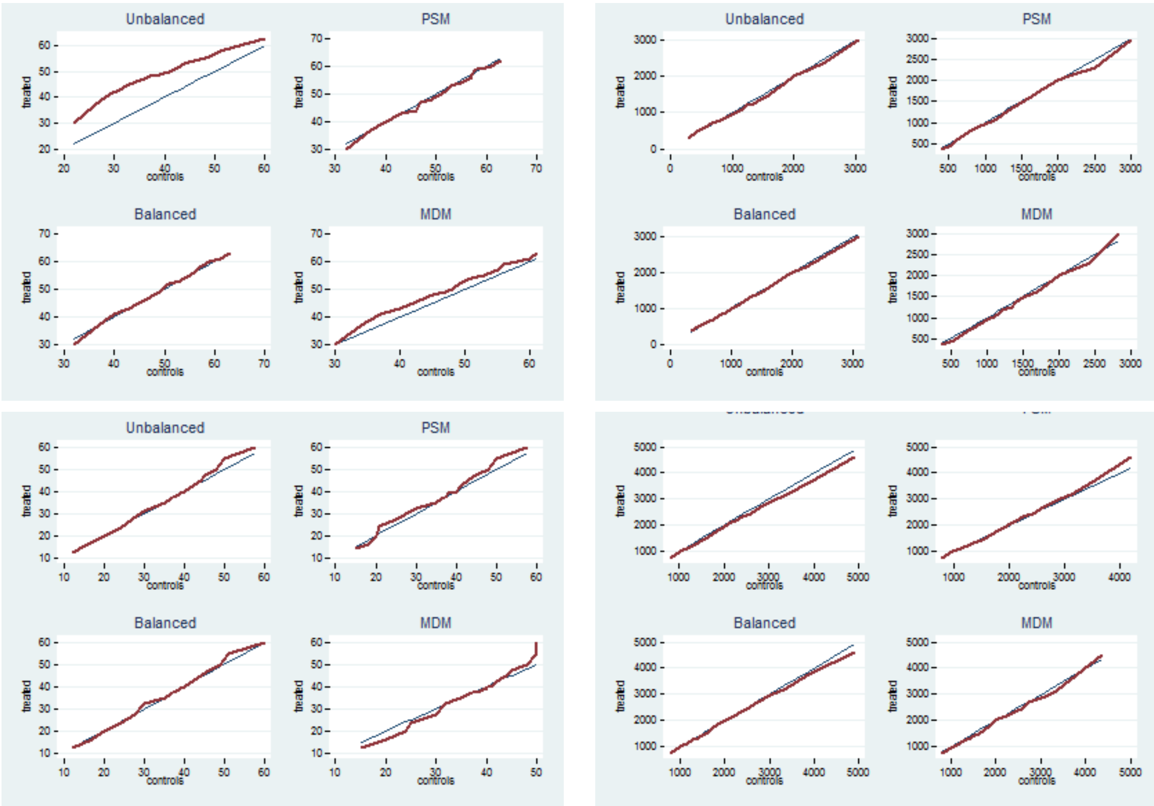

Figure A.2: Quantile-Quantile plots comparison with other matching methods
Top Left: age; Top right: earnings $(t-1)$
Bottom Left: hours worked $(t-1)$; Top right: equivalent household income $(t-1)$