



Working longer and living healthier : essays on retirement, health, and caring responsibilities in France

Elsa Perdrix

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THÈSE

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WORKING LONGER & LIVING HEALTHIER: ESSAYS ON RETIREMENT, HEALTH, AND CARING RESPONSIBILITIES IN FRANCE

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Guide de lecture

L'ensemble des chapitres de cette thèse peuvent être lus indépendamment les uns des autres. Il peut en découler certaines redites d'un chapitre à l'autre, notamment concernant la description de réformes ou de la littérature. Par ailleurs, les chapitres sont issus d'articles de recherche. Par conséquent les termes "*papier*" ou "*article*" sont parfois employés pour parler du chapitre.

All the sections of this thesis can be read independently. One of the consequence of this organisation is some repetition from one chapter to another, in particular concerning reforms description and literature review. Moreover, the Chapters are from research articles. Consequently, terms "*paper*" or "*article*" are sometimes used in reference to the chapter.

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Introduction générale

“À 60 ans, l’espérance de vie est de 27 ans pour les femmes et 22,2 ans pour les hommes. Or, ce phénomène heureux, pour lequel il y aurait lieu de se réjouir, fait figure de catastrophe. Car la réalité démographique s’accorde mal avec le contexte économique et social en place.” Trincaz (2015)

Dans les mythes gréco-romains, la jeunesse est vue comme positive (Trincaz, 2015). Par exemple, la jeunesse éternelle est le cadeau de Zeus à Ganymède. La vieillesse, au contraire, est souvent présentée comme une malédiction, notamment à travers le mythe de Pandore, qui sème sur Terre “les maladies cruelles que la vieillesse apporte aux hommes”. En revanche, le mythe de la longévité voire de l’immortalité apparaît bien plus contrasté. Il se décline autour de deux visions: la jeunesse éternelle (la fontaine de jouvence) et la résurrection (le phoenix). À cette époque, peu de récits pointent les aspects négatifs de la longévité.¹ Lorsque c’est le cas, c’est souvent en association avec la vieillesse.²

La présentation de la longévité comme malédiction prend une part croissante dans la littérature contemporaine. L’immortalité est alors présentée à la fois comme une tare pour l’individu (A. Huxley “Jouvence”³ (1939); S. de Beauvoir “Tous les hommes sont mortels” (1946); J.L. Borges “L’immortel” (1947)), mais aussi pour la société (P. Valéry “Tel quel”, dans “*Moralité*” (1941); R. Barjavel “Le grand secret” (1973)).

En soulignant les enjeux économiques et sociétaux que posent les évolutions démographiques, ces écrits font écho à la littérature en sciences économiques. Ils soulignent les enjeux du vieillissement démographique à l’aune du modèle sociétal adopté. Ainsi, en France, le système social repose sur des solidarités entre générations, entre actifs et inactifs, entre aptes au travail et inaptes, entre individus en bonne et en mauvaise santé. Ce modèle force à penser les politiques publiques sous le prisme des évolutions démographiques. Dans ce contexte, cette thèse a pour objet d’éclairer les liens existant entre les évolutions démographiques, les politiques publiques, et les conséquences de ces dernières pour les individus.

La définition du vieillissement démographique et la multiplicité des phénomènes que ce terme recoupe nécessitent d’être explicités en préalable (Section 1). Cela permet dans un second temps de décrire les enjeux de politiques publiques associés au vieillissement démographique que connaît la France dans trois domaines: le système de retraite, le système

¹On retrouve dans cette thématique par exemple le récit du juif errant, ou encore dans la religion bouddhiste, le nirvana comme moyen d’échapper au cycle de réincarnation.

²Par exemple, dans le mythe de Tithon et Eos. Eos, possédant la jeunesse éternelle, demande l’immortalité à Zeus pour Tithon. Zeus lui accorde la vieillesse éternelle.

³Titre anglais original: “After Many a Summer Dies the Swan”.

d'assurance-maladie et le système de soutien aux personnes âgées en perte d'autonomie (Section 2). Une dernière partie présente chaque chapitre de cette thèse, et l'articulation de ces derniers dans un contexte plus large de politiques publiques (Section 3).

1 Le vieillissement démographique

La hausse de l'espérance de vie est un phénomène ancien en France. Ainsi, l'espérance de vie a augmenté continuellement depuis 1750, à l'exception des périodes de guerre (Figure 1). Les premières améliorations de l'espérance de vie s'expliquent par la diminution de la mortalité infantile: alors qu'au XVIII^{ème} siècle, un enfant sur deux mourrait avant 10 ans, le taux de mortalité infantile atteint 10 % un siècle plus tard (Cambois et al., 2009). A partir des années 1950, l'amélioration de l'espérance de vie s'explique majoritairement par la diminution de la mortalité aux âges élevés. Ainsi, l'espérance de vie à 65 ans augmente depuis les années 1950 (Figure 1b). D'abord compensée partiellement par le baby-boom, cette hausse de l'espérance de vie des plus de 65 ans s'est traduite à partir des années 1990 par une accélération de la part des 65 ans et plus dans la population (Figure 2a). Dans cette section, nous verrons d'abord les différentes définitions du vieillissement démographique. Dans un second temps, les sources du vieillissement démographique seront présentées.

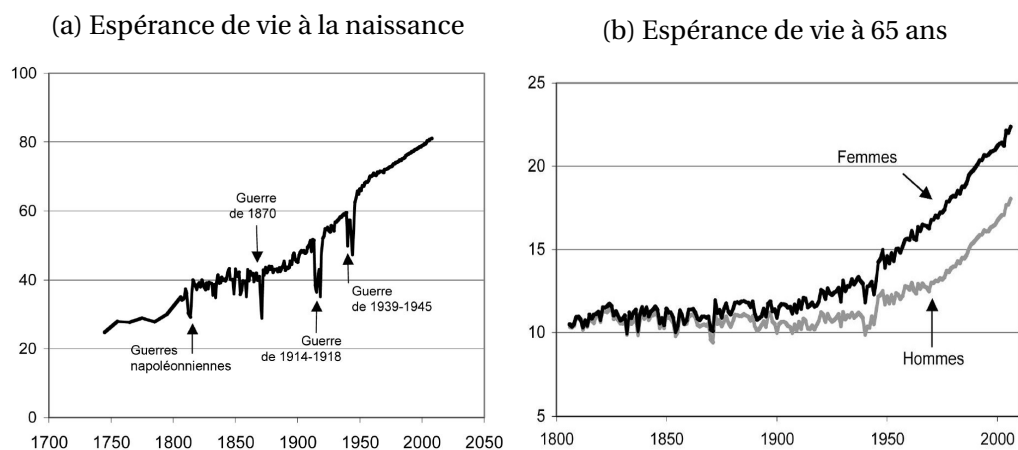
1.1 Les définitions du vieillissement démographique

Le vieillissement d'une population est l'augmentation de l'âge moyen de celle-ci. Ponthiere (2017) rappelle que différents âges peuvent être considérés dans la mesure du vieillissement démographique. Ainsi, il distingue l'âge chronologique, biologique et économique. **L'âge chronologique** requiert l'existence d'un seuil d'âge à partir duquel la personne est considérée comme âgée. Usuellement, en France, on utilise le seuil de 60 ou 65 ans.⁴ On définit ensuite par extension le vieillissement d'une population comme la part de la population au-delà de ce seuil. Ainsi, la Figure 2a montre qu'à l'exception d'une faible baisse dans les années 1980, liée à l'arrivée à l'âge de 65 ans des cohortes nées pendant la guerre, la part des 65 ans et plus en France n'a cessé d'augmenter depuis un siècle. Une seconde mesure de ce vieillissement consiste à rapporter le nombre d'individus de 65 ans et plus au nombre d'individus âgés de 20 à 64 ans (*old age dependency ratio*). La Figure 2b montre qu'à nouveau, ce ratio est en constante augmentation en France depuis un siècle.

La définition de l'âge chronologique a l'inconvénient de ne pas tenir compte du fait que les conditions d'hygiène et de santé ont considérablement évolué. Or, avoir 60 ans n'est pas la même chose en 1800 qu'en 2010. Ainsi, l'âge chronologique ne reflète pas la santé et la

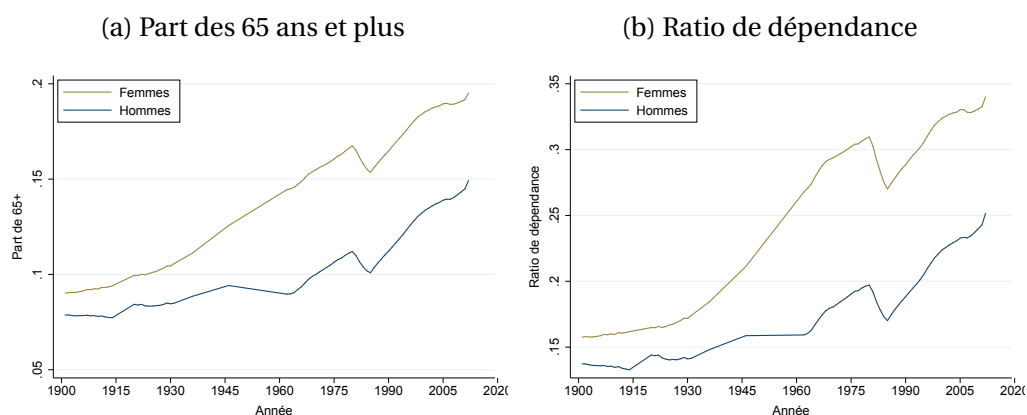
⁴Ce seuil est parfois assimilé à un seuil administratif puisque coïncidant avec l'âge d'ouverture des droits à la retraite ou de droit à des prestations spécifiques pour personnes âgées.

Figure 1 – Espérance de vie en France



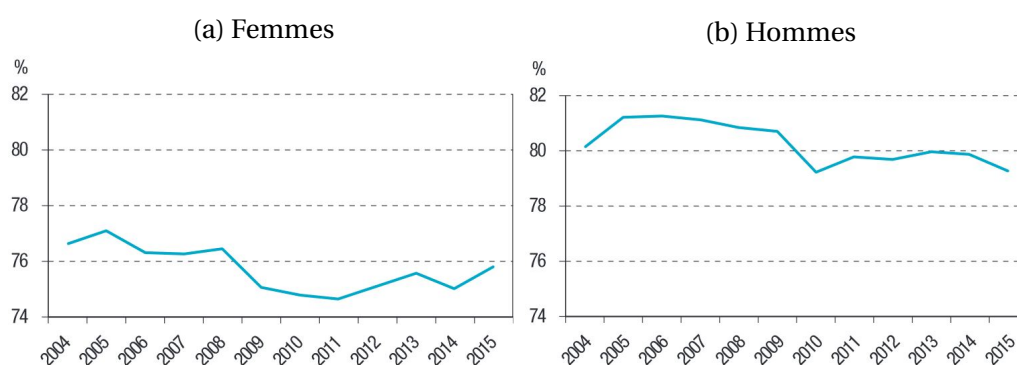
Source: Graphiques issus de Cambois et al. (2009). Figure (a) de Blayo [1975], Meslé et Vallin [2001], Pison [2005] et Pla [2009]. Figure (b) Meslé et Vallin [2001] ; Pla [2009].

Figure 2 – Evolution de l'âge chronologique en France



Source: Données démographique de l'Insee (2018).

Figure 3 – Part de l'espérance de vie sans incapacité dans l'espérance de vie totale



Source: Robine and Cambois (2017) utilisation des données EU-SILC. Calcul de l'espérance de vie sans incapacité avec la méthode Ehemu. Deroyon (2019), en utilisant les données française SILC, et la même méthode, trouve des résultats similaires.

réalité biologique de l'individu. **L'âge biologique**, défini comme une évolution défavorable liée au passage du temps, répond à cette limite. À l'échelle de la population, le vieillissement biologique peut être mesuré via différents indicateurs. Ainsi, par exemple, Sanderson and Scherbov (2010) définissent *l'adult disability dependency ratio*. Il s'agit du nombre d'individus de 20 ans et plus avec des limitations fonctionnelles, rapporté au nombre d'individus de 20 ans et plus sans limitation fonctionnelle. Cambois and Robine (2014); Jagger et al. (2009); Deroyon (2019) privilégient une mesure reposant sur l'espérance de vie sans incapacité ou en bonne santé. Les études utilisant l'espérance de vie sans incapacité montrent que l'amélioration de l'espérance de vie s'effectue suivant un scénario de compression ou de stagnation de la morbidité chez les hommes, c'est à dire que la part de la vie passée avec des incapacités tend à diminuer (Figure 3b). En revanche, pour les femmes, alors que l'augmentation de l'espérance de vie a suivi un scénario de compression de la morbidité jusqu'en 2011, elle suit désormais un scénario d'expansion (Figure 3a).

L'évolution de l'âge biologique par rapport à l'âge chronologique peut être mesurée grâce à l'âge prospectif (Sanderson and Scherbov, 2005, 2007, 2008, 2010). Cet âge est le nombre d'années restant à vivre à un âge chronologique donné. Ainsi, Sanderson and Scherbov (2007) montrent qu'en Chine, l'âge auquel les femmes avaient encore 25,5 ans d'espérance de vie est de 40 ans en 1950-55 et de 48,18 ans en 1970-75. Ils en déduisent qu'avoir 40 ans en 1950 est équivalent à avoir 48,18 ans en 1970 pour les femmes en Chine. Dans le même état d'esprit, l'âge relatif est défini par d'Albis and Collard (2013) comme l'âge chronologique à partir duquel on appartient au dernier quartile de la distribution des âges d'une population. Ils montrent qu'en France, cet âge est passé de 50 à 56 ans entre 1940 et 2000.

La mesure du vieillissement biologique a le mérite de tenir compte des évolutions d'état de santé. En matière de politiques publiques, il permet de mieux envisager, par exemple,

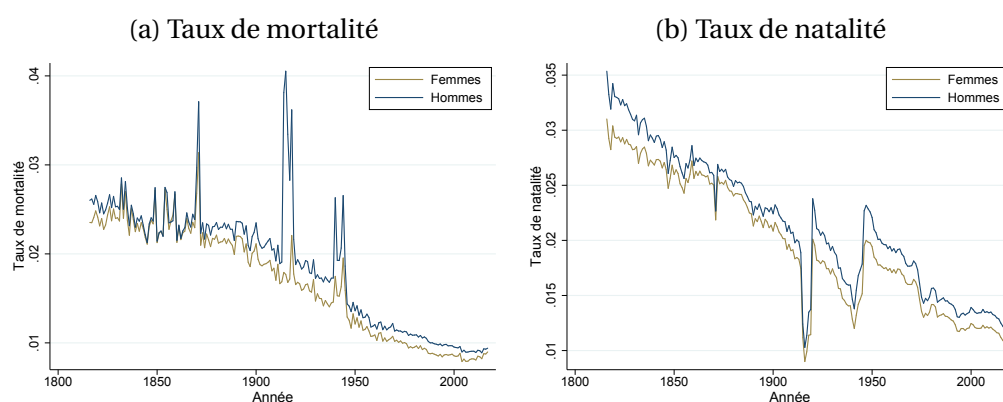
les dépenses de santé associées à chaque âge. En revanche, il a l'inconvénient de ne pas tenir compte de l'équilibre démographique sur lequel repose un système social qui requiert un équilibre entre actifs et inactifs. La mesure du **vieillissement économique** répond à cette limite. Il peut être vu comme la diminution des contributions productives relativement aux besoins de consommation. Usuellement, on le mesure par le ratio entre le nombre de personnes âgées inactives rapporté au nombre d'adultes actifs (*ratio de dépendance économique*) ou encore par le *ratio de soutien* défini comme la quantité de travail effectif rapportée au nombre effectif de consommateurs (Cutler et al., 1990).

1.2 Les sources du vieillissement démographique

Le vieillissement démographique est un phénomène d'évolution des structures de population par âge. Deux types d'évolutions de ces structures par âge, que l'on représente usuellement via la pyramide des âges, peuvent conduire à un vieillissement démographique. D'une part, un phénomène d'élargissement de la pyramide des âges vers le haut (*ageing at the top*) et, d'autre part, une diminution de la base de la pyramide (*ageing at the bottom*). Ainsi, par exemple, Sauvy (1954) montre que le vieillissement démographique que la France a connu au début du XX^{ème} siècle n'est pas attribuable à la baisse de la mortalité mais à la baisse de la natalité (vieillissement par le bas). Le vieillissement démographique récent, lié principalement à la hausse de l'espérance de vie à 60 ans et à l'arrivée des générations du baby-boom aux âges élevés, peut être considéré comme un vieillissement par le haut.

Outre les chocs liés aux guerres et épidémies, les sources de ces évolutions peuvent venir de trois principaux facteurs: des variations du taux de natalité, des variations du taux de mortalité et des migrations. Notons que l'effet de ces facteurs doit toujours être considéré au regard d'une structure de population donnée. Ainsi, une baisse du taux de fécondité conduit à un vieillissement de la population si la structure par âge est stable, ou bien n'avoir aucun impact sur le vieillissement démographique du fait d'une part importante de femmes en âge de procréer dans la population, qui absorbe alors la baisse de la fécondité. Dans les faits, ce fût en partie le cas en France dans les années 1960, où la baisse du taux de fécondité ne s'est retranscrit que peu dans le nombre de naissances, puisqu'elle fût en partie compensée par l'arrivée en âge de procréer de la génération du baby-boom (Pison, 2014). Ainsi, le taux de natalité est resté relativement stable en France (Figure 4b). En revanche, l'espérance de vie à 60 ans augmente continuellement depuis la fin de la seconde guerre mondiale. L'espérance de vie à 60 ans est passée de 12 ans environ à 23,2 ans chez les hommes et 27,7 ans chez les femmes entre 1850 et 2014 (Pison, 2018). Conjuguée à une structure des âges déséquilibrée due au vieillissement des générations du baby boom, cette diminution de la mortalité a entraîné une accélération du vieillissement de la population à partir de la fin des années 1980 (Figure 4a).

Figure 4 – Les sources du vieillissement démographique



Source: Human Mortality Database.

2 Les enjeux de politiques publiques

Le rôle de la démographie dans l'économie et son importance dans les politiques publiques n'est pas nouveau. Déjà évoqué par Ricardo (1817), il est largement exploré depuis les années 50 dans le contexte de vieillissement démographique par le haut. La compréhension des sources du vieillissement démographique constitue un enjeu de politiques publiques. Un vieillissement par le bas peut, par exemple, créer une augmentation des salaires par raréfaction de la main d'œuvre, alors qu'un vieillissement par le haut peut mener, par exemple, à des pressions sur le financement des dépenses de santé (Solignac, 2010). De même, Daric (1946) écrivait “*[Le vieillissement démographique a] pour aboutissement d'alourdir constamment la contribution demandée à la population active pour satisfaire aux besoins de la population âgée inactive*”.

Comme cela a été précisé dans la section précédente, le vieillissement démographique que connaît la France aujourd'hui est un vieillissement par le haut. Ainsi, la question des enjeux de politiques publiques liés au vieillissement démographique, telle que présentée par la suite, est celle associée à un vieillissement par le haut.

Une première section éclaire le lien entre l'organisation sociale et les problématiques liées au vieillissement démographique. Connaître l'articulation entre la structure des populations et le système social permet de comprendre la façon dont certains facteurs socio-économiques peuvent atténuer ou aggraver les problématiques associées au vieillissement démographique en France. Cela permet également d'éclairer, dans un second temps, la question du lien entre démographie et politiques publiques dans le cadre du système de retraite, d'assurance-maladie, et de soutien à la dépendance des personnes âgées.

2.1 Du vieillissement démographique aux politiques publiques

Les enjeux associés aux évolutions démographiques ne peuvent être compris qu'à la lumière de l'**organisation sociale** et du contexte économique qui l'entoure. Les difficultés françaises face au vieillissement de sa population sont fortement liées au choix d'une société de mutualisation des risques de l'invalidité, de la maladie, et de la retraite. Cette organisation requiert de conserver un ratio de dépendance économique stable pour couvrir les dépenses associées à ce système assurantiel. De fait, les facteurs relatifs à la croissance économique et au marché du travail doivent particulièrement être pris en compte.

Ces **facteurs économiques** peuvent accentuer ou atténuer les difficultés posées par le vieillissement démographique. Ainsi, l'allongement de la durée des études (Biscourp (2006), Figure 5b) mène à une entrée plus tardive sur le marché de l'emploi, qui pèse sur le ratio de dépendance économique (au dénominateur). L'augmentation du taux de chômage dans les années 1970, et son maintien à un niveau élevé depuis les années 1990, pèse également au dénominateur (Figure 5a). L'augmentation du taux d'emploi des femmes pourrait être un facteur atténuant. Cependant, il ne s'est pas accompagné d'une augmentation du taux d'emploi total et ne joue donc finalement qu'un rôle limité (Figure 5c). La stagnation du revenu par habitant depuis les années 2000 (Figure 5d) participe également à un contexte économique défavorable, du fait d'un système de cotisations sociales dépendant du niveau de revenu par habitant. Ces facteurs, conjugués au vieillissement démographique, doivent être pris en compte pour penser les évolutions des politiques publiques.

Enfin, dans ce contexte économique et démographique, chaque politique publique doit tenir compte de spécificités. Par exemple, le système de retraites est affecté par le vieillissement démographique du fait de la hausse du ratio de dépendance économique. La soutenabilité financière de l'assurance-maladie doit tenir compte à la fois du ratio de dépendance économique et de l'état de santé d'une population vieillissante (évolution de l'âge biologique et des dépenses associées).

Trois postes de dépenses du système social français sont très sensibles à la question du vieillissement démographique par le haut. Ces trois postes sont ceux dont le pilotage requiert de tenir particulièrement compte à la fois du contexte économique et démographique: le système de retraite, l'assurance maladie, et la dépendance des personnes âgées.

Les sections suivantes s'attachent à décrire le système en place et les réformes ayant eu pour but de tenir compte des contraintes démographiques. Cela permet de mettre en exergue les spécificités des évolutions de chacun de ces dispositifs. Ainsi, le système de retraite a connu des réformes majeures depuis 1993. De nombreuses évaluations de l'impact direct de ces réformes ont permis d'informer le décideur politique de l'efficacité et de l'efficience de ces mesures eu égard aux objectifs visés. En revanche, les effets indirects ont été beaucoup moins étudiés. Le système de l'assurance maladie a connu de nombreuses réformes visant à

la fois à améliorer les recettes et à limiter les dépenses. Les études ont porté sur certaines parties de ces réformes seulement, majoritairement pour des contraintes de faisabilité. Enfin, le système de compensation de la perte d'autonomie a connu trois réformes, sans parvenir à un modèle stable et pérenne de financement et d'accompagnement, soulignant ainsi certains manques dans les connaissances nécessaires à la mise en place d'un système d'aide satisfaisant.

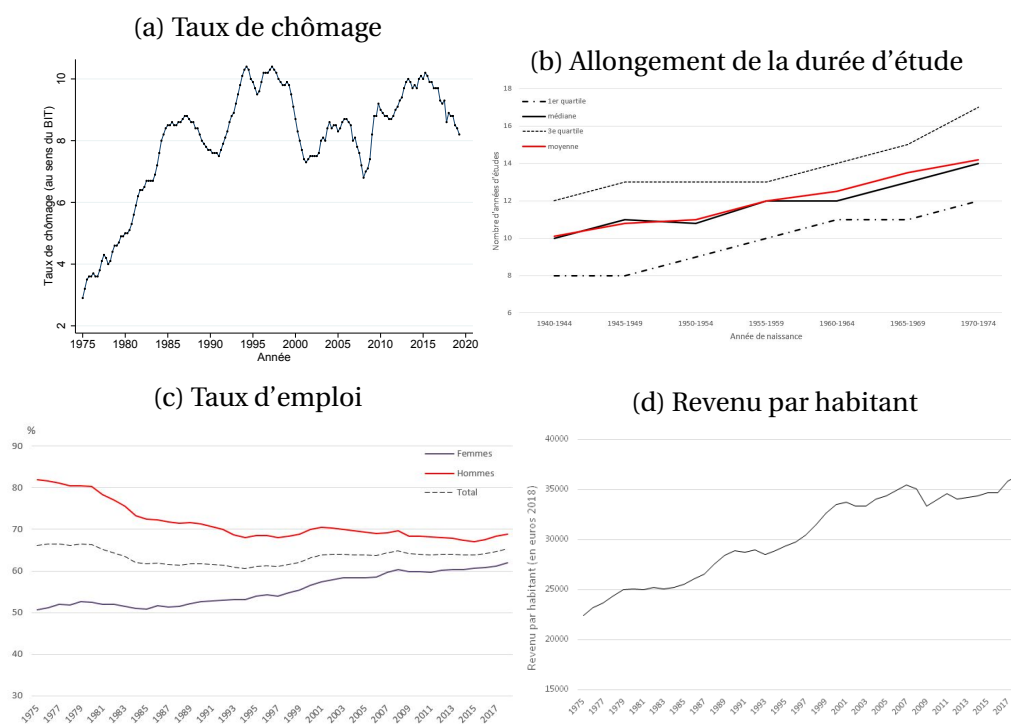
2.2 Les retraites

Le système de retraite français est un régime par répartition, qui requiert un équilibre démographique entre population active et retraitée. L'augmentation du ratio de dépendance économique pèse sur la soutenabilité financière du système. Ce problème démographique est accentué par un contexte économique défavorable. Il est possible de souligner en particulier quatre facteurs: un taux de chômage élevé (Figure 5a); un allongement du nombre d'années d'études d'environ quatre ans entre les générations nées en 1940 et celles nées en 1970 (Figure 5b); une stagnation du taux d'emploi malgré l'augmentation du taux d'emploi des femmes (Figure 5c); et une stagnation du revenu par habitant depuis une décennie (Figure 5d). Dans ce contexte, une série de réformes ont visé à rétablir l'équilibre du système des retraites, jouant à la fois sur le montant des pensions, l'âge de liquidation des droits, et les cotisations.

La première réforme des retraites visant à augmenter l'âge de départ à la retraite a été instaurée en 1993 (réforme Balladur). Cette réforme inclut trois principales mesures pour les salariés du secteur privé. Premièrement, l'augmentation du nombre de trimestres à cotiser pour bénéficier d'une retraite à taux plein⁵ (passant de 150 à 160 trimestres, progressivement, cohorte par cohorte à partir de la cohorte 1934). Deuxièmement, un changement du système d'indexation des pensions. A partir de 1993, les pensions ne sont plus indexées sur les salaires mais sur les prix. Enfin, la réforme augmente le nombre d'années prises en compte dans le calcul du salaire annuel moyen de référence (passage progressif des 10 aux 20 meilleures années). De nombreuses études se sont intéressées à l'effet de cette réforme sur l'âge de liquidation et le montant des pensions. Ainsi, les chercheurs ont montré qu'environ 10 % des salariés du privé furent réellement concernés par cette incitation à partir plus tard. En effet, une part des salariés bénéficiaient d'une retraite à taux plein à 60 ans du fait d'un nombre de trimestres cotisés à 60 ans excédant largement la durée requise, alors qu'une autre part des salariés partait à 65 ans du fait d'un nombre de trimestre cotisés en deçà du seuil requis. L'augmentation de l'âge de liquidation fût d'environ neuf mois pour les premières générations touchées par la réforme (Bozio, 2011a; Aubert, 2012). Par ailleurs, cette

⁵En France, chaque salarié pouvait bénéficier d'une retraite dès l'âge de 60 ans. Pour bénéficier du taux plein, il fallait soit avoir contribué 150 trimestres, soit avoir 65 ans.

Figure 5 – Contexte économique



Source: Figure (a): Données INSEE. Figure (b) Biscourp (2006) La durée d'études est exprimée en nombre d'années d'études de la primaire à la fin de la scolarité. Données Insee, enquête FQP 2003. Figure (c): Données INSEE. Figure (d) Données WID. Revenu par habitant en euros 2018.

réforme a conduit à une baisse en moyenne de 6 % du montant des pensions (Bridenne and Brossard, 2008).

La réforme de 2003 (réforme Fillon) comprend trois volets. Premièrement, une extension de la réforme de 1993 aux fonctionnaires. Ainsi, la durée de cotisation requise pour bénéficier du taux plein passe progressivement de 150 à 160 trimestres pour les fonctionnaires. De même, à partir de 2004, les pensions ne sont plus indexées sur le point d'indice de la fonction publique mais sur les prix. Deuxièmement, la réforme de 2003 prévoit la création d'un régime complémentaire par points obligatoire pour les fonctionnaires.⁶ Troisièmement, la réforme de 2003 marque la mise en place d'une série de dispositifs supplémentaires: le dispositif carrière longue pour les personnes ayant commencé à travailler entre 14 et 16 ans; la création de deux plans d'épargne facultatifs;⁷ la modification des règles de calcul du salaire annuel moyen de référence; la mise en place d'un dispositif de surcote visant à inciter les individus à partir plus tard à la retraite. A partir de 2009, l'alignement est étendu à tous les travailleurs (sauf les régimes spéciaux). Cette réforme a conduit à une augmentation de l'âge de liquidation des enseignants fonctionnaires (Baraton et al., 2011). Le dispositif de surcote a augmenté en moyenne de deux mois l'âge de liquidation, et a augmenté de 16 % la probabilité d'être en emploi après 60 ans (Benallah, 2011). Enfin, la réforme de 2003 a conduit à une baisse des pensions de l'ordre de 5 % pour 75 % des fonctionnaires, et une hausse d'environ 8 % pour 25 % d'entre eux (Bridenne et al., 2018).

La réforme de 2010 (réforme Woerth) est la première à modifier non seulement les incitations à partir à la retraite plus tard⁸ mais également à augmenter l'âge légal d'ouverture des droits. Ainsi, l'âge d'ouverture des droits passe progressivement de 60 à 62 ans. De plus, l'âge permettant de bénéficier d'une retraite à taux plein quelle que soit la durée de contribution passe de 65 à 67 ans. Cette réforme implique également des modifications des dispositifs carrière longue et des dispositifs de validation de durée pour le congé maternité et les périodes de chômage. Enfin, un dispositif de départ anticipé pour pénibilité au travail est mis en place. L'effet de cette réforme a fait l'objet de peu d'études puisque l'on dispose d'un recul limité pour en observer les effets. Dubois and Koubi (2017) montrent qu'elle a conduit à une hausse de la probabilité d'être actif à 60 ans de plus de 20 points. Dans la majorité des cas, cette hausse est liée à une hausse de la probabilité d'être en emploi.

Si l'effet des réformes sur les différents paramètres de la retraite (âge de liquidation, montant des pensions) ont fait l'objet de nombreuses études, il y a en revanche peu de travaux portant sur les effets collatéraux de ces réformes. Ainsi, Blake and Garrouste (2019)

⁶Retraite additionnelle de la fonction publique (RAFP).

⁷Un contrat individuel : le plan d'épargne retraite populaire (PERP) et un contrat collectif d'entreprise, le plan d'épargne pour la retraite collectif (PERCO).

⁸En augmentant la durée de cotisation requise pour bénéficier du taux plein, qui passe de 160 à 166 trimestres.

ont étudié l'effet de la réforme des retraites de 1993 sur la santé perçue, ainsi que la santé physique et mentale; Rapoport et al. (2005) ont mesuré l'effet des niveaux de pension de retraite sur la mortalité. Ces études peuvent permettre d'évaluer l'objectif de soutenabilité financière des retraites: en particulier, l'effet de déversement qui pourrait exister avec l'assurance maladie du fait du changement de l'état de santé, mais aussi l'effet sur la mortalité (modification de la durée de versement des pensions).

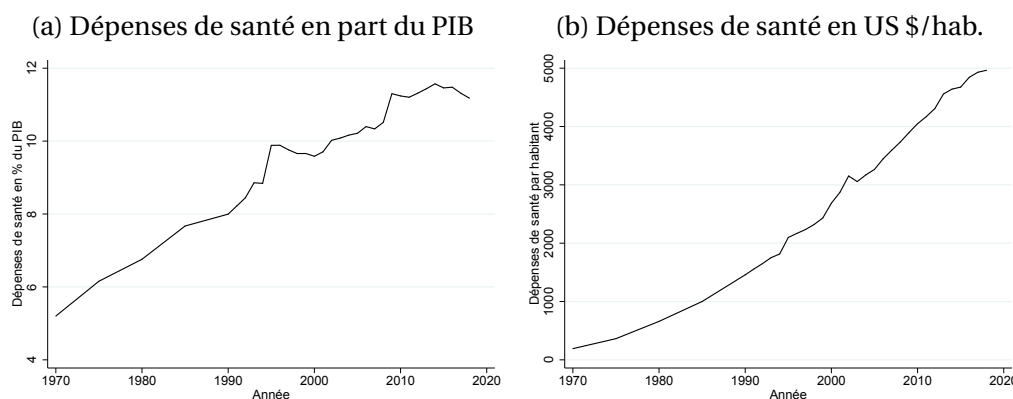
2.3 L'assurance maladie

Le système de protection contre le risque maladie est hérité des ordonnances du 4 et 19 octobre 1945. Il constitue "la garantie donnée à chacun qu'en toutes circonstances il disposera des moyens nécessaires pour assurer sa subsistance et celle de sa famille dans des conditions décentes". En 2016, les dépenses de remboursement de l'assurance maladie s'élevaient à 171,6 milliard d'euros (7,7 % du PIB). Le financement de l'assurance maladie repose principalement sur les cotisations des travailleurs.⁹ Ainsi, tout comme le régime des retraites, le financement du système de l'assurance maladie requiert une stabilité du ratio de dépendance économique. L'augmentation de la part de la population aux âges élevés engendre une baisse de la part de cotisants dans la population. De plus, l'augmentation de la part de la population aux âges biologiques élevés engendre une hausse de la dépense de santé moyenne par tête. Tout comme le système de retraites, des paramètres économiques tels qu'un taux de chômage élevé, une stagnation du revenu par habitant et du taux d'emploi, peuvent accentuer la pression financière sur les ressources. Dans le cas des dépenses de l'assurance-maladie, il faut également souligner une augmentation des dépenses de santé continue depuis le milieu des années 70 (Figures 6a et 6b). Cette augmentation s'explique par une structure des âges défavorable, mais également par une augmentation de la consommation à chaque âge (Dormont, 2009; Tenand, 2016). Cette hausse de la consommation est largement poussée par un effet volume, lié au progrès technique, puisque les prix par soin tendent à baisser (Soual, 2017).

Depuis les années 1970, du plan Durafour (1976) à la mise en place des lois de financement de la sécurité sociale (1997), en passant par les plans Bérégovoy (1982, 1983), les gouvernements successifs ont à la fois cherché à augmenter les recettes et à diminuer les dépenses (Breuil-Genier and Rupprecht, 1999). Au total, plus de 24 réformes se sont succédées entre 1976 et 2004 (Geoffard, 2006). Lorsque les réformes portent sur les dépenses, celles-ci se concentrent majoritairement sur la demande de soins, et assez peu sur l'offre. A partir de la fin des années 2000, on constate également une augmentation des réformes visant à améliorer la gouvernance et le pilotage, insistant ainsi sur l'idée que des économies d'efficience sont

⁹90 % des recettes de l'assurance maladie proviennent des cotisations et contributions des travailleurs et entreprises. Le reste provient des impôts collectés par l'Etat, notamment sur le tabac et l'alcool.

Figure 6 – Evolution des dépenses de santé en France



Source: Données OCDE, 2014. DOI: <https://doi.org/10.1787/data-00349-en>.

possibles dans le domaine de la santé. Les évolutions législatives ont alternativement porté sur des augmentations de cotisations (salariales et employeurs), de taxes (taxe sur le tabac et l'alcool, mise en place d'une taxe automobile en 1976), mais aussi des élargissements du périmètre des cotisants (retraités en 1977 avec le plan Veil; chômeurs en 1981 avec le plan Questiaux). Dans le même temps, de nombreuses mesures ont visé à contrôler les dépenses de santé via différentes mesures: dé-remboursements de médicaments¹⁰ (Plan Barre, 1976; Veil, 1977; Dufoix, 1985; Séguin, 1986); hausses du ticket modérateur; dé-remboursements de certains actes (transports et auxiliaires médicaux en 1976; soins infirmiers et analyses biologiques en 1985). Enfin, des mesures de pilotage de l'offre de soins ont été prises. On peut citer par exemple la mise en place du *numerus clausus* en 1971; la première convention nationale des médecins la même année; le forfait soins hospitaliers (en remplacement du tarif de journée) en 1978; la dotation globale pour les hôpitaux en 1983; la création du système d'objectifs quantifiés nationaux (OQN) en 1991, remplacé par l'ONDAM¹¹ en 1996; l'encadrement des prix des consultations médicales en 1979.

Les effets potentiels et avérés de ces mesures ont fait l'objet de nombreuses études, comme par exemple, l'effet de la tarification à l'activité (Or and Renaud, 2009), des modes de rémunération des médecins (Rochaix, 2004), du paiement à l'acte (Samson, 2009; Dormont and Samson, 2011), de la mise en place de la complémentaire d'entreprise obligatoire (Pierre and Jusot, 2017) ou de la régulation des prix des médicaments (Rémuzat et al., 2013). Enfin, les interactions entre système de santé, retraite, et santé de la population doivent être prises en compte. En effet, il existe des liens entre retraite et santé (van der Heide et al., 2013; Nishimura et al., 2017; van Mourik, 2020), et entre système d'assurance maladie et re-

¹⁰ Les médicaments dits "de confort", puis également les médicaments faiblement remboursés.

¹¹ Objectif national des dépenses d'assurance-maladie.

traite (French and Jones, 2017). Par conséquent, les politiques du système de santé visant à améliorer la soutenabilité financière dans un contexte de vieillissement démographique doivent tenir compte des potentiels interactions.

2.4 La dépendance des personnes âgées

Les politiques d'assurance du risque dépendance sont bien plus récentes que les politiques de couverture santé et vieillesse. La première prestation sociale spécifiquement fléchée pour l'accompagnement des personnes âgées dépendantes (la prestation spécifique dépendance, PSD) a été mise en place en 1997. Il s'agit d'une aide accordée par le département, suite à une évaluation individualisée des besoins en aide humaine et technique de la personne âgée. Le montant versé par le département ne peut être utilisé que pour le volume horaire d'aide humaine et pour les aides techniques prescrits par le département. Cette politique de dépendance a connu trois réformes (2002, marquant le passage de la PSD à l'allocation personnalisée d'autonomie (APA); puis deux réformes de l'APA en 2010 et 2016). Ces réformes visaient à améliorer la soutenabilité financière du dispositif, son équité inter-départementale et sa capacité à couvrir les besoins des personnes âgées. La dépendance¹² est aujourd'hui majoritairement prise en charge par l'APA. Cette aide représente 6,1 milliards d'euros de dépense publique en 2019. Le financement est à la charge du département, qui bénéficie pour cela du concours FFAPA¹³ et CNSA.¹⁴ Ces derniers couvraient 2,3 milliards d'euros (38,5 % de la dépense totale liée à l'APA) en 2019. Le financement en provenance de la CNSA est issu de la contribution solidarité autonomie (la journée de solidarité), de la contribution sociale généralisée (CSG), et, dans une moindre mesure, de transferts issus des caisses de retraites et de l'assurance-maladie. La part financée par les départements, quant à elle, provient des taxes locales, de la fiscalité transférée de l'Etat vers le département, et de dotations de l'Etat. La diversité des sources de financement et les nombreuses évolutions témoignent des difficultés françaises à trouver un modèle de financement pérenne.

Plusieurs dispositifs pourraient permettre d'améliorer la viabilité du système (Bozio et al., 2016). On peut citer la mise en place d'une assurance-dépendance obligatoire et publique (*le cinquième risque*); le développement de l'offre d'assurances dépendance privées ou encore du viager (Masson, 2015).

Des études ont porté sur l'effet de la mise en place d'un dispositif d'aide publique sur l'aide formelle (Fontaine, 2012), sur le nombre de bénéficiaires (Weber, 2006; Jeger, 2003), sur l'aide effectivement perçue (Petite and Weber, 2006) ou encore sur le non-recours à l'APA (Arrighi et al., 2015; Ramos-Gorand, 2016). D'autres travaux se sont intéressés aux

¹²On ne considère ici que les prestations visant à compenser une perte d'autonomie. Ainsi, les aides au logement spécifiques pour les personnes âgées n'entrent pas dans ce périmètre, de même que les soins médicaux.

¹³Fond de financement de l'APA.

¹⁴Caisse nationale de solidarité pour l'autonomie.

aidants informels, à leur insertion sur le marché du travail (Fontaine, 2009) ou encore à leur santé (Juin, 2019). Ces études semblent s'accorder sur l'efficacité du dispositif d'aide public sur l'accès à l'aide professionnelle. En revanche, elles soulignent également un niveau de soutien insuffisant et un financement non viable à long terme. L'effet de ces dispositifs d'aide formelle sur le soutien aux aidants informels est en revanche assez peu étudié. Enfin, toutes les études montrent l'existence d'hétérogénéités dans les besoins d'aides et dans les réponses à ces besoins. En particulier, la nature de la perte d'autonomie (psychique, physique), de l'aide (ménagère, corporelle, alimentaire...), ou des configurations familiales sont autant de facteurs pouvant mener à être touché à différents degrés par les politiques publiques d'accompagnement de la perte d'autonomie. Ainsi, Bonsang (2009) montre qu'il y a davantage de substitution entre aide informelle et professionnelle lorsqu'il s'agit d'aide pour des tâches non qualifiées.

En 2011, le rapport Fragonard faisait état d'un coût de la dépendance de 22,6 milliards d'euros, dont 6,8 milliards pour la dépendance stricto sensu (Fragonard, 2011). Renoux et al. (2014), avec des périmètres légèrement différents, estimaient la dépense publique à 28,2 milliards d'euros, dont 9,7 milliards pour la dépendance. On comptabilise donc, en 2011, des dépenses de dépendance d'environ 7 milliards. Ces dépenses vont continuer à augmenter du fait du vieillissement démographique. Lecroart et al. (2013) estiment qu'en 2040, on devrait atteindre entre 1,67 et 2,16 millions de bénéficiaires de l'APA (contre 1,28 en 2016). Marbot and Roy (2015) estiment que les dépenses d'APA atteindront entre 10 et 12,5 milliards en 2025, et entre 15,7 et 20,6 milliards en 2040 suivant les scénarios économiques retenus. Ces projections laissent donc entrevoir le besoin de 2 milliards supplémentaires tous les 6 ans, soit le montant que permet d'obtenir une journée de solidarité. Ce constat laisse entrevoir les limites du mode de financement actuel.

Dans ce contexte, les politiques publiques doivent à la fois mesurer l'effet des politiques actuelles de prise en charge des personnes âgées sur les configurations d'aides qu'elles entraînent, et sur le bien-être de la population. Elles doivent également prévoir l'évolution de ces politiques eu égard aux évolutions potentiels des besoins. Cela amène non seulement à repenser les modalités de financement, mais également à trouver les outils les plus adaptés à l'évolution la plus favorable possible de la morbidité de la population.

3 Présentation de la thèse

Dans cette thèse, je m'intéresse aux politiques publiques associées au vieillissement démographique dans deux domaines distincts. Le premier est celui des retraites. Les effets directs des réformes des retraites, tels que l'effet sur l'âge de liquidation ou sur le montant des pensions, ont largement été explorés. L'effet des retraites sur divers indicateurs de santé perçue

ont également fait l'objet d'études, afin de documenter les potentiels effets néfastes des réformes sur la santé. En revanche, peu d'études se sont intéressées à l'effet des réformes françaises sur la santé des personnes âgées, mesurée à travers des indicateurs administratifs tels que la mortalité et la consommation de soins. Ces deux indicateurs permettent pourtant, lorsqu'ils sont mis en parallèle des études sur les effets directs des réformes, et sur la santé, de documenter des effets indirects pouvant influencer la soutenabilité financière du système visé par les réformes des retraites. En effet, si la réforme des retraites diminue la mortalité, les gains qui en sont issus doivent tenir compte de l'allongement de la durée de versement des pensions. De plus, si la réforme des retraites modifie les comportements de consommation de soins, une part des bénéfices de la réforme pour les caisses de retraites se traduirait en variation des dépenses pour les caisses d'assurance maladie. Ainsi, l'étude de ces indicateurs de santé vise non seulement à éclairer l'impact de décaler l'âge de départ à la retraite sur l'état de santé, mais également à évaluer l'effet de la réforme des retraites sur la soutenabilité financière du système de protection sociale.

Le second domaine est celui de la prise en charge de la perte d'autonomie. Cette prise en charge fait l'objet d'une politique bien plus récente (1975). On dispose donc de peu de recul sur ces politiques. Les analyses ont jusqu'à présent principalement consisté en un recensement du nombre de bénéficiaires, des montants attribués et des types d'aide. Face au besoin de trouver un régime de protection stable pour compenser ce risque, et au besoin d'anticiper les changements démographiques pour trouver un modèle viable, les études prospectives sont particulièrement importantes. Elle permettent de mieux comprendre les besoins présents et futurs des personnes âgées, et la façon dont les aides formelle et informelle sont organisées en réponse à ces besoins. Ces éclairages permettent d'orienter les politiques publiques et de mieux anticiper les effets de potentielles réformes.

Cette thèse se focalise sur deux principaux aspects des politiques de compensation de la perte d'autonomie des personnes âgées. Dans un premier temps, je m'intéresse à la question de l'amélioration des estimations concernant le nombre de personnes âgées dépendantes auquel il est plausible de s'attendre, ainsi qu'aux facteurs influençant l'évolution future de la morbidité. Les estimations réalisées en France reposent jusqu'à présent sur une mesure administrative de la dépendance (le nombre de bénéficiaires de l'APA). Celles-ci ont l'inconvénient de confondre la situation de santé de la population et le taux de recours à une prestation. De plus, elles ne permettent pas d'anticiper les effets d'un changement de périmètre de la couverture proposée par l'allocation. Dans cette thèse, une définition épidémiologique de la dépendance est utilisée dans un modèle de microsimulation dynamique. Cet outil de projection pourrait également permettre de mesurer les effets attendus des changements de périmètre de la couverture dépendance, ou de considérer le besoin de financement associé à une politique "zéro non-recours".

Dans un second temps, dans un contexte de soutien simultané aux aidants informels et à l'accès à l'aide professionnelle, il est important de mieux connaître la façon dont s'articulent les aides formelles et informelles, et la manière dont réagissent les aidants informels à une amélioration des prestations permettant le recours à l'aide professionnelle.

3.1 Partie I: Allongement des carrières et santé

Chapitre 1 Il est souvent mentionné que la littérature sur l'impact de la retraite sur la santé ne s'accorde pas sur l'effet. Ce chapitre introductif est une revue de la littérature portant sur l'impact de la retraite sur la santé. L'analyse comparée de la littérature montre qu'une large part des contradictions présentées est en réalité expliquée par des différences de définition de la santé, des différences de phénomène observé, et enfin, des différences de méthode. Les définitions de la santé étudiées dans la littérature peuvent être regroupées en neuf catégories: la santé subjective, physique, cognitive, les pathologies, la dépression, la mortalité et la consommation de soins. Au sein d'une même catégorie d'indicateurs de santé, il existe une grande variété de mesures. Par ailleurs, trois types de phénomènes différents sont étudiés: l'effet du passage de la vie active à la retraite; l'effet de partir plus tôt à la retraite; l'effet de partir plus tard à la retraite. Enfin, la différence dans les méthodes mène à mesurer des éléments différents. D'abord, les études de corrélation doivent être distinguées des études de causalité. Ensuite, les différents outils économétriques amènent à mesurer des effets différents. Enfin, il est important de tenir compte des contrôles intégrés dans l'analyse. Bingley and Martinello (2013) montrent par exemple l'importance du contrôle par le niveau d'éducation dans le cas de l'effet de la retraite sur la santé cognitive. En tenant compte de ces distinctions, on peut conclure que la plupart des études portant sur le passage à la retraite démontre une diminution de la consommation de soins, une meilleure santé déclarée, un déclin cognitif, et des effets non significatifs sur la santé physique. Partir plus tard à la retraite conduit à une diminution de la consommation de soins, une absence d'effet sur la mortalité, un effet non-significatif sur la santé déclarée, et un déclin cognitif. Peu d'études portent sur l'effet de partir plus tôt. Enfin, de nombreux effets hétérogènes sont démontrés par type d'emploi et genre.

Chapitre 2 Dans ce chapitre, je m'intéresse à l'effet de l'allongement de la durée de carrière sur la mortalité. La réforme de 1993 est la première réforme conduisant à une augmentation de l'âge de liquidation en France. De plus, cette réforme n'affecte pas tous les individus de la même façon au sein d'une cohorte puisque seuls les individus avec une durée de carrière moyenne le sont. Ainsi, en utilisant des données administratives sur les carrières des individus, il est possible d'identifier avec précision, au sein de chaque cohorte, les individus réellement affectés par la réforme. L'étude de la mortalité permet d'observer de façon plus

large les effets de la réforme des retraites. En effet, si décaler l'âge de départ à la retraite conduit à une amélioration de l'espérance de vie, la mesure de l'objectif de soutenabilité du système de pension doit tenir compte de cette amélioration pour mesurer l'équilibre entre les contributions des travailleurs et les pensions versées sur le cycle de vie de l'individu. Enfin, dans un dessein purement scientifique, connaître l'effet sur la mortalité peut permettre de tenir compte de l'effet de sélection qui peut exister lorsque l'on observe l'effet de la retraite sur d'autres indicateurs de santé. Ce chapitre montre que l'augmentation de l'âge de départ à la retraite du fait de la réforme de 1993 n'a pas modifié de façon significative la mortalité entre 65 et 75 ans. De plus, l'utilisation d'une mesure de l'effet minimum détectable permet de conclure que s'il y avait eu un effet significatif, ce dernier aurait été d'ampleur très limitée. En effet, l'exhaustivité des données utilisées permet d'avoir un échantillon de grande taille, et donc, de détecter des effets très petits.

Chapitre 3 Ce chapitre porte sur l'effet de l'allongement de carrière sur la consommation de soins. La réforme de 1993 est utilisée pour mesurer cet effet. J'utilise les données administratives de pensions de retraite et d'assurance maladie pour identifier d'une part les individus affectés par la réforme et d'autre part leur consommations de soins. L'analyse de la consommation de soins permet de mesurer les effets de déversement possibles: dans le cas d'une augmentation de la consommation de soins induite par un allongement de la durée de carrière, la meilleure soutenabilité financière du régime des retraites permise par cet allongement est partiellement atténuée par une hausse des dépenses de santé. Ce chapitre montre que l'augmentation de l'âge de départ à la retraite du fait de la réforme des retraites de 1993 modifie à la fois la probabilité de consommer et le nombre de visites médicales entre 66 et 76 ans. Cet effet est poussé par la diminution du nombre de visites chez le médecin généraliste. La diminution est d'une ampleur similaire pour la sous-population des individus exonérés de ticket modérateur, ce qui montre qu'il ne s'agit probablement pas d'un effet de non-recours pour motif financier. Cet effet s'accompagne d'une diminution significative et de même ampleur de la consommation de médicaments sur prescription, et d'une absence de modification du nombre de jours d'hospitalisation dans les hôpitaux privés.

3.2 Partie II: Le soutien à la dépendance des personnes âgées

Chapitre 4 L'accompagnement des personnes âgées est une politique relativement récente, qui est issue des besoins d'aide grandissant, en lien avec le vieillissement démographique que connaît la France. Ces aides ont alternativement visé à couvrir un plus large public de façon plus généreuse (réforme de 2001) ou au contraire d'endiguer la forte montée en charge de ce poste de dépense de prestations (réforme de 2010). De ce constat émerge le besoin d'avoir une plus fine connaissance des besoins futurs. S'il n'est pas possible de connaître ex-

actement le nombre de personnes âgées dépendantes qui auront besoin d'aide dans dix ou vingt ans, il est en revanche possible d'aider le décideur public en proposant des scénarios d'évolution plausibles. Ainsi, la microsimulation de la population âgée dépendante permet de déterminer le nombre de personnes âgées et l'évolution de la morbidité auquel on doit s'attendre lors de la mise en place d'une politique publique. Ce travail doit être réalisé dans l'esprit du principe comptable de prudence. L'outil de microsimulation mis en place dans cette étude repose sur une mesure de la dépendance épidémiologique et non administrative, permettant notamment de simuler l'impact d'une variation de la définition administrative de la dépendance sur le nombre de bénéficiaires potentiels. Dans ces travaux, suivant un scénario *central*, le nombre de personnes âgées dépendantes augmenterait plus vite que le nombre de personnes âgées. On compterait ainsi 12,3 millions de personnes âgées dépendantes en 2060 contre 13,9 millions de personnes âgées autonomes. Parmi les personnes âgées dépendantes ainsi projetées, seules 12 % auraient une dépendance sévère (définie par des limitations dans les activités de la vie quotidienne).

Chapitre 5 Si les politiques d'accompagnement de la perte d'autonomie sont intéressantes d'un point de vue prescriptif des politiques publiques, elles le sont également dans la façon dont la prise en charge est façonnée autour de deux marchés du travail: celui des professionnels de soins (aide formelle), et celui, bénévole, de l'aide apportée par les proches (aide informelle). Ainsi, les politiques publiques ne doivent pas uniquement chercher la mise en place d'un système viable, mais également intégrer une dimension normative concernant l'aide bénévole qu'il est acceptable d'inciter, d'utiliser, dans le cadre de la prise en charge des personnes âgées. La France a fait le choix de soutenir le recours à l'aide professionnelle et de soulager le poids reposant sur les aidants informels. Ce double objectif pose la question de la substitution existante entre l'aide formelle et informelle. Ainsi, dans ce chapitre, il s'agit d'identifier la variation d'aide informelle qui découle d'une modification du recours à l'aide professionnelle au sein de la population des personnes bénéficiant d'aide formelle, et au sein de la sous-population des personnes bénéficiant de l'APA. Les résultats soulignent qu'il n'existe pas de relation à la marge intensive. En revanche, il existe une diminution de la probabilité de déclarer recevoir de l'aide informelle. Cette diminution de la probabilité de recevoir de l'aide informelle provient majoritairement des femmes, des aidants secondaires (ie. ni les conjoints, ni les enfants), et de l'aide apportée pour les activités de la vie quotidienne.

Part I

RETIREMENT AND HEALTH

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Chapter 1

Is There a Consensus on the Health Consequences of Retirement?

Summary of the chapter

We investigate the causal effect of retirement on health through the literature. We explore the potential mechanisms which explain three effects: the switch from employment to retirement, later retirement and earlier retirement. The empirical strategies used to identify the causal effects are mainly based on the observation of changes in health status at the legal age for retirement entitlement or on reforms that have led to changes in retirement incentives. Literature renders the possibility of making several observations on the average effect estimation. Retirement leads to a decrease in healthcare consumption, better self-reported health, a decline in cognition, an ambiguous effect on physical health. Later retirement has no effect on mortality, decreases healthcare consumption and cognitive abilities, has non-significant impact on self-reported health. Studies on the impact of earlier retirement are scarce due to few natural experiments exploiting such a variation. The latter studies show a decrease in mortality, no effect on healthcare consumption and worse self-reported health and cognition. Lastly, some studies find evidence of heterogeneous effects by gender, marital status and occupational status. As there are relatively few studies on this aspect, the question should be seriously explore in future research.

This Chapter has been co-authored with Clémentine Garrouste.

Introduction

Numerous papers focus on the impact of retirement on health. In order to build a consensus, it is necessary to repeat the empirical analysis over different periods and different countries. The empirical evidence-gathering process is the only way to converge towards more general results (Angrist and Pischke, 2010). Previous studies often point out an absence of consensus. It prompted researchers to build solid identification strategies, highlighting heterogeneous mechanisms and effects which can explain the average effect estimation. Ultimately, a consensus emerges and the differences in results can be explained by both the diversity of methods and indicators used, as well as periods and countries involved.

The impact of retirement on health is also a public policy concern. In most of the European countries, the number of retirees increases faster than the number of workers. In a pay-as-you-go pension system, it raises sustainability issues. Consequently, the number of pension reforms in the European countries has been increasing since the end of the 90's. Carone et al. (2016) show the average yearly number of pension reforms in Europe was multiplied by five, i.e. it has risen from 9 between 1990 and 1999 to 44 between 2009 and 2014. These reforms both affect the public and private pensions and implements eligibility criteria changes like the retirement age, the required contribution length; the pension calculation scheme; the indexation criterion for pension payments; the resources like social contributions, taxes and the schemes, i.e. merge or closure of pension schemes. A substantial part of these reforms leads to an increase in claiming age. Nevertheless, the effects of a longer working life on health have not been clearly identified.

Three questions emerge from the previous literature. First, the researchers investigate the health impact of the switch from employment to retirement. This is of interest since retirement is a social construction and thus, can evolve through public policy changes. From this perspective, the underlying mechanisms are important to understand. Health deterioration may be observed at retirement. If the reason for this deterioration is the sharp increase in leisure time, one could imagine that progressive retirement should be favoured. However, the latter public policy would probably be unsuccessful if the real reason for health deterioration is the reduced income at retirement. Second, the researchers investigate whether later retirement affect health. From a public policy perspective, this question is of interest because policy makers want to ensure that the reforms have no detrimental effect on health. Moreover, they want to ensure these pension reforms improve the public finance, which is debatable if healthcare expenditure increases following health deterioration due to the reforms. Third, researchers investigate whether earlier retirement affects health. We can distinguish this effect from the previous one since it is not necessarily symmetrical.

Results obtained can depend on methodological choices, like identification strategy, in-

stitutional framework, data and health measures. The literature on the health impact of retirement focuses on a large range of health outcomes such as self-reported health, cognition and physical health, mortality, healthcare consumption or health-related behaviour. A part of these paper study the correlation between retirement and health, while another part study causality. The latter part deals with reverse causality issues.

Most of the studies describe the literature as contradictory. In this paper, we try to reconcile the literature results. The first section presents the potential mechanisms explaining the effect of retirement on health, the second section presents the empirical method used and the last section compares the results obtained.

1 Potential Mechanisms

The first part of this section focuses on potential mechanisms explaining an impact of the switch from employment to retirement on health. The second one evokes potential mechanisms explaining an impact of a change in retirement timing on health. This distinction is essential. First, the impact and potential underlying mechanisms are not always the same. Second, from a public policy perspective, studying discontinuity at retirement does not lead to the same public policy adjustments as the impact of a reform on retirement age. In both cases, we will distinguish between several health outcomes, since there is no reason for retirement to affect all the health dimensions in the same way. Some mechanisms are thought to vary in different directions according to individual characteristics such as gender, education or income. In a third section, we focus on the income effects and health assurance effects, which may explain health variations at retirement.

1.1 Transition from Employment to Retirement

In a first strand of the literature, papers have documented the health impact of the switch from employment to retirement. Retirement is a sudden change in daily life due to changes in schedule, leisure time, income and social status. For all the above reasons, health may be impacted.

According to the Grossman theory (Grossman, 1972), at least three potential underlying mechanisms explain health changes at retirement: i) the change in the marginal cost of health investment; ii) the change in the marginal benefit of health investment; iii) the change in the depreciation rate of health investment.¹

First, the change in the marginal cost can be due to a reduced earning at retirement but also an increase in healthcare costs, through changes in complementary health insurance.

¹In Grossman (1972), the last parameter is assumed constant over time.

The earnings drop at retirement may decrease health through changes in food consumption, health-preserving behaviour, housing conditions and healthcare access. The decrease in complementary health insurance is thought to decrease healthcare access and thus, in turn, to deteriorate health. Finally, changes in the opportunity cost of time also leads to changes in health cost. However, contrary to the change in income and health insurance, the expected impact is unclear. Thus, the opportunity cost of time varies with perception and individual preferences during employment and retirement.²

Second, changes in the marginal benefit of health may arise if there are changes in utility associated with good health. There may be a change in self-perceived utility. Grossman considers health utility as a function of work productivity. Following his model, marginal benefits of health will decrease at retirement. However, one can argue that health utility depends on leisure productivity and the marginal benefits of health at retirement would increase.³ This mechanism can have different impacts according to individual characteristics, perceptions of their health utility and of their occupation, both during working lives and retirement.

Lastly, changes in the depreciation rate (assumed constant in the Grossman model) may change health. There are not only changes in behaviour at retirement (dietary, alcohol intake, cigarette consumption and physical activities), but also changes in self-perceived age and utility. These changes may accelerate or decelerate health depreciation. The expected direction of such variations is unclear and may vary with individuals. Moreover, the ability to observe the health effect just after retirement through this mechanism could be questioned. For example, Bíró and Elek (2018) claim that the health consequences of behavioural changes at retirement may only appear after a while. Therefore, retirement cannot not lead to a sudden health change through this channel.

Above all, these mechanisms are not exclusive. They can apply together and may lead to ambiguous results. Moreover, the health dimensions can all interact. The effect of retirement on one of the health outcomes can impact the other health outcomes. For example, an increase in cognitive impairment may impact abilities to walk and, consequently, deteriorate physical health.

1.2 Modification in the Retirement Age

The impact of a change in retirement timing on health can be explained through changes in costs, benefits, and health depreciation, in an inter-temporal framework.

²In particular, preference between working time, leisure time, healthcare time. For example, Frimmel and Pruckner (2018) explains that individuals would prefer using their time-off for medical care during their working life instead of during the leisure time of their retirement.

³The leisure productivity could be the ability to be efficient in activities realised during the leisure time, like sport, family help, volunteers activities, etc.

First, changes in inter-temporal income and healthcare costs, through health insurance, could play a role in explaining the impact of a retirement reform on health. In an inter-temporal framework, later retirement would increase inter-temporal income and the period during which individuals benefit from firm supplementary health insurance.⁴ This could have a positive impact on health. The opportunity cost of time has no inter-temporal dimension and thus, cannot explain the impact of later retirement on health.

Second, a variation in retirement timing could change the inter-temporal health investment done, due to variation in the time spent in employment and retirement. The expected impact depends on the marginal benefits of being in good health during employment and retirement. The expected impact is unclear since preferences for health during employment and retirement may vary from one individual to the other. Following the Grossman model, individuals invest in their health because it enables them to work. The marginal health benefit is a function of work productivity. If we fully extend this reasoning, there is no reason or them to invest in their health at retirement. Longer careers would be associated with a higher inter-temporal health investment. However, as mentioned before, this assumption can be relaxed. If health marginal benefits are higher during retirement, a longer career would decrease inter-temporal health investment and individuals would be in worse health.

Third, a change in retirement timing can change the depreciation rate of health, due to the career length and the retirement duration. Two opposing mechanisms are involved. The first is related to the so called physiological reserve hypothesis, i.e. the idea that working requires drawing on the physiological reserves. Thus, the longer an individual works, the worse their health gets. The second relies on the use-it-or-lose-it hypothesis, i.e. the longer an individual works, the better their health is. Moreover, at a given age, behavioural changes at retirement can lead to a longer or shorter period exposed to specific behaviour associated with retirement.⁵ If we consider a reform that increases the claiming age, individuals affected by the reform spent less time in retirement, and thus, the health consequences of the behavioural changes during retirement can be delayed by the same time.

1.3 Disentangling the Monetary Effects

The transition to retirement is generally accompanied by a decrease in income, and shifting the retirement age leads to changes in inter-temporal income. It is therefore difficult to distinguish the effect of a decrease in income from the cessation of professional activity on health. When focusing on a modification of the career duration due to a reform, the income effect is difficult to isolate since the inter-temporal income is modified at the same time as

⁴In France and in the US, the supplementary health insurance is cheaper during working life.

⁵For example, Zins et al. (2011) show significant changes in alcohol consumption at retirement, Eibich (2015) shows a decrease in cigarette consumption, Bernett et al. (2012) show changes in physical activities, and, as a consequence, Godard (2016) shows changes in body mass index.

the retirement age. Moreover, even when studying the same reform, according to data and empirical strategies, the measured effect is not always the same. For example, Bozio et al. (2019) measure the retirement effect of the 1993 French pension reform using the variation between cohorts and within cohort. The 1993 reform affects the income of each cohort in the same way but affects differently the claiming age. They isolate the impact of later retirement on mortality, purged from the income effect. Using the same reform but a different empirical strategy, Blake and Garrouste (2019) find a negative effect of the reform on perceived health, imputable to both the effect of an increase in activity and an income effect.⁶

The transition to retirement is sometimes accompanied by a change in healthcare coverage. In some cases, a reform affects several dimensions of the pension system simultaneously. Thus, it is often hard to differentiate from the impact of retirement and the impact of income or health insurance on health status. Moreover, this depends on the institutional framework of the country in question. Previous studies show the link between retirement decision, healthcare insurance (see French and Jones (2017) for a literature review). However, studies exploring the share of health consequences at retirement attributable to health insurance, to income drop and to other factors, are still scarce.

2 Methodological Choices

2.1 Institutional Framework

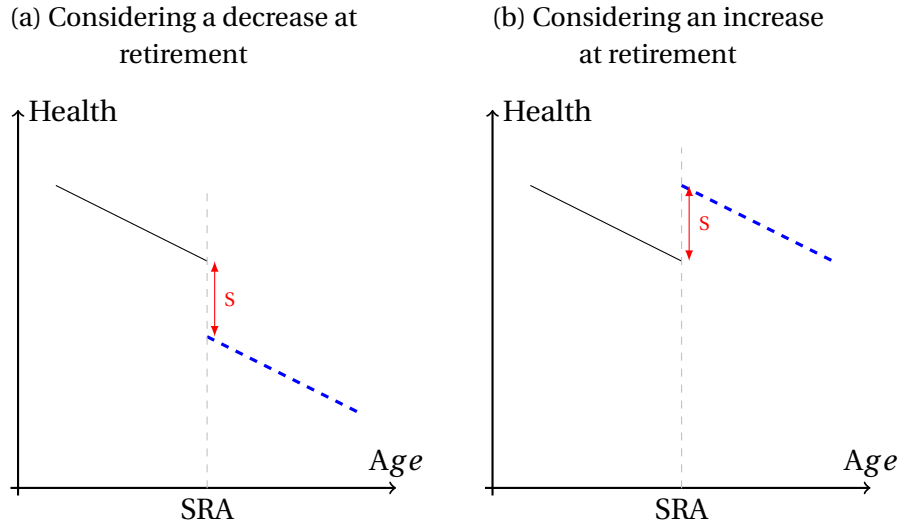
The institutional framework is specific to each country and obviously affects the results. Three main parameters affect the empirical results: the health insurance, the legal retirement age and the replacement rate. According to the country, people retire at different age, with different health assurance and with a pension which is more or less generous relatively to the previous earnings. Thus, the condition at retirement are not the same, and the differences relatively to the working conditions are heterogeneous, leading to an heterogeneous magnitude of the shock. Differences in replacement rate implies that the decrease in income due to retirement varies across countries. In fact, the replacement rate - measured in percentage of pre-retirement earnings - varies from 20 to 90% depending the country (OECD, 2019).

2.2 Choice of the Identification Strategy

The empirical strategy varies depending on the aim of the study. Studies that focus on the health consequences of the switch to retirement compare individuals in the labour force, who are close to retirement, to those newly retired. This is represented in Figure 1 as the

⁶They use a difference-in-differences strategy between sectors and between cohorts.

Figure 1 – Impact of the Switch from Employment to Retirement - Reduced Form



Notes: Figure (a) presents a decrease in health at Statutory retirement age (SRA). Figure (b) presents an increase in health at SRA. Blue dashed lines are health trend after retirement and black lines before.

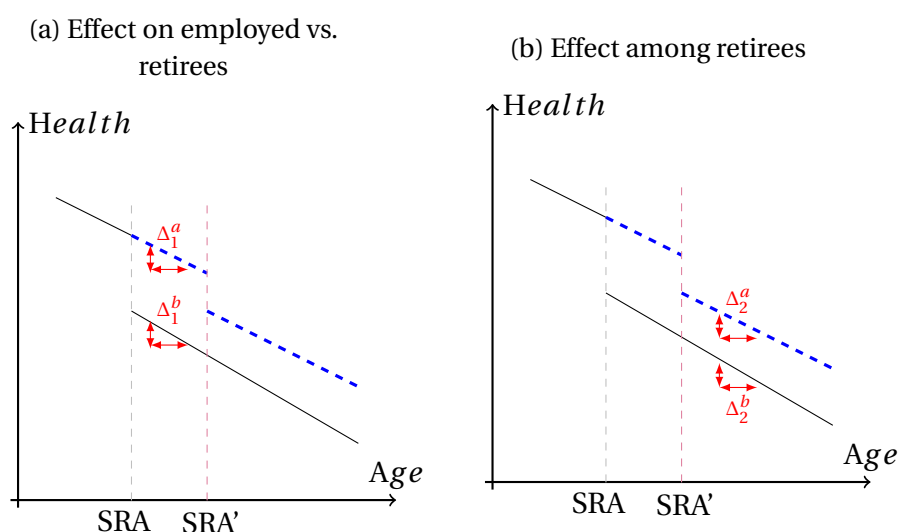
switch S . The usual econometric method to estimate S is the regression discontinuity design (RDD) or fuzzy regression discontinuity (FRDD). Some studies use several thresholds, taking advantage of differences across countries or a threshold change due to a reform, and measure the average switch.

Researchers focusing on the impact of change in retirement timing use reforms that change the retirement age threshold.⁷ Several effects can be estimated from these reforms (Figure 2). First, $\Delta_1^a - \Delta_1^b$ is the difference in health trend between those still working and affected by the reform and those retired and not affected. Second, $\Delta_2^a - \Delta_2^b$ is the difference in health trend between those affected and not affected by the reform, when all individuals are retired. Some studies measure the difference between the blue and black lines at each age, instead of the difference in leading coefficient (Δ) of the blue and black lines. The most usual methods are i) the instrumental variables (IV) strategy in a two-stage least square (2SLS) regression and ii) the difference-in-differences (DiD) design.

The time horizon under consideration has also an influence on the choice of the estimation strategy. Studies using the discontinuity at retirement consider short-term effects (Fitzpatrick and Moore, 2018), while some empirical studies test the persistence of the effects after retirement (Bonsang et al., 2012). The use of pension reforms often enables to observe the effects of a change in the retirement age in the long run, i.e. once there is enough perspective.

⁷Some studies also used variation of retirement age across countries in a similar empirical strategy.

Figure 2 – Impact of Delayed Retirement - Reduced Form



Notes: Figure (a) presents the comparison of health decline (*Delta*) between the retirees and those working at the same age. Figure (b) presents the comparison of health decline (*Delta*) between retirees at the same age, but who leave labor force at a different age. Blue dashed lines are health trend after retirement and black lines before.

2.3 Data and Variables of Interest

Data. Data used are either panel data or cross-section data. Data can come from surveys or administrative files. For two decades, there has been a convergence in survey panel data on ageing, retirement and health. Thus, HRS in the United States of America is comparable to MHAS in Mexico; ELSA in the United Kingdom; SHARE in Europe; CRELES in Costa Rica; KLoSA in Korea; JSTAR in Japan; TILDA in Ireland; CHARLS in China and LASI in India.⁸ These surveys provide very rich information, including a large range of socio-economic variables. However, these data have three drawbacks. First, there are selection biases on who answers. Second, there is an attrition bias in the case of panel surveys.⁹ Third, answers are subject to declarative bias. Most of the time, the sample size is approximately 20,000 individuals in the raw data. Administrative data appears in many recent studies as a solution to the previously mentioned drawbacks and the sample size limitation. However, there is a limited set of control variables available. Since control variables play a role in defining what is measured, the results from administrative data are rarely comparable to those of the survey data.¹⁰

⁸An harmonized version of all these data is available on Gateway to Global Aging data.

⁹selection bias of who stay from one wave to another in the sample.

¹⁰Bingley and Martinello (2013) for example, show that controlling for education may change results in cross-country studies.

Retirement Definition and Control Variables. Claiming age and retirement age are different. Most of the time, studies using administrative data have information on claiming age while those using survey data have information on retirement age. Nishimura et al. (2017) explore how definitions and methods can explain differences in results. They duplicate results from previous studies and change retirement definition (not work for pay versus self-report retired), method (fixed effect versus instrumental variable), control variables (age, gender and education versus age and gender). They show that a change of retirement's definition does not affect the results. However, the method and control variables does.

Most of the studies using administrative data use very few control variables (age, gender, marital status). Thus, the measured effect is an average effect along the population, without controls for confounding factor, or heterogeneity. One associated criticism is the following. In a population with half blue collar and half white collar, if later retirement deteriorates blue collar health by 10 and increases white collar health by 10, the effect is zero in absence of workers control variables. Control variables are not only important to measure an effect *all other things being equal*. For example, Bingley and Martinello (2013) show the importance of schooling control in cross country studies. They show that this control is necessary to insure the validity of the instrument.

Choice of Health Measures. The main health outcomes studied in the literature can be classified in nine categories: mortality; healthcare utilisation; self-reported health; depression and anxiety; cognitive abilities; physical health; pathologies; global health index; and health behaviour. Appendix A and Table A1 sum up health measures available and health outcome used in the literature.¹¹ For each of the nine health outcomes categories, there are differences between studies in health definition. These differences come from the available measure of health in the data, and the transformation of these measures researchers choose to exploit.

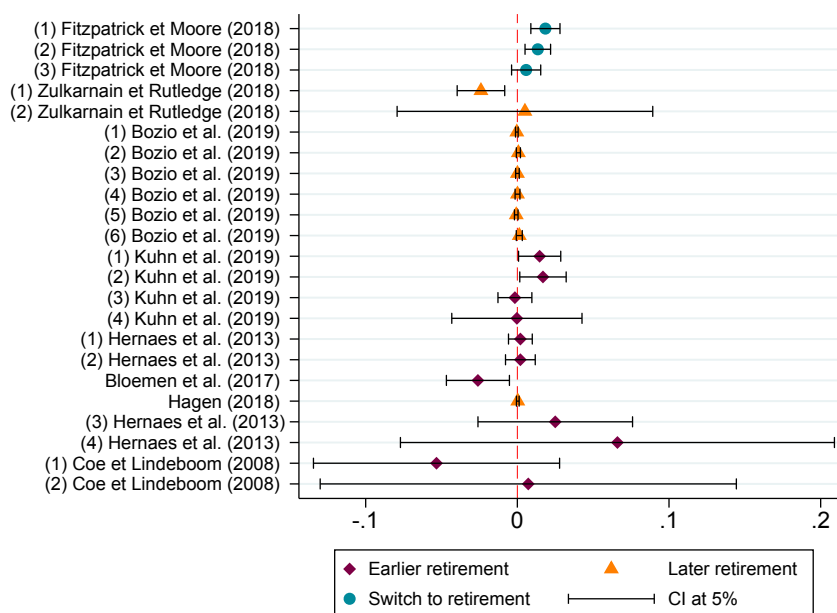
3 Consensual Results

Non-significant Effect on Administrative Measures of Health. Mortality and pathologies are the two most usual administrative measures of health.¹² The literature mainly shows that the switch from employment to retirement and delayed retirement have no significant impact either on mortality nor on the likelihood to develop pathologies.

¹¹It includes papers both on correlation between retirement and health and on the causal impact.

¹²Pathologies can come both from administrative data and survey data. In most of the studies, individuals report pathologies diagnosed by a medical practitioner. In this case, the self-report measure derives from an administrative measure.

Figure 3 – Impact of Retirement on Mortality



Notes: Bozio et al. (2019); Garrouste and Perdrix (2020). Figure 3 shows the estimated effects of retirement on mortality, distinguishing estimates at the retirement age threshold (blue circles), a decrease in retirement age (red squares) and an increase in retirement age (orange triangles). They are classified according to the size of the sample, from the largest sample at the top, to the smallest at the bottom.

Table C1 sums up studies on the causal impact of retirement on mortality,¹³ and Figure 3 shows the point estimates of these studies. Coe and Lindeboom (2008); Hernaes et al. (2013) and Nielsen (2019) show no significant impact of an earlier retirement on mortality in the United States, in Norway and in Denmark. Studies focusing on particular sub-population, however, find different results. Thus, Hallberg et al. (2015) and Bloemen et al. (2013) show a decrease in mortality among the military officers in Sweden and among the male civil servants in the Netherlands respectively, and Kuhn et al. (2019) find an increase in mortality among blue-collar men in Austria. Other studies focus on the impact of later retirement. Hagen (2018) and Bozio et al. (2019) find no significant impact among women civil servants in Sweden and in the private sector in France. These effects are precisely estimated, thanks to exhaustive administrative data. Zulkarnain and Rutledge (2018) show a decrease in death probability in the Netherlands due to later retirement among men. Finally, only one study is interested in the impact of the switch from employment to retirement on mortality. Fitzpatrick and Moore (2018) show a discontinuity in the number of deaths at retirement in the United States, which could be explained both by the change in healthcare coverage and income decrease at retirement in the United States.

¹³See Appendix B for details concerning the correlation between retirement and mortality.

Most of the studies on pathologies find a non-significant impact. Coe and Lindeboom (2008) find no significant effect of earlier retirement on high blood pressure, diabetes, cancer and heart attacks in the US. Analysing men and women separately, Hessel (2016) and Neuman (2008) also find no significant effect on chronic conditions at retirement respectively in Europe and in the US.¹⁴ Atalay and Barrett (2014) is the only study finding that later retirement decreases the probability of having migraines, hypertension and back pain in Australia among women, but not among men.

Decrease in Healthcare Consumption. Table C2 sums up studies on the impact of retirement on healthcare consumption (in particular, doctor visits, hospital stays and drug consumption). Figure 4 shows results on healthcare consumption. Most of the studies on the impact of the switch from employment to retirement find a decrease in doctor visits (Eibich, 2015; Coe and Zamarro, 2015; Bíró and Elek, 2018; Shai, 2018; Nielsen, 2019; Frimmel and Pruckner, 2020). Few studies find a non-significant impact (Gorry et al., 2018; Nielsen, 2019). As far as we know, only two studies find an increase in doctor visits (Zhang et al., 2018; Lucifora and Vigani, 2018). Both argue that this result is owing to a large opportunity cost of time. Most of the studies on the impact on hospital stays find either a decrease or a non significant impact.¹⁵

Since there is no change in the number of pathologies at retirement, one may question the origin of this decrease at retirement. Some argue that there is a health improvement; others think that it is due to administrative medical visits an employee has during the working life (Bíró and Elek, 2018; Nielsen, 2019). Others argue that doctor visits are not only a consequence of health status but may be a cause to declare a particular health status.¹⁶ Finally, the decrease found in healthcare consumption needs to be resonated with studies on other health outcomes like self-reported health, physical and cognitive health.

Improvement in Self-reported Health and Decrease in Depressive Symptoms. Table C3 sums up studies on the causal impact of retirement on self-reported health and Figure 5 presents the point estimates. All the studies find that the switch to retirement increases self-reported health (Eibich, 2015; Zhu, 2016; Johnston and Lee, 2009; Coe and Zamarro, 2011; Hessel, 2016).¹⁷ Studies on the impact of later retirement on self-reported health show

¹⁴ All these studies control at least for gender, age, marital status, education and income.

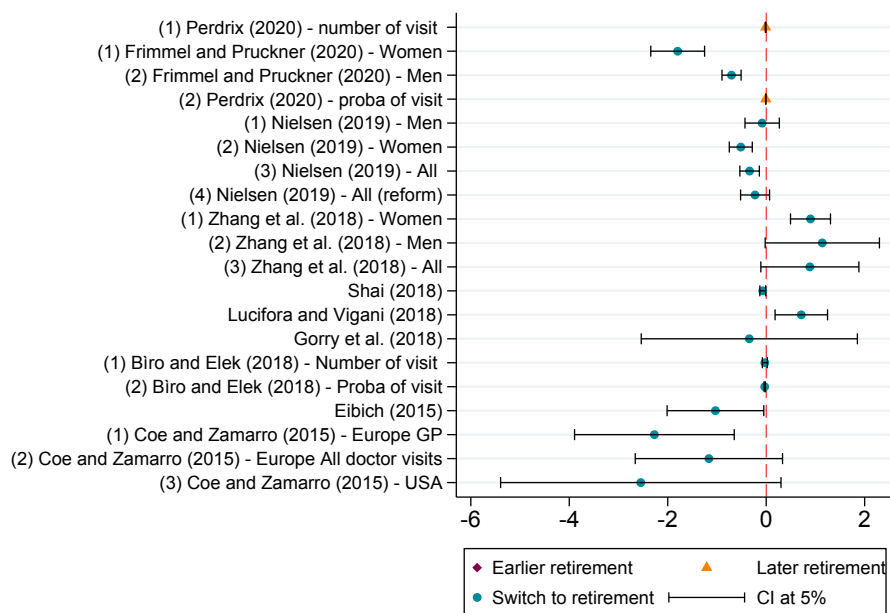
¹⁵ Bíró and Elek (2018); Gorry et al. (2018); Nielsen (2019); Frimmel and Pruckner (2020); Kuusi et al. (2020) find a decrease in hospital stays, significant at the 5% level. Eibich (2015); Coe and Zamarro (2015); Nielsen (2019); Grötting and Lillebø (2018) find no significant differences. Once again, Zhang et al. (2018) is the only paper showing an increase in hospital stays after retirement in Urban China.

¹⁶ If individuals are aware of their pathologies mainly through doctor visits for example.

¹⁷ Atalay and Barrett (2014); Behncke (2012); Coe and Lindeboom (2008); Latif (2012) are the only one study finding no significant impact.

Figure 4 – Impact of Retirement on Healthcare Consumption

(a) Doctor Visits

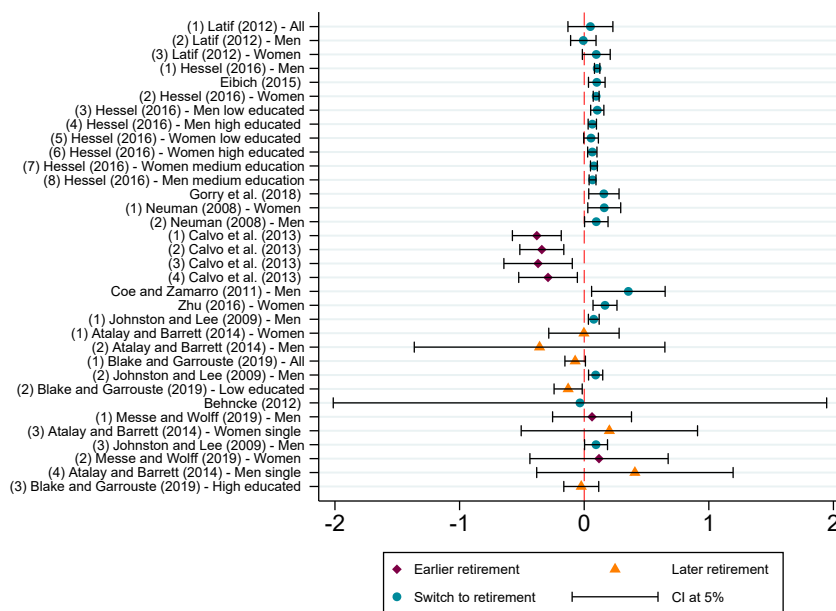


(b) Hospital Stays



Notes: Perdrix (2020). Figure 4 shows the estimated effects on doctor visits and hospital stays, distinguishing between estimates at the retirement age threshold (blue circles), a decrease in retirement age (red squares) and an increase in retirement age (orange triangles). They are classified according to the size of the study sample, from the largest sample at the top, to the smallest at the bottom.

Figure 5 – Impact of Retirement on Self-reported Health



Notes: Garrouste and Perdrix (2020). Figure 5 shows the estimated effects on self-reported health, distinguishing between estimates at the retirement age threshold (blue circles), a decrease in retirement age (red squares) and an increase in retirement age (orange triangles). They are classified according to the size of the study sample, from the largest sample at the top, to the smallest at the bottom. Studies of the impact of going from working to retirement show a positive or non-significant effect.

mainly non-significant impacts. However, Blake and Garrouste (2019) show that this non-significant impact can dissimulate heterogeneous effect.

All studies on the causal impact of retirement on health index show a decrease in health. these studies build health index on the basis of declarative health on several health dimension. Blake and Garrouste (2019) find that later retirement decreases the Duke index, in particular among the less educated.¹⁸ Coe and Zammarro (2015) find a decrease in the index of Bound et al. (1999).¹⁹ Johnston and Lee (2009) find a decrease of GHQ12 among men without diploma.²⁰ Zhu (2016) finds a decrease of SF-36 among women.²¹ There is only one study using health index that does not conclude in a significant decrease. Eibich (2015) finds no significant effect at the retirement discontinuity on health measured through SF-12.²²

Studies on the causal impact of retirement on depression are consistent (see Table C4 in Appendix). Thus, all studies show either that retirement causes significantly less depression

¹⁸DiD, control for age, income, gender, children, education, household size, marital status, living area.

¹⁹2SLS, control for occupation, age, gender, marital status, race, education, drinking, smoking, wealth, income, health insurance, employment status.

²⁰RDD, control for age, marital status, education, income, tenant, urban location, living area.

²¹2SLS, controls for age, gender, marital status, education, public vs private sector, number of hours worked per week, stressful situation at work, sickness absence.

²²FRDD, controls for age, year and individual fixed effect.

(Charles, 2004; Calvo et al., 2013; Atalay and Barrett, 2014) or that there is a non-significant effect of retirement on depression (Coe and Zamarro, 2011; Neuman, 2008; Behncke, 2009; Fonseca et al., 2014; Coe and Lindeboom, 2008; Heller-Sahlgren, 2017; Zulkarnain and Rutledge, 2018; Atalay and Barrett, 2014; Blake and Garrouste, 2019).

Heterogeneous Impacts on Cognitive Abilities and Physical Health. Table C5 sums up studies on the impact of retirement on cognitive abilities. Since this outcome is sometimes hard to compare from one study to another, Figure 6 presents the point estimates only for the most comparable studies. Almost all studies show a decrease in immediate and delayed memory due to retirement (Bonsang et al., 2012; Bingley and Martinello, 2013; Behncke, 2012; Kajitani et al., 2017). Moreover Mazzonna and Peracchi (2012) find a negative impact of the duration spent in retirement on cognitive abilities. Celidoni et al. (2017) show that retirement is associated with an acceleration of the cognitive decline.

However, there are heterogeneous effects by occupational groups and gender. Coe et al. (2012) find an increase in memory for blue collar men in the US and a non-significant impact for white collar men. All the same, Kajitani et al. (2017) show that the cognitive decline is slower for individual who had job requiring complex interaction with data.

Comparison of studies on the causal impact of retirement on physical activities should be interpreted with caution since the measure of physical health diverges from one study to another. Behncke (2009) finds an increase in the number of difficulties with activity daily living (ADL), difficulties with walking and hearing, and of metabolic syndrome in the UK.²³ Coe and Lindeboom (2008) find no significant effect on the number of ADL among American men.²⁴ Neuman (2008) finds a significant increase in ADL limitation among women but not among men. However, there is no significant impact on major muscle functions and mobility.²⁵ Hessel (2016) shows that retirement decreases the probability of reporting functional limitations among both men and women.²⁶

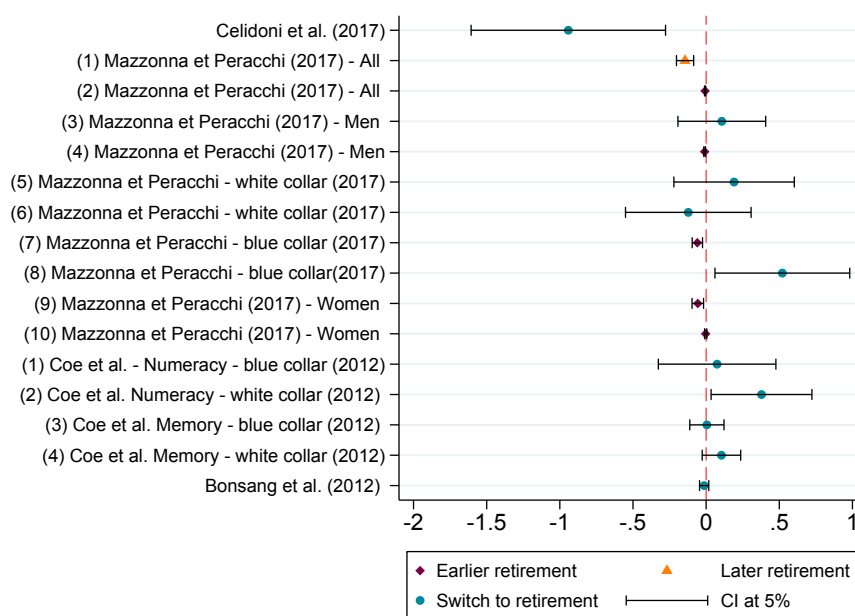
²³LATE, pension reform as an IV, controls for gender, age, marital status, household size, children, grandchildren, birth country, education, occupational group, physical activities at work, living area, self-reported health, cognitive function.

²⁴2SLS, control for blue collar, age, education, marital status, income, race, US-born, children, wave.

²⁵2SLS, control for gender, occupation, geographic area, employers type, long-term sickleave.

²⁶Fixed effect model, control for gender, age, race, marital status, assets, debt, education.

Figure 6 – Impact of Retirement on Cognitive Abilities



Notes: Figure from Garrouste and Perdrix (2020). It shows the estimated effects on cognitive abilities, distinguishing between estimates at the retirement age threshold (blue circles), a decrease in retirement age (red squares) and an increase in retirement age (orange triangles). They are classified according to the size of the study sample, from the largest sample at the top, to the smallest at the bottom. Several studies are missing: Coe et al. (2012) due to the absence of information on confidence interval; Coe and Zamarro (2011) due to the large standard error of this study compared to the other; Bingley and Martinello (2013) due to the different aim of their study (they find a significant negative impact on cognitive abilities); Rohwedder and Willis (2010) due to their macro-economic framework (they find a negative effect); Behncke (2012) due to very different definition of the outcome (significant increase of problem with cognition).

4 Conclusion

This paper provides a comparison of studies on the impact of retirement on health. We detail previous studies per outcome making a distinction between switching to retirement and earlier or later retirement. We highlight that the results are not as contradictory as would seem. Studies show that retirement leads to a decrease in healthcare consumption, an increase in self-reported health and a cognitive decline. Most of the studies show that later retirement has no impact neither on mortality nor on pathologies. Considering this absence of effect, one may also expect a non-significant impact on healthcare consumption. However, studies on healthcare consumption show a decrease of doctor visits and drug consumption (for men but not for women). The reason for this decrease could be due to various channels, one of which is the frequently quoted health changes. Studies show no significant impact of later retirement on self-reported health. Studies find a decrease or a non-significant impact on depression, raising question on whether it is a lack of statistical power or an absence of effect. One study focuses on the impact of later retirement on cognitive abilities, and shows a detrimental effect. Studies on the impact of an earlier retirement are scarce due to few natural experiment exploiting such a variation.

To conclude, the results in the literature are relatively consensual. However, at least three elements could complete the literature. First, studies on the impact of retirement on physical health being very hard to compare, the results need to be harmonised to fully understand the source of these differences (country, health measure, heterogeneity...). Second, studies finding non-significant impact do not distinguish between the absence of effect and the inability to detect an effect, except for Bozio et al. (2019). It would be useful to provide computation of minimum detectable effects to determine at which point the lack of statistical power can be related to sample size limitation. Third, only a few recent studies point out the large heterogeneity in the effect. This question should be explored further.

Appendix to

Is-There a Consensus on the Health Consequences of Retirement?

A Definition of Health Outcomes

Mortality. It is the most homogeneous health outcome since it is similar in all countries studied. However, this measure is not anymore perfectly comparable once considering death by cause. Indeed, the method used to fulfill death certificate changes from one country to another. It can affect the prevalence of cause of death. It also affects the share of unknown cause of death which differ from one country to another. Most of the studies use death probability at a given age. As far as we know, only one study use a death count instead of the probability (Fitzpatrick and Moore, 2018).

Healthcare Consumption. It includes two types of measures: self-reported healthcare consumption, and administrative record of healthcare consumption. The first one is subject to declarative and memory bias, while the second differs from one country to another due to differences in care covered by the health insurance system.

Self-reported Health. It came from two main measures: the US-scale and the European-scale. Both are a five-scales answer to “how do you assess your health in general”. In the US scale, the possible answers are “excellent”, “very good”, “good”, “fair” and “bad” while the European one are “very good”, “good”, “fair”, “poor” and “very poor”. The European survey SHARE is one of the rare survey that ask both questions. It shows that 43% of individuals that answers “very good” in the EU-scale report “excellent” in the US-scale while 47% report “very good”.²⁷ However, 90% of those who answer “very bad” at the EU-scale answer “poor” at the US-scale and 9% answer “fair”. All the same, 94% of those who respond “bad” in the EU-scale also respond “fair” or “bad” in the US-scale. It highlights that the use of a discrete variable from 1 to 5 is probably not comparable between US and EU scales. However, a dichotomous variable equal to 1 if the individual declare the worse health or equal to 1 if the individual declare one of the two worse health could be comparable. Others studies used sometimes others measures like the Likert 8-scales,²⁸ self-reported change in health, or Duke index.

Depression. It relies on three types of measures. The first one is the CES-D scale from 0-no depressive symptom to 60- severe depression. The score is computed from the answer to

²⁷ Computation of the authors, using SHARE, wave 1, 2004/05.

²⁸ Answer to “On a scale from 1- very good to 8- very poor, how do you rate your health?”

twenty questions on self-confidence,²⁹ confidence with past and future, well-being feelings, loneliness. The possible answers to all these questions are “never”, “rarely”, “sometime”, “often”, “very often”, “every time”. A simplified version of the CES-D scale, using eight questions with two possible answers per question also exists. The second one is the EURO-D scale, a twelve questions scales. It includes questions on happiness, depression, hope for future, suicidal feelings, guilty feelings, sleeping trouble, no interest in things, fatigue, concentration, fearfulness. The third one relies on administrative measures like antidepressant use.

Cognition. Depression and cognitive abilities are sometimes called “mental health”. It is a misnomer that may create confusion between different measures. Studies on cognitive abilities used four measures: memory, verbal fluency, numeracy and orientation. Most of the time, memory is measured through the number of words over a list of ten words that an individual have to repeat just after (immediate memory) and after ten minutes (delayed memory). Verbal fluency is measured through the number of animals an individual can list in one minute. Numeracy is measured through the ability an individual has to compute from 100 to 0 subtracting 7 by 7. Orientation in time is measured through the answer to questions on the actual year, month, day, season.

Physical Health, Pathologies, Health Index and Health Behaviour. Measures of physical health, pathology, health index and health behaviour are not standardised. Table A2 shows there is almost one definition per paper. **Physical health** includes functional limitation, activity daily living (ADL) and instrumental activity daily living limitation (IADL), grip strength. Functional limitations include difficulties to reach its arm above shoulders, difficulties with stairs climbing and with carrying a bag over 5 kilos. Activity daily living (ADL) includes difficulties with eating, dressing, bathing, getting in and out of bed, going to the toilet. Instrumental activity living (IADL) includes difficulties with taking its drugs, dealing with administrative stuffs, going to shopping, giving a phone call, taking by its own transports, cleaning the house, preparing a meal. **Health index** relies on SF-12, SF-36, GQH, or computation of several health measures by the authors. Syse et al. (2017) show that retirement is associated with a higher probability to report a physical health improvement (using SF-12 as health measure) between ages 57 and 66. However Mein et al. (2003) show no significant differences in health at retirement using SF-36. **Health behaviour** includes studies on the body mass index (as a proxy of food behaviour), on smoking and drinking, physical exercises, well-being, and on questions about satisfaction with health. Lastly, studies on **pathology** include either a list of pathologies, or the study of one particular pathology.

²⁹e.g. “I have the feeling to be as good as the others”.

Table A1 – Health Outcomes Used (First Part)

Authors	Health measure in the raw data	Variable used in the study
MORTALITY		
Coe and Lindeboom (2008); Hernaes et al. (2013); Bloemen et al. (2013); Hallberg et al. (2015); Kuhn et al. (2019); Hagen (2018); Zulkarnain and Rutledge (2018); Nielsen (2019); Bozio et al. (2019)	Death register	Death probability before a given age (see Table C1)
Quaade et al. (2002); Tsai et al. (2005); Bamia et al. (2007); Carlsson et al. (2012); Kühntopf and Tivig (2012)	Death register	Survival curve
Fitzpatrick and Moore (2018)	Death register	Number of deaths
HEALTHCARE CONSUMPTION		
Hallberg et al. (2015); Grøtting and Lillebø (2018); Frimmel and Pruckner (2018); Hagen (2018); Nielsen (2019); Bíró and Elek (2018) Perdrix(2020)	Administrative register	Number of doctor visits, days in hospital, spendings for all care
Eibich (2015); Coe and Zamarro (2015); Lucifora and Vigani (2018); Shai (2018); Zhang et al. (2018); Gorry et al. (2018)	Self-reported	Number of doctor visits, days in hospital, spendings for all care
SELF-REPORTED HEALTH		
Buxton et al. (2005); Gueorguieva et al. (2009); Latif (2012); Calvo et al. (2013); Gorry et al. (2018)	US-Scale	Variable $\in [1, 5]$
Dave et al. (2006); Atalay and Barrett (2014)	US-Scale	= 1 if poor
Behncke (2012); Zhu (2016)	US-Scale	= 1 if fair or poor
Neuman (2008)	US-Scale	= 1 if improved or unchanged
van Solinge (2007); Eibich (2015); Messe and Wolff (2019)	EU-scale	Variable $\in [1, 5]$
Johnston and Lee (2009); Coe and Zamarro (2011); Hessel (2016)	EU-scale	= 1 if bad or very bad
Neuman (2008)	Self-reported	Health change $\in [1, 5]$
Westerlund et al. (2009)	Likert scale	= 1 if L $\in [1; 4]$
Blake and Garrouste (2019)	Duke index	$\in [1; 100]$
DEPRESSION		
Dave et al. (2006); Neuman (2008); Behncke (2012); Calvo et al. (2013); Gayman et al. (2013)	CES-D $\in [0, 8]$	Variable $\in [1, 8]$
Coe and Lindeboom (2008)	CES-D $\in [0, 8]$	= 1 if CES-D ≥ 4
Fonseca et al. (2015)	CES-D $\in [0, 8]$	= 1 if CES-D ≥ 3
Westerlund et al. (2010)	CES-D $\in [0; 60]$	= 1 if CES-D ≥ 17 for men and if CES-D ≥ 23 for women
Coe and Zamarro (2011); Heller-Sahlgren (2017)	EURO-D	Variable $\in [0, 12]$
Coe and Zamarro (2011)	Self-reported	Feeling depressed last month.
Charles (2004)	Self-reported	Feeling depressed last month, feeling lonely.
Butterworth et al. (2006); Horner and Cullen (2016)	ICD-10 and ICD-9	
Olesen et al. (2015); Zulkarnain and Rutledge (2018)	Antidepressant use	
Buxton et al. (2005); Atalay and Barrett (2014)	Anxiety, mood disorders, high stress, depressive disorders.	
Mojon-Azzi et al. (2007)	Change in depression	
Blake and Garrouste (2019)	Duke index	
COGNITIVE ABILITIES		
Rohwedder and Willis (2010); Coe and Zamarro (2011); Bonsang et al. (2012); Coe et al. (2012); Mazzonna and Peracchi (2012); Fisher et al. (2014); Bingley and Martinello (2013); Mazzonna and Peracchi (2017)	Memory	Immediate and delay recall from 0 to 20
Roberts et al. (2011); Mazzonna and Peracchi (2012)	Verbal fluency	72-score
Behncke (2012)	Problem with cognitive function	
Coe et al. (2012)	Self rated memory	
Mazzonna and Peracchi (2012)	Numeracy, orientation in time	
Fisher et al. (2014)	Mental status	Close to MMSE
Kajitani et al. (2017)	Respondent's address, date and day of the interview, respondent's mother's maiden name, name of the current and previous Prime Minister, respondent's date of birth and age, ability to continuously deduct 3 from 20.	
Celidoni et al. (2017)	Probability of having a decline higher than 20% at the memory test.	

Notes: This Table includes all articles on correlation and causality between retirement and health published in French or English after 2000.

Table A2 – Health Outcomes Used (Second Part)

Authors	Outcome used
PHYSICAL HEALTH	
Buxton et al. (2005); Dave et al. (2006); Neuman (2008); Behncke (2012); Gayman et al. (2013)	Activity daily living (ADL) and instrumental activity daily living limitation (IADL) limitations.
Buxton et al. (2005)	Self report physical complaints.
Dave et al. (2006); Neuman (2008)	Mobility index from 0 to 5.
Mojon-Azzi et al. (2007)	Change in impediment.
Coe and Lindeboom (2008)	Number of ADL.
Neuman (2008)	Muscle functions.
Jokela et al. (2010); Syse et al. (2017)	Physical subscale from SF-36 and SF-12.
Hessel (2016)	Having limitations.
Blake and Garrouste (2019)	Duke index
PATHOLOGIES	
Coe and Lindeboom (2008)	High blood pressure, diabetes, cancer, heart attack.
Neuman (2008)	High blood pressure, diabetes, cancer, lung disease, heart problems, strokes, psychiatric problems, arthritis.
Johnston and Lee (2009)	Hypertension, asthma, heart condition, diabetes, arthritis.
Behncke (2012)	Angina, heart attack, stroke, diabetes, arthritis, cancer, high C-reactive protein, high fibrinogen, low hemoglobin.
Atalay and Barrett (2014)	Hypertension, Migraine, Back pain, Disc disorder, Heart condition.
Hessel (2016)	Dummy equal one if having at least one chronic condition.
HEALTH INDEX	
Mein et al. (2003); Zhu (2016)	SF-36.
Johnston and Lee (2009)	GHQ-12.
Coe and Zamarro (2011)	Following Bound (1999): index from regression: $a+b*(L)+u$, with L =number of: ADL, IADL, chronic diseases, mobility limitation, body mass index (BMI).
Insler (2014)	High blood pressure, diabetes, cancer, lung and heart problems, stroke, psychological problem, arthritis, obese.
Eibich (2015)	SF-12.
Syse et al. (2017)	PCS-12 (from SF-12).
Blake and Garrouste (2019)	Duke index
HEALTH RELATED BEHAVIOUR	
Johnston and Lee (2009)	Body mass index.
Lee and Smith (2009)	Smoking, regular exercise.
Zins et al. (2011)	Drinking.
Bonsang and Klein (2012)	Life satisfaction. From 0 “totally unhappy” to 10 “fully happy”. Computed from questions on satisfaction with health, household income, free time.
Atalay and Barrett (2014)	Overweight, smoking, low exercise level.
Eibich (2015)	Smoking, drinking, physical activities, health conscious diet, sleep duration, body mass index.
Fonseca et al. (2015)	Life satisfaction on a scale from 1 to 5.
Hashimoto (2015)	Smoking, body mass index, fruit intake, and social participation to voluntary services.
Ayyagari (2016)	Smoking.
Godard (2016)	Overweight and obesity (computed from body mass index).
Motegi et al. (2016)	Smoking, drinking, light and heavy exercise, walking, sleeping time.
Zhao et al. (2017)	Smoking, drinking.

Notes: This Table includes all articles on correlation and causality between retirement and health published in French or English after 2000.

B Correlation Between Retirement and Health

Mortality. All studies show a correlation between retirement and mortality. Thus, the mortality rate is higher among those who leave the labor force earlier (Bamia et al., 2007; Carlsson et al., 2012). Life expectancy is higher among those who leave later (Kühntopf and Tivig, 2012). Death rate increases significantly among the Danish who benefit from an early retirement offer compared to those employed at the same age (Quaade et al., 2002). Death probability is higher among those who leave earlier (Tsai et al., 2005). This correlation between retirement and mortality can be explained by the fact that individuals with the worse health choose to retire earlier (self selection) (Scharn et al., 2018) and by the fact that retirement causes a change in mortality risk.

Depression and Anxiety. Butterworth et al. (2006) show that the share of depressed among the Australian retirees aged between 45 and 74 years old is always significantly higher than the share of depressed among those of the same age in the labour force. This result takes into account controls for gender, living alone or in couple, marital status, income, occupational group, living area. Buxton et al. (2005) show the same result among the English aged between 50 and 65, controlling for the same variables. In a twice smaller sample, Horner and Cullen (2016) show no significant difference between the retirees and employed of an aluminium company. Syse et al. (2017) show that among the Norwegian aged between 57 and 66 years old in 2002, retirees have a lower probability of being depressed, and a lower probability to have a deterioration of their depression. Studies that focus on the antidepressant use show no significant changes at retirement (Leinonen et al., 2013; Olesen et al., 2015). Oksanen et al. (2011) show that this result hide heterogeneous effect: the antidepressant use is higher among those who report choosing retirement due to their health condition than among those who retire for another reason.

Self-reported Health. Mojon-Azzi et al. (2007) show that a significant higher proportion of retirees declares health deterioration than the workers among the Swiss. Westerlund et al. (2009) show that the share of individuals reporting a bad health increases along the last years of work; there is a drop down at retirement; and finally an increase at the same rate during retirement.

C Results on Causal Impact

Table C1 – Studies on the Causal Impact of Retirement on Mortality

Authors	Country Sample		Method	IV	Controls	Result	Death age
Impact of earlier retirement on mortality							
Coe and Lindeboom (2008)	USA		RDD	ERA offer.	Age, marital status, education, income, white/blue collar, race, US-born, children, wave FE.	NS	within 4 and 6 years
Hernaes et al. (2013)	NOR	n.a.	DiD	ERA: 67 to 62.	Gender, marital status, education, income, industry, previous paid sick leave, pension histories, public sector worker, treatment and cohort FE.	NS	by age 67, 70, 74, 77
Bloemen et al. (2013)	NLD	Male civil servants.	2SLS	ERA decrease.	Age, individual and year FE.	Decrease	within 5 years
Hallberg et al. (2015)	SWE	Military officer.	2SLS	ERA 60 to 55.	Cohort, income, income interacted with cohort, education.	Decrease	age≤ 71
Kuhn et al. (2019)	AUT	Blue-collar men	2SLS	Decrease in SRA.	Age, income, sickness leave, industry, living area.	Increase	age≤ 73
Nielsen (2019)	DNK	Exclusion of disability and early pension beneficiaries.	DiD	SRA 67 to 65.	Gender, marital status, education, income, average hospital utilisation.	NS	before 2012
Nielsen (2019)	DNK	Exclusion of disability and early pension beneficiaries	RDD	SRA 67 to 65.	Gender, marital status, education, income, average hospital utilisation.	NS	before 2012
Impact of later retirement on mortality							
Hagen (2018)	SWE	Women civil servants.	DiD	SRA from 63 to 65.	school, cohort FE, income, sickness leave.	NS	65-69
Zulkarnain and Rutledge (2018)	NLD	Men born between 1943 and 1954.	2SLS	Delayed retirement.	Age FE, marital status, income, year FE.	Decrease	62-65
Zulkarnain and Rutledge (2018)	NLD	Women born between 1943 and 1954.	2SLS	Delayed retirement.	Age FE, marital status, income, year FE.	NS	62-65
Bozio et al. (2019)	FRA	Private sector.	2SLS	SRA increase.	Age, cohort, income, disability.	NS	65-74
Impact of the switch from employment to retirement on mortality							
Fitzpatrick and Moore (2018)	USA	Men.	RDD	ERA.	Age.	Increase	62
Fitzpatrick and Moore (2018)	USA	Women.	RDD	ERA.	Age.	NS	62

Notes: This Table includes only studies on the causal impact on mortality.

Abbreviations: n.a. in column “sample” is for no particular restriction in the sample, except “answer the survey”, and other practical exclusion restriction. Countries abbreviations are the 3-letters codes from the United Nation. Method abbreviations are: DiD, Difference in Difference; 2SLS, two stage least square; RDD, Regression Discontinuity Design. Instrumental variable (IV) abbreviations are: ERA, Early Retirement Age; SRA, Statutory Retirement Age; LRA, Late Retirement Age. Controls abbreviation is: FE, Fixed-effect. Result’s column contains “NS” for non significant results at the 5% level.

Table C2 – Studies on the Impact of Retirement on Healthcare Consumption

Authors	Country Sample		Method	IV	Controls	Results on			Age	
						Doctor visits	Hospital	Drugs		
Impact of the switch from employment to retirement										
Eibich (2015)	DEU	Civil servants & self-employed.	RDD	ERA: 60. SRA: 65.	Age, individual, year and month FE.	Decrease	NS	n.a.	55-70	
Coe and Zamarro (2015)	EU + USA	Men, worker at age 50.	RDD	SRA.	Age, income, education, marital status, ethnic group, race.	Decrease	NS	n.a.	50+	
Bíró and Elek (2018)	HUN	Women	2SLS (TPM)	ERA: 57 ⇒ 69	Age, individual fixed-effect	Decrease	Decrease	Decrease	56-60	
Bíró and Elek (2018)	HUN	Men	2SLS (TPM)	ERA: 60 ⇒ 69	Age, individual fixed-effect	Decrease	Decrease	Decrease	57-63	
Gorry et al. (2018)	USA	Workers at age 50	2SLS	SS threshold	Age, healthcare coverage	NS	Decrease	Decrease	50-93	
Shai (2018)	ISR	Men.	DiD	2004: SRA 65 ⇒ 67 and 2003: ERA 61.5 ⇒ 65 (resp. 56.5 ⇒ 60)	Age, year FE, marital status, living area, health fund, household size, education.	NS	n.a.	n.a.	40-74	
Nielsen (2019)	DNK	-	RDD	ERA: 60.	Gender, marital status, education, income.	Decrease	Decrease	n.a.	60-70	
Nielsen (2019)	DNK	-	2SLS	SRA: 67 ⇒ 65.	Gender, marital status, education, income.	NS	NS	n.a.	60-70	
Frimmel and Pruckner (2018)	AUT	Private sector.	FRDD	2000: ERA 60 ⇒ 61.5 (men) 55 ⇒ 56.5 (women).	Age, year and individual FE.	Decrease	Decrease	NS	41-74	
Kuusi et al. (2020)	FIN	Workers before ERA	2SLS	SRA: 63	year, age, individual fixed-effect	n.a.	Decrease	Decrease	62-67	
Grotting and Lillebø (2018)	NOR	-	RDD	SRA: 67.	Age.	NS	n.a.	n.a.	56-79	
Lucifora and Vigani (2018)	EU	-	RDD	ERA and SRA.	Age, education, marital status, household size, children, industry, occupational group, income, SRH.	Increase	n.a.	n.a.	50-69	
Zhang et al. (2018)	CHN	n.a.	RDD	SRA: 60 (men) 50 (women).	Age, gender, marital status, education.	Increase	Increase	n.a.	40-75	
Impact of later retirement										
Hagen (2018)	SWE	Women, civil servants.	DiD	SRA: 63 ⇒ 65.	Education, income, cohort FE, sickness leave.	NS	NS	NS	65-69	
perdrix (2020)	FRA	Men, private sector.	2SLS	SRA Increase.	Age, income, sickness leave, chronic condition, living area.	Decrease	NS	Decrease	66-76	
Impact of earlier retirement										
Hallberg et al. (2015)	SWE	Men from the army.	2SLS	SRA of military officers: 60 ⇒ 55.	Dummy for military officer, county dummies, income, education, interaction terms.	n.a.	Decrease	n.a.	56-79	

Notes: This Table includes only studies on the causal impact on healthcare consumption.

Abbreviations: n.a. in column “sample” is for no particular restriction in the sample, except “answer the survey”, and other practical exclusion restriction. Countries abbreviations are the 3-letters codes from the United Nation. Method abbreviations are: LATE, Local Average Treatment Effect; 2SLS, two stage least square; DiD, Difference in Difference; RDD, Regression Discontinuity Design; FRDD, Fuzzy Regression Discontinuity Design. Instrumental variable (IV) abbreviations are: ERA, Early Retirement Age; SRA, Statutory Retirement Age. Controls abbreviations are: SRH, Self-Reported Health; FE, Fixed-effect. Result’s columns contains “NS” for non significant results at the 5% level.

Table C3 – Studies on the Causal Impact of Retirement on Self-reported Health

Authors	Country	Sample	Method	IV	Controls	SRH	Result	Age
Impact of the switch from employment to retirement								
Behncke (2012)	GBR	In employment in wave 1.	LATE	Reform.	Age, gender, marital status, education, household size, children, grandchildren, birth country, occupational group, physical activities at work, living area, SRH, cognitive function, number of ADL.	Dummy	NS	n.a.
Zhu (2016)	AUS	woman	2SLS	SRA changes.	Age, gender, marital status, education, public vs private sector employment, number of hours worked per week, stressful situation at work, sick-leave.	Dummy	Increase	50-75
Johnston and Lee (2009)	GBR	Men without university diploma.	RDD	SRA.	Age, marital status, education, income, tenant, living area.	Dummy	Increase	60-70
Hessel (2016)	EU	Men and women separately.	2SLS	SRA by country.	Age, gender, marital status, education, assets, debt, race.	Dummy	Increase	50-74
Coe and Lindeboom (2008)	USA	Men	2SLS	ERA window.	Age, education, marital status, income, white/blue collar, race, US-born, children, wave FE.	Dummy	NS	50-70
Eibich (2015)	DEU	Civil servants and self-employed.	FRDD	SRA: 60. LRA: 65.	Age, individual FE, year and month FE.	0-bad to 5-good	Increase	55-70
Latif (2012)	CAN	n.a.	2SLS	Age specific incentive to retire.	Age, gender, marital status, income, education, living area.	0-bad to 5-good	NS	55+
Gorry et al. (2018)	USA	Workers at age 50	2SLS	SS threshold	Age, health insurance coverage	1-bad to 5-good	Increase	50-93
Neuman (2008)	USA	In employment in wave 1.	2SLS	ERA window	Gender, socio-economic status, living area, type of employer, long term sick-leave.	Dummy no deterioration	Increase	50+
Impact of earlier retirement								
Calvo et al. (2013)	USA	in employment before retirement	GLS IV	Reform	age, wealth, income, spouse, gender, race, education, blue-collar	1-bad to 5-good	Decrease	55-75
Messe and Wolff (2019)	FRA	private sector	2SLS	Reform ERA	age, living in a couple, number of children, education, unemployment spell during career, working condition	Dummy	NS	62-69
Impact of later retirement								
Atalay and Barrett (2014)	AUS	n.a.	LATE	1993 reform.	Married, living alone, education, income.	Dummy	NS	60-64
Blake and Garrouste (2019)	FRA	-	DiD	SRA increase	age, gender, education, household size, children, marital status, income, living area	Duke (100)	Increase	62-77

Notes: This Table includes only studies on the causal impact on self-reported health.

Abbreviations: n.a. in column “sample” is for no particular restriction in the sample, except “answer the survey”, and other practical exclusion restriction. Countries abbreviations are the 3-letters codes from the United Nation. Method abbreviations are: LATE, Local Average Treatment Effect; 2SLS, two stage least square; RDD, Regression Discontinuity Design; FRDD, Fuzzy Regression Discontinuity Design. Instrumental variable (IV) abbreviations are: ERA, Early Retirement Age; SRA, Statutory Retirement Age; LRA, Late Retirement Age. Controls abbreviations are: SRH, Self-Reported Health; ADL, Activity Daily Living limitations; FE, Fixed-effect. Result’s columns contains “NS” for non significant results at the 5% level.

Table C4 – Studies on the Causal Impact of Retirement on Depression

Author	Country	Sample	Method	IV	Controls	Outcome	Depression	Age
Switch from employment to retirement								
Neuman (2008)	USA	In employment in wave 1.	2SLS	ERA window	Gender, socio-economic status, living area, type of employer, long term sick-leave.	CES-D	NS	50+
Behncke (2012)	GBR	In employment in wave 1.	LATE	Incentive by age	Age, gender, marital status, education, household size, children, grandchildren, birth country, occupational group, physical activities at work, living area, SRH, cognitive function, ADL.	CES-D	NS	n.a.
Fonseca et al. (2014)	EU + USA	n.a.	2SLS	SRA by country	Age, gender, marital status, education, income, country, living area, ADL.	CES-D	NS	50+
Coe and Zamorro (2011)	EU	Men, working before age 50.	2SLS	SRA by country	Age, gender, marital status, education, income, occupational group, race, drinking, smoking, wealth, health insurance, employment status.	Euro-D + self-report	NS	50-69
Heller-Sahlgren (2017)	EU	n.a.	FRDD	SRA by country	Age, gender, education, individual and country FE, lagged mental health.	Euro-D	NS	50-75
Charles (2004)	USA	Men	2SLS	1983 SS amendment	Age, marital status, education, SRH, race, time fixed effect, children, living area.	Self-report	Decrease	60-70
Later retirement								
Calvo et al. (2013)	USA	Born between 1931 and 1941.	2SLS	ERA window	Age, gender, education, practice effect, SRH.	CES-D	Decrease	55-75
Atalay and Barrett (2014)	AUS	Women.	2SLS	1993 reform	Marital status, education, income.		Decrease	60-64
Atalay and Barrett (2014)	AUS	Men.	2SLS	1993 reform	Marital status, living alone, education, income.	Self-assess	NS	60-64
Zulkarnain and Rutledge (2018)	NLD	Men and Women separately. Born between 1943 and 1954.	2SLS	2009 reform	Age, wave, marital status, income.	Prescribed antidepressant drugs	NS	62-65
Blake and Garrouste (2019)	FRA	-	DiD	SRA increase	age, gender, education, household size, children, marital status, income, living area	Duke (100)	NS	62-77

Notes: This Table includes only studies on the causal impact on depression.

Abbreviations: n.a. in column “sample” is for no particular restriction in the sample, except “answer the survey”, and other practical exclusion restriction. Countries abbreviations are the 3-letters codes from the United Nation. Method abbreviations are: LATE, Local Average Treatment Effect; 2SLS, two stage least square; FRDD, Fuzzy Regression Discontinuity Design. Instrumental variable (IV) abbreviations are: ERA, Early Retirement Age; SRA, Statutory Retirement Age. Controls abbreviations are: SRH, Self-Reported Health; ADL, Activity Daily Living limitations; FE, Fixed-Effect. Result’s column contains “NS” for non significant results at the 5% level.

Table C5 – Studies on the Impact of Retirement on Cognitive Abilities

Authors	Country	Sample	Method	IV	Controls	Memory	Results on Verbal fluency	Numeracy	Age
Switch from employment to retirement									
Bonsang et al. (2012)	USA	Retired after age 50, and stop working at retirement.	2SLS	SS incentive.	Age, individual fixed effect.	Decrease	n.a.	n.a.	55-70
Coe et al. (2012)	USA	Men blue collar born in 1931 and later, working after age 50.	2SLS	ERA window	Age, education, race, ethnicity, wave.	Increase	n.a.	n.a.	50-80
Coe et al. (2012)	USA	Men white collar born in 1931 and later, working after age 50.	2SLS	ERA window	Age, education, race, ethnicity, wave.	NS	n.a.	n.a.	50-80
Bingley and Martinello (2013)	USA, GBR, EU	Retired after age 50. Men and women separately, and both together.	2SLS	ERA and SRA by country.	Age, gender, country, education.	Decrease	n.a.	n.a.	50-75
Rohwedder and Willis (2010)	USA, GBR, EU	n.a.	2SLS	SRA by country.	Age, country.	Decrease	n.a.	n.a.	60-64
Coe and Zamarro (2015)	EU	Men worker before age 50.	2SLS	SRA by country.	Age, gender, marital status, education, income, wealth, occupational group, race, drinking, smoking, health insurance, employment status.	NS	n.a.	n.a.	50-69
Behncke (2012)	GBR	In employment in wave 1.	LATE	Reform.	Age, gender, marital status, education, household size, children, grandchildren, birth country, occupational group, physical activities at work, living area, SRH, cognitive function, number of ADL.	Increase in problem with cognition			n.a.
Mazzonna and Peracchi (2012)	EU	working after age 50.	2SLS	SRA and ERA.	Age, education, country, age interacted with country.	NS/decrease	NS/decrease	NS/decrease	50-70
Earlier retirement									
Mazzonna and Peracchi (2012)	EU	Women working after age 50.	2SLS	SRA and ERA.	Age, education, country, age interacted with country.	Decrease	Decrease	Decrease	50-70
Mazzonna and Peracchi (2012)	EU	Men working after age 50.	2SLS	SRA and ERA.	Age, education, country, age interacted with country.	Decrease	NS	Decrease	50-70
Later retirement									
Celidoni et al. (2017)	EU	Working in wave 1.	2SLS	ERA and SRA by country	Age, gender, education, country, low cognition in wave 1, wave 2 refreshment sample, less than 2 repetitions of the memory test.	Retirement accelerate cognitive decline			50-75

Notes: This Table includes only studies on the causal impact on cognitive abilities.

Abbreviations: n.a. in column “sample” is for no particular restriction in the sample, except “answer the survey”, and other practical exclusion restriction. Countries abbreviations are the 3-letters codes from the United Nation. Method abbreviations are: LATE, Local Average Treatment Effect; 2SLS, two stage least square. Instrumental variable (IV) abbreviations are: ERA, Early Retirement Age; SRA, Statutory Retirement Age; SS, Social Security. Controls abbreviations are: SRH, Self-Reported Health; ADL, Activity Daily Living limitations. Result’s columns contains “NS” for non significant results at the 5% level.

Chapter 2

Impact of Later Retirement on Mortality

Summary of the chapter

This paper investigates the impact of delaying retirement on mortality among the French population. We take advantage of the 1993 pension reform in the private sector to identify the causal effect of an increase in claiming age on mortality. We use administrative data which provide detailed information on career characteristics, dates of birth and death. Our results, precisely estimated, show that an exogenous increase of one year in the claiming age has no significant impact on the probability to die. To test the power of our sample to detect statistically significant effects for rare events like death, we compute minimum detectable effects (MDE). Our MDE estimates suggest that, if an impact of later retirement on mortality would be detectable, it would remain very small in magnitude.

This Chapter has been co-authored with Antoine Bozio and Clémentine Garrouste.

Introduction

In a context of demographic ageing, most developed countries have carried out reforms in order to maintain the financial sustainability of pension systems. Most of these reforms have consisted in increasing incentives for delayed retirement. These policies have been widely regarded as successful in so far as labour market participation of older workers has increased in nearly every country which implemented a reform (Coile et al., eds, 2019). However, the impacts of a longer working life on other outcomes, like health, have been harder to establish.

As of today, there is no consensus in the literature on the causal impact of later retirement on health outcomes. Five dimensions of health have attracted most of researchers' attention: self-reported health¹; physical health²; depression³; cognitive functioning⁴ and health related behaviour⁵. The most consistent relationships established is an increase of self-reported health at retirement and a decrease in cognitive functioning. More detailed literature reviews are provided in van der Heide et al. (2013) and Nishimura et al. (2017). There are few studies looking at the impact of later retirement on mortality. The expected results are not necessarily obvious. One may think that work preserves health, through maintaining physical activities and social interactions. In that case, we may expect a positive impact of delaying retirement on health and a negative impact on mortality. On the contrary, one may think that work is detrimental to health because of strain and stress. In that case, we may expect an increase in mortality consecutive to an increase in retirement age. Delayed retirement may also affect mortality through inter-temporal income effects on health. Since income has an impact on health investment (Grossman's theory) it may change health.

¹ Coe and Lindeboom (2008); Coe and Zamarro (2011); Eibich (2015); Gorry et al. (2018) show that retirement has a positive effect on self-reported health. Blake and Garrouste (2019) find a negative effect on perceived and physical health, concentrated on the less-educated, while Messe and Wolff (2019) find non-significant impact of early retirement on health.

² These studies used activity daily living (ADL), instrumental activity daily living (IADL), and mobility index (walking ability, strength, climbing stairs). Bound and Waidmann (2007) find a positive effect on male (but not female) physical health. Neuman (2008) find no significant effect on muscle function and mobility.

³ Bradford (1979); Carp (1967); Sheppard (1985) show retirement may be stressful and associated with a feeling of ageing and loneliness. Delaying retirement is associated with stress and strains (Ekerdt et al., 1983; Atalay and Barrett, 2014). Coe and Lindeboom (2008); Neuman (2008); Behncke (2012); Fonseca et al. (2014); Coe and Zamarro (2011) find a non significant effect of early retirement on depression while Calvo et al. (2013); Charles (2004); Belloni et al. (2016) find a decrease in depression. Picchio and van Ours (2019) show heterogeneous effects by gender and marital status.

⁴ Most of the studies on cognitive abilities show that retirement has either a negative or a non significant impact (Bingley and Martinello, 2013; Bonsang et al., 2012; Coe and Zamarro, 2011; Rohwedder and Willis, 2010; Celidoni et al., 2017; Kajitani et al., 2017). Moreover, Mazzonna and Peracchi (2017) find heterogeneous effects across occupational groups.

⁵ Godard (2016) shows retirement is associated with an increase of obesity risk. Celidoni and Rebba (2017) show an increase in the probability of having physical activities, no significant impact on smoking and a positive impact on male alcohol consumption. Ayyagari (2016) find an increase of tobacco consumption at retirement among the ever smokers.

Moreover, there is evidence regarding an association between income and mortality.⁶

Mortality is an interesting health outcome for several reasons. First, mortality is an objective health measure, available in most datasets, in particular panel data and administrative data. Second, it conjugates various health problems individuals may have experienced during their life. Third, it has the advantage of being easier to interpret – contrary to self-reported health which could simply capture well-being. Fourth, mortality measurement does not vary across different countries, so it is easy to draw up international comparisons. Self-reported health is known to vary across countries, even conditioning on objective measures of health, as cultural differences in the way respondents rank their own health vary.

Only a limited set of studies estimates the causal impact of retirement on mortality, with contrasting results. One part of the literature finds no significant impact. Thus, Coe and Lindeboom (2008) and Hernaes et al. (2013) find no significant impact of early retirement on mortality respectively in the U.S. and in Norway. Similarly, Hagen (2018) finds no significant impact of an increase in retirement age due to the Swedish pension system reform on women's mortality. On the other hand, two studies find a reduction in mortality following early retirement. Hallberg et al. (2015) and Bloemen et al. (2017) find that a decrease in early retirement age is associated with a decline in mortality, among the Swedish military officers and the Dutch male civil servants respectively. In contrast, three studies find that retirement could increase mortality. Kuhn et al. (2019) find that early retirement leads to an increase by 2.4 percentage points of the death probability before age 67 among blue-collar male workers in Austria. Zulkarnain and Rutledge (2018) find that delaying retirement reduces death probability within five years for men aged 62-65 in the Netherlands. Fitzpatrick and Moore (2018) find a two percent increase of death counts for American men at the ERA – i.e., at age 62 –, but no effect for women.

Our paper contributes to this small literature by exploiting the 1993 French pension reform which was the first to reverse the trend towards earlier retirement in that country. The reform consisted in increasing the contribution length required for a full-rate pension progressively by cohort of birth. The reform impacted individuals born in the same year differently, according to the contribution length they had acquired at the ERA, i.e., age 60 at the time. We use the change in retirement incentives as an instrumental variable using a two-stage-least-square (2SLS) estimator to measure the impact on mortality. We use administrative data encompassing the universe of private sector wage earners in France born between 1930 and 1950 – the 2017 data from *Caisse Nationale d'Assurance Vieillesse* (CNAV) – which gathers more than 10 million observations, from 450,000 to 650,000 retirees per cohort.

The first stage of the 2SLS regression shows a strong and significant effect of the 1993

⁶Rapoport et al. (2005) show that doubling income leads to a decrease of mortality by 10%. On the opposite, Snyder and Evans (2006) show higher income groups are significantly associated with higher mortality rate.

reform on claiming age, both for the youngest cohorts strongly affected by the reform and for the oldest cohorts only partially affected. The second stage of the 2SLS shows that an exogenous increase in claiming age by one quarter has no significant impact neither on the probability to die between ages 65 and 72, nor between ages 72 and 77. This non significant result holds also for men and women separately.

Contrary to a large share of the literature, our results are precisely estimated, i.e., we find very precise effect around 0. We discuss in the paper the sample size necessary to estimate significant effects of such a small size, and we review previous literature in that light. We also discuss the interpretation of different studies which focus on specific subset of the population. Romer (2020) points out the relevance of an analysis on confidence intervals rather than on the point estimates significance only. Following that methodological line, we suggest that using minimal detectable effect procedure more systematically could be a way to identify the ability to estimate small effects with rare events data.

This paper is structured as follows: Section 1 presents the institutional framework and the 1993 French pension reform while Section 2 presents the data, the sample and the method, Section 3 the results and Section 4 a discussion of the results.

1 Institutional Framework

The French pension system is a mandatory pay-as-you-go pension scheme. There are several pension schemes, and individuals contribute to the one associated with their professional occupation group (private sector, public sector, etc.). The 1993 French pension reform only affected wage earners in the private sector. Hence, we focus in this section on pension rules in the private sector before and after the 1993 reform.

1.1 Private Sector Pensions Before the 1993 Reform

In the private sector, pension benefits depend on (i) the pension rate; (ii) the reference wage (equal to the average of the ten best earning years of an individual); (iii) the share of career an individual worked within the private sector scheme.

Early retirement age (ERA) is set at age 60, and a full-rate pension can be claimed either at age 65, or at an earlier age provided that the wage-earner has contributed at least the required contribution length – set at 37.5 years before the reform (or 150 quarters).⁷ Individuals benefit from a contributed quarter for each period in employment, sick-leave, or short-term unemployment. There was, at the time, no actuarial adjustment of pension benefits after reaching the full replacement rate. The full replacement rate was 50%, and a penalty of

⁷For individuals with severe disability and functional limitations, the disability pension can be claimed at age 60 whatever the contribution length.

10% – higher than actuarial fairness – was applied for each year of early retirement or missing contribution length before conditions for the full-rate were reached. Hence, the financial incentives, as well as the reference norms, coincided largely with claiming a pension at the full-rate age.

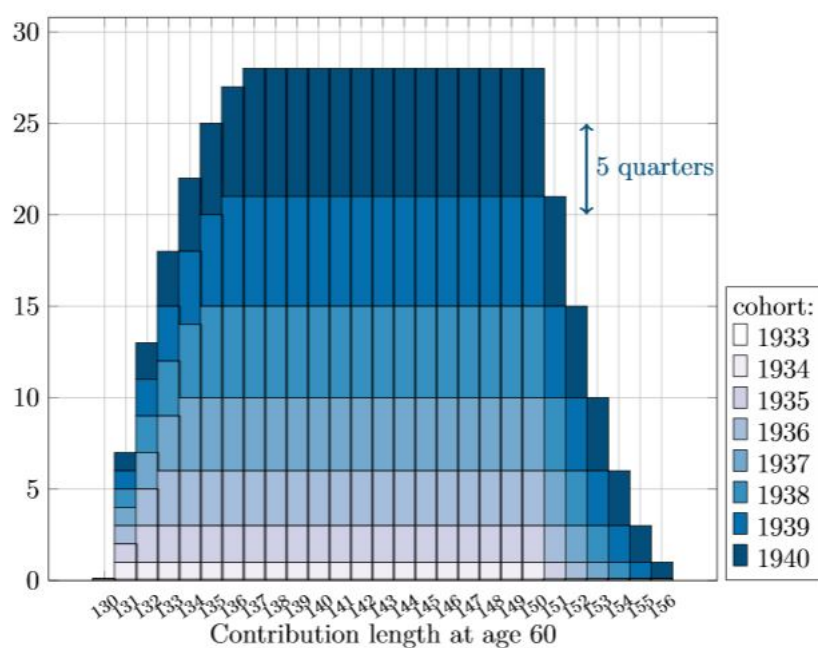
1.2 The 1993 Pension Reform

In 1993, the Ballardur government reformed the pension system for private sector employees (see Appendix A for more details on the 1993 reform). This reform changed three parameters. First, it changed the indexation rules for pension, from wage growth to consumption price inflation. This affected all cohorts by reducing pension benefits at claiming age, and later with less dynamic pension indexation. Second, the number of years considered for computing the reference wage increased from the best 10 years to the best 25 best years. This change was phased-in progressively, affecting younger cohorts more intensively. Finally, the reform changed the required contribution length for a full-rate pension. It was gradually increased, cohort by cohort, from 37.5 years to 40 years (or from 150 to 160 quarters), starting with the 1934 cohort. Individuals born in 1934 had to contribute 151 quarters for a full pension, cohort 1935 had to contribute 152 quarters, and so on (see Appendix A for details). All individuals in the same cohort were not affected in the same way, as shown in Figure 1. Using the change in the required contribution length, we exploit the variation between and within cohorts to identify the causal effect of later retirement on mortality. Thus, Figure 1 illustrates the progressive increase in incentives to delay retirement across cohorts, and how this phasing-in of the reform impacted wage earners differently, with different career lengths at age 60. Within each cohort only wage earners with a specific contribution length at age 60 were really impacted (those between 131 and 160 quarters of contribution) and the intensity of the reform was higher for younger cohorts.

Figure 2 shows that individuals in cohort non affected by the reform bunched at 150 quarters, the requirement for the full rate. From cohort 1934 (the first cohort affected by the reform), bunching at the full rate moves to the right for each cohort affected. It highlights significant behavioral responses to the 1993 reform.

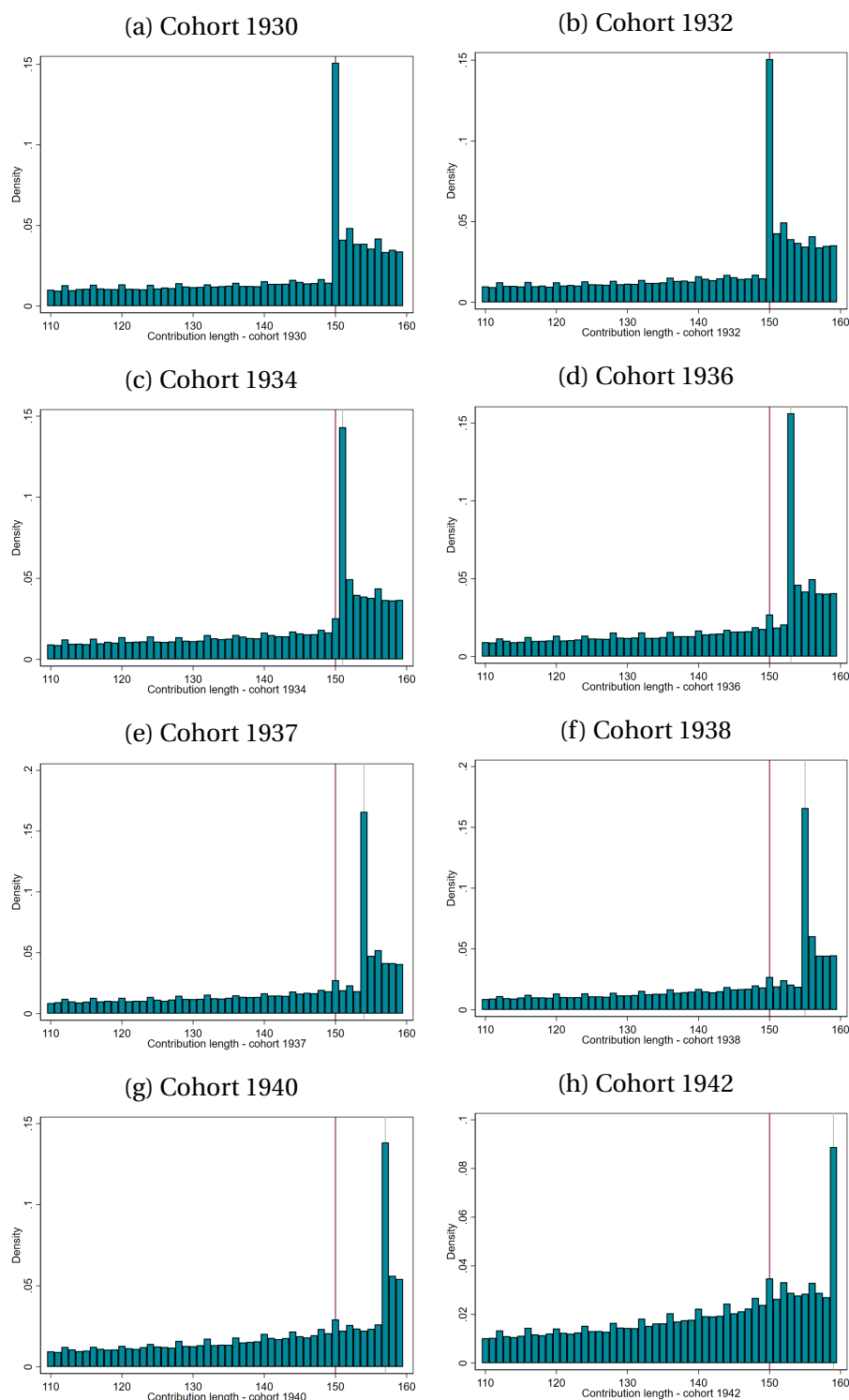
Workers in a same cohort are differently affected by the change in required contribution length (but affected in the same way by the two other parts of the reform): individuals with very long careers, having contributed at age 60 more than the required contribution length, were unaffected by the reform – they would qualify for the full rate at age 60 regardless of the reform. Conversely, individuals with short careers, i.e., less than 130 quarters of contribution at age 60, were not affected by the change in required contribution length as the full-rate was obtained at age 65 anyhow. Individuals eligible for a disability pension due to their health condition were not affected by the reform and could still claim a disability pension at age 60.

Figure 1 – Impact of the 1993 Reform on Contribution Length Necessary to Get the Full-rate



Notes: This figure presents the impact of the 1993 reform on the number of contributed quarters required to reach the full-rate by cohort and contribution length at the ERA, i.e., at age 60. Whatever the contribution length at age 60, a wage-earner born in 1933 is not impacted by the reform (zero added quarter required). Cohort born in 1934 who had contributed at age 60 between 130 and 150 quarters need to delay retirement by one quarter in order to qualify for the full-rate. Cohort born in 1935 who had contributed at age 60 between 131 and 150 quarters need to delay retirement by two quarters to reach the full replacement rate. Those from the same cohort who had contributed 151 quarters at age 60 had to delay retirement by one quarter.

Figure 2 – Distribution of Claimants by Contribution Length



Notes: This is the density by contribution length at retirement by cohort, for individuals who have contributed between 110 and 160 quarters. The red line shows the 150 quarters contribution (the required contribution before the reform). For cohorts 1930 and 1932 (cohorts not affected by the reform), there is bunching at 150 quarters, which corresponds to the required contribution length to retire with a full replacement rate. For cohorts 1934 and older (affected by the reform), bunching moves to the right, showing individuals seem to respond to the reform's changed incentives.

Sample: Individuals born between 1930 and 1942, with a contribution length between 110 and 160 quarters.

Source: Cnav 2017.

2 Data and Empirical Strategy

2.1 Data

In this study we use exhaustive administrative data from the main pension scheme of the private sector, the *Caisse Nationale d'Assurance Vieillesse* (CNAV).⁸ These data encompass all the retirees born between 1930 and 1950 and who have contributed at least one quarter in the Cnav pension scheme during their career. We observe all retirees still alive, and all those who died between 2003 and 2017. The sample is exhaustive for the cohorts we are interested in, with 500,000 observations per cohort on average. These data contain all the information required for pension benefit computation (reference wages, number of contributed quarters) but no socio-economic information on individuals, except date of birth and gender.

Sample Selection. The 1993 reform affects all individuals from cohort 1934 onwards. For our study, we select individuals born between 1933 and 1943. One cohort (born in 1933) is unaffected by the reform, while cohorts 1934 to 1943 are progressively more impacted by the change in incentives. Cohort 1943 is the first cohort fully impacted by the reform, and the last cohort not affected by the following French pension reform.⁹ Thus, our sample is made up of individuals who (i) are born between 1933 and 1943; (ii) have contributed between 80 and 180 quarters at age 60.¹⁰

Given that we observe mortality outcomes between 2004 and 2017 we do not observe mortality outcomes for the same ages for all the cohorts affected. As a result, we split our sample into two panels including individuals alive at the same age. In the first panel (Panel A), we observe the probability to die between 65 and 72 for individuals born between 1938 and 1943.¹¹ In the second panel (Panel B), we observe the probability to die between 72 and 77 for individuals born between 1933 and 1938.

This enables us to have a global view of the impact of later retirement on mortality. As the effects on mortality could appear a long time after retirement, time is needed to observe the health consequences of later retirement. Panel A shows the impact just after retirement, at age 65, whereas Panel B gives us the effect between age 72 and 77, conditional on being alive at age 72. Due to data constraints, we have no information on the potential effect between ages 60 and 65. Thus, the results presented in the following section are for individuals alive at

⁸The Cnav is the main pension scheme. It covers all the private sector wage earners. In France, 85% of the labor force contribute at least once in this pension scheme (source: EIR 2004). 90% of those affected by the 1993 reform had mainly contributed to the Cnav pension scheme.

⁹The 2004 reform affects cohorts born in 1944 and later.

¹⁰As a robustness check, we test variants to this restriction (see Figure 6).

¹¹The choice of age 65 rather than claiming age enables to avoid a selection bias on mortality between individuals with different claiming age.

least at age 65, without any information on the impact of the reform between ages 60 and 65. We do not observe mortality after age 77 yet, and thus have no information on the potential impact after age 77.

Note that Panel A and B include different cohorts, which might not be fully comparable. In particular, we may presume that cohorts born during World War II (Panel A) could have specific health conditions.¹² As we use variations within cohorts to identify the impact of the pension reform, these differences should not threaten the internal validity of the estimation.

Variables of Interest. The data used allow for the computation of the number of quarters contributed during the working life of an individual, and the number of contributed quarters contributed at age 60. Moreover, we have information on the exact claiming age, defined as the age at which an individual claim for the first time a pension. This age can differ from the retirement age, i.e., the age at which an individual leaves the labor force to retire. We have no information on when individuals actually leave the labor force.¹³

The administrative data we exploit only contain a few individual characteristics which we can control for: we know if individuals benefit from a disability pension, and thus, we can use this as a control for health condition. We also have information on the reference wage, i.e., the average of the best earnings.

Descriptive Statistics. Table 1 presents descriptive statistics. The average number of quarters contributed is 156 quarters in Panel A, compared to 153 in Panel B. This difference between the two samples was expected since individuals in Panel A are more intensively affected by the reform, and thus, have to contribute more quarters to benefit from a full-rate pension. Consistently, additional years of contribution required by the reform to obtain a full-rate is higher in Panel A than in Panel B (1.29 versus 0.41). Apart from the fact that the two samples are affected differently by the reform, they remain very close to national averages. For instance, the mean claiming age in our data is 61.4 for Panel A (resp. 61.2 for Panel B), which is very close to the national mean claiming age of those who benefit from a pension (61.9 in 2004 according to Benallah and Mette (2009)). Reference wages are also similar in our sample and in these national statistics. The death probability and mean age of death is higher in Panel B since we observe individuals at older ages. In Panel A, individuals are observed between ages 65 to 72; and in Panel B, between ages 72 and 77. The death probability and the average age at death are different in these two panels. However, there are two different populations observed at different age ranges.

¹²Stress due to the war, malnutrition during childhood, due to the Second World War II affect health during the whole life (Kesternich et al., 2014; Lindeboom et al., 2010; Van den Berg et al., 2006).

¹³Bozio (2011a) exploits another source of data, with a smaller sample, but with information on past employment history, which he uses for assessing the impact of the 1993 reform on employment.

We have also conducted a comparison of our sample characteristics to the national statistics from INSEE, the French Institute of National Statistics, whose detailed results are presented in Appendix B. A number of differences needs to be noted, as they reflect the selection of our sample on private sector workers. First, the share of women is slightly lower than those of men (Table B2). Second, the death probability between ages 65 and 77 is close to national statistics for each cohort, with slightly different death rates in our sample than national average at some ages (see Tables B3 and B4).

Table 1 – Descriptive Statistics of the Variables of Interest

Variable	Mean	Std. Dev.	Min.	Max.	N
Panel A – Cohort 1938 to 1943					
Contribution length (in quarters)	155.69	22.27	80	206	2,198,258
Contribution length at age 60	150.38	25.70	80	180	2,198,258
Claiming age	61.41	2.03	60	66.5	2,198,258
Reference earnings (in euros)	14,704.78	7,246.37	0	1,816,800	2,198,258
Δ RCL	1.29	2.66	0	10	2,198,258
Disability pension	0.18	0.62	0	1	2,198,258
Age of death	71.87	3.69	65	79.92	393,049
Death probability between 65 and 72 yo.	0.0899	.	0	1	2,198,258
Panel B – Cohort 1933 to 1938					
Contribution length (in quarters)	152.94	23.27	80	206	1,900,893
Contribution length at age 60	148.31	26.489	80	180	1,900,893
Claiming age	61.24	1.913	60	67	1,900,893
Reference earnings (in euros)	13,695.08	6,763.97	0	1,989,700	1,900,893
Δ RCL	0.41	1.12	0	5	1,900,893
Disability pension	0.18	0.62	0	1	1,900,893
Age of death	77.67	3.18	72	84.92	478,666
Death probability between 72 and 75 yo.	0.1091	.	0	1	1,900,893

Notes: This table shows descriptive statistics of our samples.

Sample: Individuals selected are those who had contributed at age 60 between 80 and 180 quarters, at least once in the private sector, and retire between ages 59 and 67. Moreover, Panel A selects only individuals born between 1938 and 1943, and alive at age 65; Panel B selects only individuals born between 1933 and 1938, alive at age 72. In Panel A (resp. panel B), the mean contribution length is 155.69 quarters (resp. 152.936).

Source: Cnav 2003-2017.

2.2 Empirical Strategy

The main challenge to measure the impact of later retirement on health is reverse causality.¹⁴ Less healthy people may be inclined to leave employment at an earlier age, whereas healthier people tend to stay on the labour market, which would create a positive correlation between retirement age and health status. Health has a strong effect on work choices. Previous studies show that health problems influence retirement plans and, more generally,

¹⁴Health and retirement are endogenously related (Kerkhofs et al., 1999; Llana-Nozal Ana et al., 2004; Lindboom and Kerkhofs, 2009).

the labor force behavior of older workers (Bound et al., 1999; Dwyer and Mitchell, 1999; Au et al., 2005; McGarry, 2004; Disney et al., 2006).

To address this endogeneity issue, we exploit the exogenous variation in retirement age created by the 1993 reform, as an instrument for assessing the causal impact on mortality. The 1993 reform affected differently individuals of the same cohort depending on the exact number of quarters of contribution at the ERA. For example, the reform consisted in an incentive to retire one quarter later for individuals born in 1934 and who had contributed 150 quarters at age 60. With 151 quarter of contributions, individuals of the same cohort were not affected by the reform. To be a valid instrument, we have to assume that the number of contributed quarters at age 60 is independent from the reform. This assumption is very likely for the first cohorts affected by the reform since they could not have anticipated this reform. For the last cohort affected, the assumption is stronger as individuals could have responded by increasing labor force participation before the ERA, but this option would have been open to a limited number of individuals.¹⁵ Within cohorts 1933 and 1934, we could estimate the impact of the reform in a difference-in-differences setting, following equation (2.1):

$$A_i = \delta_0 + \delta_1 \mathbb{1}(yob_i = 1934) \times \mathbb{1}(CL_{60_i} = 150) + \delta_2 \mathbb{1}(yob_i = 1934) + \delta_3 \mathbb{1}(CL_{60_i} = 150) + \varepsilon_i \quad (2.1)$$

with A_i (claiming age, in quarter of years), $\mathbb{1}(yob_i = 1934)$ a dummy equal to one if individual i is born in 1934, $\mathbb{1}(CL_{60_i} = 150)$ a dummy variable equal to one if contribution length of individual i equal to 150 at age 60, ε_i the error term following a normal distribution. The interaction term $\mathbb{1}(yob_i = 1934) \times \mathbb{1}(CL_{60_i} = 150)$ captures the causal impact of the reform on retirement age within cohort.

With the progressive phasing-in of the reform we can exploit all the different impacts of the reform on different cohorts, in the spirit of a generalised difference-in-differences model (with cohorts and quarters of contributions dummies). We go one step further by exploiting the intensity of the reform, by computing the number of quarters of contribution needed to reach the full-rate, i.e. ΔRCL .

The first-stage in our two stage least square (2SLS) estimation is an ordinary least square (OLS) regression. It represents the impact of the number of added quarters due to the reform on the claiming age, and can be written as follows:

$$A_i = \alpha_0 + \alpha_1 \Delta RCL_i + \sum_g \alpha_{2,g} \mathbb{1}(yob_i = g) + \sum_t \alpha_{3,t} \mathbb{1}(CL_{60_i} = t) + \alpha_4 X_i + \zeta_i \quad (2.2)$$

with A_i , the claiming age; ΔRCL_i , the number of additional quarters required to get a full

¹⁵Only individuals who were not working before the ERA could have responded with increasing labor force participation.

pension due to the reform;¹⁶ $\mathbb{1}(yob_i = g)$, dummies for cohort; $\mathbb{1}(CL_{60_i} = t)$, dummies for the contribution length at age 60; X_i , the pensioners' individual characteristics (gender, annual reference wage and a dummy for being disability pension recipient); ζ_i , the error term, following a normal distribution.

The second-stage equation is the causal impact of later retirement due to the reform on mortality between ages 65 and age 72 (Panel A), and between ages 72 and 77 (Panel B), estimated using OLS. It can be written as follows:

$$q_i = \beta_0 + \beta_1 \hat{A}_i + \sum_g \beta_{2,g} \mathbb{1}(yob_i = g) + \sum_t \beta_{3,t} \mathbb{1}(CL_{60_i} = t) + \beta_4 X_i + \tau_i \quad (2.3)$$

with q_i equal to zero if individual i is alive at age 72 (respectively at age 77), and equal to one if individual i died between ages 65 and 72 (respectively between ages 72 and 77), \hat{A}_i , the variation in claiming age due to the reform, and τ_i , the error term, following a normal distribution. Technically, identification is obtained if $\alpha_1 \neq 0$ and if ΔRCL affects mortality exclusively through A_i , i.e. the exclusion restriction. This is confirmed by the first stage estimates in Section 3.

3 Results

We first present reduced-form results with graphical evidence, before detailing the 2SLS results for each panel.

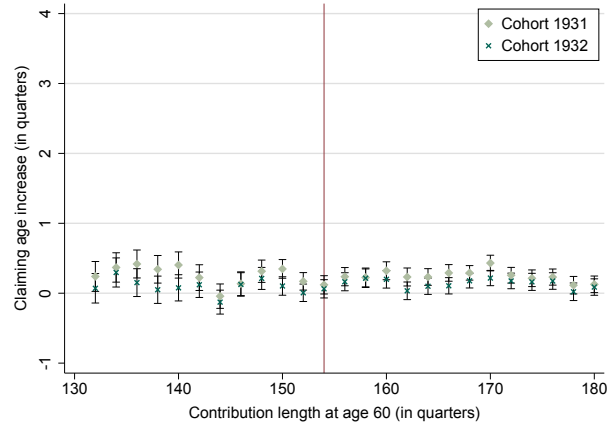
3.1 Impact of the Reform on Claiming Age and Mortality

Impact of the Reform on Retirement. Figure 3 presents the impact of the 1993 reform on claiming age for different cohorts and according to the contribution length at age 60. Figure 3b compares two affected cohorts (1936 and 1938) with an unaffected cohort (1933). Cohort 1936 had to delay retirement by three quarters to get the full rate if contribution length was below 151, while cohort 1938 had to report retirement by five quarters if contribution length was below 155 quarters. We observe strong effects of the reform on claiming age for those individuals affected. The increasing intensity of the reform is also evident in the stronger impact for the younger cohorts. For contribution length above 155 quarters at age 60 there are no cohorts affected and we do not detect any differences in claiming behavior. Figure 3c presents similar effects for younger cohorts (1940 and 1942) compared with cohort 1938. Figure 3a presents the results for three unaffected cohorts (1931 and 1932 versus 1933). No difference in claiming age is detected.

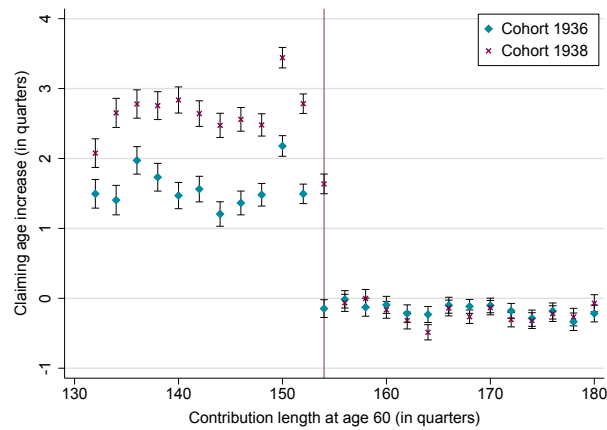
¹⁶Thus, ΔRCL_i varies according to birth year, and contribution length at age 60.

Figure 3 – Impact of the 1993 Reform on Claiming Age

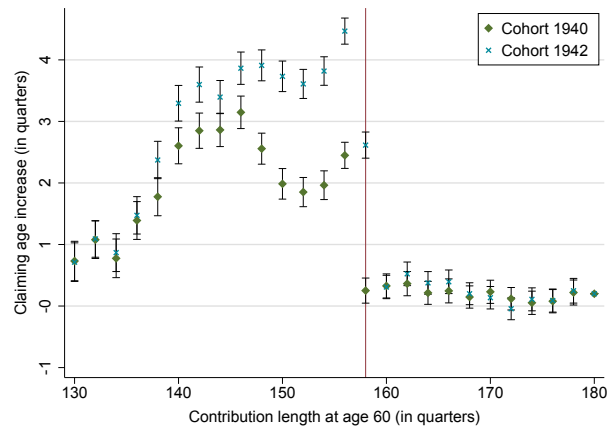
(a) Placebo Test: Cohorts 1931 and 1932 vs 1933



(b) Treated Cohorts (1938 and 1936) vs Controls (1933)



(c) Treated Cohorts (1940 and 1942 vs 1938)

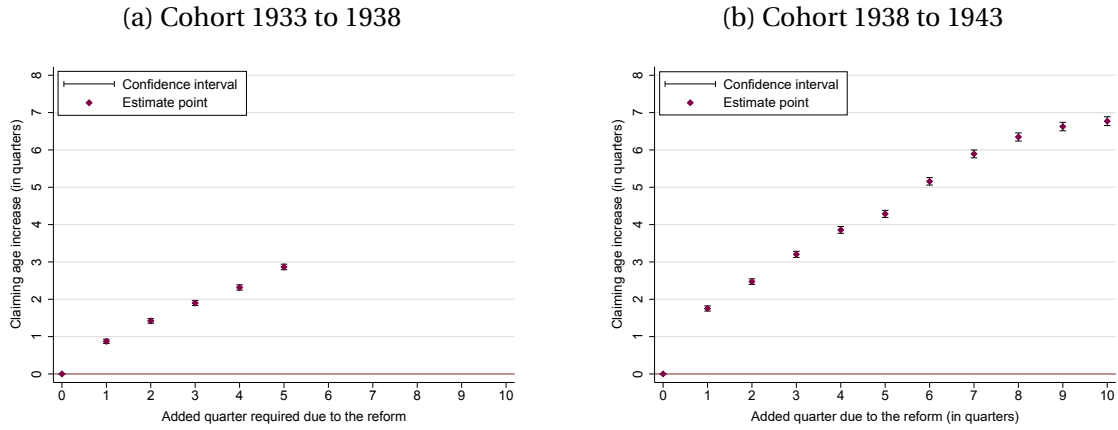


Notes: Average impact of the contribution length at age 60 on the claiming age for untreated cohorts (1931 and 1932), taking cohort 1933 (untreated) as reference Figure (a); for treated cohorts (1938 and 1936), taking 1933 cohort as reference Figure (b); for 1940 and 1942 cohorts, taking 1938 cohort as reference Figure (c). Confidence Intervals at 95%.

Sample: Individuals from Panel A and B.

Source: Cnav 2017.

Figure 4 – Impact of the Reform on Claiming Age



Notes: Average impact of the number of added quarter an individual experience due to the reform on the claiming for cohorts 1933 to 1938, and for cohorts 1938 to 1943. Confidence Intervals at 95%. The point estimate are those of the equation: $A_i = \alpha_0 + \sum_{r=0}^{10} \alpha_{1,r} \mathbb{1}(\Delta RCL_{i,r}) + \sum_g \alpha_{2,g} \mathbb{1}(yob_i = g) + \sum_t \alpha_{3,t} \mathbb{1}(CL_{60_i} = t) + \alpha_4 X_i + \zeta_i$. This equation is the same as Equation (3) but allowing for non linear effect of the number of added quarter due to the reform ΔRCL .

Sample: Individuals from Panel A and B.

Source: Cnav 2017.

Figure 3 presents the graphical results of the first stage estimate of our main specification, allowing for heterogenous impact of the intensity of the reform, as specified in the following equation.

$$A_i = \alpha_0 + \sum_{r=0}^{10} \alpha_{1,r} \mathbb{1}(\Delta RCL_{i,r}) + \sum_g \alpha_{2,g} \mathbb{1}(yob_i = g) + \sum_t \alpha_{3,t} \mathbb{1}(CL_{60_i} = t) + \alpha_4 X_i + \zeta_i$$

The impact is strong, and proportional to the intensity of the treatment. The coefficients plotted on this Figure are reported in Table D3. It shows that the assumption we have made concerning the linear effect in the first stage of our 2SLS is not an issue here.

These graphical results are confirmed by the first stage regression (see Table 2, column (3)). It shows a large impact of an increase in the required contribution length on claiming age. An increase in the contribution length by one quarter implies a 0.696 (resp. 0.672) additional quarter in claiming age for men of Panel A (resp. Panel B), and 0.589 (resp. 0.425) for women, both significant at 1%. This result confirms that the 1993 reform can be used as an instrumental variable to estimate the causal impact of claiming age on mortality.

Individuals postpone almost the entire additional required contributions to obtain a full pension, meaning that they respond to the incentives to work longer. An increase of the required contribution length by one quarter (three months) induces a deferral of 2 months (resp. 1.68 for Panel B) in the claiming age for younger cohorts (resp. older cohorts). The effect is slightly lower for women, who postpone the claiming age by close to two months.¹⁷

¹⁷There may be an income effect. Individuals who did not respond to the incentives, undergo a pension cut.

Our results are similar to Bozio (2011a) who estimated, on a smaller sample and for the first cohorts affected only, the impact of the 1993 reform on claiming age and on probability to stay in work. His estimates pointed to a very similar effect of the reform on claiming or labor force participation for men, and a slightly smaller effect on labor force participation for women.

Impact of the Reform on Mortality. In Figure 5, we show similar graphical evidence with mortality outcome instead of claiming age. This is akin to the reduced-form estimation on mortality. The effects are never significant, whatever the cohort, gender, or the treatment intensity.

3.2 Impact of Claiming Age on Mortality – IV Estimates

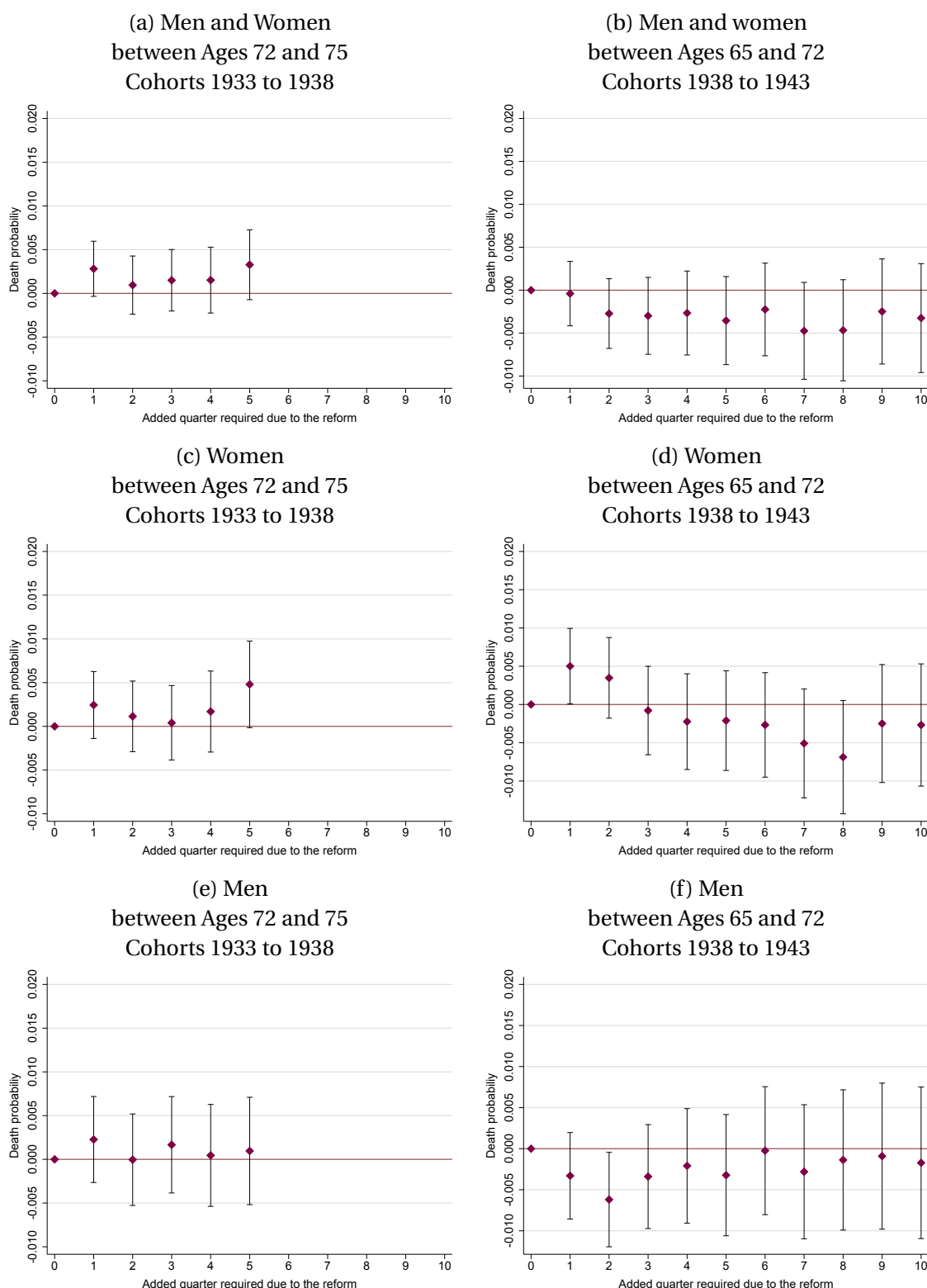
Table 2 presents the main results of the analysis for the two samples (Panels A and B). In column (1) we report the coefficient of an OLS regression of claiming age on mortality. The correlation is negative and significant for all samples: -0.00099 for men born between 1938 and 1943 (resp. -0.00094 for those born between 1933 and 1938) and -0.00042 (resp. -0.00039) for women, meaning that a higher claiming age is associated with a lower probability to die. The correlation may be explained by a selection bias as workers in good health are likely to be those who retire later ("healthy worker effect").

In column (2) we report the coefficients of the impact of the pension reform on mortality (the reduced form estimation of equation (2.3)). The negative correlation turns insignificant for Panel A and Panel B. In column (3) we report the first stage impact (i.e., the impact of the reform on claiming age) which shows strong and significant effects, while column (4) reports the 2SLS estimates.

The results from the IV estimation show that an exogenous increase in claiming age has no significant impact, neither on the probability to die between ages 65 and 72 (Panel A), nor on the probability to die between ages 72 and 77 (Panel B). This non-significant effect is very close to zero. This result is also not significant for men and women separately. Our data contain little information on socio-economic characteristics, preventing us from doing a complete heterogeneity analysis. Nonetheless, as a robustness check, we present results by life-time earnings quartile, a good proxy for many socio-economic factors (Table D7 in Appendix).

Thus, the reform may affect mortality by reducing income. Furthermore, the first stage shows that individuals react massively to the reform by increasing the claiming age, meaning that the effect of postponing retirement prevails on the income effect.

Figure 5 – Impact on Mortality by Treatment Intensity



Notes: Average impact of the number of added quarter an individual experiences due to the reform on the probability to die, respectively between ages 72 and 75 for cohorts 1933 to 1938, and between ages 65 and 72 for cohorts 1938 to 1943. Confidence Intervals at 95%.

Sample: Individuals from Panel A and B.

Source: Cnav 2017.

Table 2 – Main Estimates of the Impact of Delaying Retirement on Mortality

	(1)	(2)	(3)	(4)	
	OLS	Reduced Form	1st stage	2SLS	Obs.
Dependant var.	q_i	q_i	A_i	q_i	
Explanatory var.	A_i	ΔRCL	ΔRCL	\hat{A}_i	
Panel A: Cohorts 1938 to 1943, observed between ages 65 and 72					
All	-0.00049*** (0.00003) <i>0.00000</i>	-0.00023 (0.00028) <i>0.42299</i>	0.64607*** (0.00603) <i>0.00000</i>	-0.00035 (0.00044) <i>0.42293</i>	2,198,258
Male	-0.00099*** (0.00005) <i>0.00000</i>	0.00004 (0.00042) <i>0.91704</i>	0.69616*** (0.00788) <i>0.00000</i>	0.00006 (0.00060) <i>0.91703</i>	1,283,687
Female	-0.00042*** (0.00004) <i>0.00000</i>	-0.00043 (0.00035) <i>0.22495</i>	0.58855*** (0.00941) <i>0.00000</i>	-0.00073 (0.00060) <i>0.22486</i>	914,571
Panel B: Cohorts 1933 to 1938, observed between ages 72 and 77					
All	-0.00045*** (0.00004) <i>0.00000</i>	0.00038 (0.00035) <i>0.27354</i>	0.56020*** (0.00684) <i>0.00000</i>	0.00068 (0.00062) <i>0.27362</i>	1,900,893
Male	-0.00094*** (0.00007) <i>0.00000</i>	0.00007 (0.00054) <i>0.89240</i>	0.67153*** (0.00941) <i>0.00000</i>	0.00011 (0.00081) <i>0.89240</i>	1,081,343
Female	-0.00039*** (0.00004) <i>0.00000</i>	0.00055 (0.00043) <i>0.20540</i>	0.42517*** (0.01013) <i>0.00000</i>	0.00128 (0.00101) <i>0.20561</i>	819,550

Standard errors in parentheses. P-values in italics.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: A_i is the claiming age in quarter of individual i ; q_i is a dummy equal 1 if individual died; ΔRCL is the number of added quarter required due to the reform; \hat{A}_i is the variation of claiming age due to the reform, in quarter. Column (1) presents the coefficients from an OLS regression of claiming age on mortality; column (2) the coefficient of the reduced form impact of the reform on mortality; column (3) the first stage impact, i.e. the impact of the reform on claiming age; and finally column (4) presents the coefficients of the 2SLS estimation. All these regressions include controls for year of birth, dummies for contribution length at age 60, gender, reference wage and being a disability pension recipient. The detail of the coefficient for the control variables are in Appendix D8 to D13.

Sample: Results are for samples of individuals who had contributed at age 60 between 80 and 180 quarters; retired between ages 59 and 67; contribute at least once during their career in the private sector and for Panel A who are born between 1938 and 1943, and alive at age 65; for Panel B, who are born between 1933 and 1938 and alive at age 72. The F-statistics of the first stage is systematically high enough to not worry about weak instrument issue. Thus, it is 11,477.23 for the whole panel A and 7,798.24 (resp. 3,915.25) for men (resp. women). For panel B, it is 6,705.05 and 5096.00 (resp. 1761.31) for men (resp. women). The Durbin-Wu-Hausman in Panel A (resp. Panel B) is 20.27 (resp. 6.15) with a p-value of 0.0000 (resp. 0.0131) showing there is an endogeneity issue that justify to prefer 2SLS rather than OLS.

Source: Cnav data 2017.

Detecting Small Effects with Rare Events Data. In each sub-sample, we would like to know if the non significant result can be interpreted as an absence of link between retirement age and mortality or a lack of power. To this aim, we compute minimum detectable effect. The minimum detectable analysis gives us the lowest detectable effect. Thus, a minimum detectable effect of x means that with an estimated coefficient non significant and lower than x , we could not conclude the absence of association between the dependant variable and the treatment variable, i.e., we accept the null hypothesis with a risk of making a type II error higher than 20%, the usual threshold of statistical power (see Appendix C). We compute MDE estimates for each sample, for a two-side hypothesis test, at a 5% significance level, and a statistical power of 20%. There is not enough power to detect an effect when the MDE is above the confidence interval of the estimated beta. Panel A includes 2,198,258 observations, with a share of treated of 23.20%, a death probability of 8.99%. The minimum detectable effect is -0.00049, which is higher in absolute value than our estimated β (-0.00035). It means that if there were an effect lower than -0.00049, it would have been detected. Panel B includes 1,900,893 observations, with a share of treated of 15.14%, a death probability of 10.91%. The minimum detectable effect is 0.0017 in Panel B, which is higher than our estimated β (0.00068). It means that an impact higher than 0.0017 would have been detected if it had occurred, or in other words that, if there is an effect on mortality, it is lower than 0.0017 in Panel B and lower in absolute value than -0.00035 in Panel A (see Table C2 in Appendix).

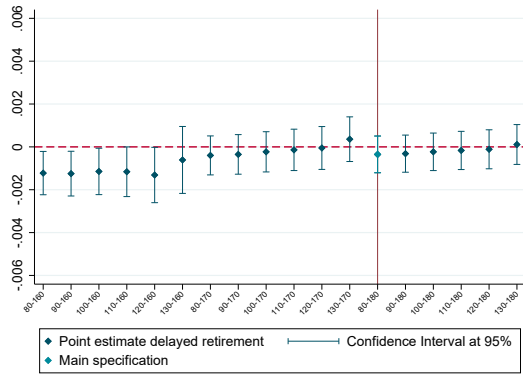
In each sub-sample, the effect is not detectable, meaning that we cannot conclude between absence of effect and lack of statistical power. However, our MDE estimates suggest that, if there is an effect on mortality, it is very small in magnitude. We later discuss the economic significance of such an impact (see Section 4).

3.3 Robustness Checks

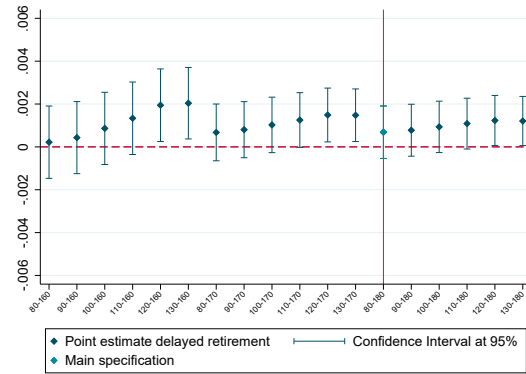
Sample Selection. We test several alternatives to our sample restrictions. Figure 6 shows the causal effect of later retirement on mortality for each panel depending on the sample selection. Our main specification is a selection of individuals who contribute between 80 and 180 quarters at age 60. Figures 6a, 6c and 6e (Panel A) show the estimated causal impact of later retirement on the probability to die between ages 65 and 72 with various sample selections based on contribution length at ERA, and Figures 6b, 6d and 6f (Panel B) show the impact on the probability to die between 72 and 77. For the whole Panel A (resp. B), this effect is non-significant in 16 (resp. 14) over 18 samples tested (See Figures 6a and 6b) at the 5% level, and never significant at the 1% level. When we consider sub-sample by gender, it is never significant.

Figure 6 – Robustness Checks for Sample Selection

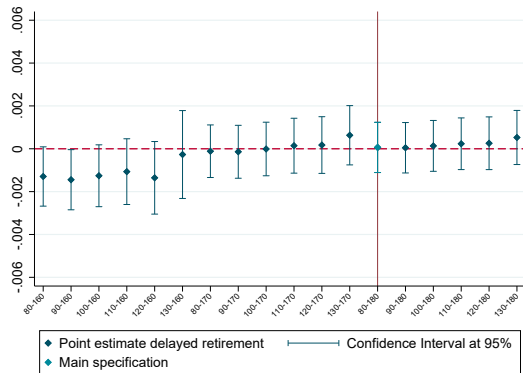
(a) Effect on the Probability to Die between 65 and 72 (Panel A)



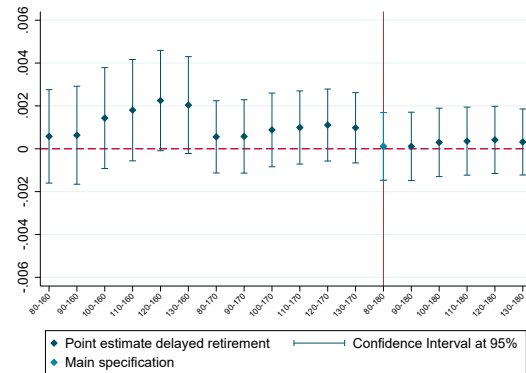
(b) Effect on the Probability to Die between 72 and 77 (Panel B)



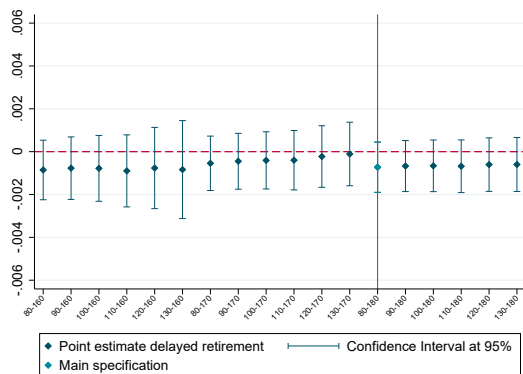
(c) Effect on the Probability to Die between 65 and 72 (Men Panel A)



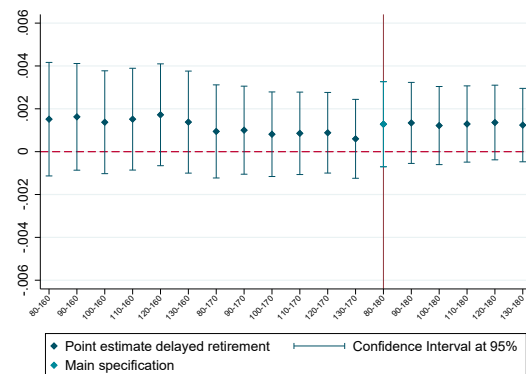
(d) Effect on the Probability to Die between 72 and 77 (Men Panel B)



(e) Effect on the Probability to Die between 65 and 72 (Women Panel A)



(f) Effect on the Probability to Die between 72 and 77 (Women Panel B)



Notes: We test several alternatives to our sample restrictions. Our main specification is a selection of individuals who contribute between 80 and 180 quarters at age 60.

Source: Cnav 2017.

Additional Controls. Our data do not provide much information concerning individuals socio-economic characteristics. We use *Echantillon interrégime des retraités* (EIR) data, an administrative dataset of retirees born in early October of even years (details in Appendix D). This data is smaller than the CNAV data, but include individual characteristics such as having children, marital status, and socio-professional characteristics. We rerun our model on this data, without control, as in Cnav data, and with control for marital status, profession and children (see Table D1). With and without controls, our results are very similar, showing that adding controls does not change the results.

Mortality Measures. We check alternative mortality definitions, e.g., death between ages 65 and 66, 66 and 67, 67 and 68, and so on (see results in Appendix, Table D2). An exogenous increase of claiming age by one quarter has a non significant impact at the conventional 5% threshold. This may be explained by the very low death rate within a year, which is statistically hard to capture.

Results by Quartile of Lifetime Earnings. We use the reference wage as a proxy of individuals' average lifetime earnings – the reference wage is the average of the best 25 years of earnings. Table D7 shows the impact of delaying retirement due to the reform on mortality by quartile of reference wage in each Panel (2SLS estimates). The coefficients are significant and negative at the 10% level for men in the third quartile and women in the second quartile of Panel A. The coefficients are significant and positive at the 10% level for the men of the first quartile of Panel B, and significant and positive at the 5% for women of the second quartile in Panel B. The coefficient estimated are always very small in magnitude (between -0.001 and 0.007). Thus, the sign of the effects is positive or negative depending on the subgroup and the coefficients are rarely significant at 10% (4 coefficients out of 24) and once at 5%. As we have a large sample, the significant level at 1% would be more pertinent. Consequently, the effect is likely to be 0 whatever the quartile.

Non-linear Impact of Treatment. Our main model assumes linear impact of delayed retirement due to the reform on mortality. Table D4 shows there is no significant impact on mortality at the reduced form when we allow for heterogeneous effects of delaying retirement on mortality.¹⁸ Table D5 shows the results of later retirement on mortality assuming heterogeneous treatment effect. It shows no significant impact, and in a similar range to our main estimates.

Alternative Models. As a robustness check, we estimate the impact of later retirement on mortality, using alternative econometric models. Thus, Table D6 provides the results associ-

¹⁸2 coefficients over 45 are significant at the 5% level and 2 coefficients over 45 are significant at the 10% level.

ated with an IV-Probit (1), a pseudo-2SLS, as suggested by Foster (1997) (2), an IV-GMM (3). All these models show non significant results. Moreover, the reduced forms using Probit or Logit models also show non significant results.

4 Discussion

We have found that an exogenous increase in the retirement age in France led to non-significant impact on mortality. In order to interpret the implications of such results, three issues need to be discussed: i) are the results consistent with previous studies?; ii) in what respect the French reform carries information for other reforms, i.e., assessing the external validity of the study; and iii) what is the economic significance of the results?

Previous Literature. We carry out a comparison with previously published studies. We compare our results to those obtained in the literature on the effects of later retirement on mortality. When results are non-significant, we also compute the MDE estimates to assess whether each study had the statistical power to estimate the possible impact.

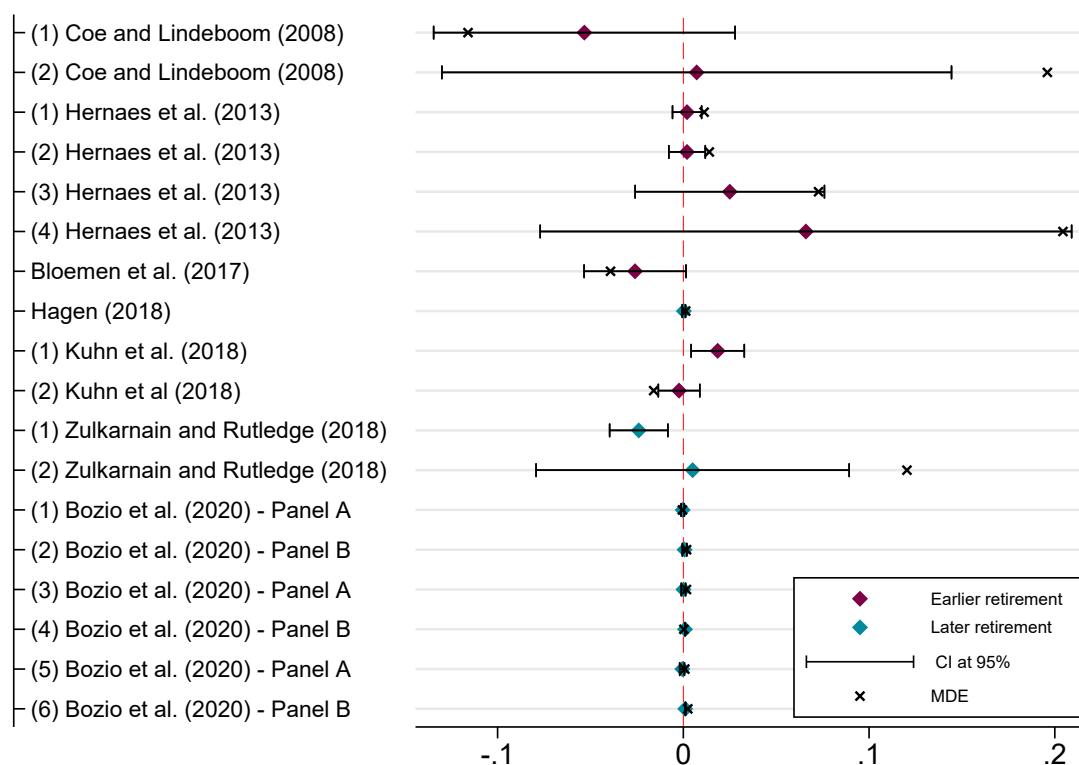
The effect of postponing retirement is not necessarily symmetric to the impact of early retirement, and most of the studies focus on the causal impact of early retirement (Coe and Lindeboom, 2008; Hernaes et al., 2013; Hallberg et al., 2015; Bloemen et al., 2017; Kuhn et al., 2019). We therefore split the sample by making separate comparisons between studies exploiting increase or decrease in retirement ages.

Figure 7 shows our point estimates and confidence intervals at 95% and those obtained in the previous studies. It also shows the computation of MDE when results are non-significant. It relies on estimates of papers presented in detail in Table 3.¹⁹

Two results stand out from this comparison. First, few studies have enough statistical power to conclusively estimate impact on mortality of retirement age changes. Apart from our study, only Hernaes et al. (2013), Hagen (2018) and Kuhn et al. (2019) have enough precision to draw inference on the likely impact. In those three cases, estimated impact are very close to zero. Second, even if one takes seriously the point estimates of all these studies, the average impacts remain very small: for all studies together, the average estimate is slightly positive, around 0.0011, for studies focusing on later retirement the impact is slightly negative around -0.0020. And if one compare our results with the most precisely estimated effects of reforms delaying retirement, we find very similar results: the baseline estimates of Hagen

¹⁹The magnitude of the treatment is not the same between the previous studies and ours. We look at the effect of an additional quarter in claiming age versus one additional quarter, resp. one additional year, spent in early retirement (Hernaes et al. (2013), resp. Kuhn et al. (2019)) or an increase of four to five months of the actual retirement age (Hagen, 2018).

Figure 7 – Our Results with those of the Previous Studies



Notes: This Figure presents a meta-analysis of the literature regarding the causal effect of later vs earlier retirement on mortality. For each row, we show point estimates, confidence intervals at 95%. MDE are only shown for non-significant effects. Coe and Lindeboom (2008) measure the impact of early retirement on the probability to die within four years – see row (1), within six years – see row (2). See Table 3 for details on each point-estimate. The six last lines show our point estimates and confidence intervals at 95% for each panel, for men and women. Rows (1) and (2) show the estimation on the all sample for Panel A and resp. B, rows (3) and (4) for men (resp. Panels A and B), rows (5) and (6) for women, resp. Panels A and B.

(2018) is a non-significant positive point estimate of 0.00028 compared to our estimates of -0.00035 and 0.00068 in our two samples.

Table 3 – Literature Review on the Impact of Retirement on Mortality

Authors (year)	Country Population	Pension rules or reform	Method	Outcome	Point estimates
Coe and Lindeboom (2008)	USA HRS, blue- and white- collar workers, men	Age specific retirement incentives of the US Social Security system	IV	Mortality (1) within 4 years : (2) within 6 years :	-0.0533 (0.0414) Table 9 (column 2) 0.0072 (0.07) Table 9 (column 4)
Hernaes et al. (2013)	Norway register data	Introduction of early retirement scheme	DD and IV	Mortality (1) by age 67 (2) by age 70 (3) by age 74 (4) by age 77	0.002 (0.004) Table 4 (column 2) 0.002 (0.005) Table 4 (column 4) 0.025 (0.026) Table 4 (column 6) 0.066 (0.073) Table 4 (column 8)
Hallberg et al. (2015)	Sweden Military	Introduction of early retirement scheme	DD	Causes of death ages 56–70	Early retirement offer reduces mortality
Bloemen et al. (2017)	The Netherlands civil servant, men	Early retirement reform	IV	Mortality within 5 years	-0.026 (0.014) Table 2 (column 3)
Hagen (2018)	Sweden local government workers, women	Reform increasing incentives to retire later	DD	Mortality by age 69	0.000283 (0.000454) Table 9 (column 7)
Kuhn et al. (2019)	Austria blue-collar	Extension of early retirement scheme	DD and IV	Mortality (1) by age 73 for men (2) by age 73 for women	0.0185 (0.0073) Table 3 (column 1, IV) -0.0023 (0.0057) Table 3 (column 4, IV)
Zulkarnain and Rutledge (2018)	The Netherlands people born btw 1943 and 1954	Reform that induced delayed retirement	IV	5-year mortality rate (1) for men aged 62-65 (2) for women aged 62-65	-0.024 (0.008) Tables 4b and 4c (resp. columns 2 and 1) 0.005 (0.043) Table 4b (column 5)

Notes: We report the point-estimates for studies measuring the causal impact of later or earlier retirement on mortality. IV: instrumental variables. RDD: regression discontinuity design DD: difference-in-differences.

External Validity. All the studies exploiting exogenous changes of retirement age to assess its causal impact on health outcomes have the drawbacks to be local results, for which generalisation to other settings is problematic. Our study faces similar limits. First, the reform does not affect individuals with very long or very short careers, which means that our results concern only a subset of individuals with average career length. Individuals with such careers have particular socio-economic characteristics, which can be endogenous with health status. In particular, it is possible that detrimental impact of retirement on mortality could be found for individuals with very long careers. Second, this reform does not affect individuals eligible for disability pension. Individuals in poor health affected by the reform have been able to retire with disability pensions, and thus without postponing their claiming age.²⁰

On the other hand, our study shows the impact of increased retirement age for the population effectively affected by the reform, which carries out implications for a large part of wage earners with average career length, representing a large share of the population.

Quantification of the Effect in Relative Terms. We have found impact estimates that are non significant, of opposite sign, and relatively small in magnitude, even for MDE estimates. What is important to discuss is the economic significance of such results.

The minimum detectable effect is small in magnitude: a one quarter increase in claiming age, if having an impact on death probability, is lower than a probability to die by 0.0017 (Panel B). It is equivalent to an increase of the probability to die between 72 and 77 by 1.56%. This variation is lower than the variation of the death probability between ages 72 and 77 between cohorts 1932 and 1933 (1.59%); lower than the variation of the death rate at age 74 between cohorts 1933 and 1938 (13.24%). It means that if an effect on mortality occurs due to the reform that affect the youngest cohorts, who benefit from a higher life expectancy, this impact is lower than the mortality gain due to their cohort. Another comparison point could be with the impact of education on mortality. The variation we find is lower than the 3.6% decrease in 10 years mortality due to an additional year of education, according to Lleras-Muney (2005).

In light of these comparisons, our estimates suggest that increasing retirement age, around the age of 60, – for a population excluding those with very long or very short career length –, has no detrimental impact on mortality.

²⁰Bozio (2011a) shows a small share of treated individuals asks for a disability pension as a result of the reform.

Conclusion

This paper investigates the impact of delaying retirement on mortality among the French population. We take advantage of the 1993 pension reform in the private sector to identify the causal effect of an increase in claiming age on mortality. We use administrative data which provide detailed information on career characteristics, dates of birth and death. Our results show that an exogenous increase of the claiming age has no significant impact on the probability to die.

This effect is precisely estimated thanks to a large sample size and the strong explanatory power of the excluded instrument. To distinguish between power issues and really small effects, we use the minimal detectable effect procedure which has been largely ignored by the previous literature.

Our results show that a pension reform, which has succeeded in raising retirement age for a subgroup of the population, has done so without detrimental effects on mortality. This result does not extend to the mortality at older ages, and does not extend to the entire population, as the affected group may be healthier than the population average and did not include individuals with very long careers or very short ones.

Appendix to

Impact of Later Retirement on Mortality: Evidence from France

The following Appendix is in four parts. The first contains details on the institutional framework concerning the French pension system and the 1993 reform. The second contains details on the sample. The third contains details about the minimum detectable effect methodology. The last contains robustness checks, based on the construction of alternatives specifications.

A The Institutional Framework

In France, the pension system is a mandatory pay-as-you-go system. Pension amounts depend on the time workers contribute to this system and their best-earning years.

Replacement Rate. The full replacement rate is 0.5. If neither the required contribution length (D) nor the required age (i.e. 65) is reached, the replacement rate decreases by a δ factor for each missing quarter. Therefore, the replacement rate is computed as follows:

$$\tau = 0.5 - \delta \times \max[0, \min(4 \times (65 - a), D - d)] \quad (2.4)$$

where δ is the minimization coefficient, equals 1.25% per missing contributions quarter, a is the claiming age, d the number of contribution quarters and D , the needed quarters required for a full pension. Before 1993, parameter D was equal to 150 quarters (i.e. 37.5 years) and the pension amount paid was proportional to the average wages of the ten best-earning years. In 1993, the government led by Prime Minister E. Balladur chose to reform the pension system. Following the 1993 reform, D goes gradually from 150 to 160 depending on the cohort. This reform concerned only the private sector. The rules didn't change in other sectors.

The Political Context of the 1993 Pension Reform. The 1993 reform was the first one of the French pension system which aims at increasing the claiming age. Individuals were not expected this. The reform was adopted 22nd July 1993 during the summer holiday. The decree was published one month after the vote, i.e. 28th of August. The application was scheduled for the 1st January 1994. As there has not been any communication beforehand, individuals could absolutely not anticipate the reform and the ensuing consequences.

The Details of the 1993 Pension Reform. First, following the 1993 reform, the number of years of contributions required for a full pension was gradually raised from 37.5 to 40 years, cohort by cohort, starting with the 1934 generation. The number of contribution quarters required for a full pension increased by one quarter per year: 151 for the 1934 generation (in 1994) and so on, through to 160 for the 1943 generation (in 2003). Second, the reform raised gradually the number of years required for the pension amount calculation for each generation from 10 to 20 years. This last parameter does not vary within cohort. Third, the reference wage was indexed on prices starting from 1993, but this last measure does not vary by cohort. We exploit the variation between cohorts and within cohort to identify the causal effect of later retirement on mortality, thus we focus only on the first measure (see Table A2).

Table A1 – Progressive Increase in Required Contribution Length in Private Sector, due to the 1993 Reform.

Birth year	Nb of contr. quarters (to get a full pension)
1933 and before	150
1934	151
1935	152
1936	153
...	...
1942	159
1943 and after	160

Notes: Individuals born in 1933 or before, have to contribute 150 quarters to benefit for a full replacement rate, those born in 1934 have to contribute 151 quarters, and so on.

Table 2 presents the progressive increase in required contribution duration (D) following the reform, starting from 1934 cohort. Individuals born in 1933 or before, have to contribute 150 quarters to benefit from a full replacement rate. Cohort 1934 have to contribute 151 quarters to get a full pension, cohort 1935 have to contribute 152 quarters and so on, and so forth. Table A2 shows the number of additional quarters individuals have to contribute to get a full pension of each even cohort, depending on their contribution duration at 60. Individuals born in 1934 and who contribute between 131 and 150 quarters at age 60 are required to contribute one additional quarter following the reform ($\Delta RCL = 1$). Individuals born in 1936 and who contribute 131 or 152 quarters at age 60 are also required to contribute one additional quarter following the reform.

Table A2 – Variation of Required Contribution Length due to the Reform

Variation of required contribution length ΔRCL	Cohort	Contribution length at age 60
0	1930	All
	1932	All
	1934	$\in [0; 130] \cup [151; +\infty[$
	1936	$\in [0; 130] \cup [153; +\infty[$
	1938	$\in [0; 130] \cup [155; +\infty[$
	1940	$\in [0; 130] \cup [157; +\infty[$
	1942	$\in [0; 130] \cup [159; +\infty[$
1	1934	$\in [131; 151[$
	1936	$\in (\{131\}; \{152\})$
	1938	$\in (\{131\}; \{154\})$
	1940	$\in (\{131\}; \{156\})$
	1942	$\in (\{131\}; \{158\})$
2	1936	$\in (\{132\}; \{151\})$
	1938	$\in (\{132\}; \{153\})$
	1940	$\in (\{132\}; \{155\})$
	1942	$\in (\{132\}; \{157\})$
3	1936	$\in [133; 151[$
	1938	$\in (\{133\}; \{152\})$
	1940	$\in (\{133\}; \{154\})$
	1942	$\in (\{133\}; \{156\})$
4	1938	$\in [134; 151[$
	1940	$\in (\{134\}; \{153\})$
	1942	$\in (\{134\}; \{155\})$
5	1938	$\in [135; 151[$
	1940	$\in (\{135\}; \{152\})$
	1942	$\in (\{135\}; \{154\})$
6	1940	$\in (\{136\}; \{151\})$
	1942	$\in (\{136\}; \{153\})$
7	1940	$\in [137; 151[$
	1942	$\in (\{137\}; \{152\})$
8	1942	$\in (\{138\}; \{151\})$
9	1942	$\in [139; 151[$

Notes: Individuals born in 1934 and who contribute between 131 and 150 quarters at age 60 are required to contribute one additional quarter following the reform ($\Delta RCL = 1$). Individuals born in 1936 and who contribute 131 or 152 quarters at age 60 are also required to contribute one additional quarter following the reform.

B Data Details

This section presents the description of the Cnav data. We observe all retirees still alive, and all those who died between 2003 and 2017. Table B1 describes cohorts 1933 to 1943 observed in the data. For cohort 1933, Cnav data includes information about death between ages 71 and 84; for cohort 1934, information about death between ages 70 and 83. Given we observe mortality outcomes between 2004 and 2017 we do not observe mortality outcomes for the same ages for all the cohorts affected. As a result, we split our sample into two panels including individuals alive at the same age. In the first panel (Panel A), we observe the probability to die between 65 and 72 for individuals born between 1938 and 1943 (see Table B1). In the second panel (Panel B), we observe probability to die between 72 and 77 for individuals born between 1933 and 1938 (see Table B1).

We compare the sample characteristics to the national statistics from INSEE (the French institute of national statistics). Table B2 shows that the share of women is lower in our sample than in the INSEE data for Panel A and B respectively. Tables B3 and B4 shows the death probabilities per cohort.

Table B1 – Description of Cohorts

Year of birth	Death observed from age to age	
1933	71	84
1934	70	83
1935	69	82
1936	68	81
1937	67	80
1938	66	79
1939	65	78
1940	64	77
1941	63	76
1942	62	75
1943	61	74

Notes: For cohort 1933, Cnav data includes information about death between ages 71 and 84; for cohort 1934, information about death between ages 70 and 83.

Table B2 – Share of the Sample per Cohort and Gender

Year of birth	Men			Women			Total
	N	Share	% INSEE	N	Share	% INSEE	
Panel A : Cohort 1938 to 1943, alive at age 65							
1938	212,603	59.07	47.23	147,290	40.93	52.77	359,893
1939	218,937	58.89	47.57	152,834	41.11	52.42	371,771
1940	211,437	59.15	48.22	146,003	40.85	51.78	357,440
1941	197,403	58.32	48.59	141,102	41.68	51.41	338,505
1942	214,805	57.86	48.96	156,451	42.14	51.04	371,256
1943	228,502	57.21	49.01	170,891	42.79	50.99	399,393
Total	1,094,476	58.40	48.27	914,571	41.60	51.73	2,198,258
Panel B : Cohort 1933 to 1938, alive at age 72							
1933	169,199	55.78	44.87	134,125	44.22	55.13	303,324
1934	177,871	56.50	45.32	136,967	43.50	54.68	314,838
1935	179,575	57.10	45.74	134,926	42.90	54.26	314,501
1936	183,216	57.26	46.41	136,769	42.74	53.59	319,985
1937	183,191	57.20	46.90	137,047	42.80	53.10	320,238
1938	188,291	57.40	47.23	139,716	42.60	52.77	328,007
Total	1,081,343	56.89	45.28	819,550	43.11	54.72	1,900,893

Notes: This table shows the share of men and women in each cohort of our study. Individuals selected are those who contribute between 80 and 180 quarters, at least once in the private sector, and retire between ages 59 and 67. Moreover, panel A selects only individuals born between 1938 and 1943, and alive at age 65; panel B selects only individuals born between 1933 and 1938, alive at age 72. This table also shows national statistics from INSEE (the French institute of national statistics). Cohort 1933 in Panel B includes 303,324 individuals, and 56.89 % of them are men.

Source: Cnav Data and Insee data.

Table B3 – Death Rate by Cohort – Cohorts 1938 to 1943

year of birth	65 and 66		66 and 67		67 and 68		Between age 68 and 69		69 and 70		70 and 71		71 and 72	
	Panel A	Insee	Panel A	Insee	Panel A	Insee	Panel A	Insee	Panel A	Insee	Panel A	Insee	Panel A	Insee
1938	0.60	1.11	1.17	1.15	1.28	1.21	1.35	1.28	1.42	1.36	1.50	1.45	1.54	1.52
1939	1.05	1.07	1.16	1.11	1.25	1.18	1.36	1.30	1.44	1.36	1.43	1.41	1.53	1.51
1940	1.05	1.04	1.17	1.08	1.21	1.13	1.29	1.24	1.32	1.27	1.44	1.40	1.49	1.49
1941	1.04	1.02	1.14	1.09	1.19	1.14	1.29	1.24	1.33	1.31	1.37	1.40	1.46	1.48
1942	1.07	1.02	1.16	1.09	1.19	1.14	1.19	1.18	1.29	1.26	1.38	1.39	1.46	1.46
1943	1.05	1.03	1.11	1.07	1.19	1.15	1.23	1.21	1.29	1.30	1.33	1.37	1.44	1.47
Total	0.798		1.15		1.22		1.28		1.35		1.41		1.48	

Notes: This table shows the death rate per cohort for individuals selected in Panel A, and compared to death rate in the whole French population. Individuals selected are those who contribute between 80 and 180 quarters, at least once in the private sector, and retire between ages 59 and 67, alive at age 65. 0.60% individuals born in 1938 in Panel A died between ages 65 and 66, which is lower than the French death rate for this cohort (1.11% for the cohort 1938).

Source: Cnav 2017 and Insee life table by cohort data.

Table B4 – Death Rate by Cohort – Cohorts 1933 to 1938

year of birth	72 and 73		73 and 74		Between ages 74 and 75		75 and 76		76 and 77	
	Panel B	Insee	Panel B	Insee	Panel B	Insee	Panel B	Insee	Panel B	Insee
1933	2.00	1.87	2.15	1.20	2.24	2.15	2.40	2.39	2.54	2.59
1934	1.97	1.82	2.10	1.96	2.19	2.11	2.30	2.25	2.42	2.43
1935	1.94	1.78	2.05	1.92	2.18	2.05	2.31	2.22	2.44	2.41
1936	1.97	1.78	1.94	1.83	2.05	1.95	2.21	2.15	2.38	2.38
1937	1.88	1.71	1.95	1.83	2.07	1.95	2.23	2.15	2.29	2.28
1938	1.80	1.67	1.90	1.79	2.02	1.91	2.11	2.06	2.29	2.31
Total	1.92		2.01		2.12		2.26		2.39	

Notes: This table shows the death rate by cohort for individuals selected in panel B, and compared to death rate in the whole French population. Individuals selected are those who contribute between 80 and 180 quarters, at least once in the private sector, and retire between ages 59 and 67, alive at age 72. 2% individuals born in 1933 in panel B died between ages 72 and 73, which is higher than the french death rate for this cohort (1.87% for the cohort 1933).

Source: Cnav 2017 and Insee life table by cohort data.

Table B5 shows the number of individuals affected by the reform per number of additional quarters they had to contribute following the reform. Individuals selected are those who contribute between 80 and 180 quarters, at least once in the private sector and who retire between ages 59 and 67. In Panel A, there are 288,625 individuals born in 1938 who do not have to contribute more following the reform and 46,140 individuals who have to contribute five additional quarters to get a full pension. In Panel B, there are 51,219 individuals born in 1934 who have to contribute one additional quarter to get a full pension.

Table B5 – Share of Each Cohort Affected by the Reform

Year of birth	Added quarter required due to the reform										
	0	1	2	3	4	5	6	7	8	9	10
Panel A											
1938	288,625	6,325	6,539	6,478	5,786	46,140	0	0	0	0	
1939	293,831	6,742	6,883	6,435	6,620	6,177	45,083	0	0	0	0
1940	276,442	6,911	6,941	6,318	6,377	6,590	6,560	41,301	0	0	0
1941	258,179	6,515	7,149	6,229	6,336	5,943	6,386	5,701	36,067	0	0
1942	278,258	7,345	7,884	7,210	6,812	6,599	7,243	6,800	6,267	36,838	0
1943	292,844	8,243	8,559	7,909	7,867	7,469	7,847	7,341	7,534	6,903	36,877
Total	1,688,179	42,081	43,955	40,579	39,798	78,918	73,119	61,143	49,868	43,741	36,877
% Total	76.80	1.91	2.00	1.85	1.81	3.59	3.33	2.78	2.27	1.99	1.68
Panel B											
1933	303,324	0	0	0	0	0	0	0	0	0	0
1934	263,619	51,219	0	0	0	0	0	0	0	0	0
1935	261,162	5,407	47,932	0	0	0	0	0	0	0	0
1936	262,654	5,869	5,764	45,698	0	0	0	0	0	0	0
1937	259,601	5,515	6,027	5,318	43,777	0	0	0	0	0	0
1938	262,686	5,770	5,999	5,913	5,294	42,345	0	0	0	0	0
Total	1,613,046	73,780	65,722	56,929	49,071	42,345	0	0	0	0	0
% Total	84.86	3.88	3.46	2.99	2.58	2.23	0	0	0	0	0

Notes: This table shows the number of individuals affected by the reform, by number of added quarter they had to contribute following the reform. Individuals selected are those who contribute between 80 and 180 quarters, at least once in the private sector, and retire between ages 59 and 67. Panel A selects only individuals born between 1938 and 1943 and alive at retirement; Panel B selects only individuals born between 1933 and 1938, alive at age 72. In Panel A, there are 288,625 individuals born in 1938 who do not have to contribute more following the reform and 46,140 individuals who have to contribute five additional quarters following the reform if they want a full replacement rate. *Source:* Cnav data.

C Minimum Detectable Effect Analysis

In statistics, there are two types of error when testing if hypothesis H_0 , "the result is zero" against H_1 , "The result is different from zero" (see Table C1):

- The error type I, which is the probability of rejecting the null hypothesis whereas it is true;
- the error II type which is the probability of accepting the null hypothesis whereas it is false.

Table C1 – The Two Types of Error when Testing H_0

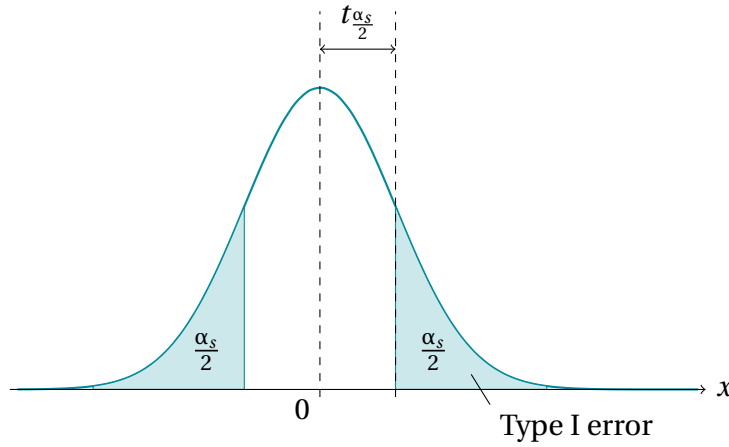
		True Value	
		H_0 is true	H_1 is true
Measured Value	H_0 is accepted	OK	Error type II
	H_0 is rejected	Error type I	OK

The error type I is always tested through the p-value computation. Thus, a significant result at the 5% level means that the probability making a mistake when assuming $H_1 : \beta \neq 0$ is lower than 5%. We use the p-value to test the probability to make type I error:

$$P\left(\left|\frac{\hat{\beta}}{\sigma_{\hat{\beta}}}\right| < t_{\frac{\alpha}{2}}\right) = 1 - \alpha \Leftrightarrow P\left(-t_{\frac{\alpha}{2}} < \frac{\hat{\beta}}{\sigma_{\hat{\beta}}} < t_{\frac{\alpha}{2}}\right) = 1 - \alpha$$

If $\left|\frac{\hat{\beta}}{\sigma_{\hat{\beta}}}\right| > t_{\frac{\alpha}{2}}$, we reject the null hypothesis at the α level. In other words, if $\frac{\hat{\beta}}{\sigma_{\hat{\beta}}} \geq t_{\frac{\alpha}{2}} \cup \frac{\hat{\beta}}{\sigma_{\hat{\beta}}} \leq -t_{\frac{\alpha}{2}}$, the probability to make a mistake rejecting H_0 hypothesis is lower than 5% (type I error).

Figure C1 – Graphical Representation of Type I Error – 2 Tailed-test



Notes: This is the distribution of Y under the H_0 hypothesis. Blue areas are the probability of making type I error (ie. accepting H_1 wheareas it is false).

When a result is non significant, we face a risk of making a type II error, a much more forgotten type of error in economics studies. The error type II is the probability of accepting $H_0: \beta = 0$ while it is false. Usually, we use a 20% power threshold.

The power analysis test for this type of error is:

$$P\left(\left|\frac{\hat{\beta}}{\sigma_{\hat{\beta}}}\right| \geq t_{\frac{\alpha}{2}} \mid \beta\right) = \kappa \Leftrightarrow P\left(\frac{\hat{\beta}}{\sigma_{\hat{\beta}}} \geq t_{\frac{\alpha}{2}} \cup \frac{\hat{\beta}}{\sigma_{\hat{\beta}}} \leq -t_{\frac{\alpha}{2}} \mid \beta\right) = \kappa$$

This formula can be simplify while the statistical power is compute either under the assumption of beta positive or negative but never both. As a proof, consider A, the event " $\frac{\hat{\beta}}{\sigma_{\hat{\beta}}} \geq t_{\frac{\alpha}{2}}$ " and B the event " $\frac{\hat{\beta}}{\sigma_{\hat{\beta}}} \leq -t_{\frac{\alpha}{2}}$ "

$$\Leftrightarrow P(A \cup B \mid \beta) = \kappa$$

knowing that $A \cap B = \emptyset$, $P(A \cup B \mid \beta) = \kappa \Rightarrow P(A \mid \beta) + P(B \mid \beta) = \kappa$. Moreover, this two probabilities are conditional to β . Consequently, $P(A \mid \beta) \neq 0 \Rightarrow P(B \mid \beta) = 0$ and $P(B \mid \beta) \neq 0 \Rightarrow P(A \mid \beta) = 0$. Graphically, that is equivalent to assume the H_1 distribution is either on the right or on the left to the H_0 distribution, but cannot be on both sides (see Figure C2).

So that, if $\hat{\beta} > 0$ but not significant, $P(A \cup B \mid \beta) = \kappa \Rightarrow P(A \mid \beta) = \kappa$ and if $\hat{\beta} < 0$ but not significant, $P(A \cup B \mid \beta) = \kappa \Rightarrow P(B \mid \beta) = \kappa$.

The following details are considering the case $\hat{\beta} > 0$ but not significant.

$$P(A \mid \beta) = \kappa \Leftrightarrow P\left(\frac{\hat{\beta}}{\sigma_{\hat{\beta}}} \geq t_{\frac{\alpha}{2}} \mid \beta\right) = k$$

$$\begin{aligned}
 &\Leftrightarrow P\left(\left(\frac{\hat{\beta}-\beta}{\sigma_{\hat{\beta}}}\geq t_{\frac{\alpha}{2}}-\frac{\beta}{\sigma_{\hat{\beta}}}\right)|\beta\right)=k \\
 &\Leftrightarrow \Phi\left(\frac{\beta}{\sigma_{\hat{\beta}}}-t_{\frac{\alpha}{2}}\right)=1-k \\
 &\Rightarrow \frac{\beta}{\sigma_{\hat{\beta}}}-t_{\frac{\alpha}{2}}=t_{1-\kappa}\Leftrightarrow \frac{\beta}{\sigma_{\hat{\beta}}}=t_{1-\kappa}+t_{\frac{\alpha}{2}} \\
 &\Leftrightarrow \beta=\left(t_{1-\kappa}+t_{\frac{\alpha}{2}}\right)\sigma_{\hat{\beta}}
 \end{aligned}$$

If $\hat{\beta} > 0$, The minimum detectable effect is $\left(t_{1-\kappa}+t_{\frac{\alpha}{2}}\right)\sigma_{\hat{\beta}}$.

The following details are considering the case $\hat{\beta} < 0$ but not significant.

$$\begin{aligned}
 P(B|\beta) &= \kappa \Leftrightarrow P\left(\left(\frac{\hat{\beta}}{\sigma_{\hat{\beta}}}\leq -t_{\frac{\alpha}{2}}\right)|\beta\right)=k \\
 &\Leftrightarrow P\left(\left(\frac{\hat{\beta}-\beta}{\sigma_{\hat{\beta}}}\leq -t_{\frac{\alpha}{2}}-\frac{\beta}{\sigma_{\hat{\beta}}}\right)|\beta\right)=k \\
 &\Leftrightarrow \Phi\left(\frac{\beta}{\sigma_{\hat{\beta}}}+t_{\frac{\alpha}{2}}\right)=1-k \\
 &\Rightarrow \frac{\beta}{\sigma_{\hat{\beta}}}+t_{\frac{\alpha}{2}}=t_{1-\kappa}\Leftrightarrow \frac{\beta}{\sigma_{\hat{\beta}}}=t_{1-\kappa}-t_{\frac{\alpha}{2}} \\
 &\Leftrightarrow \beta=\left(t_{1-\kappa}-t_{\frac{\alpha}{2}}\right)\sigma_{\hat{\beta}}
 \end{aligned}$$

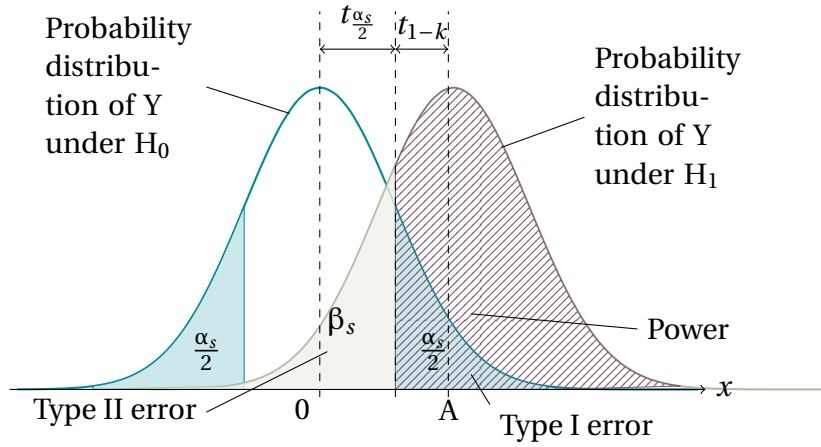
If $\hat{\beta} < 0$, the minimum detectable effect is $\left(t_{1-\kappa}-t_{\frac{\alpha}{2}}\right)\sigma_{\hat{\beta}}$.

The minimum detectable effect (MDE) is the smallest effect we could detect taking into account the probability of being in the treatment group, the size and the variance of the sample. The higher the MDE, the lower the power.

The green curve in Figure C1 is the β distribution under the assumption H_1 is true ($\beta \neq 0$). For a β_s significance level, H_1 will be rejected if the distribution is in the green area (type II error). Consequently, the power of our test is the red dashed area.

In this paper, we want to test the hypothesis H_0 : "the effect of delaying retirement due to the reform on mortality is equal to 0" against the alternative hypothesis H_1 "the effect of delaying retirement due to the reform is different from 0". This computation is interesting for the following sample: first for the estimation of the impact of delaying retirement on mortality for cohort 1938 to 1943, because of the non significant negative impact we found (-0.00035, with a standard error of 0.00044) and second for the impact of delaying retire-

Figure C2 – Graphical Representation of Statistical Power



ment on mortality respectively for men and women born between 1933 to 1938 with non significant impacts of resp. 0.000884 (standard error: 0.00011), and 0.00102 (standard error: 0.000858). In each case, we would like to know if the non significant result is due to a lack power or can be interpreted as a null effect. Thus, we compute the MDE for each sub-sample.

$$\beta_1 > \underbrace{(t_{1-k} + t_{\alpha/2})SE(\hat{\beta}_1)}_{\text{Minimum Detectable Effect}} \quad (2.5)$$

where $t_{1-k} + t_{\alpha/2} = 0.84 + 1.96 = 2.80$ (or $t_{1-k} - t_{\alpha/2} = 0.84 - 1.96 = -1.12$), according to student table²¹, for a two-tailed test at the 5% level and a power of 20%.

Table C2 – Minimum Detectable Effect

Specification	$\hat{\beta}$	SE	N	MDE	Variation in mortality
Panel A - All	-0.00035	0.00044	2,198,258	-0.00049	-0.54%
Panel A - Men	0.00006	0.0006	1,283,687	0.00168	1.87%
Panel A - Women	-0.0007	0.0006	914,571	-0.000672	-0.75%
Panel B - All	0.00068	0.00062	1,900,893	0.001736	1.59%
Panel B - Men	0.00011	0.00081	1,081,343	-0.00413728	-3.79%
Panel B - Women	0.00128	0.00101	819,550	0.002828	2.59%

Notes: In Panel A, composed by all individuals born between 1938 and 1943, considering the sample size and the share of treated, the smallest effect we could detect is -0.00049. So that, an effect non significant but higher than -0.00049 can lead to the conclusion of an absence of effect but we cannot conclude on a non significant effect lower than -0.00049. This -0.00049 effect is equivalent to a variation of death probability by -0.54%.

²¹See, for example Bloom (1995) for Student table.

D Robustness Checks

We rerun the 2SLS regressions on the EIR data, which contains information on socio-demographics characteristics. EIR data includes individuals from all pension schemes, born in early October of each even years. We select individuals who contribute the major part of their career to the private sector, born in 1934 or 1938 and alive at 70. This data contains information on gender, year of birth, contribution length, reference wages, marital status, children or not and professions.

Table D1 shows the results are virtually unchanged whatever the specification, i.e. with or without socio-demographics controls.

Table D1 – Effect of Claiming Age (2nd Stage) with EIR Data - with and without Control for Individual Characteristics

	(1)	(2)	(3)	(4)	(5)
	Without control	Marital status	Profession	Children	All
Claiming age	0.00432 (0.00513)	0.00424 (0.00515)	0.00434 (0.00516)	0.00436 (0.00515)	0.00426 (0.00519)
N	11,809	11,809	11,809	11,809	11,809

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: We select from EIR data individuals who have contributed the major part of their career to the private pension scheme, born in 1934 and 1938, have contributed between 80 and 180 quarters at age 60, are alive at age 70. Death probability is between ages 70 and 74. The first model "without control" control only for variables we have in CNAV data: gender, year of birth, contribution length at age 60 and reference wage. The second model "marital status" add controls for being widow and being married. The third model "Profession" add controls for being farmer and being an executive. The fourth model add control for having at least three children. The last model includes controls for marital status, profession, and children. It shows the estimated impact of an exogenous increase of claiming age on mortality does not change when adding controls for socio-economic characteristics.

Source: EIR data 2004, 2008 and 2012. This is a French administrative dataset, representative of French retirees. There has been one EIR wave every four years since 1988. Each EIR wave includes all retirees born in early October of an even year of birth. It contains all the information collected by pension schemes, necessary for benefit computation (contribution length, reference wage, claiming age, etc.) and some socio-demographics variables (marital status, number of children, being a past farmer, being a past executive)

Table D2 shows the causal effect of claiming age on mortality at one year, at two, three, four, five and six years respectively. An exogenous increase of claiming age by one quarter has no significant impact on mortality at one year, whatever the age. The effect is never significant at 5%, i.e. the conventional level.

Tables D3 and D4 present the results, controlling for heterogeneous impact of the reform.

Table D3 presents the OLS regression 2.6 of the impact of the 1993 pension reform on the claiming age, allowing for non-linear impact of the reform, and with control for contribution length at age 60, cohort, gender, and reference wage.

$$A_i = \alpha_0 + \sum_{r=0}^{10} \alpha_{2,r} \mathbb{1}(\Delta RCL_i = r) + \sum_g \alpha_{2,g} \mathbb{1}(yob_i = g) + \sum_t \alpha_{3,t} \mathbb{1}(CL_{60_i} = t) + \alpha_4 X_i + \zeta_i \quad (2.6)$$

Table D2 – Effect of Claiming Age on the Probability to Die - 2SLS - by Age Range

	72 and 73	73 and 74	74 and 75	75 and 76	76 and 77
Claiming age	0.000532* (0.000276)	0.0000482 (0.000282)	-0.000336 (0.000288)	0.000148 (0.000302)	0.000361 (0.000308)
N	1,900,893	1,900,893	1,900,893	1,900,893	1,900,893

	65 and 66	66 and 67	67 and 68	68 and 69	69 and 70	70 and 71
Claiming age	-0.000163 (0.000164)	0.000295* (0.000170)	0.000157 (0.000173)	-0.000124 (0.000179)	-0.0000399 (0.000185)	-0.000316* (0.000188)
N	2,198,258	2,198,258	2,198,258	2,198,258	2,198,258	2,198,258

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This is the second stage of 2SLS. Individuals selected are those who have contributed between 80 and 180 quarters, at least once in the private sector, and retired between ages 59 and 67. Panel A includes individuals born between 1938 and 1943, and alive at retirement; Panel B includes individuals born between 1933 and 1938, alive at age 72.

An exogenous increase of claiming age by one quarter has a no significant impact on mortality between ages 73 and 74.

Source: Cnav data.

Individuals selected are those who contributed between 80 and 180 quarters, at least once in the private sector, and retired between ages 59 and 67. Panel A selects only individuals born between 1938 and 1943, and alive at age 65. Panel B selects only individuals born between 1933 and 1938, alive at age 72. It shows all cohorts affected, both in Panel A and B, answer to the incentive to retire later. The intensity of the reaction increases with the intensity of the incentive. Taking into account these heterogeneous treatment effects does not change the results (see Table D5).

Table D4 presents the OLS regression of the impact of the reform on mortality (reduced form), allowing non-linear association between the variation of required contribution length due to the reform and mortality. This regression controls for contribution length at age 60, cohort, gender, and reference wage. Individuals selected are those who had contributed between 80 and 180 quarters, at least once in the private sector, and retired between ages 59 and 67. Panel A (resp. B) selects only individuals born between 1938 and 1943, and alive at age 65 (resp. born between 1933 and 1938, alive at age 72). Table D4 shows there is no significant impact on mortality at 5% when we allow heterogeneous effects – see column "All" of each panel.

Table D3 – Effect of the Reform on Claiming Age
– Control for Heterogeneous Treatment Effect

	Panel A: 1938 - 1943			Panel B: 1933 - 1938		
	All	Men	Women	All	Men	Women
$\Delta RCL = 0$	<i>Ref.</i>	.	.	<i>Ref.</i>	.	.
$\Delta RCL = 1$	1.840*** (0.0394)	1.847*** (0.0470)	1.856*** (0.0673)	0.873*** (0.0304)	1.004*** (0.0419)	0.724*** (0.0449)
$\Delta RCL = 2$	2.596*** (0.0427)	2.659*** (0.0513)	2.545*** (0.0721)	1.420*** (0.0325)	1.695*** (0.0454)	1.081*** (0.0476)
$\Delta RCL = 3$	3.359*** (0.0469)	3.443*** (0.0561)	3.292*** (0.0798)	1.898*** (0.0349)	2.196*** (0.0484)	1.515*** (0.0511)
$\Delta RCL = 4$	4.022*** (0.0512)	4.191*** (0.0615)	3.824*** (0.0865)	2.316*** (0.0377)	2.790*** (0.0519)	1.750*** (0.0557)
$\Delta RCL = 5$	4.480*** (0.0534)	4.803*** (0.0646)	4.118*** (0.0894)	2.866*** (0.0407)	3.421*** (0.0559)	2.196*** (0.0603)
$\Delta RCL = 6$	5.344*** (0.0562)	5.735*** (0.0681)	4.878*** (0.0939)			
$\Delta RCL = 7$	6.085*** (0.0587)	6.551*** (0.0713)	5.489*** (0.0979)			
$\Delta RCL = 8$	6.580*** (0.0613)	7.037*** (0.0746)	6.017*** (0.102)			
$\Delta RCL = 9$	6.860*** (0.0636)	7.311*** (0.0775)	6.330*** (0.106)			
$\Delta RCL = 10$	6.995*** (0.0659)	7.478*** (0.0805)	6.476*** (0.109)			
N	2,198,258	1,283,687	914,571	1,900,893	1,081,343	819,550

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table presents the OLS regression of the impact of the 1993 pension reform on the claiming age, allowing non-linear impact of the reform, and with control for contribution length at age 60, cohort, gender, and reference wage. Individuals selected are those who contributed between 80 and 180 quarters, at least once in the private sector, and retired between ages 59 and 67. Panel A selects only individuals born between 1938 and 1943, and alive at age 65. Panel B selects only individuals born between 1933 and 1938, alive at age 72. It shows all cohorts affected, both in Panel A and B, answer to the incentive to retire later. The intensity of the reaction increases with the intensity of the incentive.

Source: Cnav data.

Table D4 – Effect of the Reform on the Mortality – Reduced Form with Non-linear Effect

	Panel A: 1938 - 1943			Panel B: 1933 - 1938		
	All	Men	Women	All	Men	Women
$\Delta RCL = 0$	<i>Ref.</i>	.	.	<i>Ref.</i>	.	.
$\Delta RCL = 1$	-0.000401 (0.00196)	-0.00330 (0.00282)	0.00501** (0.00250)	0.00281* (0.00161)	0.00227 (0.00251)	0.00244 (0.00195)
$\Delta RCL = 2$	-0.00272 (0.00213)	-0.00619** (0.00307)	0.00348 (0.00268)	0.000946 (0.00170)	-0.0000422 (0.00267)	0.00114 (0.00206)
$\Delta RCL = 3$	-0.00299 (0.00234)	-0.00339 (0.00336)	-0.000789 (0.00296)	0.00150 (0.00179)	0.00166 (0.00281)	0.000404 (0.00217)
$\Delta RCL = 4$	-0.00266 (0.00255)	-0.00209 (0.00369)	-0.00224 (0.00321)	0.00152 (0.00192)	0.000451 (0.00297)	0.00169 (0.00236)
$\Delta RCL = 5$	-0.00354 (0.00266)	-0.00323 (0.00387)	-0.00211 (0.00332)	0.00328 (0.00204)	0.000959 (0.00313)	0.00480* (0.00253)
$\Delta RCL = 6$	-0.00224 (0.00280)	-0.000242 (0.00408)	-0.00267 (0.00349)			
$\Delta RCL = 7$	-0.00473 (0.00293)	-0.00281 (0.00428)	-0.00508 (0.00364)			
$\Delta RCL = 8$	-0.00467 (0.00306)	-0.00137 (0.00447)	-0.00688* (0.00379)			
$\Delta RCL = 9$	-0.00248 (0.00317)	-0.000908 (0.00464)	-0.00249 (0.00392)			
$\Delta RCL = 10$	-0.00325 (0.00329)	-0.00172 (0.00483)	-0.00268 (0.00405)			
N	2,198,258	1,283,687	914,571	1,900,893	1,081,343	819,550

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table presents the OLS regression of the impact of the reform on mortality (reduced form), allowing non-linear association between the variation of required contribution length due to the reform and mortality. This regression controls for contribution length at age 60, cohort, gender, and reference wage. Individuals selected are those who had contributed between 80 and 180 quarters, at least once in the private sector, and retired between ages 59 and 67. Moreover, Panel A selects only individuals born between 1938 and 1943, and alive at age 65. Panel B selects only individuals born between 1933 and 1938, alive at age 72.

Source: Cnav data.

Table D5 – Effect of Later Retirement on Mortality
– Control for Heterogeneous Treatment Effect

	All	Men	Women
Panel A: 1938 to 1943			
Claiming age	-0.000519 (0.000397)	-0.000270 (0.000544)	-0.000441 (0.000535)
N	2,198,258	1,283,687	914,571
Panel B: 1933 to 1938, alive at age 72			
Claiming age	0.000759 (0.000618)	0.000164 (0.000800)	0.00131 (0.000994)
N	1,900,893	1,081,343	819,550

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table presents the second stage of 2SLS regression of the impact of later retirement on mortality, allowing for non-linear impact of the reform, and with control for contribution length at age 60, cohort, gender, and reference wage. Individuals selected are those who had contributed between 80 and 180 quarters, at least once in the private sector, and retired between ages 59 and 67. Panel A selects only individuals born between 1938 and 1943, and alive at age 65. Panel B includes only individuals born between 1933 and 1938, alive at age 72.

Source: Cnav data.

Table D6 – Effect of Later Retirement on Mortality
– Using Other Specifications

	(1) iv-Probit	(2) Pseudo 2SLS	(3) iv-GMM	(4) RF probit	(5) RF logit
Panel A: 1938 to 1943, alive at age 65					
Claiming age	0.00417 (0.00277)	0.00783 (0.00566)	0.000647 (0.000440)		
Reform				0.00254 (0.00184)	0.00506 (0.00366)
N	2,198,258	2,198,258	2,198,258	2,198,258	2,198,258
Panel B: 1930 to 1938, alive at age 72					
Claiming age	0.00569 (0.00351)	0.0104 (0.00682)	0.00122* (0.000628)		
Reform				0.00326* (0.00197)	0.00582 (0.00382)
N	1,900,893	1,900,893	1,900,893	1,900,893	1,900,893

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table presents the results using IV-probit (1); Pseudo 2SLS (2), ie, the first stage is a OLS regression, the second stage is a Logit regression, using the claiming age estimated at the first stage as a dependant variable; IV GMM (3); and reduced form using a probit (4) and using a logit (5). All the regressions include controls for contribution length at age 60, cohort, gender, and reference wage. Individuals selected are those who had contributed between 80 and 180 quarters, at least once in the private sector, and retired between ages 59 and 67. Panel A selects only individuals born between 1938 and 1943, and alive at age 65. Panel B includes only individuals born between 1933 and 1938, alive at age 72.

Source: Cnav data.

Table D7 – Effect of Later Retirement on Mortality
– by Reference Wage Quartile

		1st quartile	2nd quartile	3rd quartile	4th quartile
Panel A: 1938 to 1943, alive at age 65					
All	Claiming age	-0.00000801 (0.000794)	0.00106 (0.00106)	-0.000636 (0.000821)	0.000327 (0.000651)
	N	554,078	551,869	549,182	543,129
Men	Claiming age	-0.00107 (0.00116)	-0.000702 (0.00140)	-0.00197* (0.00107)	-0.000313 (0.000845)
	N	320,922	322,215	320,413	320,137
Women	Claiming age	0.000968 (0.00113)	-0.00253* (0.00136)	0.000401 (0.00114)	-0.000738 (0.000835)
	N	232,902	229,361	223,747	228,561
Panel B: 1933 to 1938, alive at age 72					
All	Claiming age	0.00320* (0.00172)	0.00159 (0.00174)	-0.000134 (0.00118)	-0.000777 (0.000911)
	N	479,408	478,472	471,662	471,351
Men	Claiming age	0.00425* (0.00230)	-0.00306 (0.00201)	-0.00220 (0.00166)	-0.000308 (0.00109)
	N	271,416	270,123	274,609	265,195
Women	Claiming age	-0.000374 (0.00233)	0.00773** (0.00381)	-0.00173 (0.00169)	0.00209* (0.00123)
	N	209,821	204,590	201,574	203,565

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table presents the second stage of 2SLS regression, by reference wage quartile, of the impact of later retirement on mortality, with control for contribution length at age 60, cohort, gender, and reference wage. Individuals selected are those who had contributed between 80 and 180 quarters, at least once in the private sector, and retired between ages 59 and 67. Panel A selects only individuals born between 1938 and 1943, and alive at age 65. Panel B includes only individuals born between 1933 and 1938, alive at age 72.

Source: Cnav data.

Table D8 – Main Results with the Detail of Control Variables – Cohort 1933 to 1938, All

	Naive analysis	Reduced form	1 st stage	2 nd stage
Claiming age (in quarter)	-0.00045*** (0.00004) 0.00000			0.00068 (0.00062) 0.27362
Number of added quarters		0.00038 (0.00035) 0.27354	0.56020*** (0.00684) 0.00000	
Born in 1933	(Ref.)	(Ref.)	(Ref.)	(Ref.)
born in 1934	-0.00353*** (0.00080) 0.00001	-0.00368*** (0.00080) 0.00000	0.07040*** (0.01454) 0.00000	-0.00373*** (0.00081) 0.00000
born in 1935	-0.00434*** (0.00080) 0.00000	-0.00463*** (0.00081) 0.00000	0.11107*** (0.01465) 0.00000	-0.00470*** (0.00083) 0.00000
born in 1936	-0.00776*** (0.00079) 0.00000	-0.00819*** (0.00082) 0.00000	0.16740*** (0.01484) 0.00000	-0.00830*** (0.00085) 0.00000
born in 1937	-0.00870*** (0.00079) 0.00000	-0.00925*** (0.00083) 0.00000	0.20377*** (0.01506) 0.00000	-0.00939*** (0.00088) 0.00000
born in 1938	-0.01135*** (0.00078) 0.00000	-0.01205*** (0.00085) 0.00000	0.31220*** (0.01534) 0.00000	-0.01227*** (0.00094) 0.00000
Pension	-0.00000*** (0.00000) 0.00000	-0.00000*** (0.00000) 0.00000	0.00004*** (0.00000) 0.00000	-0.00000*** (0.00000) 0.00000
Disability pension	-0.06660*** (0.00077) 0.00000	-0.06967*** (0.00071) 0.00000	6.93274*** (0.01414) 0.00000	-0.07442*** (0.00437) 0.00000
Woman	-0.07822*** (0.00052) 0.00000	-0.07812*** (0.00053) 0.00000	-0.21539*** (0.01409) 0.00000	-0.07797*** (0.00055) 0.00000
N	1,900,893	1,900,893	1,900,893	1,900,893

Notes: This table presents the main results with the detail of coefficients for the following control variables: cohort, gender, reference wage and a dummy for being recipient of a disability pension. The regressions also include control for contribution length at age 60. Individuals selected are those who had contributed between 80 and 180 quarters, at least once in the private sector, and retired between ages 59 and 67, born between 1933 and 1938, alive at age 72.

Source: Cnav data.

Table D9 – Main Results with the Detail of Control Variables – Cohort 1933 to 1938, Men

	Naive analysis	Reduced form	1 st stage	2 nd stage
Claiming age (in quarter)	-0.00094*** (0.00007) 0.00000			0.00011 (0.00081) 0.89240
Number of added quarters		0.00007 (0.00054) 0.89240	0.67153*** (0.00941) 0.00000	
Born in 1933	(Ref.)	(Ref.)	(Ref.)	(Ref.)
Born in 1934	-0.00631*** (0.00119) 0.00000	-0.00645*** (0.00120) 0.00000	0.00357 (0.01724) 0.83617	-0.00645*** (0.00120) 0.00000
Born in 1935	-0.00653*** (0.00119) 0.00000	-0.00671*** (0.00121) 0.00000	-0.06295*** (0.01723) 0.00026	-0.00670*** (0.00120) 0.00000
Born in 1936	-0.01104*** (0.00118) 0.00000	-0.01134*** (0.00121) 0.00000	-0.05656*** (0.01746) 0.00120	-0.01133*** (0.00120) 0.00000
Born in 1937	-0.01328*** (0.00118) 0.00000	-0.01370*** (0.00123) 0.00000	-0.04065** (0.01768) 0.02151	-0.01369*** (0.00122) 0.00000
Born in 1938	-0.01656*** (0.00116) 0.00000	-0.01719*** (0.00125) 0.00000	0.06334*** (0.01799) 0.00043	-0.01719*** (0.00127) 0.00000
Pension	-0.00000*** (0.00000) 0.00000	-0.00000*** (0.00000) 0.00000	0.00003*** (0.00000) 0.00000	-0.00000*** (0.00000) 0.00000
Disability pension	-0.08887*** (0.00124) 0.00000	-0.09372*** (0.00119) 0.00000	5.17721*** (0.01877) 0.00000	-0.09429*** (0.00432) 0.00000
N	1,081,343	1,081,343	1,081,343	1,081,343

Notes: This table presents the main results with the detail of coefficients for the following control variables: cohort, gender, reference wage and a dummy for being recipient of a disability pension. The regressions also include control for contribution length at age 60. Individuals selected are men who had contributed between 80 and 180 quarters, at least once in the private sector, and retired between ages 59 and 67, born between 1933 and 1938, alive at age 72.

Source: Cnav data.

Table D10 – Main Results with the Detail of Control Variables – Cohort 1933 to 1938, Women

	Naive analysis	Reduced form	1 st stage	2 nd stage
Claiming age (in quarter)	-0.00039*** (0.00004) 0.00000			0.00128 (0.00101) 0.20561
Number of added quarters		0.00055 (0.00043) 0.20540	0.42517*** (0.01013) 0.00000	
Born in 1933	(Ref.)	(Ref.)	(Ref.)	(Ref.)
Born in 1934	0.00003 (0.00099) 0.97533	-0.00018 (0.00100) 0.85800	0.15056*** (0.02438) 0.00000	-0.00037 (0.00102) 0.71662
Born in 1935	-0.00156 (0.00099) 0.11595	-0.00198** (0.00101) 0.04908	0.32803*** (0.02483) 0.00000	-0.00240** (0.00112) 0.03149
Born in 1936	-0.00335*** (0.00098) 0.00065	-0.00396*** (0.00102) 0.00010	0.44278*** (0.02522) 0.00000	-0.00453*** (0.00122) 0.00020
Born in 1937	-0.00229** (0.00098) 0.02003	-0.00306*** (0.00104) 0.00335	0.50721*** (0.02573) 0.00000	-0.00372*** (0.00131) 0.00461
Born in 1938	-0.00376*** (0.00098) 0.00011	-0.00471*** (0.00106) 0.00001	0.61937*** (0.02626) 0.00000	-0.00551*** (0.00143) 0.00012
Pension	-0.00000*** (0.00000) 0.00000	-0.00000*** (0.00000) 0.00000	0.00005*** (0.00000) 0.00000	-0.00000*** (0.00000) 0.00000
Disability pension	-0.04555*** (0.00090) 0.00000	-0.04880*** (0.00080) 0.00000	8.42691*** (0.01970) 0.00000	-0.05960*** (0.00855) 0.00000
N	819,550	819,550	819,550	819,550

Notes: This table presents the main results with the detail of coefficients for the following control variables: cohort, gender, reference wage and a dummy for being recipient of a disability pension. The regressions also include control for contribution length at age 60. Individuals selected are women who had contributed between 80 and 180 quarters, at least once in the private sector, and retired between ages 59 and 67, born between 1933 and 1938, alive at age 72.

Source: Cnav data.

Table D11 – Main Results with the Detail of Control Variables – Cohort 1938 to 1943, All

	Naive analysis	Reduced form	1 st stage	2 nd stage
Claiming age (in quarter)	-0.00049*** (0.00003) 0.00000			-0.00035 (0.00044) 0.42293
Number of added quarters		-0.00023 (0.00028) 0.42299	0.64607*** (0.00603) 0.00000	
Born in 1938	(Ref.)	(Ref.)	(Ref.)	(Ref.)
Born in 1939	0.00396*** (0.00067) 0.00000	0.00386*** (0.00067) 0.00000	0.17421*** (0.01322) 0.00000	0.00392*** (0.00068) 0.00000
Born in 1940	0.00154** (0.00067) 0.02151	0.00131* (0.00068) 0.05450	0.40635*** (0.01357) 0.00000	0.00145** (0.00073) 0.04741
Born in 1941	0.00086 (0.00068) 0.20252	0.00058 (0.00070) 0.40316	0.46330*** (0.01401) 0.00000	0.00075 (0.00077) 0.33503
Born in 1942	0.00077 (0.00066) 0.24472	0.00047 (0.00070) 0.49976	0.46457*** (0.01404) 0.00000	0.00064 (0.00079) 0.42155
Born in 1943	0.00075 (0.00065) 0.24784	0.00047 (0.00071) 0.51138	0.40077*** (0.01432) 0.00000	0.00061 (0.00080) 0.44683
Pension	-0.00000*** (0.00000) 0.00000	-0.00000*** (0.00000) 0.00000	0.00005*** (0.00000) 0.00000	-0.00000*** (0.00000) 0.00000
Disability pension	-0.08005*** (0.00070) 0.00000	-0.08388*** (0.00063) 0.00000	7.81524*** (0.01366) 0.00000	-0.08114*** (0.00346) 0.00000
Woman	-0.07210*** (0.00042) 0.00000	-0.07207*** (0.00042) 0.00000	-0.04099*** (0.01239) 0.00094	-0.07209*** (0.00042) 0.00000
N	2,198,258	2,198,258	2,198,258	2,198,258

Notes: This table presents the main results with the detail of coefficients for the following control variables: cohort, gender, reference wage and a dummy for being recipient of a disability pension. The regressions also include control for contribution length at age 60. Individuals selected are those who had contributed between 80 and 180 quarters, at least once in the private sector, and retired between ages 59 and 67, born between 1938 and 1943, alive at age 65.

Source: Cnav data.

Table D12 – Main Results with the Detail of Control Variables – Cohort 1938 to 1943, Men

	Naive analysis	Reduced form	1 st stage	2 nd stage
Claiming age (in quarter)	-0.00099*** (0.00005) 0.00000			0.00006 (0.00060) 0.91703
Number of added quarter		0.00004 (0.00042) 0.91704	0.69616*** (0.00788) 0.00000	
Born in 1938	(Ref.)	(Ref.)	(Ref.)	(Ref.)
Born in 1939	0.00423*** (0.00097) 0.00001	0.00397*** (0.00098) 0.00005	0.13015*** (0.01570) 0.00000	0.00396*** (0.00099) 0.00006
Born in 1940	0.00166* (0.00098) 0.09051	0.00109 (0.00099) 0.26959	0.30142*** (0.01625) 0.00000	0.00108 (0.00103) 0.29879
Born in 1941	0.00039 (0.00099) 0.69594	-0.00031 (0.00102) 0.76423	0.28960*** (0.01688) 0.00000	-0.00033 (0.00108) 0.76303
Born in 1942	0.00048 (0.00098) 0.62637	-0.00036 (0.00103) 0.73021	0.27567*** (0.01705) 0.00000	-0.00037 (0.00109) 0.73357
Born in 1943	0.00033 (0.00096) 0.73262	-0.00059 (0.00105) 0.57478	0.20993*** (0.01741) 0.00000	-0.00060 (0.00111) 0.58623
Pension	-0.00000*** (0.00000) 0.00000	-0.00000*** (0.00000) 0.00000	0.00005*** (0.00000) 0.00000	-0.00000*** (0.00000) 0.00000
Disability pension	-0.10815*** (0.00108) 0.00000	-0.11424*** (0.00103) 0.00000	6.16194*** (0.01811) 0.00000	-0.11462*** (0.00381) 0.00000
N	1,283,687	1,283,687	1,283,687	1,283,687

Notes: This table presents the main results with the detail of coefficients for the following control variables: cohort, gender, reference wage and a dummy for being recipient of a disability pension. The regressions also include control for contribution length at age 60. Individuals selected are men who had contributed between 80 and 180 quarters, at least once in the private sector, and retired between ages 59 and 67, born between 1938 and 1943, alive at age 65.

Source: Cnav data.

Table D13 – Main Results with the Detail of Control Variables – Cohort 1938 to 1943, Women

	Naive analysis	Reduced form	1 st stage	2 nd stage
Claiming age (in quarter)	-0.00042*** (0.00004) 0.00000			-0.00073 (0.00060) 0.22486
Number of added quarter		-0.00043 (0.00035) 0.22495	0.58855*** (0.00941) 0.00000	
Born in 1938	(Ref.)	(Ref.)	(Ref.)	(Ref.)
Born in 1939	0.00377*** (0.00082) 0.00000	0.00371*** (0.00082) 0.00001	0.22118*** (0.02253) 0.00000	0.00387*** (0.00085) 0.00000
Born in 1940	0.00146* (0.00082) 0.07617	0.00132 (0.00083) 0.11383	0.51218*** (0.02297) 0.00000	0.00169* (0.00094) 0.07123
Born in 1941	0.00180** (0.00083) 0.03031	0.00164* (0.00086) 0.05644	0.65917*** (0.02352) 0.00000	0.00212** (0.00103) 0.04007
Born in 1942	0.00179** (0.00081) 0.02760	0.00165* (0.00086) 0.05395	0.67210*** (0.02343) 0.00000	0.00214** (0.00106) 0.04347
Born in 1943	0.00211*** (0.00080) 0.00799	0.00204** (0.00087) 0.01843	0.59870*** (0.02382) 0.00000	0.00248** (0.00106) 0.01973
Pension	-0.00000*** (0.00000) 0.00000	-0.00000*** (0.00000) 0.00000	0.00005*** (0.00000) 0.00000	-0.00000*** (0.00000) 0.00111
Disability pension	-0.04917*** (0.00082) 0.00000	-0.05315*** (0.00070) 0.00000	9.43299*** (0.02052) 0.00000	-0.04630*** (0.00567) 0.00000
N	914,571	914,571	914,571	914,571

Notes: This table presents the main results with the detail of coefficients for the following control variables: cohort, gender, reference wage and a dummy for being recipient of a disability pension. The regressions also include control for contribution length at age 60. Individuals selected are women who had contributed between 80 and 180 quarters, at least once in the private sector, and retired between ages 59 and 67, born between 1938 and 1943, alive at age 65.

Source: Cnav data.

Chapter 3

Does Later Retirement Change your Health-care Consumption ?

Summary of the chapter

This paper examines the causal impact of later retirement on doctor visits among the French elderly. This question is of interest since spillover effects may arise if later retirement increases healthcare expenditure. I exploit the 1993 French pension reform in a two-stage least square to deal with the endogeneity of retirement. This reform leads to a progressive increase in claiming age, cohort by cohort from 1934 to 1943. I use a two-part model to disentangle between extensive and intensive margin. I use the administrative data *HYGIE* to observe both healthcare consumption between 2005 and 2015 and past careers. I find that an increase in retirement by four months decreases significantly the probability to have at least one doctor visit per year by 0.815 percentage point and decreases the number of doctor visits by 1.14% between ages 67 and 75. This effect is driven by the consumption of generalist doctor visits, and tends to be stronger for the first ages of consumption observed.

Introduction

The accelerating number of reforms that increase the claiming age in Europe has led to a growing interest regarding the impact of retirement on health. This interest is threefold. First, it is important to ensure that these reforms do not have adverse health effects. Second, there could be several opposing mechanisms at play, which make the overall effect of such reforms uncertain. Lastly, over the last few years, studying the impact of retirement on healthcare use has been seen as a relevant complement to studies focused on health issues. This additional question has two motivations. First, observations on the impact of later retirement on health, combined with results on healthcare use, provide important information from a public policy perspective. For example, findings showing worse health and less healthcare use could be interpreted as an increase in the number of people forgoing medical care. Second, we must account for spillover effects to avoid an overestimation of the financial benefits associated with pension reforms.

The potential mechanisms explaining the effect of the switch from employment to retirement on health may differ from those explaining the effect of delayed retirement on health¹ and those mechanisms can vary depending on which dimension of health one considers.² The impact of delayed retirement on healthcare consumption may affect retirees through changes in health and health investment, due to the time spent in employment and in retirement. It could also be the result of a change in the expected timing of retirement. Finally, it could be due to a change in inter-temporal income.

This paper explores the causal impact of later retirement on healthcare consumption in France. I focus on doctor visits out of the hospital setting, hospital stays in private hospitals, and expenditure on prescription drugs. I use waves 2005 to 2015 of the administrative data *HYGIE*, which include information on career and healthcare consumption from the private pension scheme *CNAV* and the National Health Insurance. Since individuals can choose to retire for health reasons, there is a reverse causality issue to consider. I use the 1993 French pension reform as an instrumental variable to address this issue. This reform was the first one to induce later retirement in France, and it did not affect individuals within and between cohorts with the same intensity. However, on average, it led to an increase in claiming age (Aubert, 2009; Benallah and Mette, 2009; Bozio, 2011b) and in elderly' labour force participation (Bozio, 2011b).

This paper aims at contributing to the literature in several ways. First, it is the first one to focus on the French case. Second, I draw several distinction: between the extensive mar-

¹For example, the opportunity-cost of time play a role explaining differences at retirement but not explaining differences among retirees according to their retirement timing.

²For example, the increase in the exposure to a repeated physical task over the career due to a pension reform may explain an impact on physical health but not necessarily on cognitive health.

gin and the intensive margin; between volume and price effects, between several categories of healthcare use. Those distinctions allow for analyses of the potential underlying mechanisms. I find that an exogenous increase in claiming age leads to a small but statistically significant decrease in the probability to have at least one doctor visit a year. Moreover, it decreases the average number of doctor visits per year among consumers. The effect is driven by general practitioner visits. When focusing on sub-samples by age range, I show that the impact at the extensive margin is significant from ages 68 to 76 while, from ages 66 to 70, it is significant at the intensive margin.

These results are consistent with Bíró and Elek (2018). Using a similar econometric method, they find that an increase in claiming age led to a significant decrease in doctor visits among women in Hungary at the extensive margin, but not at the intensive margin. Hagen (2018) also observe a decrease in drug prescriptions but not in inpatient care among female civil servants in Sweden. While Bíró and Elek (2018) do not provide any potential mechanism explaining these results, Hagen (2018) concludes that working is health preserving. Using a different empirical strategy, Shai (2018) focuses on a reform of the Israeli pension system that increased the statutory retirement age from 65 to 67. He finds a slightly significant increase in doctor visits among men between ages of 65 and 69 who retired later due to a reform compared to a control group of men aged 50 to 64 (not retired) and 70 to 74 (retired from age 65). He suggests that later retirement deteriorates health and increases healthcare expenditure. He assumes that this health decline comes from a delayed entrance in retirement, a time where individuals are more likely to engage in healthier behaviours.

This paper is organised as follows: Section 1 presents the literature and theoretical mechanisms. Section 2 presents the French pension reform used as an instrumental variable. Section 3 and 3.3 respectively present the administrative data and the empirical strategy. Finally, Section 4 and 4.4 present the main results and the potential underlying mechanisms.

1 Literature Review and Underlying Mechanisms

There is a large literature on the impact of the switch from employment to retirement, and on the impact of delayed retirement on various dimensions of health. However, studies that focus on healthcare consumption are scarce and most papers are only interested in the consequences of the switch from employment to retirement on healthcare consumption (11 over 13 papers, see Table 1). The expected overall impact is unclear. The Grossman model (Grossman, 1972) predicts contradictory effects of retirement on healthcare use. On the one hand, marginal benefits of health investment decrease at retirement.³ On the other hand, marginal costs also decrease because of a lower opportunity cost of time. Moreover, the budget con-

³According to Grossman, health benefits are mainly through work productivity.

straint may vary throughout individuals at retirement through earnings and consumption changes. Lastly, the health stock depreciation may change at retirement.⁴

Only two papers documented the impact of a variation in retirement age on healthcare consumption among retirees, as summed up in Table 1. The impact of delayed retirement among retirees on healthcare consumption is not expected to be the same as the impact of the switch from employment to retirement. Marginal benefits of health investment, budget constraints and depreciation of the health stock vary in an inter-temporal framework. Moreover, changes in the opportunity cost of time cannot explain the differences in healthcare consumption due to a change in retirement timing among pensioners anymore.

Almost all the studies on the impact of the switch from employment to retirement find a decrease in healthcare consumption at retirement. Thus, Coe and Zamarro (2015); Eibich (2015); Bíró and Elek (2018); Shai (2018); Nielsen (2019); Frimmel and Pruckner (2020) and Kuusi et al. (2020) find a decrease in doctor visits in Europe and the USA, in Germany, Hungary, Denmark, Austria and Finland, respectively. Nielsen (2019) finds a statistically significant decrease at the early retirement age threshold but not at the statutory retirement age while Eibich (2015) finds a decrease in healthcare consumption at both thresholds. Bíró and Elek (2018); Gorry et al. (2018); Nielsen (2019); Frimmel and Pruckner (2020); Kuusi et al. (2020) also find a decrease in inpatient care and Bíró and Elek (2018); Gorry et al. (2018); Kuusi et al. (2020) find a decrease in prescription drugs consumption.

The authors provide several explanations for this decrease. The main mechanism is through an health improvement (Coe and Zamarro, 2015; Eibich, 2015; Shai, 2018; Frimmel and Pruckner, 2020). Thus, Eibich (2015) shows that individuals report a better health at retirement by engaging in healthier habits (smoking less, drinking less alcohol, having a physical activity more often, they also report better sleep and higher sleep duration). Consequently, he attributes the healthcare consumption decrease to an overall better health, due to healthier behaviours and greater well-being. Besides, Coe and Zamarro (2015) point out that most of the previous studies find a better self-reported health at retirement. Frimmel and Pruckner (2020) argue that the decrease in healthcare consumption is partly driven by the decrease in psychiatric and orthopaedic hospital care and in psychotropic drugs medication for musculoskeletal disorders. These care are typically associated with healthcare and not with health prevention.

However, other authors consider this mechanism as unlikely. Bíró and Elek (2018) believe that health changes are slow and that the sudden healthcare consumption change at retirement cannot be attributed to a sudden change in health. They offer three other mechanisms. First, individuals in employment have doctor visits for their sick-leave certificate

⁴Changes in health habits at retirement like physical activities, alcohol and tobacco consumption may impact the depreciation rate of health, which may impact healthcare consumption.

while pensioners do not need it (see also Nielsen (2019)). Second, individuals may be willing to invest more in their health while working. In this line, Frimmel and Pruckner (2020) show a decrease in screening participation and preventive care at retirement. Third, the income drop at retirement may decrease healthcare consumption. Nielsen (2019) also considers the opportunity cost of time: it would be higher during retirement because individuals would prefer using time off work to visit a doctor rather than using personal time for the visit.

Only three studies do not find a decrease in healthcare consumption at retirement. Grøtting and Lillebø (2018) find a negative non significant result on hospital stays in Norway but a significant decrease among the lowest education levels. Lucifora and Vigani (2018) uses cross-country differences in retirement age in Europe. Assuming normal distribution of the number of doctor visits, they find an increase in doctor visits in Europe at retirement. Their main explanation for this result is the opportunity-cost of time. To support this explanation, they show that the founded result is higher for those with long working hours. Zhang et al. (2018) also find an increase in healthcare consumption in Urban China. They consider that the main underlying mechanism is the opportunity cost of time, particularly high in Urban China. This could explain the difference with results found in Europe and the United States.

An other strand of the literature focuses on the impact of a change in retirement age on healthcare consumption. As far as I know, only one study targets the impact of later retirement on healthcare consumption (Hagen, 2018) and another one focus on the impact of earlier retirement (Hallberg et al., 2015). Both these studies use reforms that spurred individuals towards an earlier or later retirement. They find either a non significant or a negative impact on healthcare consumption. Thus, Hagen (2018) uses the Swedish pension reform of local government workers as an instrumental variable. This reform increases the claiming age from 63 to 65 years old. He finds no significant change in inpatient care but a significant decrease in drugs consumption for women between ages of 65 and 69. Hagen (2018) assumes that work is health preserving for the women civil servants, and that it explains the results. Hallberg et al. (2015) use the Swedish early retirement offer at age 55 implemented for military officers (rather than 60 before the reform) as an instrumental variable. They focus on the impact of this exogenous decrease in claiming age on healthcare consumption. They find a significant decrease in inpatient care consumption between ages 56 and 70, and interpret it as a consequence of health improvement linked to earlier retirement.

Thus, the literature and underlying mechanisms concerning the impact of the switch from employment to retirement on health is well documented. However, there is little knowledge regarding the impact of later retirement on healthcare consumption among retirees, and the associated underlying mechanisms (in particular, is health a cause or consequence of healthcare consumption changes due to later retirement). The purpose of this paper is to fill this gap.

Table 1 – Literature Review on the Impact of Retirement on Healthcare Consumption

Authors (year)	Country	Sample	Age	Method	Instrument	Results on		
						Doctor	Hospi	Drugs
Impact of the switch from employment to retirement								
Coe and Zamarro (2015)	Europe + USA	Men, workers at 50y.o.	50+	RDD	SRA	↘	NS	-
Eibich (2015)	DEU	Civil servants & self-employed	55-70	RDD	ERA: 60. SRA: 65	↘	NS	-
Bíró and Elek (2018)	HUN	Women	54-60	2SLS (TPM)	ERA: 57	↘	↘	↘
Bíró and Elek (2018)	HUN	Men	57-63	2SLS (TPM)	ERA: 60	↘	↘	↘
Gorry et al. (2018)	USA	Workers at age 50	50-93	2SLS	SS threshold	NS	↘	↘
Grøtting and Lillebø (2018)	NOR	-	56-79	FRDD	SRA: 67	-	NS	-
Lucifora and Vigani (2018)	EU	-	50-69	RDD	ERA and SRA	↗	-	-
Shai (2018)	ISR	Men	40-74	DiD	SRA: 65 ⇒ 67	↘	-	-
Zhang et al. (2018)	CHN	Workers	40-75	RDD	SRA: 60 (♂) 50 (♀)	↗	↗	-
Nielsen (2019)	DNK	Cohort 1939, without ERP or DRP	60-70	2SLS	SRA: 67 ⇒ 65	NS	NS	-
Nielsen (2019)	DNK	-	55-65	RDD	ERA: 60	↘	↘	-
Frimmel and Pruckner (2020)	AUT	Private sector	41-74	FRDD	ERA: 60 ⇒ 65 (♂) 55 ⇒ 60 (♀)	↘	↘	NS
Kuusi et al. (2020)	FIN	Workers before ERA	62-67	2SLS	SRA: 63	-	↘	↘
Impact of later retirement								
Hagen (2018)	SWE	Women, civil servants	65-69	DiD	SRA: 63 ⇒ 65	-	NS	↘
This paper	FRA	Men, private sector	66-76	2SLS (TPM)	SRA ↗	↘	NS	↘
Impact of earlier retirement								
Hallberg et al. (2015)	SWE	Men, military	56-79	2SLS	SRA: 60 ⇒ 55	-	↘	-

FIGURE 1: RETIREMENT AND HEALTH

Notes: Results on (1) doctor visits; (2) hospital stays; (3) drugs. No particular sample restriction is notified with "-".

Abbreviations: Countries abbreviations are 3-letters codes from the United Nation. Column method: (F)RDD, (fuzzy) regression discontinuity design; DiD, difference in difference; 2SLS, two-stage least square; TPM, two part model. Column instrument: ERA, early retirement age; SRA, statutory retirement age. Other columns: NS: non significant at the 5% level; "-" No particular sample restriction, or, for the results' columns: Not applicable; ERP, early retirement pension; DRP, disability retirement pension.

2 The 1993 Pension Reform in the Private Sector

Before the 1993 pension reform, workers from the private sector could claim a pension from age 60. However if they wanted to benefit from a full pension,⁵ they had to have contributed up to at least 150 quarters or to leave at age 65 or after. Individuals may contribute quarters when in employment but also when in sick-leave, maternity-leave, or unemployment. The maximum number of contributed quarters per year is four. Being out of the labour force⁶ prevents an individual from validation of quarters. Lastly, there is no increment (neither before nor after the reform), so no financial incentive arises to claim for pension after reaching the full replacement rate.

In 1993, the first pension reform leading to an increase in career length was implemented. This reform only applied to workers from the private sector. Individuals could not have anticipated it because there was no announcement before the reform. Moreover, the reform was voted and adopted very quickly.⁷

As a consequence, required contribution length for a full pension has gradually increased from 150 to 160 quarters, cohort by cohort, starting with the 1934 cohort. As shown in Table 2, cohort 1934 had to contribute 151 quarters for a full pension, cohort 1935 had to contribute 152 quarters and so on and so forth.

Table 2 – Increase in Required Contribution Length in the Private Sector

Birth year	Nb of contr. quarters (to get a full pension)	
	in quarter	in year
1933 and before	150	37 years and 6 months
1934	151	37 years and 9 months
1935	152	38 years
1936	153	38 years and 3 months
...	...	
1942	159	39 years and 9 months
1943 and after	160	40 years

Notes: Individuals born in 1933 or before, have to have contributed 150 quarters to benefit from a full replacement rate; those born in 1934 have to contribute 151 quarters; and so on.

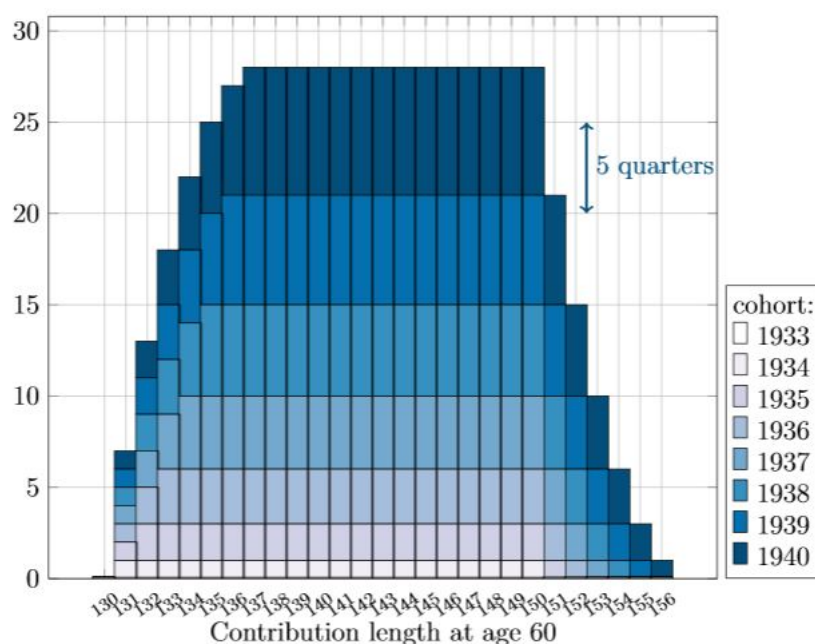
This reform changed the incentive to claim pension at a certain age. This is different from a change in the mandatory claiming age. Thus, individuals affected by the reform can leave

⁵The full replacement rate is 0.5. It decreases by a δ factor, equal to 1.25 % per quarter of missing contributions. See Appendix A for more details.

⁶i.e. being unemployed and not looking for a job or unemployed for a long period of time.

⁷The reform was voted in July 1993. The implementing decree was published one month later with an application date on the 1st January 1994.

Figure 1 – Impact of the 1993 Reform on Contribution Length Necessary to Get the Full-rate



Notes: Scheme from Bozio et al. (2019). It represents the number of added quarters required to reach the full-rate by cohort and contribution length at age 60 due to the reform. Cohort 1934 who had contributed at age 60 between 130 and 150 quarters need one quarter more in order to qualify for the full-rate. Cohort 1935 who had contributed at age 60 between 131 and 150 quarters need two quarters more to reach the full replacement rate. Those from the same cohort who had contributed 130 and 151 quarters at age 60 have to delay retirement by one quarter.

at the same age than before the 1993 reform, if they accept a decrease in their pension. In my analysis, I measure the impact on the compliers (those who delayed retirement if affected and do not if not affected) and not on the always-takers and the never-takers.

Finally, note that workers are not all affected in the same way. Individuals with very short career would only be granted a full pension from age 65 because they had not contributed enough beforehand. Similarly, individuals with very long career have contributed at age 60 largely more than the required contribution length, so that they can leave at age 60 regardless of the required contribution length, and are not affected by the reform. Figure 1 illustrates this fact for the first cohorts affected by the reform. In this paper, I exploit both variation within cohort (between contribution length at age 60) and between cohort (for a same contribution length at age 60). More details are available in Bozio et al. (2019).

3 Data and Empirical Strategy

I use the 1993 pension reform as an instrumental variable to estimate the causal impact of later retirement on healthcare consumption. It requires data including both information on contribution length and claiming age; and information on healthcare consumption.

3.1 Data

I use administrative data *HYGIE*, provided by Irdes,⁸ which include information from the private pension scheme (CNAV) and from the National Health Insurance. It includes 1/20em of all individuals born between 1935 and 1989 and who have contributed at least once in the private sector. The data include information on careers (number of contributed quarter, claiming age, pension). All health information are aggregated at the yearly level for every individual between 2005 and 2015. Thus, the healthcare consumption of individuals born in 1935 is observed between the ages of 70 and 80, those born in 1936, between the ages of 69 and 79 etc. (See Table B1).

The number of doctor visits and total expenditure for visits, the number of days in private hospitals⁹ and the total associated cost, the total cost of prescription drugs constitute the healthcare-related parameters. Doctor visits are split between general practitioners, and specialist practitioners. This includes doctor visits provided out of the hospital. Ambulatory surgeries are excluded. Therefore, doctor visits only include consultation and no acts. More details on the French healthcare system are provided in Appendix A.2.

3.2 Sample Selection

Sample Selection. I selected all men,¹⁰ born between 1935 (the oldest I observe) and 1943 (the last cohort affected by the 1993 reform but not by the following pension reforms); who had contributed at least once during their career in the private sector;¹¹ who had contributed between 131 and 160 quarters at age 60;¹² who were alive and retired before age 67. I observe consumption between the ages of 66 and 76 for individuals born between 1935 and 1943 (See Table B1). As a complementary analysis, I provide results by age range. For this analysis, I select individuals born between 1939 to 1943 and observe their consumption between ages

⁸Institut de recherche et de documentation en économie de la santé.

⁹Private hospitals provide both schedule care and emergency care. In 2015, 25% of emergencies care (excluding paediatric emergencies) were in the private sector (Toulemonde, 2017).

¹⁰The sample selection on men is due to data constraint. See Appendix B for more information. Note that the 1993 reform affects mostly men, and thus, it remains of interest to explore the impact of the reform among men only.

¹¹The 1993 reform affects only the private sector.

¹²i.e. in the labour force at age 60 at least from 32 years and 9 months and maximum from 40 years.

66 and 68; I select individuals born between 1938 and 1943 and observe their consumption between the ages of 67 and 69 and so on and so forth until the selection of individuals born between 1935 to 1939, for whom I observe their consumption between the ages of 74 and 76 (See Table B2). Note that since the reform has no impact on mortality (Bozio et al., 2019), the selection on individuals alive at different ages does not bias the empirical strategy.

Since the reform only affects individuals who had contributed between 131 and 160 quarters at age 60, the sample is restricted to this population. Small changes in this threshold are not expected to drive the results but large changes may. By including in the panel individuals that were not affected but with very different characteristics than the affected, bias may arise. For example, the inclusion of individuals with very long career (more than 170 quarters at age 60) leads to the inclusion of individuals that were not affected by the reform since they started working around 16 years old (control group) while the treatment group started working between the ages of 23 and 27. Moreover, note that it is not possible to include individuals with either less than 131 quarters or more than 160 quarters since these individuals are not affected by the reform but left at very different claiming ages (the first group left at age 65 and the second at age 60). As a robustness check, I show that the change of this contribution length threshold does not statistically significantly change the results when applying to a small variation of the threshold but changes the results when adding a large range of individuals not affected by the reform but with different characteristics than the treatment group (see Figure C1 of Appendix C.1).

Variables of Interest. I use several measures of healthcare consumption. The first one is the probability of having at least one doctor visit. Second, for consumers, I take into account the yearly number of doctor visits as well as the expenditure on doctor visits.¹³ This last expenditure includes both the part that is reimbursed by the insurance and the out-of-pocket payment.¹⁴ All these healthcare use variables are used through logarithm transformation among the consumers. I distinguish between general practitioners and specialist practitioners. I also factored in the number of dental visits and the total expenditure on dental visits; the number of days spent in private hospitals and the associated expenditure;¹⁵ the expenditure on prescription drugs, as well as the total expenditure on all the previously quoted medical care.

¹³In euros 2016. I use the inflation index from the French national institute of statistics INSEE <https://www.insee.fr/fr/information/2417794>.

¹⁴Appendix A.2 provides details concerning the French health insurance system and reimbursement rate.

¹⁵The impact of delayed retirement on hospital care in the private sector can be interpreted as the impact on the whole hospital care only under two additive assumptions. First, delayed retirement does not change the preference between public and private hospitals. Second, the preference between public and private are not exclusives.

Descriptive Statistics. Table 3 provides descriptive statistics regarding the health and careers of individuals included in this study. In the main sample, 75.7 % of observations have at least one doctor visit a year. Thus, in the main sample, 24.3 % of observations do not consume any doctor visit. It is higher than the 10 % of non-consumers found among the 75 and older in France by Calvet (2012) and Sourty-Le-Guellec (1999) among the French registered at the National Health Insurance. Moreover, 72 % had at least one general practitioner visit during the year, which is, once again, lower than the national statistics (Calvet and Montaut (2013) show that after age 60 only 7 % do not consume any doctor visit). One explanation may be that I focus on men who worked in the private sector, and had contributed between 131 and 160 quarters at age 60, who usually are in better health than the average French inhabitant.¹⁶

In the whole sample, individuals who have or had a chronic condition after age 65 account for 44% of the observations. Among these individuals, 83% had a doctor visit. Moreover, 71% of observations from the main sample are individuals who benefited from a co-payment exemption, meaning that they did not have any out-of-pocket payment for doctor visits. The 29% of observations without this exemption have an out-of-pocket payment for doctor visit around 30% of the total expenditure if they don't have a supplementary health insurance (see Appendix A.2 for more details). Those with this co-payment exemption are most of the time consumers (94%) which is expected since having large expenditure for healthcare in France is one of the reason why an individual can benefit from a co-payment exemption.

I find no significant differences in career characteristics between the main sample and sub-samples of doctor consumers, of individuals with chronic condition and with co-payment exemption. Thus, the selection of consumers does not appear to bias the sample according to career characteristics. The average claiming age is 61.87 years old for the whole sample as well as the subsample of those with at least one doctor visit a year; the average number of added quarter required due to the reform (ΔRCL) is 3.518 quarters (resp. 3.417 for consumers); the contribution length at age 60 is 149.5 (resp. 149.8).

Figure 2 shows the point estimate of the impact of the number of added quarter required on number of doctor visits by year of consumption (Figure 2a) and by age (Figure 2b), controlling for age, contribution length at age 60, suffering from a chronic disease, and the living area (reduced-form estimation). It shows that the average level of consumption is higher among the not-affected for almost all year of consumption and at all ages. Moreover, it seems that in average, the more an individual is affected, the lower his healthcare consumption is.

¹⁶This selection leads to the exclusion of self-employed workers, inactive, handicapped, and a large part of blue collars, which are in average in worse health than the whole population.

Table 3 – Descriptive Statistics

	All	GP	Consumers of Specialist	Ambulatory care	Co-payment exemption	Individuals with Chronic condition
Probability of	General practitioner visit	0.725 (0.447)	1 (0)	0.936 (0.244)	0.957 (0.203)	0.906 (0.292)
	Specialist practitioner visit	0.510 (0.500)	0.660 (0.474)	1 (0)	0.674 (0.469)	0.637 (0.481)
	Doctor visit	0.757 (0.429)	1 (0)	1 (0)	1 (0.230)	0.831 (0.374)
	Hospital stay	0.120 (0.325)	0.156 (0.363)	0.230 (0.421)	0.158 (0.364)	0.151 (0.358)
	Chronic condition	0.440 (0.496)	0.487 (0.500)	0.512 (0.500)	0.483 (0.500)	1 (0)
	Co-payment exemption	0.710 (0.454)	0.888 (0.315)	0.886 (0.318)	1 (0)	0.788 (0.409)
Number of	General practitioner visits	4.590 (5.923)	6.335 (6.112)	6.491 (6.413)	6.064 (6.116)	5.836 (6.229)
	Specialist practitioner visits	2.458 (4.624)	3.206 (5.077)	4.817 (5.525)	3.248 (5.067)	3.097 (4.934)
	Doctor visits	7.048 (8.531)	9.541 (8.729)	11.31 (9.237)	9.311 (8.664)	8.933 (8.760)
	Hospital stays (in days)	0.433 (4.651)	0.556 (5.040)	0.754 (5.627)	0.554 (5.050)	0.566 (5.396)
Expenditure for	General practitioner visits	127.0 (142.0)	174.0 (140.3)	182.9 (152.6)	167.3 (141.2)	163.0 (144.5)
	Specialist practitioner visits	236.0 (545.7)	308.6 (606.3)	434.7 (701.7)	310.3 (608.2)	297.6 (608.3)
	Doctor visits	314.3 (474.1)	420.3 (505.9)	552.7 (560.0)	415.2 (505.0)	399.4 (507.3)
	Prescription drugs	713.2 (1258.6)	934.6 (1337.7)	1047.6 (1535.2)	926.2 (1362.4)	922.6 (1399.2)
	Hospital stays	291.0 (1749.8)	374.5 (1904.6)	540.5 (2297.3)	378.8 (1957.3)	378.6 (2033.1)
	Total expenditure	2277.8 (4200.6)	2973.0 (4501.1)	3630.8 (5211.4)	2960.3 (4569.0)	2922.9 (4708.0)
Career	Claiming age	61.87 (2.113)	61.73 (2.019)	61.79 (2.048)	61.78 (2.043)	61.83 (2.073)
	Added quarters	3.518 (3.073)	3.411 (3.050)	3.417 (3.043)	3.434 (3.051)	3.547 (3.087)
	Contrib. length at age 60	149.5 (8.076)	149.8 (8.028)	149.8 (7.997)	149.7 (8.050)	149.6 (8.106)
N		66,698	48,324	34,040	50,488	47,365
						29,323

Notes: “Added quarters” is the number of added quarters required due to the reform. “Contrib. length at age 60” is the contribution length at age 60. Hospital stays include only private hospital stays. Drugs include only prescription drugs.

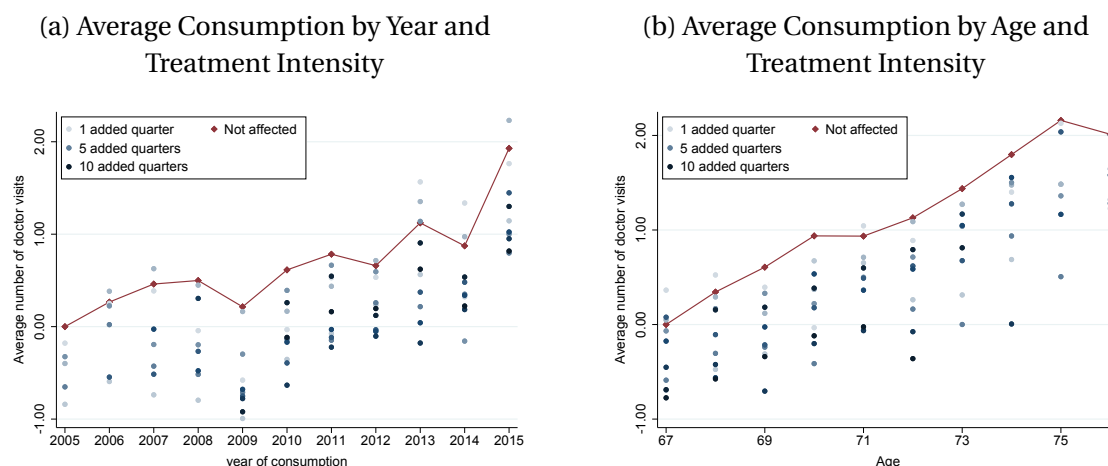
Sample: Men who had contributed at least once in the private sector and had contributed at age 60 between 131 and 160 quarters, retired before age 67, ages comprised between 66 and 76.

Source: HYGIE 2005 – 2015.

3.3 Empirical Strategy

Using Log-transformation. As reminded by Lumley et al. (2002) the normality assumption is a strong one in the empirical strategy I planned to use. The skewness of healthcare distribution prevents from this assumption (see Figure B2a and B2b). This skewness is due to both left-censor data and long right-tail distribution. Using a logarithm transformation among the consumers solves the long-right-tail issue (see Figure B2c and B2d).

Figure 2 – Healthcare Consumption among Individuals Affected and not Affected by the Reform



Notes: This graph presents the reduced-form. It is the point estimates of the number of added quarter required on the number of doctor visits, controlling for age, year, contribution length at age 60, department, and having a chronic condition, estimated using OLS regression. It shows the number of doctor visits by year (Figure a) and by age (Figure b) for individuals not affected by the reform (red square) and individuals affected (blue circles). The most dark blue the circle is, the most important the treatment intensity is.

Sample: Men who had contributed at least once in the private sector and had contributed at age 60 between 131 and 160 quarters, retired before age 67, ages comprised between 66 and 76.

Source: HYGIE 2005-2015.

Using Two-part Model. A large proportion of the observed population has zero consumption for a given point of time. Two main models enable us to tackle this issue: sample selection models (eg. Heckman models) and two-part models. As reminded by Madden (2008), there is a huge literature on the choice between these two models (Leung and Yu, 1996; Jones, 2000). I chose a two-part model for two main reasons: first, delayed retirement may affect differently the probability to consume and the level of consumption. From a public policy point of view, this distinction is of great interest, because the potential mechanisms explaining a zero consumption may differ from those explaining a change in level.¹⁷ Moreover, only measuring the overall effect could lead to a wrong interpretation in terms of public policy.¹⁸ The second reason to study both extensive and intensive margins is that two-part models allow for logarithm transformation without issue regarding logarithm transformation for in-

¹⁷One may argue that foregoing healthcare can only be measured through the probability to consume and not through the level of consumption.

¹⁸Let us imagine that the pension reform leads to both an increase of the share of individuals foregoing healthcare for financial reason but also deteriorates the health of those who can still afford care. The latter increase their healthcare consumption as a consequence of a worse health. We could at this point conclude that the reform is detrimental to both health and access to the healthcare system. However, without any distinction between extensive and intensive margin, such a conclusion is impossible. Consider this numerical example: a population with 80% of consumers before the reform and each consumer consume 10 euros. It means an average consumption of 8 euros. Due to a reform, the share of consumers decreases to 60%, and the consumption per individual increases to 12 euros. The average consumption is 7,20 euros. We wrongly conclude that the reform decreases the healthcare consumption. In reality, it increases the consumption among the consumers but decreases the probability to consume.

dividuals with zero consumption. Equation 3.1 is an ordinary least square regression.¹⁹ It gives the impact of claiming age on the probability to consume care (impact at the extensive margin). Using logarithm transformation in an ordinary least square model, Equation 3.2 gives the impact of claiming age on the level of consumption (intensive margin) among the consumers.

$$\mathbb{1}_{HC_{i,t}>0} = \beta_0 + \beta_1 A_{i,t} + \beta_1 X_{i,t} + \nu_{1,t} + \varepsilon_{i,t} \quad (3.1)$$

$$\log(HC_{i,t} | HC_{i,t}>0) = \gamma_0 + \gamma_1 A_{i,t} + \gamma_2 X_{i,t} + \nu_{2,t} + \nu_{i,t} \quad (3.2)$$

$HC_{i,t}$ is the healthcare consumption of individual i at date t and $\mathbb{1}_{HC_{i,t}>0}$ its associated dummy. $A_{i,t}$ is the claiming age of individual i . It is constant across t . $X_{i,t}$ is a control vector for contribution length at age 60, number of contributed quarters for sick-leave, logarithm of pension, department,²⁰ year of birth. These variables are also time-invariant. Finally, ν_t is a wave fixed effect. $\varepsilon_{i,t}$ and $\nu_{i,t}$ are error terms, following a normal distribution, and jointly independent. Thus, these two equations are assumed to be independent.²¹ Note that there is no individual fixed effect since all independent variables are time invariant. The main specification includes a weight inversely proportional to the number of observations, to avoid a bias associated with the number of time each individuals is observed. All individuals are alive at age 72 and the only reason I can not observe every individual the same number of time is the re-sampling process. Finally, as an additional result, the regressions are estimated in balanced panels of three ages of observation. All individuals are therefore observed the same number of time, at the same ages. Thus, the absence of individual fixed effect is not an issue.

This model takes into account the skewness of the healthcare consumption distribution, but not the reverse causality issue. I use an instrumental variable (IV) to measure the causal impact of claiming age on healthcare consumption.

Using Instrumental Variable. The reverse causality issue emerges as soon as the explanatory variable may be both a cause and a consequence of the variable to explain. In this study, individuals may choose to retire due to their health (Llena-Nozal Ana et al., 2004). As a consequence, individuals who leave later may be in better health than those who leave earlier. To observe the causal impact of later retirement on health, I use the 1993 pension reform as an instrumental variable. This reform is exogenous to the individuals' health, and leads individuals to delay their retirement. I assume that the reform is independent from the health status (exclusion restriction). This assumption is not testable but highly credible because the reform applies to every worker in the private sector, without health consideration. Secondly,

¹⁹I check that the marginal effect from the probit model provides similar results. See Appendix C.2.

²⁰This control serves as a proxy for local supply of healthcare services and also to control for specificities of Alsace-Moselle departments, which were used to be a part of Germany from 1871 to 1919, and kept for historical reason a higher National Health Insurance coverage.

²¹It is one of the main difference with Heckman models.

to be relevant, the reform must impact the claiming age (non-zero assumption). I show in the following section that this assumption is verified. Thirdly, I assume total independence with respect to the instrument. This assumption means, in particular, that there is no anticipation effect nor bypass effect.²² It is highly credible for the first cohorts affected. Those individuals cannot have anticipated this reform since it is the first one to increase the claiming age in France. On the opposite, the last affected cohort was aware of the reform next to a decade before their retirement. They could then choose to be never-taker and not react to the reform, which is not an issue since I am interested in the compliers. Moreover, they have very low flexibility to change their contribution length. Finally, I assume that individuals react in the same direction to the incentive (ie. there is no defiers, it is the monotonicity assumption).

The combination of a two part model and instrumental variable strategy can be written as following:

First part: impact at the extensive margin.

$$A_{i,t} = \alpha_0 + \alpha_1 \Delta RCL_{i,t} + \alpha_2 X_{i,t} + \nu_{1,t} + \varepsilon_{i,t} \quad (3.3)$$

$$1_{HC_{i,t}>0} = \beta_0 + \beta_1 \hat{A}_{i,t} + \beta_2 X_{i,t} + \nu_{2,t} + v_{i,t} \quad (3.4)$$

Second part: impact at the intensive margin for the consumers.

$$A_{i,t}|_{HC_{i,t}>0} = \delta_0 + \delta_1 \Delta RCL_{i,t} + \delta_2 X_{i,t} + \nu_{3,t} + \varepsilon'_{i,t} \quad (3.5)$$

$$\log(HC_{i,t})|_{HC_{i,t}>0} = \gamma_0 + \gamma_1 \hat{A}_{i,t} + \gamma_2 X_{i,t} + \nu_{4,t} + v'_{i,t} \quad (3.6)$$

HC_i is the healthcare consumption of individual i , $1_{HC_{i,t}>0}$ its associated dummy variable, and $\log(HC_{i,t})|_{HC_{i,t}>0}$ is the logarithm of healthcare consumption among the consumers. $A_{i,t}$ is the claiming age of individual i and $\hat{A}_{i,t}$ the variation of claiming age of individual i due to the reform. It is invariant with t . $\Delta RCL_{i,t}$ the number of added quarter due to the reform for individual i given his birth cohort and its contribution length at age 60 and $X_{i,t}$ the control vector for contribution length at age 60, number of contributed quarters for sick-leave, logarithm of pension, department, year of birth. These variables are also time invariant. ν_t is wave fixed effect.

The first part measures the impact of an exogenous increase in claiming age on the probability to consume healthcare. The second part measures the impact of an exogenous increase in claiming age among the consumers on the level of healthcare consumption. In

²²There is no way for individuals to move from the treatment to the control group.

both part, I use a two stage least square estimator.²³ Thus, Equation 3.3 and Equation 3.5 estimate the effect of an increase in required contribution length on claiming age (1st stage). If the first stage is relevant, the reform can be used as an instrumental variable (non-zero assumption verified). Then, Equation 3.4 estimates the impact of an exogenous increase in claiming age on the probability to consume and Equation 3.6 on the level of healthcare consumption among consumers (2nd stage).

Note that in many case, it is not possible to disentangle retirement from income effect, since both changes occur at the same time. In this empirical strategy, due to the nature of the reform used as an IV, I can observe the effect of later retirement independently from income effect of retirement. The reform affects the amount of pension of all the retirees with the same intensity. Since I observe the difference between cohort and within cohort for different contribution length, this effect is isolated. Another income effect could happen since those who choose not to delay their retirement when affected see a decrease of their pension. However, the 2SLS estimator measures the impact for the compliers (local average treatment effect, LATE). Thus, there is no issue regarding those who choose not to react to the reform.

4 Results

4.1 Impact of the Reform on Claiming Age

Table 4 shows the impact of one added quarter required to benefit from a full pension on claiming age (in quarter). The results are shown for a large set of samples. Column (1) shows the whole sample and the sub-samples of individuals having at least once a year a general practitioner visit, specialist practitioner visit or other healthcare. Column (2) and (3) present the same results for the sub-samples of individuals who benefit from a co-payment exemption and individuals who have or had a chronic condition after age 65. A single quarter increase in the required contribution length to get a full pension increases claiming age by 0.859 quarter. This impact is similar in all samples: between 0.778 quarter for the sample of individuals who have at least one specialist doctor visit; and 0.880 in the sample of individuals with a chronic condition and who receive at least one generalist doctor visit during the year. This result is consistent with the existing literature Bozio (2011a) and Bozio et al. (2019).

Figure 3 shows that the average claiming age increases by added required quarters, following a linear trend with a leading coefficient very close to one. This result shows that this

²³As a robustness check, I show in Table C2 that the results are very close using alternative models like count data models, generalized method of moments, generalised least square, and iv-probit in the first part.

Table 4 – Impact of the Reform on Claiming Age

		(1) Main sample	(2) Co-payment exemption	(3) Chronic condition
Had at least once during the year:	All	Reform	0.859*** (0.0123)	0.850*** (0.0224)
		N	66,698	47,365
	General practitioner visit	Reform	0.844*** (0.0115)	0.840*** (0.0231)
		N	48,324	42,911
	Specialist practitioner	Reform	0.778*** (0.0134)	0.753*** (0.0173)
		N	34,040	30,161
	Dental visit	Reform	0.796*** (0.0157)	0.786*** (0.0192)
		N	7,396	6,149
	Ambulatory care	Reform	0.830*** (0.0698)	0.816*** (0.0849)
		N	50,488	44,705
	Prescription drugs	Reform	0.830*** (0.0698)	0.816*** (0.0849)
		N	51,855	45,846
	Hospital stay	Reform	0.839*** (0.0105)	0.833*** (0.0203)
		N	8,008	7,140
	Any of the previous care	Reform	0.863*** (0.00538)	0.860*** (0.0194)
		N	52,463	46,317

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

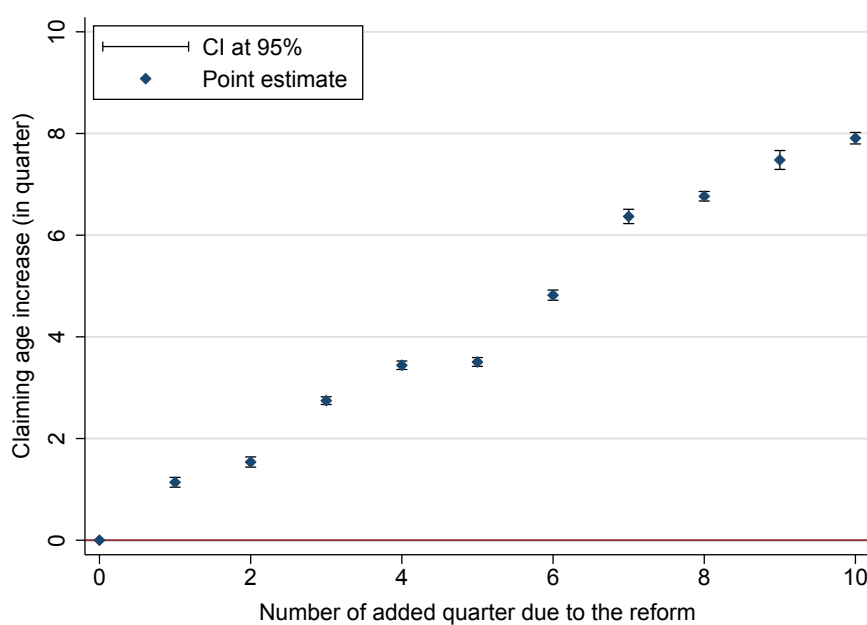
Notes: This table shows the impact of the number of added quarters required due to the reform on claiming age.

Sample: Main sample is men who had contributed at least once in the private sector and had contributed at age 60 between 131 and 160 quarters, retired before age 67. Column (1): estimation in the main sample. Column (2), estimation in the sub-sample of individuals with a co-payment exemption. Column (3): estimation in the sub-sample of individuals with a chronic condition. The first line is with all individuals following the selection criterion of the column, the second line is among individuals who visit at least once during the year a general practitioner, the third line, a specialist practitioner, and the last line is among individuals who either have at least once a doctor visit (general, specialist or dentist), a stay in private hospital, or a consumption of prescription drugs.

Source: HYGIE 2005-2015.

impact is not only driven by the least or the most affected by the reform. Thus, I conclude that the 1993 reform can serve as an instrumental variable to highlight the causal impact of later retirement on healthcare consumption, and that the variation in intensity can be assumed as linear.

Figure 3 – Impact of the Reform on Claiming Age



Notes: This graph shows the average impact of the number of added quarters an individual experiences due to the reform on the claiming age (1st stage regression). Confidence Intervals at 95 %.

Sample: Men who had contributed at least once in the private sector and had contributed at age 60 between 131 and 160 quarters, retired before age 67.

Source: HYGIE 2005 – 2015.

4.2 Impact of Later Retirement on the Probability to Consume Care

Column (1) of Table 5 shows the causal impact of delaying retirement on the probability to have at least one general practitioner visit, specialist practitioner visit, dental visit, any doctor visit, prescription drugs and stay in private hospitals. An exogenous increase in claiming age by one quarter statistically significantly decreases the probability to have at least one doctor visit by 0.815 percentage point ie. one consumer less over 120 individuals. Moreover, the decrease in the probability to visit a general practitioner visit (−0.828 percentage point) is greater than the decrease in the probability to visit a specialist practitioner (−0.724 percentage point). Probably as a consequence of the decrease in doctor visit, the probability to consume prescription drugs decreases by 0.599 percentage point. However, the probability to visit a dentist and have an hospital stay does not change significantly.

Table 5 – Impact of Later Retirement on Healthcare Consumption

		Probability	Number of	Expenditure for	Price for
Generalists	Claiming age	-0.00828*** (0.00104)	-0.00522** (0.00260)	-0.00370 (0.00259)	0.00152 (0.000987)
	N	66,698	48,324	48,324	48,324
Specialists	Claiming age	-0.00724*** (0.00253)	-0.00797 (0.00533)	-0.0177** (0.00766)	-0.00970*** (0.00341)
	N	66,698	34,040	34,040	34,040
Dentists	Claiming age	-0.000332 (0.000889)	-0.00252 (0.00525)	-0.0202* (0.0120)	-0.0177* (0.00984)
	N	61,567	7,396	7,396	7,396
Total ambulatory	Claiming age	-0.00815*** (0.00126)	-0.0114*** (0.00349)	-0.0164*** (0.00564)	-0.00499 (0.00315)
	N	66,698	50,488	50,488	50,488
Drugs	Claiming age	-0.00599*** (0.00105)	n.a. n.a.	-0.0138*** (0.00290)	n.a. n.a.
	N	66,698	n.a.	51,855	n.a.
Hospital	Claiming age	-0.000433 (0.00110)	-0.00661 (0.00948)	-0.00917 (0.00906)	-0.00257 (0.00734)
	N	66,698	8,008	8,008	8,008
Total	Claiming age	-0.00516*** (0.000871)	n.a. n.a.	-0.0236*** (0.00444)	-n.a. n.a.
	N	66,698	n.a.	48,468	n.a.

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Retire one quarter later due to the reform leads to a decrease in the probability to have a doctor visit by 0.815 percentage point, and a decrease in the number of doctor visits among the consumers by 1.14%, the expenditure for doctor visits by 1.64% and the expenditure per visit by 0.00499 (but not significantly).

Sample: Men who had contributed at least once in the private sector and had contributed at age 60 between 131 and 160 quarters, retired before age 67.

Source: HYGIE 2005 – 2015.

4.3 Impact of Later Retirement on Healthcare Consumption

Among the consumers, an exogenous increase by one quarter in claiming age statistically significantly decreases the number of doctor visits by 1.14 % (Table 5, Column (2)). One a baseline of 9.30 doctor visits per year, it means a decrease in the number of visits by 0.10 visit per individual, ie. around one visit less for one individual over 10. The overall consumption of doctor (taking into account both the extensive and intensive margin) decreases significantly by 0.9% the number of practitioner visits. Expenditure for doctor visits decreases by 1.64% among consumer but the price per doctor visits does not significantly changes. Thus, the variation in expenditure is driven by the decrease in the number of doctor visits. The overall effect on the expenditure for doctor visits decreases by 4% of annual expenditure.

This effect on doctor visits can be split between the effect on generalist practitioners and specialist practitioner visits. Interestingly, the number of generalist doctor visits significantly decreases by 0.522% but not the price per generalist practitioner visits. At the reverse, the number of specialist practitioner visits does not varies significantly but the price per visit significantly decreases by 0.97%. A large part of the generalist practitioners in France have an agreement with the National Health Insurance to apply the regulated price (23€ for a standard visit in 2015). At the reverse, a minority of specialist practitioner have such an agreement. It may explain the reason why there is no price effect for generalist practitioners consumption but there is one for specialists. Regarding the decrease in price for specialist, two mechanisms could apply. First, individuals who retire later would choose more often specialist doctors with an agreement (ie. in average, at a given speciality, less expensive). Second, individuals who retire later would visit different type of specialist practitioners.²⁴

There is no significant impact on the number of dental visits or expenditure for dentist. There is also a negative non significant impact on the number of days in private hospital and on the expenditure for hospital stays. It supports the absence of substitution effect between ambulatory care and hospital care.

The decrease in healthcare consumption is similar in the whole sample and in the sub-sample of individuals having a chronic condition (Table D1). Later retirement decreases the probability to have a doctor visit by 1.45 percentage points and the number of doctor visits by 1.67% among consumers among those having a chronic condition. the decrease is slightly lower in the main sample, meaning that the impact is not massively driven neither by those with a chronic condition nor those without.

Figure 4 shows the point estimate for sub-sample of individuals between ages 66 and 68, 67 and 69 and so on and so forth until a sample of individuals aged between 74 and 76. It shows that the effect is most of the time negative but not always significant. The negative

²⁴Each speciality has a different average price.

impact at the extensive margin tend to be statistically significant only for the oldest samples while the negative impact at the intensive margin is mainly statistically significant for the youngest samples.

4.4 Underlying Mechanisms

As highlighted by numerous studies, one may think individuals who retire later consume less healthcare because they are in better health. This mechanism could apply for at least three reasons. First, work could be health preserving (us-it-or-loose it hypothesis);²⁵ second, a longer working life could increase the duration during which individuals had an incentive to invest in health because of the opportunity cost of sick-leave; third, a more progressive retirement through arrangement with the employers could happens due to the reform²⁶ at the end of the working life for those who were affected by the reform. This effect would be consistent with the literature on self-reported health. However, this potential “health” mechanism has to be mitigated. Table D3 shows a slightly significant increase by 0.209 percentage point in the probability to have a chronic condition after age 65 due to later retirement.

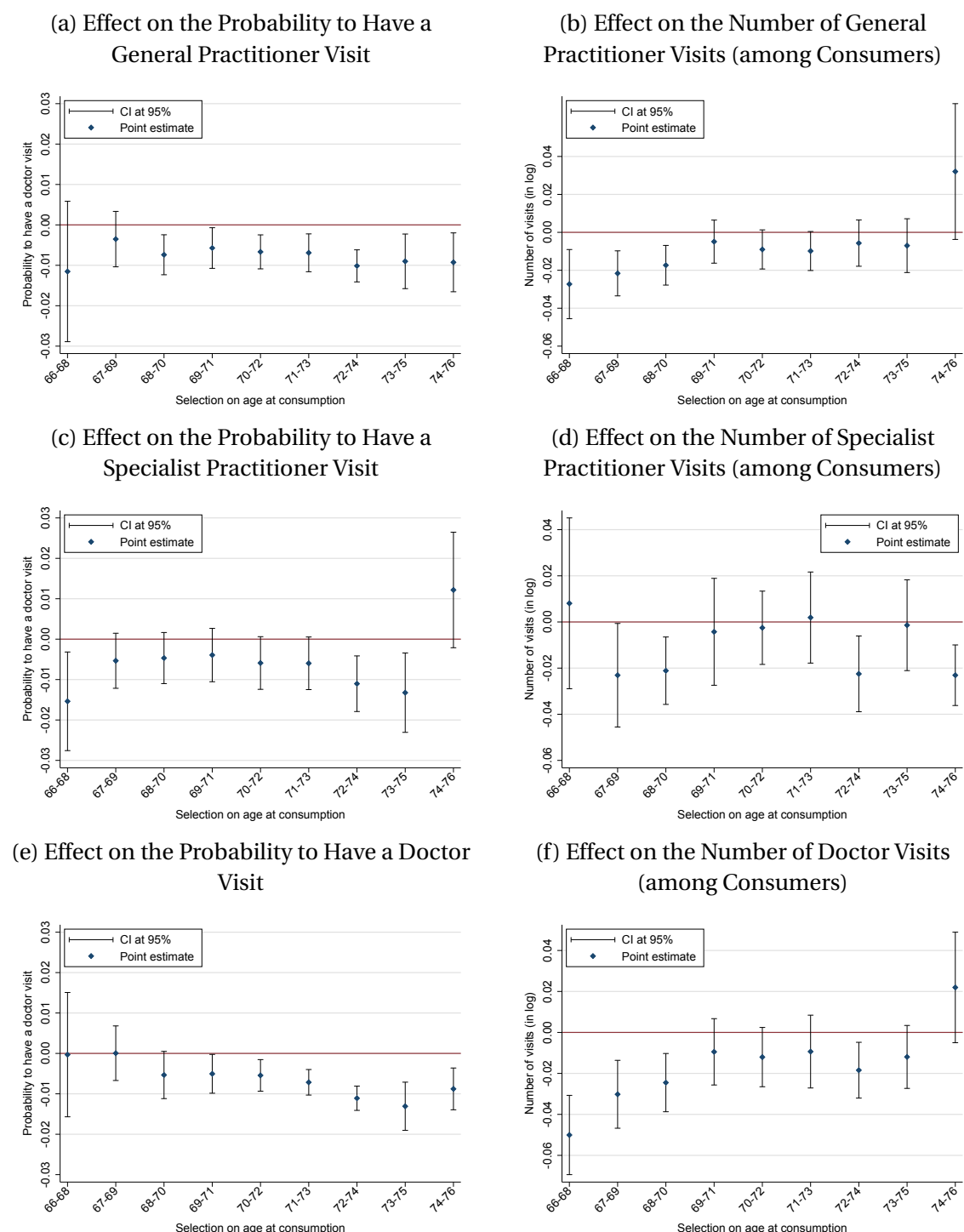
The variation in inter-temporal income is not likely to play a major role in this study for at least two reasons. First, all individuals in a given cohort see the amount of their pension affected by the reform the same way. Second, Table D2 of Appendix D shows that, among those with a co-payment exemption, the results are similar (a decrease by 0.740 percentage point in the probability to have a doctor visit, and a decrease by 1.30% in the number of doctor visits). There is no impact on dentist visits and private hospital stays. It suggests that neither the healthcare cost nor the income would explain the observed decrease. Thus, the decrease is probably not associated with an increase in the share of individual foregoing healthcare consumption. The increase seems to be due to a decrease among those with a high level of consumption (See Tables D4 and D5).

Lastly, one may think the decrease is attributable to a decrease in health investment, through a decrease in preventive care for those who retire later. This decrease could be a compensation of an increasing investment during working life or due to the fact individuals affected by the reform are, at the same age, closer to their retirement date (and thus, to their last investment). This result would be consistent with the decrease in preventive care found at retirement by Frimmel and Pruckner (2020). Unfortunately, this hypothesis cannot be tested in this study.

²⁵Cognitive and physical abilities are preserved when used. Thus, later retirement preserves health.

²⁶Working scheduling, or lighter working hours, part-time paid full time, pre-retirement offer...

Figure 4 – Impact of Later Retirement on Healthcare use by Age Range



Notes: Point estimates of the impact of later retirement on the probability to have a general practitioner visit (Figure a), a specialist practitioner visit (Figure c) and any doctor visit (figure e). It shows a significant decrease in the probability of having a generalist doctor visit among individuals aged between 68 to 70, and all older groups. Figure (b), (d) and (f) respectively show, among consumers, the impact of later retirement on the number of doctor visits (general, specialist, all).

Sample: Men who had contributed at least once in the private sector and had contributed at age 60 between 131 and 160 quarters, retired before age 67.

Source: HYGIE 2005 – 2015.

Conclusion

In this paper, I use a two stage least square estimator in a two part model to estimate the causal impact of later retirement on healthcare consumption at extensive and at intensive margins. I focus on a sample of men who worked in the private sector, aged from 66 to 76. I use the first French pension reform that increased claiming age as an instrumental variable. Moreover, this paper is one of the first to focus on the impact of a variation in retirement timing on retirees on their healthcare consumption rather than on the impact of the switch from employment to retirement. I show that a one quarter delayed retirement due to the reform decreases statistically significantly the probability to have at least one doctor visit (extensive margin) and the number of doctor visits among consumers (intensive margin). This result is consistent with previous findings. Three main potential mechanisms could explain it. First, one may think that the better individual's health is, the latter he retire. It would be the case if the use-it-or-loose-it hypothesis holds; if individuals invest more in their health when in employment; or if later retirement due to this reform is associated with a better anticipation of retirement life. In this study, I cannot provide evidence of this underlying mechanism since I don't have health, well-being or life-satisfaction indicators. However, the slightly significant increase in the probability to have a chronic condition after age 65 make this "health mechanism" potentially unlikely or not the only one to play a role. Another mechanism could be an increase in the share of individuals foregoing healthcare among those who delayed retirement. However, I found a similar impact among those with a co-payment exemption, which make this mechanism unlikely. Finally, one may think that individuals who retire later decrease their healthcare investment more often than the others, and thus, consume less preventive care. This mechanism could be a compensation of a longer investment in health (through a longer working life) or by the fact that at each given age, they are closest to their last health investment from their working life.

The decrease in healthcare consumption due to the reform is of double financial gain for the public finance.²⁷ However, it is impossible to draw a conclusion from a public policy perspective without any qualitative understanding regarding the underlying mechanism explaining this result. This paper shows the importance for more research in this field. If the decrease in healthcare consumption is associated with a better health, through a confirmation of the use-it-and-loose-it hypothesis, the public policy recommendation would be in favor of a policy that increase the incentive for retirees to have social, physical and cognitives activities. If the health improvement is through the health investment during employment, the public policy advice would be to increase incentives for health investment during retirement. If there is no health variation due to delayed retirement but a decrease in preventive

²⁷A decrease both in public expenditure for pension and for healthcare.

healthcare utilisation, the public policy would increase incentives for health investment during retirement.

Finally, this paper does not pretend to have an external validity. Those results stand only for men from the private sector, with average career length. The extrapolation to women, self-employed or civil servants may be wrong. Moreover, an increase in claiming age for individuals who retire between age 60 and 65 may have a different impact on health than an increase in claiming age for those who retire between age 65 and 67. Thus, the results should not be extended to other pension reforms that change claiming age at an earlier or later age.

Appendix to

Does Later Retirement Change your Healthcare Consumption?

A Institutional Framework

A.1 The 1993 Pension Reform

The pension is computed using the following formula:

$$P = \tau \times PC \times W_{ref}$$

with τ the replacement rate; PC, the proratisation coefficient; and W_{ref} the reference wage. W_{ref} is equal to the best N years of wages.

The replacement rate formula is:

$$\tau = 0.5 - \delta \times \max[0; \min(4 \times (65 - a); D - d)]$$

with a , the claiming age; D, the required contribution length to benefit from a full replacement rate; d the number of quarters contributed; and δ , the minimization coefficient, equal to 1.25 % per missing quarter.

The 1993 reform changes :

- D, The number of quarters required to benefit from a full pension
 - For cohorts born before 1934, D equals 150 quarters
 - Each cohort born in 1934 and after has one added quarters compared to the previous cohort
 - From cohort 1943, D equals 160 quarters
- N, the number of best years of wages
 - Before 1993, N equals 10
 - N increases by one year every year
 - N equals 25 years from 2010
- Pensions are indexed on price and not wages. In practice, this indexation applies already from 1987.

Thus, the change on the number of quarters required affects only a little share of individuals in each cohort, because all individuals with very short career will leave at age 65 whatever the change in D, and individuals with very long career will leave at age 60 whatever the change in D. The change in N affects each cohort in the same way. The indexation change affects all cohorts in the same way. As a consequence, assuming that all individuals in each cohort are affected in the same way by the change in N and indexation, the difference between individuals affected and not affected by the D change within each cohort captures only the effect of this part of the 1993 reform.

A.2 The Health Insurance System in France

In France, there is a public mandatory health insurance for almost all the French. The reimbursement rate is defined at the national level for each care.²⁸ Moreover, contribution varies according to the status on the labour market (student, worker, unemployed, retired...).

In average, this mandatory public coverage reimburse 78 % of the healthcare expenditure. However, there is heterogeneity in the reimbursement rate. In particular, individuals suffering from chronic diseases benefit from a 100% reimbursement of their expenditures associated with their chronic disease from the public health insurance to cover.

To cover expenditure which are not reimbursed by the National Health Insurance, individuals can subscribe to a private supplementary health insurance. It can be through an individual contract or a collective firm contract. Before 2016,²⁹ private sector employees can benefit from supplementary health insurance through a collective firm contract paid both by employees and employers. The firm has to pay at least 50% of the insurance fees. 51 % of private sector firms offer a collective supplementary insurance in 2015 (Lapinte and Peronnin, 2018) and 75 % of private sector employees benefit from a collective supplementary insurance. At retirement, employees can keep on benefiting from this coverage but without any of the firm previous contribution. Since the Evin Law (1989), the insurance has to apply the same fees the three first years after retirement. Once these three years passed, the fees of supplementary insurance can change. However, in average, a major part of retirees are not affected by this price change because most of them change their health insurance at retirement. Thus, Franc et al. (2007) show that 51% of beneficiaries of mandatory collective firm contract change their contract at retirement, 39% of beneficiaries of optional collective firm contract change their supplementary insurance at retirement, 23% of new retirees with an individual supplementary health insurance change their contract at retirement.

The healthcare supply is highly regulated in France, following different rules at hospital (inpatient care) and out of hospital (ambulatory care). Ambulatory care are provided by gen-

²⁸Except in Alsace-Moselle area, where there is a higher coverage rate.

²⁹This supplementary coverage is mandatory for private sector employee from 2016.

eralists³⁰ and specialist practitioners.³¹ The standard regulated price for generalist doctor visits in France was 23€ in 2015. For the specialist, there is a higher variation according to the speciality. Thus, the fees go from 25 to 150€. The National Health Insurance reimburses 70% of the regulated doctor fees, with a few exceptions. The healthcare pathway encourages patients to visit first general practitioners, and if needed, benefit from a prescription to visit specialist practitioners.³² Following this healthcare pathway is highly encouraged since the reimbursement rate from National Health Insurance is cut by 40% if the patient does not visit first a general practitioner. Fees of ambulatory care are regulated for both generalists and specialists.

Inpatient care is provided in hospital which can be private for-profit, private non-for-profit and public. If an individual benefits from an administrative acknowledgement of long-term care illness, its reimbursement rate is 100 % for all medical care related to his long-term care illness. There are several other conditions to benefit from a co-payment exemption: having an inpatient stay longer than 30 days or having a work accident, for example.

³⁰Generalist is one of the French speciality of medicine. General practitioners provide primary care and ensure the continuity of medical follow-up.

³¹In France, there are 26 main medical specialities including oncology, rheumatology, dermatology, ophthalmology, cardiology...

³²This system was voted in 2004, and implemented from July, 2005, through the Douste-Blazy law.

B Data Details

Table B1 – Age of each Cohort per Wave

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1935	70	71	72	73	74	75	76	77	78	79	80
1936	69	70	71	72	73	74	75	76	77	78	79
1937	68	69	70	71	72	73	74	75	76	77	78
1938	67	68	69	70	71	72	73	74	75	76	77
1939	66	67	68	69	70	71	72	73	74	75	76
1940	65	66	67	68	69	70	71	72	73	74	75
1941	64	65	66	67	68	69	70	71	72	73	74
1942	63	64	65	66	67	68	69	70	71	72	73
1943	62	63	64	65	66	67	68	69	70	71	72

Notes: I observe cohort 1935 between ages 70 and 80; cohort 1936 between ages 69 and 79; etc. In the main sample, the observation in gray are excluded.

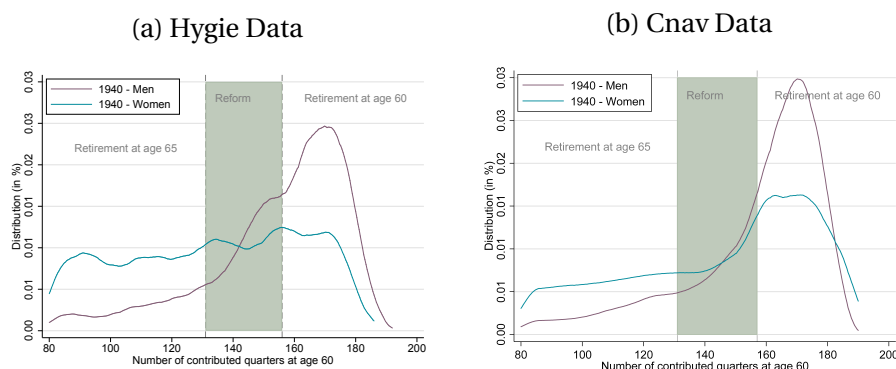
Table B2 – Age of each Cohort per Wave – Selection for the Analysis by Age Range

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1935	70	71	72	73	74	75	76	77	78	79	80
1936	69	70	71	72	73	74	75	76	77	78	79
1937	68	69	70	71	72	73	74	75	76	77	78
1938	67	68	69	70	71	72	73	74	75	76	77
1939	66	67	68	69	70	71	72	73	74	75	76
1940	65	66	67	68	69	70	71	72	73	74	75
1941	64	65	66	67	68	69	70	71	72	73	74
1942	63	64	65	66	67	68	69	70	71	72	73
1943	62	63	64	65	66	67	68	69	70	71	72

Notes: I observe cohort 1935 between ages 70 and 80; cohort 1936 between ages 69 and 79; etc. In blue, observations selected in the analysis between ages 66 and 68. The selection is shifted by one year. It leads, three time later, to the selection in red of individuals aged between 69 to 71 years old, until the group of those aged between 74 and 76 years old, in orange in the Table.

The Selection of Men. On Figure B1, the distribution by contribution length at age 60 is drawn. The Figure B1a shows the distribution in the HYGIE data. The Figure B1b shows the same picture using the exhaustive data from the private pension scheme (Cnav). The male distribution is similar in both datasets while it not the case for women. HYGIE data do not include information on the additive quarters one may get. Since these additional quarters are mainly for childbirth, and for years were a parent stop working to raise children, the consequence is a wrong contribution quarters length for women that benefit from these added quarters. I underestimate the number of contributed quarter for women in HYGIE

Figure B1 – Distribution by Contribution Length at Age 60



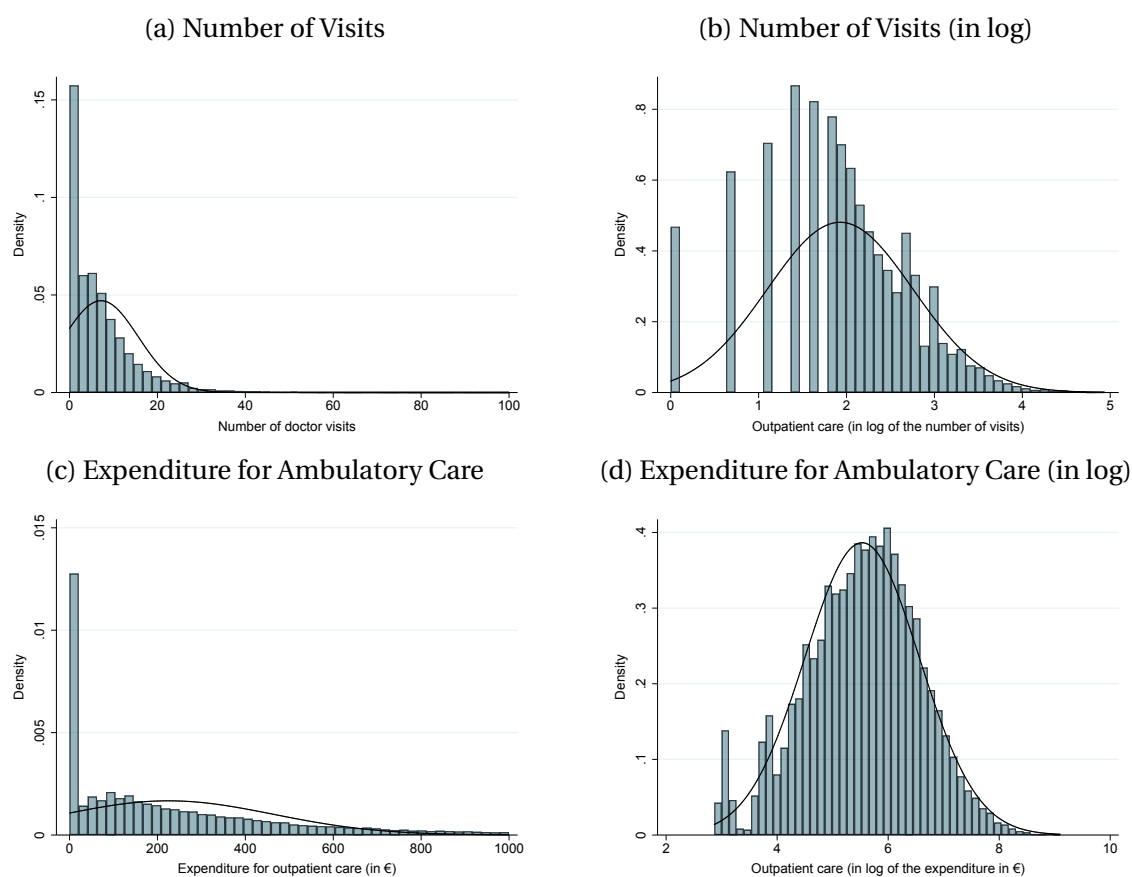
Notes: Kernel density by contribution length at age 60 of individuals who had contributed between 80 to 200 quarters at age 60.

Source: Figure (a): HYGIE data. Sample of individuals born in 1940, who had contributed at least once in the private sector. Figure (b): Cnav 2017. Stock of individuals born in 1940. The Cnav data include all the French who had contributed at least once in the private sector. It shows the real distribution of contribution length at age 60.

data, and in particular for women with a high number of contributed quarter at age 60. This is not a surprise for two reasons. First, women with a high contribution length at age 60 are those with the lowest level of education. In France, it is a group with in average more children (Davie and Mazuy, 2010) and therefore, more quarters for childbirth. Secondly, they may probably stop working to raise children more often and thus, have associated contributed quarters I do not observe in Hygie data.

Distribution of Healthcare Consumption. The following Figures show the number of doctor visits and expenditure for doctor visits both without and with log transformation.

Figure B2 – Healthcare Distribution



Notes: This graph shows the density of the number of doctor visits (a) and the log of the number of doctor visits among the consumers (b). It also shows the expenditure for doctor visits (c) and the log of expenditure among consumers (d).

Sample: Men who had contributed at least once in the private sector and had contributed at age 60 between 131 and 160 quarters, retired before age 67.

Source: HYGIE 2005-2015.

C Robustness Check

C.1 Sample Selection on Contribution Length

In the main analysis, I select individuals who have contributed between 131 and 160 quarters at age 60. All individuals who have contributed between 131 and 151 quarters are affected by the reform. Those who have contributed between 152 and 159 quarters are not all affected, depending on their birth year. In a difference-in-difference design, I have to include at least one contributed quarter where nobody is affected by the reform. Thus, I can include all individuals who have contributed less than 130 quarters and those who have contributed more than 160. However, I cannot include both because those who have contributed less than 130 quarters leave with a full replacement rate from age 65 while those who have contributed more than 160 leave at age 60. I include as a control group those who have contributed 160 quarters and more. This choice is more logical since the affected are those who would have been retired at age 60 but have to leave later due to the reform. As a consequence, it makes less sense to compare it to the group of individuals who leave at age 65 than the group who leave at age 60.

Lastly, note that the identification strategy relies on the fact that those who are affected are similar to those who are not affected. It is true when considering individuals who have contributed 159 quarters compared to those who have contributed 160 quarters. However, it is probably wrong when comparing those with 159 quarters with those with 180 quarters. Thus, the empirical strategy becomes probably less precise, or wrong with the inclusion of individuals with a very large contribution length.

Figure C1 shows the results using alternative sample selection regarding to the contribution length. The dash line separates the case where the treated are compared to the non treated who leave at age 65 (all points at the left of the line) and the case where the treated group is compared to the non treated group who leave at age 60 (points at the right of the line). The expected results of this robustness check is that the main sample (131 to 160 quarters) provides results not statistically different from the results using close contribution length thresholds.

Figures C1(a) and (b) show the impact of the reform on claiming age. Points the most on the left of these figures show smaller average impact. This is expected since the more the dot is on the left, the more individuals not affected by the reform and leaving at age 60 are included.

Figures C1(c) show the impact of delayed retirement by one quarter due to the reform on the probability to consume. The effect founded is not statically different from adjacent samples. However, adding a high number of individuals not affected by the reform that leave at age 65 (thus, later than the affected) leads to a non significant impact or, in three cases

over eight, a positive significant impact very close to zero. Adding individuals with very long career, who leave at age 60 and are not affected by the reform leads to a smaller effect but still significant, except for the three last sample tested (those with individuals who started working close to age 16).

Figures C1(d) show the impact of one quarter more due to the reform on the number of doctor visits (in log). The impact is never statistically different when adding individuals who leave at age 65. It is not statistically different for the two samples with individuals who leave at age 60 and that are the closest to the main estimation. However, once adding a high number of individuals not affected by the reform, who leave at age 60, the effect turns non significant. Note that it is probable that the individuals with between 170 and 180 quarters contributed at age 60 have different health condition than those between 150 and 160 quarters contributed and thus, are not very comparable.

Note that I never consider individuals with more than 180 quarters. Individuals with more than 180 quarters are those who started working before age 16. These individuals exists only for the cohorts born before 1943 (a law forbid full time employment before age 16 from 1959). In my sample, these individuals are rare and I consider these individuals as atypical compared to the rest of the sample.

Table C1 – Individuals Affected and not Affected in the Sample

Contrib. length at age 60		Claiming age	If continuous career, Started working at age
[0; 130]	Not affected (NT)	65 y.o.	27,5 y.o. and later
[131; 151]	Affected (T)	btw 60 and 65 y.o.	between 22,25 and 27,25 y.o.
[152; 159]	NT + T	btw 60 and 65 y.o.	between 20,25 and 22 y.o.
[160; 180]	Not affected (NT)	60 y.o.	between 16 and 20 y.o.

Notes: Individuals who contributed between 0 and 130 quarters at age 60 are not affected by the reform, they retire from age 65 at the full replacement rate, and started working at age 27,5 years old if they had a continuous caree. Individuals who contributed between 131 and 151 quarters are affected by the reform, they retire with a full replacement rate between age 60 and 65, and if they had a continuous career, they started working between age 22,25 and 27,25.

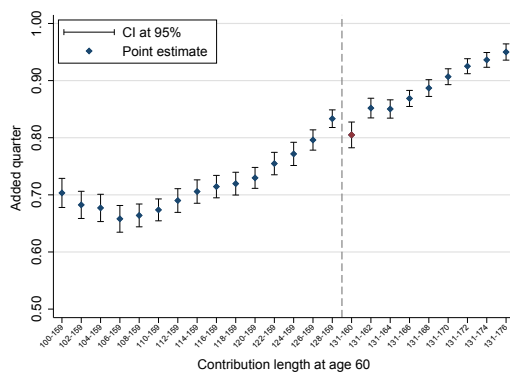
C.2 Results Using Other Econometric Specifications

To test the robustness of the econometric specification, I provide in Table C2 results using alternative econometric specification. I measure the impact of later retirement on the probability to consume using probit regression and using Poisson regression.

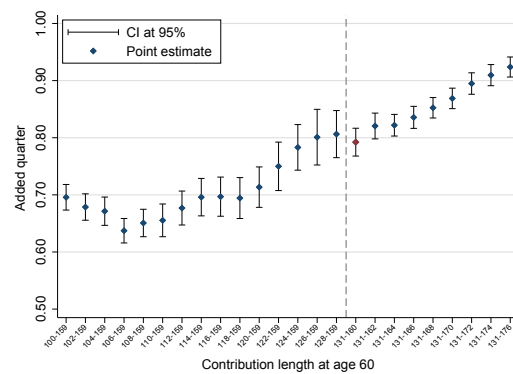
I measure the impact of later retirement on the number of doctor visits among consumers, using a semi-parametric specification using discrete transformation of healthcare variables, in a generalized method of moments (GMM) (Hansen, 1982). It also shows similar results.

Figure C1 – Sensitivity to Contribution Length Selection

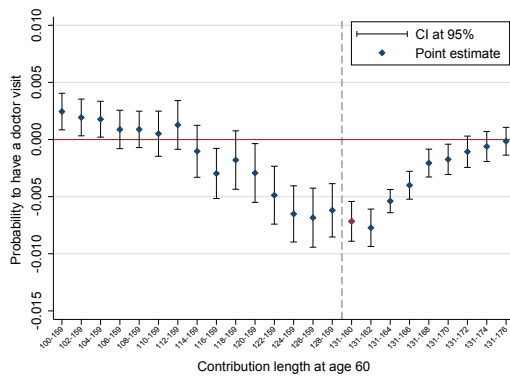
(a) Impact of the Reform on Claiming age
(1st stage) – All



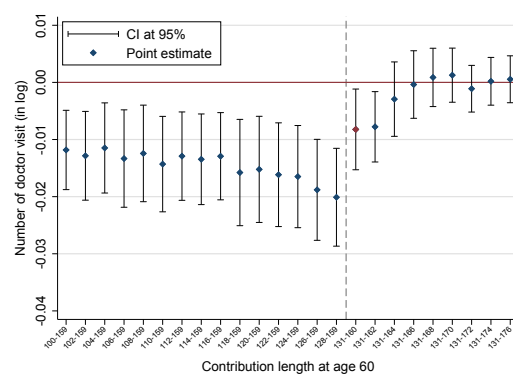
(b) Impact of the Reform on Claiming age
(1st stage) – Consumers



(c) Impact of Later Retirement on
Probability to Have a Doctor Visit (2nd
Stage) – All



(d) Impact of Later Retirement on the
Number of Doctor Visits (2nd Stage) –
Consumers



Notes: Point estimates of the impact of later retirement on doctor visits. The red dot is the point estimate of our main sample.

Sample: Men who had contributed at least once in the private sector and had contributed at age 60, retired before age 67.

Source: HYGIE 2005-2015.

Table C2 – Impact of Later Retirement on Healthcare Consumption using Alternative Models

	Probability to consume			Level of consumption
	iv-probit	iv-reg GMM	iv-poisson GMM	iv-poisson GMM
Generalist	-0.00750*** (0.00209)	-0.00828*** (0.00217)	-0.00752*** (0.00214)	-0.00419 ** (0.00173)
Specialist	-0.00713*** (0.00257)	-0.00722*** (0.00269)	-0.00464*** (0.00265)	-0.00685 (0.00473)
Dentist	-0.000265 (0.00166)	-0.000227 (0.00163)	-0.000584 (0.00189)	-0.0205 (0.0411)
Ambulatory	-0.00960*** (0.00253)	-0.00998*** (0.00266)	-0.00679*** (0.00210)	-0.00560*** (0.00183)
Drugs	-0.00789*** (0.00255)	-0.00803*** (0.00264)	-0.00472*** (0.00199)	-0.00224 *** (0.00047)
Hospital	-0.000308 (0.00162)	-0.000247 (0.00164)	-0.000518 (0.00183)	-0.0218 (0.0291)
Any care	-0.00709*** (0.00257)	-0.00722*** (0.00263)	-0.00386*** (0.00198)	-0.00346 *** (0.000655)
N	66,698	66,698	66,698	66,698

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: All coefficients are marginal effects. Retire one quarter later due to the reform leads to an average increase in the probability to have a generalist practitioner visit by 0.7 percentage point, estimated using a probit model.

Sample: Men who had contributed at least once in the private sector and had contributed at age 60 between 131 and 160 quarters, retired before age 67.

Source: HYGIE 2005 – 2015.

D Additional Results

D.1 Results for Alternative Samples

Impact among Individuals with Chronic Condition. To test if the effect is driven by individuals with particular healthcare consumption, I observe the impact of later retirement on the probability to consume doctor visits and on the level of consumption among individuals who had or have a chronic condition.³³ Table D1 shows that among individuals with chronic condition, a one quarter increase in claiming age due to the reform decreases significantly the probability to have a doctor visit by 1.46 percentage point and the number of doctor visits by 1.80% among consumers. The decrease is slightly higher than the main result.

Table D1 – Results among the Healthcare Consumers with Chronic Condition

		Probability	Number of	Expenditure for	Price for
Generalists	Claiming age	-0.0138*** (0.00114)	-0.0103** (0.00506)	-0.0103* (0.00569)	-0.0000628 (0.00172)
	N	29,323	23,546	23,546	23,546
Specialists	Claiming age	-0.0155*** (0.00359)	-0.0126** (0.00519)	-0.0293*** (0.00914)	-0.0167*** (0.00634)
	N	29,323	17,429	17,429	17,429
Dentists	Claiming age	-0.00128 (0.00228)	-0.000441 (0.00671)	-0.0125 (0.0181)	-0.0121 (0.0151)
	N	27,317	3,524	3,524	3,524
Total ambulatory	Claiming age	-0.0146*** (0.00120)	-0.0180*** (0.00502)	-0.0300*** (0.00863)	-0.0119** (0.00536)
	N	29,323	24,376	24,376	24,376
Drugs	Claiming age	-0.0122*** (0.00120)	n.a. n.a.	-0.0261*** (0.00625)	n.a. n.a.
	N	29,323	n.a.	24,773	n.a.
Hospital	Claiming age	-0.00210 (0.00162)	-0.0267* (0.0161)	-0.0294** (0.0142)	-0.00266 (0.0153)
	N	29,323	4,428	4,428	4,428
Total	Claiming age	-0.0121*** (0.00132)	n.a. n.a.	-0.0307*** (0.00749)	n.a. n.a.
	N	29,323	n.a.	23,218	n.a.

Standard errors in parentheses

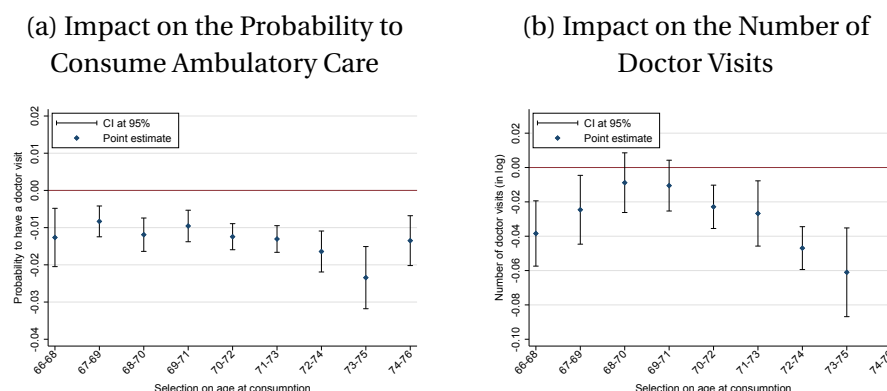
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Delay retirement by one quarter due to the reform significantly decreases by 1.46 percentage point the probability to consume a doctor visit and decreases the number of doctor visits by 1.80% among the consumers. *Sample:* Men who had contributed at least once in the private sector and had contributed at age 60 between 131 and 160 quarters, retired before age 67, and have or had after age 65 an administrative recognition of a chronic condition.

Source: HYGIE 2005 – 2015.

³³I identify those with a chronic condition through the variable “Have an administrative recognition of a chronic condition”.

Figure D1 – Impact of Later Retirement among those with a Chronic Condition



Notes: This graph shows the average impact of later retirement on the number of doctor visits at particular age range. Confidence Intervals at 95%.

Sample: Men who had contributed at least once in the private sector and had contributed at age 60 between 131 and 160 quarters, retired before age 67.

Source: HYGIE 2005 – 2015.

Impact among Individuals with Co-payment Exemption. To test the potential price-sensitivity effect, I focus on the subsample of those who benefit from a co-payment exemption.³⁴ Table D2 shows the impact of later retirement on the probability to consume and the level of healthcare consumption. It shows that delay retirement by one quarter due to the reform significantly decreases by 0.740 percentage point the probability to consume a doctor visit and decreases the number of doctor visits by 1.30% among the consumers. These results are not statistically different from the main sample, meaning that the effect is not driven by a price elasticity effect.

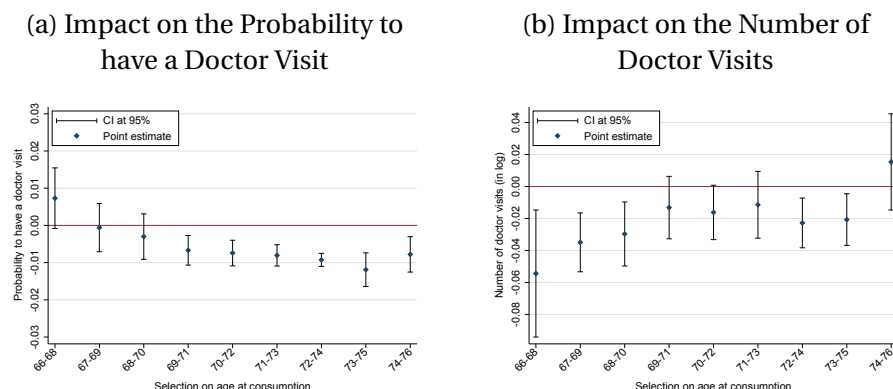
D.2 Results for Alternative Outcomes

Results on the Probability to Have a Chronic Condition After Age 65. Table D3 show that delayed retirement by one quarter leads to an increase in the probability to have a chronic condition after age 65 by 0.209 percentage points. This effect seems to be temporary. Thus, as shown in figure D3 this result holds only between age 67 and 70. Thereafter, there is no significant impact between age 70 and 75.

Impact on each Quartile of Healthcare Distribution. Studying the impact of later retirement on consumption quartile provides additional information regarding the impact of later retirement on healthcare consumption. Thus, Table D4 shows the impact of later retirement on the probability to be in each quartile of healthcare distribution. It shows that there is a

³⁴Can benefit from this exemption in the sample: individuals who need care associated with work accident and occupational illness; individuals with long-term illness.

Figure D2 – Impact of Later Retirement among those with a Co-payment Exemption



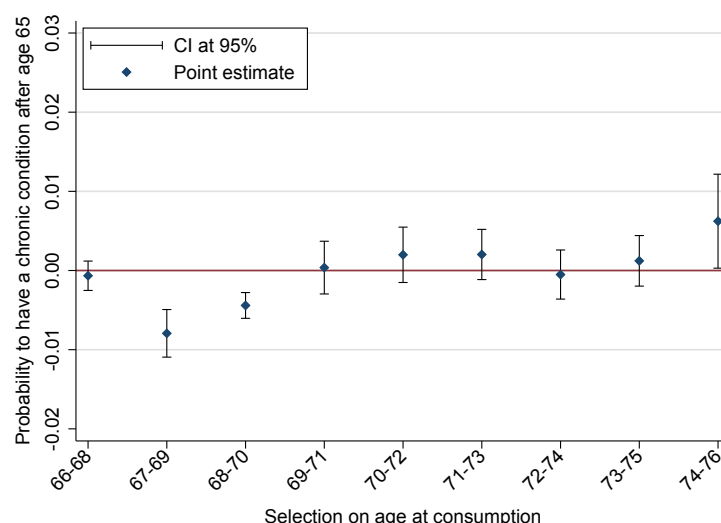
Notes: This graph shows the average impact of later retirement on the number of doctor visits at particular age range. Confidence Intervals at 95%.

Sample: Men who had contributed at least once in the private sector and had contributed at age 60 between 130 and 180 quarters, retired before age 67.

Source: HYGIE 2005 – 2015.

Figure D3 – Impact of Later Retirement on the Probability to Have a Chronic Condition after Age 65

Figure D4 – Impact on the Probability to Have a Chronic Condition after Age 65



Notes: This graph shows the average impact of later retirement on the probability to have a chronic condition after age 65, by age range. Confidence Intervals at 95%.

Sample: Men who had contributed at least once in the private sector and had contributed at age 60 between 130 and 180 quarters, retired before age 67.

Source: HYGIE 2005 – 2015.

Table D2 – Results among the Healthcare Consumers with Co-payment Exemption

		Probability	Number of	Expenditure for	Price for
Generalists	Claiming age	-0.00822*** (0.00178)	-0.00625** (0.00303)	-0.00460* (0.00275)	0.00165* (0.000972)
	N	47,365	42,911	42,911	42,911
Specialists	Claiming age	-0.00784*** (0.00261)	-0.00947* (0.00531)	-0.0176** (0.00712)	-0.00809** (0.00382)
	N	47,365	30,161	30,161	30,161
Dentists	Claiming age	-0.000730 (0.00114)	-0.0000767 (0.00706)	0.00554 (0.0145)	0.00561 (0.0135)
	N	43,525	6,149	6,149	6,149
Total ambulatory	Claiming age	-0.00740*** (0.000986)	-0.0130*** (0.00376)	-0.0178*** (0.00550)	-0.00484 (0.00332)
	N	47,365	44,705	44,705	44,705
Drugs	Claiming age	-0.00416*** (0.00108)	n.a. n.a.	-0.00889** (0.00423)	n.a. n.a.
	N	47,365	n.a.	45,846	n.a.
Hospital	Claiming age	-0.000167 (0.00150)	-0.00757 (0.0114)	-0.00522 (0.00923)	0.00235 (0.00819)
	N	47,365	7,140	7,140	7,140
Total	Claiming age	-0.00285*** (0.000718)	n.a. n.a.	-0.0224*** (0.00360)	n.a. n.a.
	N	47,365	n.a.	42,567	n.a.

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Delay retirement by one quarter due to the reform significantly decreases by 0.740 percentage point the probability to consume a doctor visit and decreases the number of doctor visits by 1.30% among the consumers.

Sample: Men who had contributed at least once in the private sector and had contributed at age 60 between 131 and 160 quarters, retired before age 67, and benefit from a co-payment exemption.

Source: HYGIE 2005 – 2015.

significant increase in the probability to be in the first quartile of consumption and a decrease in the probability to be in the last quartile of the distribution. It can be interpreted as an overall negative impact driven by a increase in the number a “small” consumers.

Table D5 shows the impact of later retirement on the quartile of healthcare distribution (ie. the outcome is a discrete variable having the value 1, 2, 3 and 4). It shows similar results: individuals who delayed retirement tend to be “smaller” consumers than the others.

Table D3 – Impact on the Probability to Have a Chronic Condition after Age 65 and Co-payment Exemption

	Chronic Condition	Exemption
Claiming age	0.00209*** (0.000608)	-0.00224 (0.00227)
N	66,698	66,698

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Delayed retirement by one quarter leads to an increase in the probability to have a chronic condition after age 65 by 0.209 percentage points. Delayed retirement by one quarter leads to a non significant decrease in the probability to benefit from a co-payment exemption by 0.224 percentage points.

Sample: Men who had contributed at least once in the private sector and had contributed at age 60 between 131 and 160 quarters, retired before age 67.

Source: HYGIE 2005 – 2015.

Table D4 – Results on the Probability to be in each Healthcare Expenditure Quartile

	P($0 < \text{HCE} < 523$)	P($523 \leq \text{HCE} < 1075$)	P($1075 \leq \text{HCE} < 1994$)	P($1994 \leq \text{HCE}$)
Claiming age	0.00601*** (0.00133)	0.00200 (0.00235)	-0.00359** (0.00181)	-0.00354* (0.00210)
N	52,463	52,463	52,463	52,463

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Retire one quarter later due to the reform leads to an average increase in the probability to be in the first quartile of healthcare expenditure by 0.6 percentage point, and a decrease in the probability to be in the last quartile by 0.36 percentage point.

Sample: Men who had contributed at least once in the private sector and had contributed at age 60 between 131 and 160 quarters, retired before age 67.

Source: HYGIE 2005 – 2015.

Table D5 – Results on the Healthcare Quartile

	Impact of later retirement on
Generalist visit quartile	-0.0106** (0.00479)
N	48,324
Specialist visit quartile	-0.0136 (0.0101)
N	34,040
dentist visit quartile	-0.0170 (0.0220)
N	7,396
Doctor visit quartile	-0.0121* (0.00728)
N	50,488
Drugs expenditure quartile	-0.0155*** (0.00212)
N	51,855
Hospital stay quartile	-0.0304*** (0.0112)
N	8,008
Total healthcare expenditure quartile	-0.0194*** (0.00576)
N	48,468

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Retire one quarter later due to the reform leads to a decrease in the quartile of doctor consumption by 0.0121 (the number of doctor practitioner visits of one individual over 100 is in the quartile directly lower due to the reform).

Sample: Men who had contributed at least once in the private sector and had contributed at age 60 between 131 and 160 quarters, retired before age 67.

Source: HYGIE 2005 – 2015.

Part II

LONG TERM CARE

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Chapter 4

Dynamics of the Disability Process in Ageing Populations

Summary of the chapter

We develop a novel methodological approach to quantify the projected increase in long-term care needs within ageing populations. Our model relies on epidemiological measures of disability at old age, and we estimate the dynamic of transitions from autonomous states to different degrees of disability. By estimating the transitions in health status, we make explicit that a key assumption of these projections consists in how life expectancy gains are allocated to the different possible health transitions. In our baseline scenario we obtain a projection of between 2.4 and 3.6 millions disabled elderly in France by 2060. Even if uncertainty remains, our various scenarios point to an expansion of morbidity. The probability to remain autonomous appears to be one of the major parameter influencing the projection of long-term care needs.

This Chapter has been co-authored with Mahdi Ben Jelloul, Antoine Bozio, Audrey Rain and Léa Toulemon.

Introduction

In the last decade, most developed countries have experienced an increasing trend in the demand for long-term care provision. With increased life expectancy, and ageing baby boom cohorts, many policy pundits fear a very steep rise in care needs from disabled elderly. This has prompted researchers to develop models to quantify the extent of the additional care needs, as those will have to be funded either by private insurance, individuals' savings or public provision. The key question looming in the background has been whether we can expect compression or expansion of morbidity, i.e., do life expectancy gains in autonomous state will dominate gains of years of life with some disability.

While the principle of long-term care projections is similar to the ones carried out for pension liabilities—they depend on age/gender changes in death rates—, they crucially rely on estimating the change in disability prevalence at each age/gender. A large part of the research on that topic has consisted in estimating characteristics predicting current long-term care uses, in order to project long-term trend based on mortality scenarios. With that approach, long-term care needs are bypassed by measures of use, or by administrative eligibility criteria to current long-term care provision.¹ The obvious drawback of such modelling is that it remains completely independent from the underlying health changes, and very much influenced by current care provision. Moreover, the use of administrative measures of health makes the results hardly comparable between countries, and subject to changes in the disability definition across time. To get a grasp at whether developed countries now face a “long-term care time bomb” or not, one has to dig deeper into the ageing process underlying the change in long-term care needs.

Progress has come here mostly from epidemiologists, using tools like dynamic microsimulation models, initially the preserve of economists. This approach relies on epidemiological measures of the disability status, exploiting survey data where Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL) are reported. Prevalence of different disability status are projected using models which take as inputs trends from underlying diseases leading to different disability levels.² While this approach relies on very detailed health status and underlying health conditions, mortality remains projected separately—using official mortality projections—and changes in health conditions are not taken into account in

¹See Rutter et al. (2011); Schofield et al. (2018) for surveys; Bontout et al. (2002); Duée and Rebillard (2006); Lecroart et al. (2013); Marbot and Roy (2015) for studies on French data; Hancock et al. (2005) for the U.K.; and Fukawa (2012) for Japan.

²For example, Kingston et al. (2018b) project prevalence for several diseases, using the PacSim model in the U.K. Ahmadi-Abhari et al. (2017) forecast future prevalence of dementia in the U.K. using IMPACT-BAM model. For a review of previous microsimulation models on dementia, see Norton et al. (2013). Légaré et al. (2014) project the disability status of the Canadian population, using LifePaths, or more recently the model POHEM from Statistics Canada.

the conditional death rates. Life expectancy gains are thus distributed homogeneously to all health states. This is far from being an innocuous assumption, as elderly disability projections largely depend on the source of life expectancy gains, either in autonomous state, or with light or severe disability condition.

This paper aims to contribute to this literature with a novel methodological approach to quantify long-term care needs. It relies, like epidemiological models, on an epidemiological measure of long-term care needs, but, crucially, it is the dynamic process of disability at older age that is estimated—the flow onto disability states rather than the stock of disabled individuals. Projections are then realised with different scenarios, depending on assumptions about the distribution of life expectancy gains across the different health transitions.

This approach is made possible by the use of the panel element of the Survey of Health, Ageing and Retirement in Europe (SHARE), the European version of Ageing surveys—like HRS in the U.S.—which offers detailed epidemiological measures of disability status, based on ADL and IADL, as well as very large socio-economic characteristics. We model disability transitions using a scale of four disability states, with death representing a fifth states. Both health decline and recovery are possible, but only transition to the closest disability scale is allowed. In thus, we follow recent epidemiological models of elderly disability process (Barberger-Gateau et al., 2000; Pérès et al., 2005). We estimate transitions in health status using a multinomial logit, controlling for observable characteristics. We then use for a baseline prevalence of disability the CARE-M survey, a French cross-section data source about elderly population, and we mobilize the dynamic microsimulation model TAXIPP-LIFE, developed by the Institut des politiques publiques (IPP). We use official mortality projections (Insee, Blanpain and Chardon (2010)). We test alternative scenarios depending on the life expectancy evolution and allocation of those gains across dependency states. It allows us to highlight which parameters matter the most in determining the evolution of the ratio of disability-life expectancy over the total life expectancy.

Our main results relate to the projections of elderly disabled French population. According to our baseline scenario, the number of disabled elderly in France—with any level of disability—will increase from 5.3 in 2016 to 12.3 million individuals in 2060. Among these 12.3 million disabled, 2.84 million individuals will be severely disabled in 2060. We also compute the ratio of disability-free life expectancy over total life expectancy. It shows a ratio of 0.65 for women and 0.82 for men in our baseline scenario. However, this ratio turns out to vary widely depending on the scenarios (more or less 0.15 for women and 0.1 for men).

Finally, we also show that the probability to remain autonomous is the parameter having the highest impact on morbidity. The required evolution of this parameter to obtain a stagnation of morbidity is relatively high. Thus, one may conclude that a stagnation of morbidity required to experience a change in several transition probabilities at the same time.

Thus, diminish the probability to remain autonomous, through preventing individuals from falling into dependency states could appear as a priority to keep individuals autonomous but cannot be sufficient.

Our paper contributes to the literature on three aspects. First, we suggest a novel approach for projecting elderly disabled population, based on estimating the disability process rather than the stock of disabled individuals. This approach is made possible by the use of panel data of ageing surveys. Being able to characterise the factors which influence changes in transition probabilities to different health status, is a key ingredient for understanding the future composition of elderly disabled population into light or severe disablement. In addition, the methodology we suggest can be implemented for a very large number of countries, where these panel ageing surveys are now available (HRS in the U.S., ELSA in England, JSTAR in Japan, KLoSea in Korea, CHARLS in China, etc.).

Second, we bridge the gap between epidemiological approaches and economics by avoiding a measure of disability linked to the receipt of specific benefit, and relying instead on explicit disability scales. Such approaches allow to make explicit the differences between long-term care needs and the provision of care.

Finally, we make a step towards a better understanding of the underlying causes behind the co-evolution of morbidity and mortality. Our model makes explicit the fact that any projection of long-term care needs rely on assumptions about the allocation of life-expectancy gains to different health status. Most previous studies assume a constant share between life expectancy in good health and overall life expectancy, and this particular assumption weight heavily on overall projections.

This paper is organized as follows. We present in Section 1 the European panel data SHARE, the French cross-section data CARE, and the sample we exploit. Then, we present our method which relies on three main steps: estimating the transition rates between dependency states, building scenarios and projecting elderly disability (Section 2). Finally, we present our baseline results (Section 3) and alternative scenarios results.

1 Data and Sample

This paper relies on two surveys. First, the European panel survey SHARE provides information on dependency states from 2004 and 2017 for individuals aged 50 and over, living in the community. From this database, we recover the effects of socioeconomic factors associated with the probability to switch from one dependency state to another. Then, the French survey CARE-M is used to determine the prevalence of each dependency state in the French population of elderly aged 60 and over and living in the community.

1.1 Data

SHARE Data. We use the Survey of Health, Ageing, and Retirement in Europe (SHARE) (Börsch-Supan, 2020). This is a European panel database related to health and working life of individuals aged 50 and over, living in the community in one of the 21 European countries included in the survey. The first wave was in 2004, and the following waves are every two years.

The target population is both defined at the household and individual level : at least one member of the household should be born in 1954 (for the first wave) or earlier but the partner is also included in the sample, independently from his age.³

CARE-M Data. We also use the French data on health and ageing: the survey “*Capacités, aides et ressources de seniors - Ménage*”⁴ (CARE-M). This survey, realised in 2015 by the DREES⁵, is representative of the French elderly aged 60 and over, living in the community.⁶ It includes about 10,000 individuals. This survey includes information on individual socio-economic characteristics and health (in particular, limitation with activity daily living and instrumental activity daily living). Health questions slightly differ in this survey and in SHARE data. Appendix A describes choices we have done to make health questions comparable in both surveys.

The Elderly Followed in CARE and SHARE Data. Combining those surveys only allows us to follow the elderly living in the community. Indeed, the surveyed population in SHARE data consists in individuals living in the community. Individuals are not surveyed anymore if entering in a nursing home. Associated limitations are discussed in Section 5.

1.2 Variables of Interest and Sample Selection

Measuring Dependency. We build an indicator relying on the epidemiological measurement of dependency following Barberger-Gateau et al. (2000) and Pérès et al. (2005). It provides a more flexible tool for dependency projection than an administrative measure (which relies on being recipient for disability allowances). Moreover, it avoids biases linked to the non-take-up rate, and difficulties with comparison across time and countries.

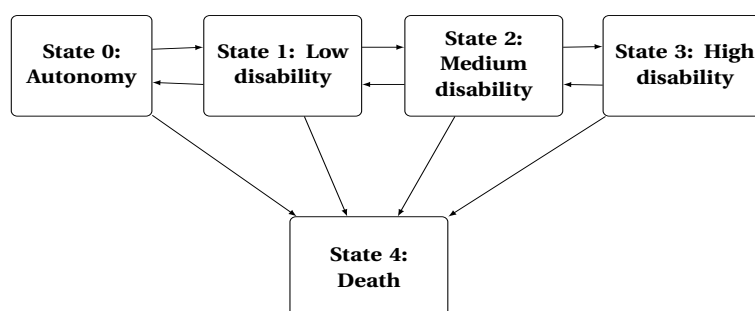
³The population of households is defined as “all households with at least one member born in 1954 (for the first wave) or earlier, speaking the official language of the country and not living abroad or in an institution such as prison during the duration of the field work”.

⁴Ability, help, and wealth of the elderly - household.

⁵Direction de la recherche, des études, de l'évaluation, et des statistiques; Direction of research, studies, evaluation and statistics.

⁶There is an equivalent of this survey for elderly living in nursing home (CARE-I) but we do not use it here.

Figure 1 – Transition Process from one State to Another



Notes: State 1 "low disability" is defined as having at least one of the functional limitation (Rosow limitation): walking 100 meters, climbing one flight of stairs and lifting or carrying weight over 5 kilos. State 2 "medium disability" is defined as having at least one of the following instrumental activity daily living (IADL) limitation: difficulties with phone call, shopping, taking medications, and managing money. For women, it also includes preparing hot meal and doing work around the house. State 3: "high disability" is defined as having at least one of the following activity daily living (ADL) limitations: difficulties with bathing or showering, dressing, using the toilet, getting in or out of bed, eating, cutting up food.

Source: Barberger-Gateau et al. (2000) and Pérès et al. (2005).

The study of disability process requires to make a trade-off between the statistical precision of the estimation and our ability to describe the population trajectories.

Following Pérès et al. (2005), we consider 5 dependency states: "State 0: autonomy" consists in having no limitation; "State 1: low disability" is having at least one Rosow's functional limitation (Rosow and Breslau, 1966), "State 2: medium autonomy" is having at least one instrumental activity daily living (IADL) limitation (Lawton and Brody, 1969) and "State 3: high disability" is having at least one activity daily living (ADL) limitation (Katz et al., 1970). Finally, "State 4" is death (Table A1 of Appendix A).⁷

We consider that at each state an individual has a non-zero probability to die. We also allow for transitions in both directions, meaning that remissions can occur. However we only authorize the transition to occur at the closest level: for example an individual in state 1 can only switch to state 0, 2 or to death (See Figure 1).

Sample in SHARE. We use data from waves 4, 5 and 6. We restrict our sample to individuals from countries surveyed in wave 4, 5 and 6, who answer questions on health and are observable at least in two consecutive waves. Those restrictions lead us to consider 13 countries : Austria, Belgium, Czech Republic, Denmark, Estonia, France, Germany, Italy, Netherlands, Slovenia, Spain, Sweden and Switzerland. Including those countries in the sample instead of France allows us to measure a large range of disability states while keeping a sufficient statis-

⁷As far as we know, it is the only study where 5-level scale is considered. previous studies relies on 3 states being "having no limitation", "having limitations" and "death". Cambois and Robine (2014); or four dependency states: "autonomy", "functional limitations", "limitation in activity daily living" and "death" (Cambois and Lièvre, 2007; Crimmins et al., 2009).

tical power. To avoid sample selection issues, we exclude the spouse respondent.⁸ Lastly, we restrict our sample to elderly aged 60 years old and over as the CARE-M survey only includes individuals from 60 years old and over. Table A2 shows the number of interviewees by country, with a total amount of 80,609 observations. Table 1 provides descriptive statistics of our sample. The mean age is 72 years old and the sample contains 43% of men. 62.53% of observations are related to autonomous individuals (State 0), 20.55% are slightly disabled (State 1), 7.06% are in State 2 (medium dependency) and 5.51% are highly dependent (State 3).

Table 1 – Descriptive Statistics

Country	Age	Men share	Disability				
			State 0 Autonom.	State 1 Low	State 2 Medium	State 3 High	State 4 Death
Austria	71.92	39.46	63.19	20.03	7.16	5.73	3.90
Belgium	72.32	48.43	61.38	19.61	7.03	7.95	4.03
Czech Republic	71.24	38.05	62.72	20.12	7.13	5.32	4.71
Denmark	71.81	43.94	70.18	14.60	5.30	3.54	6.39
Estonia	72.61	34.10	52.02	25.08	9.84	8.38	4.69
France	72.93	44.09	63.43	19.46	8.19	5.18	3.74
Germany	71.01	49.47	69.86	18.48	5.13	4.41	2.13
Italy	72.04	44.57	56.18	25.33	7.19	6.43	4.87
Netherlands	70.75	44.96	68.98	18.86	6.32	3.03	2.81
Slovenia	71.69	42.21	56.96	27.19	8.09	5.51	2.24
Spain	74.01	43.67	51.64	25.23	9.20	7.52	6.41
Sweden	72.27	47.14	74.15	14.08	4.25	1.66	5.86
Switzerland	71.73	47.85	79.69	12.75	3.05	1.69	2.82
Total	72.15	43.11	62.53	20.55	7.06	5.51	4.35

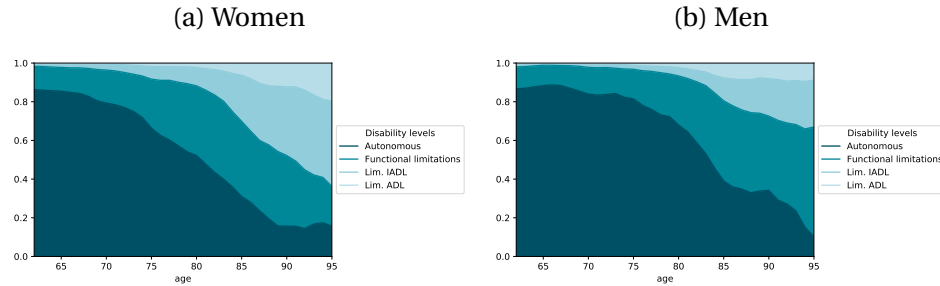
Sample: All elderly aged 60 and over, in one the 13 countries included (See Table A2) main surveyed in SHARE, respondent at least in two consecutive waves, and respondent to the health questionnaire.

Source: SHARE wave 4, 5 and 6.

Prevalence from the CARE-M Survey. We measure the initial prevalence of the French elderly population relying on the CARE-M survey. We select, as in the SHARE data, the elderly aged 60 and over, living in the community and who answer the health questionnaire. Figure 2 shows that in 2015, for both gender, the share of autonomous was higher than 80% at age 60. It decreases at each age and get at 20% after age 90.

⁸The sampling process differs from one country to another. Sampling is at the individual level or the household level, using household register, census, or telephone directory. These registers used for the sampling process are sometimes stratified by counties. Moreover, the spouse is interviewed regardless of his age and we keep in this study only individuals aged 60 and over. Lastly, it allows to be closer to the CARE-M survey sampling, in which the spouse is not interviewed.

Figure 2 – Prevalence of each Dependency State by Age in France



Sample: All elderly aged 60 and over, living in the community in France, respondent to the health questionnaire.

Source: CARE ménage, 2015.

2 Method

Our method relies on two steps. First, we estimate transition probabilities from one state to another, using SHARE data (section 2.1). Second, we use a microsimulation model to realise a projection of the number of dependent elderly in 2060 (section 2.2).

2.1 Transition Between Dependency States

We estimate the probability that an individual switches from one state i at period t to another state j at t , conditionally to his state in $t - 1$ and to observed characteristics X . Such a *markovian process* is estimated through a multinomial logit model (Equation 4.1).

$$\frac{\mathbb{P}(Y_t = j | X_{t-1}, Y_{t-1} = i)}{\mathbb{P}(Y_t = i | X_{t-1}, Y_{t-1} = i)} = \exp(X'_{t-1} \kappa_{ij}) \quad (4.1)$$

with Y_t the state observed at time t and κ_{ij} is the conditional probability to switch from one state i to another state j . Individual characteristics, denoted by X_t are age, gender and time. Note that the subsequent dependency projection might be improved by adding control variables. However, the current microsimulation model does not allow projecting the evolution of additional variables. Reassuringly, Appendix B.1 shows that the estimated matrix does not change significantly when adding socio-economic control variables.

The multilogit model relies on the Independence of Irrelevant Alternatives (IIA). According to this assumption, adding an option does not change the odds ratio. Since we allow only transition to the closest states, it is not possible to increase the number of option. Thus, this assumption is not an issue in our model.

We report estimates of the marginal effect from the multilogit presented in Equation 4.1 in the following section, estimated over the whole period. For each age a and gender g , the

$\mathcal{P}|_{a,g}$ matrix describes the probability to switch from state i to state j , such that :

$$\mathcal{P}|_{a,g} = \begin{pmatrix} P_{00} & P_{01} & - & - & P_{04} \\ P_{10} & P_{11} & P_{12} & - & P_{14} \\ - & P_{21} & P_{22} & P_{23} & P_{24} \\ - & - & P_{32} & P_{33} & P_{34} \end{pmatrix}$$

Some transition probabilities are not presented because they are considered as not “allowed”. However, in few cases, we observe in the data some transitions which are not allowed in the model. We re-assign the transition to the closest state. For example, if we observe a transition from state 1 to state 3, we re-assign the individual from state 3 to state 2. Table B2 shows that only a small share of our sample requires a re-assignment process. Moreover, Appendix B.2 shows the sensitivity of our results to this re-assignment process.

Lastly, we test the sensitivity of our results to the sample selection of country. We show that considering a pool of European countries does not change significantly transition probabilities and the projected number of disabled (See Appendix B.3) compared to a sample including the French population only. We also show that excluding eastern European countries or northern European countries does not change significantly our results (See Appendix B.4).

2.2 Dynamic Microsimulation

We initially estimate transition probabilities where $P_{t,i,j}$ is the probability to switch from state i to state j at date t and where each probability $\mathcal{P}_t|_{a,g}$ is age, gender and time indexed. There is one transition matrix by period t , between 2015 and 2060 (thus, t goes from 0 to 35), indexed $\mathcal{P}_t|_{a,g}$. In what follows, the indices age and gender are implicit. Our method relies on four steps: i) Defining the unconditional death probability $P_{t,..,4}$ at each period, relying on the French national institute of statistics (section 2.2.1); ii) Calibrating conditional death probabilities $P_{t,i,4}^c$ according to the unconditional death probability $P_{t,..,4}$ (section 2.2.2); iii) Adjusting the other transition probabilities (section 2.2.3); iv) Assigning a dependency state at each new elderly (section 2.2.4).

2.2.1 The Unconditional Death Probability $P_{t,..,4}^c$

We rely on the French National Office for Statistics (INSEE) mortality projections in order to align our microsimulation model with credible demographic targets (Blanpain and Chardon, 2010). We consider in this paper three *insee scenarios* (called “old”, “central”, and “young”), which correspond to different hypothesis for the INSEE population forecasts. These scenarios are computed using different values for life expectancy (LE) for men and women, fertility index, and net migration, as described in Table 2. These *insee scenarios* also provides death

probability by period, age and gender. We use the death probability from these scenarios to obtain calibrated death probabilities $P_{t,,4}^c$ by gender and age at each period t .

Table 2 – INSEE Scenario from 2015 to 2060

	Scenario young	Scenario central	Scenario old
Life expectancy Women	88.6 y.o	91.1 y.o.	93.6 y.o
Life expectancy Men	83.5 y.o	86.0 y.o	88.5 y.o.
fertility index	2.1	1.95 from 2015	1.8
Net migration	+150,000	+100,000	+50,000

Notes: Insee young scenario relies on the hypothesis of: a life expectancy for women (resp. men) of 88.6 years old (resp. 83.5 years old); a fertility index of 2.1 and a net migration of 150,000 individuals.

Source: Blanpain and Chardon (2010).

2.2.2 Calibration of Conditional Death Probabilities $P_{t,i,4}$

As a second step, we allocate the death probabilities gains linked to $P_{t,,4}^c$ to each conditional death probability $P_{t,i,4}$. We obtain calibrated probabilities $P_{t,i,4}^c$. We test three hypothesis concerning the way death probabilities gains are adjusted according to the initial dependency state. The first one relies on an homogeneous reallocation hypothesis. The second and third one rely on an heterogeneous reallocation. In the second hypothesis, we consider that all the gains are assigned to the states 0 and 1, and in the last one we consider that all the gains are assigned to the states 2 and 3.

The choice relying on an homogeneous allocation of death risk gains reflects a situation where the decrease in death probabilities is due to a proportional decrease in each initial states (odds ratios remain constants). This choice allows for the easiest comparison between several hypothesis we test. Moreover, it is the usual benchmark in other studies (see Comas-Herrera et al. (2006); Favreault et al. (2015) for example). This assumption is also the implicit one in all models that project first the death probability and thereafter, among the alived, the dependency state (Kingston et al., 2018a). However, this scenario is not the most credible regarding to the recent years.

The choice of reallocation on autonomous individuals corresponds to a situation where the death rate decrease is due to a decrease in death risk of the most autonomous. This is the case, for example, if the number of lethal road accidents decreases. The choice of reallocation on disabled individuals corresponds to a situation where the death rate decrease is due to a decrease in death risk of the most disabled. It corresponds to a situation where the death rate decrease is due to a decrease in death risk of the most disabled. This is the case, for example, if the survival rate having Alzheimer increases. These “extreme scenarios” show, other things being equal, the maximum magnitude that the reallocation of mortality gains can have on the evolution of the number of dependant elderly and on the morbidity.

Homogeneous Allocation of $P_{t,,4}^c$ on $P_{t,i,4}$. Our baseline model consists in weighting homogeneously all transition probabilities by a λ_t factor at each period of time, as presented in Equation 4.2.

$$\forall t \in [1;35]$$

$$P_{t,,4}^c = \lambda_t \times \frac{(N_{t,0} \cdot P_{t,0,4} + N_{t,1} \cdot P_{t,1,4} + N_{t,2} \cdot P_{t,2,4} + N_{t,3} \cdot P_{t,3,4})}{N_t} \quad (4.2)$$

with $P_{t,,4}^c$ the calibrated death probability unconditionally to the initial state at period t , N_t the total population in t , $N_{t,i} \forall i \in \{0, 1, 2, 3\}$ the population in the initial state i in t .

Note that Equation 4.2 is equivalent to the following: $\forall t \in [1;35]$

$$\lambda_t = \frac{P_{t,,4}^c}{P_{t,,4}} \quad (4.3)$$

Heterogeneous Allocation of $P_{t,,4}^c$ on $P_{t,i,4}$. Instead of allocating the decline in death probabilities on an homogeneous way, one could assign the latter to autonomy or disability states. A parameter μ enables to choose which proportion of this gain is attributed to autonomous states. This parameter is defined such that :

$$\forall i \in \{0, 1\} P_{t,i,4}^c = \mu_t P_{t,i,4} \text{ and } \forall i \in \{2, 3\} P_{t,i,4}^c = \lambda_t \cdot P_{t,i,4}$$

Thus, mortality gains are adjusted as follows:

$$N \cdot P_{t,,4}^c = \mu_t \cdot N_0 \cdot P_{t,0,4} + \mu_t \cdot N_1 \cdot P_{t,1,4} + \lambda_t \cdot N_2 \cdot P_{t,2,4} + \lambda_t \cdot N_3 \cdot P_{t,3,4} \quad (4.4)$$

with $P_{t,,4}^c$ is the calibrated death probability unconditionally to the initial state at period t , N_t the total population in t , $N_{t,i} \forall i \in \{0, 1, 2, 3\}$ the population in the initial state i in t .

We first consider an “**autonomous scenario**”, where all gains are attributed to autonomous states 0 and 1. It corresponds to a scenario where $\mu = 0$: any decrease in death probability entirely translates into a decrease in death probabilities of the autonomous individuals. Thus, equation 4.4 can be re-written as follow:

$$N \cdot P_{t,,4}^c = \lambda_t \cdot N_2 \cdot P_{t,2,4} + \lambda_t \cdot N_3 \cdot P_{t,3,4} \quad (4.5)$$

which leads to :

$$\lambda_t = \frac{N_t \cdot P_{t,,4}^c}{N_{t,2} P_{t,2,4} + N_{t,3} P_{t,3,4}} \quad (4.6)$$

Then, we consider the opposite case where all mortality gains are assigned to the disability states. The “**disability scenario**” corresponds to a parameter $\mu = 1$.

Thus, equation 4.4 can be re-written as follow:

$$N.P_{t,,4}^c = \lambda_t \cdot N_0 \cdot P_{t,0,4} + \lambda_t \cdot N_1 \cdot P_{t,1,4} \quad (4.7)$$

which leads to :

$$\lambda_t = \frac{N_t(P_{t,,4}^c - P_{t,,4})}{N_{t,2}P_{t,2,4} + N_{t,3}P_{t,3,4}} + 1 \quad (4.8)$$

2.2.3 Adjustment of Other Probabilities $P_{t,i,j}$

we have, $\forall t, \forall i \in \{0, 1, 2, 3\}$:

$$P_{t,i,0} + P_{t,i,1} + P_{t,i,2} + P_{t,i,3} + P_{t,i,4} = 1 \quad (4.9)$$

To make Equation 4.9 holds after death calibration, we adjust these probabilities by a parameter β_t such that, \forall initial state $i \in \{0, 1, 2, 3\}$:

$$\beta_{t,i} \cdot (P_{t,i,0} + P_{t,i,1} + P_{t,i,2} + P_{t,i,3}) + \lambda_{t,i} \cdot P_{t,i,4} = 1 \quad (4.10)$$

which leads to (Details in Appendix C):

$$\beta_{t,i} = \frac{1 - \lambda P_{t,i,4}}{1 - P_{t,i,4}} \quad (4.11)$$

This adjustment is our baseline scenario. This method is equivalent to consider that the decrease in death probability from each initial states leads to an increase of all other transition probabilities from this initial state, such that odds ratios are preserved. The latter can be interpreted as follows. If mortality decreases, the number of years spent in each dependency state increases. However, the relative time spent in each state remains constant. This benchmark scenario is the easiest to compare with our alternative scenario and thus constitute a good baseline. Moreover, it is the implicit assumption in many previous studies. Note that we can consider this scenario as pessimistic, because while mortality decreases the population's health does not improve.

Heterogeneous Adjustment of Probabilities. Lastly, we consider how a change in a given transition probability impacts the projected number of dependent individuals. We make varying the probability of staying autonomous P_{00} as it is the transition rates which concerns the highest number of individuals. Mortality in state 0, $P_{t,0,4}$, remains constant. For the odds to stay autonomous to increase by $\alpha \left(\frac{P_{t,0,0}^c}{P_{t,0,0}} = \alpha \frac{P_{t,0,0}}{P_{t,0,0}} \right)$, and $P_{t,0,0}^c + P_{t,0,1}^c + P_{t,0,4}^c$ to sum to 1, we adjust $P_{t,0,0}$ and $P_{t,0,1}$ as follows :

$$P_{t,0,0}^c = \frac{\alpha \left(1 + \frac{P_{t,0,0}}{P_{t,0,1}}\right)}{1 + \left(\alpha \frac{P_{t,0,0}}{P_{t,0,1}}\right)} P_{t,0,0} \quad (4.12)$$

$$P_{t,0,1}^c = \frac{1 + \frac{P_{t,0,0}}{P_{t,0,1}}}{1 + \left(\alpha \frac{P_{t,0,0}}{P_{t,0,1}}\right)} P_{t,0,1} \quad (4.13)$$

Thus, we have:

$$\frac{\alpha \left(1 + \frac{P_{t,0,0}}{P_{t,0,1}}\right)}{1 + \left(\alpha \frac{P_{t,0,0}}{P_{t,0,1}}\right)} P_{t,0,0} + \frac{1 + \frac{P_{t,0,0}}{P_{t,0,1}}}{1 + \left(\alpha \frac{P_{t,0,0}}{P_{t,0,1}}\right)} P_{t,0,1} + \lambda_t P_{t,0,4} = 1 \quad (4.14)$$

If this probability increases, the path into dependency will slow down, because people stay autonomous for a longer period. We increase the probability to stay autonomous by an α factor. We provide results for two scenarios: one with $\alpha = 1.015$ and another with $\alpha = 1.03$. These values enable us to mimic a scenario where the ratio disability-free life expectancy over total life expectancy at age 65 remains approximately constant ($\alpha = 1.015$) or increases ($\alpha = 1.03$).

2.2.4 Attribution of a Dependency State of Future Elderly

As our forecasts begin at 60 years old, we need to assign an initial dependency state to the newly 60 years old individuals. This assignment is realised according to an hypothesis of evolution θ of dependency prevalence for the 60 years old individuals in France. Thus, the share of dependent elderly at period t is computed following Equation 4.15. Using SHARE data, we estimate that $\theta = 0.1$.

$$1 - S_0^t = (1 - \theta)^{t-t_0} \times (1 - S_0^{t_0}), \quad (4.15)$$

with t the period, t_0 the first period and $S_0^{t_0}$ the share of autonomous individuals at period $t = 0$.

2.2.5 Testing Several Scenarios from these Consecutives Choices

Our method relies on a serie of three choices, as sum up in Table 3. The first choice is regarding to the ageing of the population, with one scenario that favor a “young” population, a “central”, and an “old” population. The second choice is regarding the allocation of death risk gains across time on individuals with various dependency state. The “baseline” choice is

considering homogeneous allocation between states. The “autonomy” choice is considering that the mortality gains are all attributed to individuals in good health (eg: less strokes, car accident...). The “disability” choice is considering that the mortality gains are all attributed to dependant individuals (eg: death risk decrease of severe disease like dementia, Alzheimer, Parkinson). Finally, the third choice is regarding the adjustment of transition probabilities between several dependency states. The “homogeneous adjustment” is considering an homogeneous adjustment of probabilities. It is the case if the mortality gains affect all individuals in each initial dependency state in the same way. The “heterogeneous adjustment” is considering an increase of the probability to stay autonomous. It is the case of a physical activities program for the new elderly for example. The combination of these choices leads to the creation of six scenarios presented in this paper (Table 4).⁹

Table 3 – Definition of Choices for Scenarios

Choice 1: Death rate projection ($P_{t,...,4}^c$)		
Young LE <i>insee</i> scenario	Central LE <i>insee</i> scenario	Old LE <i>insee</i> scenario
Choice 2: Allocation of death rate by initial state ($P_{t,i,4}^c$)		
Homogeneous allocation λ_t	Allocation to autonomous states $\mu_t = 1$	Allocation to disabled states $\mu_t = 0$
Choice 3: Adjustment of other transitions ($P_{t,i,j}^c, j \neq 4$)		
Homogeneous adjustment β_t	Heterogeneous adjustment α_t	

Table 4 – Definition of Six Scenarios

	Choice 1 Insee scenario	Choice 2 Death allocation	Choice 3 Probabilities adjustment
Main scenario <i>Figure 3</i>	Central	Homogeneous	Homogeneous
Young scenario <i>Figure E1a</i>	Young	Homogeneous	Homogeneous
Old scenario <i>Figure E1a</i>	Old	Homogeneous	Homogeneous
Autonomy scenario <i>Figure E1c</i>	Central	Autonomy	Homogeneous
Disability scenario <i>Figure E1c</i>	Central	Disability	Homogeneous
Remain autonomous scenario <i>Figure E1b</i>	Central	Homogeneous	Heterogeneous

In the main scenario, we project the number of individuals in each dependency state

⁹As summary of each parameter is in Appendix D.

using the central *insee scenarios* to calibrate total death rate by age and gender, considering homogeneous allocation of mortality by initial dependency state, and adjusting the other transition homogeneously. The young and old scenarios consist in testing the sensitivity of our projection to the *insee scenarios*. Then, the autonomy and disability scenarios are extreme cases of mortality gains targeted on a particular population (either in good health or in bad health). Lastly, the “remain autonomous scenario” is a case where we increase the probability to remain autonomous.

3 Results

3.1 Transition Probabilities

Table 5 reports estimated probabilities to switch from one state to another, conditional on observed characteristics. The probability to stay autonomous from one wave to another reaches 82%. Once an individual turns dependent, he still has a 34% probability to recover, while being more prone to stay dependent, in some cases in an even worse status. The death probability becomes higher than 10% once individuals enter the medium state of dependency, and reaches 23% when they turn highly dependent.

Table 5 – Transition Matrix

			Autonomy S0	Low S1	Disability Medium S2	High S3	Death S4
Disability	Autonomy	S0	0,82	0,16	x	x	0,02
	Low	S1	0,34	0,36	0,23	x	0,07
	Medium	S2	x	0,33	0,27	0,26	0,13
	High	S3	x	x	0,27	0,50	0,23

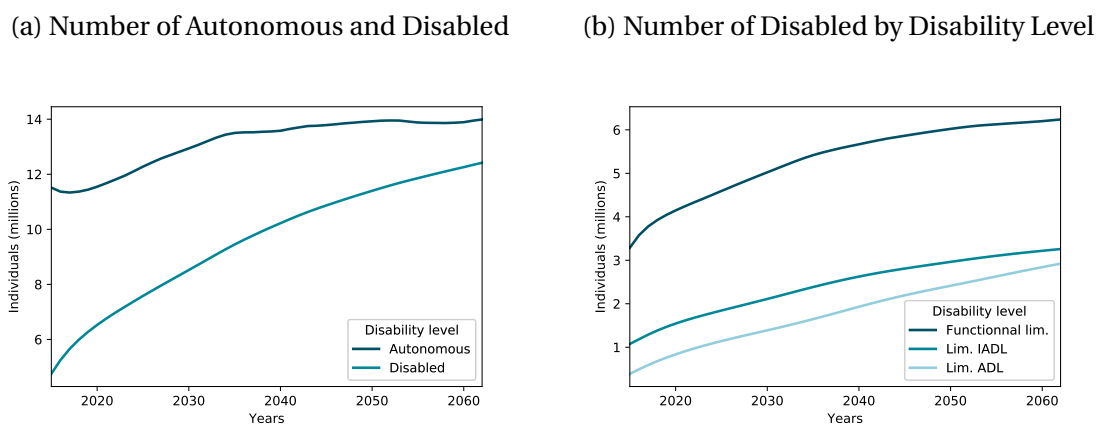
Notes: The estimated probability to remain autonomous is 82%. An individual with low disability has 34% chance to recover, 36% to remain low disabled and 23% to become more disabled.

Sample: All elderly aged 60 and over, in one the 13 countries included (See Table A2) main surveyed in SHARE, respondent at least in two consecutive waves, and respondent to the health questionnaire.

Source: SHARE waves 4, 5 and 6.

Tables E1 provides estimations for men and women. Gender differentials are more striking for the last two states of dependency, especially for death probability. For instance, men are three times more likely to die than women when they reach the second state of dependency. Using recent waves instead of old waves shows small changes (See Appendix E.2).

Figure 3 – Evolution of Dependency in the Population 60+



Sample: All elderly aged 60 and over, in one the 13 countries included (See Table A2) main surveyed in SHARE, respondent at least in two consecutive waves, and respondent to the health questionnaire.

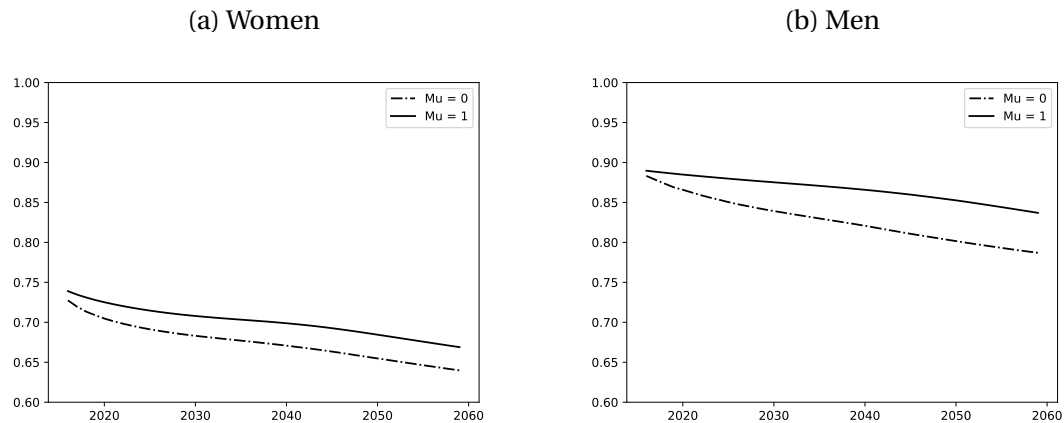
Source: SHARE Waves 4, 5 and 6.

3.2 Projections

Projection of the Number of Disabled. Figure 3a shows the evolution of the number of autonomous and disabled individuals under the main scenario (central *insee scenario* and all gains homogeneously reallocated). The number of disabled individuals increases more rapidly than the overall number of individuals aged 60 and over, which leads to 12.3 millions of disabled individuals and 13.9 autonomous ones in 2060. In this setting, 47% of individuals aged 60 and over will be disabled, considering a very broad definition of dependency (from functional limitations to ADL limitations). The largest share of the disabled population in 2060 will be individuals with functional limitations : they will represent 23% of the overall population in 2060, while individuals with limitations in IADL and ADL will represent respectively 12% and 11% of the population (Figure 3b).

Figures E1 of Appendix E shows the variation of the estimated number of elderly according to our scenarios. It shows that each parameters' variation leads to a variation in the number of estimated dependant elderly by around one million. Thus, the *insee scenario* lead to a projected number of highly dependant between 2.4 millions (scenario young) and 3.7 millions (scenario old) (Figure E1a); the variation in the allocation process of death risk gains leads to a variation of the estimated number of disabled between 2.6 and 3.4 millions elderly (Figure E1b); the increase in the probability to remain autonomous leads an estimated number of disabled between 1.6 and 2.9 millions (Figure E1c).

Figure 4 – Ratio Disability-free Life Expectancy over Total Life Expectancy after Age 65 by Death Allocation Scenarios



Notes: In 2060, considering the “disability” scenario where ($\mu = 0$), the ratio life expectancy in good health over total life expectancy is projected to be 0.65 (resp. 0.85) for women (resp. men). Considering the “autonomy” scenario where ($\mu = 1$), the ratio life expectancy in good health over total life expectancy is projected to be 0.68 (resp. 0.84).

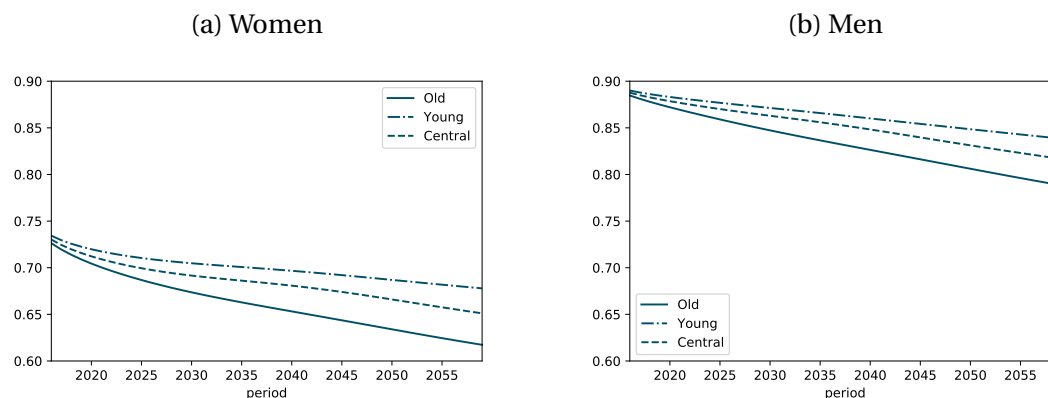
Projection of Morbidity. While we have shown that our scenarios provide similar variation in the number of dependant elderly, it is not the case when focusing on morbidity.¹⁰ Death gains reallocation is the parameter having the smallest impact on morbidity projection. Thus, Figure 4 show that both the “Autonomy” ($\mu = 0$) and “Disability” ($\mu = 1$) scenarios lead to an expansion of morbidity between 2015 and 2060. Moreover, this parameter, *everything being equal*, does not change a lot the projected ratio. The “Autonomy” scenario leads to a 0.68 (0.84) disability-free life expectancy over total life expectancy among women (men) while the “Disability” scenario leads to 0.65 (0.79). Thus, varying mortality gains reallocation can modify the morbidity by 0.03 (0.05).

The projected morbidity is more sensitive to the demographic scenarios (Figure 5). The ratio goes from 0.61 (0.79) (old scenario) to 0.68 (0.84) (young scenario) among women (men). The difference in morbidity ratio by demographic scenario varies by 0.07 (0.06). Whatever the demographic scenario considered, the projection provides an expansion of morbidity. This result is consistent with previous findings. Our central scenario relies on choices very close to Kingston et al. (2018a) and projected results are similar.

Finally, Figure 6 shows the impact of an increase in the probability to remain autonomous on morbidity. It shows that this parameter has a much larger impact on morbidity (0.15 for women and 0.1 for men). It shows that ensuring a constant morbidity requires the probability of remaining autonomous to increase over time by 1.5%. It is an increase five time larger than the increase of this ratio observed in England and in Europe (respectively 0.23 and 0.28

¹⁰We use as a measure of morbidity the ratio disability-free life expectancy (DFLE) over total life expectancy (LE). Disability-free years are all years without ADL limitation, ie, in states 0, 1 or 2.

Figure 5 – Ratio Disability-free Life Expectancy over Total Life Expectancy after Age 65 by Demographic Scenarios



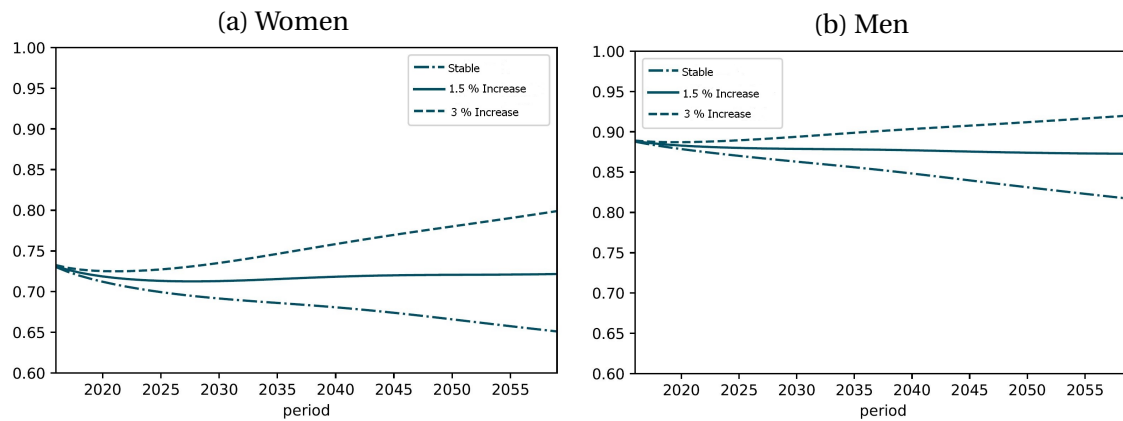
Notes: In 2060, considering the “old” scenario, the ratio life expectancy in good health over total life expectancy is 0.61 for women (resp. 0.79 for men). With the “central” scenario, it is 0.65 (resp. 0.82) and with the “young” scenario, 0.68 (resp. 0.84).

percentage point, as shown in Figure 7).¹¹ It appears that neither increasing life expectancy gains nor allocating life expectancy gains to autonomous states is sufficient alone to ensure a constant morbidity rate.

It seems that, among the several parameter tested, the probability to remain autonomous ($P_{0,0}$) has the most important impact on morbidity in the future. However, the required growth of $P_{0,0}$ allowing to have a stagnation of morbidity is very high. Thus, public policies that intend preventing from having a morbidity expansion have to favor an increase in $P_{0,0}$ (policies that decreases the risk of entering in autonomy loss process) but cannot relies on this parameter only.

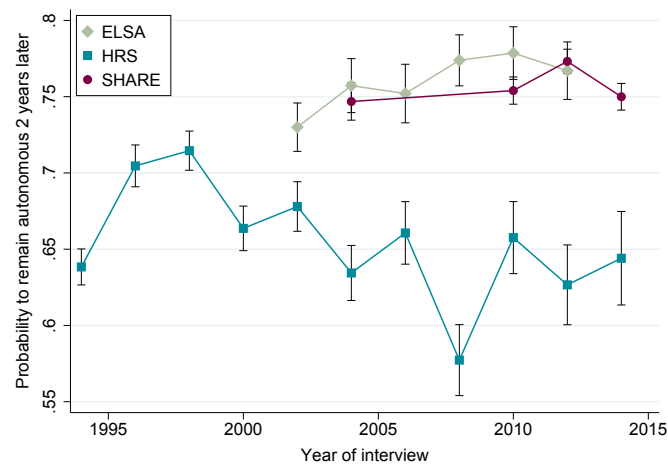
¹¹Computed on a baseline probability to remain autonomous of 82%.

Figure 6 – Ratio Disability-free Life Expectancy over Total Life Expectancy after Age 65 by Probabilities Adjustment Scenarios



Notes: In 2060, considering the main scenario (alpha stable) the ratio life expectancy in good health over total life expectancy is projected to be 0.65 (resp. 0.82) for women (resp. men). Considering the “remain autonomous” scenario with an alpha increase of 1.5%) the ratio life expectancy in good health over total life expectancy is projected to be 0.72 (resp. 0.87) for women (resp. men). *Sample:* All elderly aged 60 and over, in one the 13 countries included (See Table A2) main surveyed in SHARE, respondent at least in two consecutive waves, and respondent to the health questionnaire. *Source:* SHARE Waves 4, 5 and 6.

Figure 7 – Probability to Remain Autonomous in Europe, the USA, and England



Notes: All point estimates are from multilogit estimation, including controls for age and gender. Point estimates in SHARE slightly differ from the transition matrix results because the transition are computed every two years while in our main model, every years.

Sample: All elderly aged 60 and over, living in the community, respondent to the health questionnaire in HRS for the USA, in ELSA for England, and in SHARE for Europe.

Source: Harmonised data from Gateway to global aging data. SHARE, Wave 1 to 7 except wave 3; ELSA, wave 1 to 7 and HRS, wave 2 to 16.

4 Discussion

Considering Flows Rather than Stocks. Contrary to previous studies, we consider the evolution of the ratio of life expectancy in good health over the total life expectancy as a consequence of the modification of the model parameters. In the related literature (Lecroart et al. (2013); Marbot and Roy (2015); Roussel (2017)), keeping a constant morbidity is implicitly the result of an exogenous shock such as advances in medicine, or a high death rate of individuals in bad health. Our main contribution is to analyse dependency considering flows from one state to another instead of considering the stock of dependent individuals. It allows us to make endogenous the mortality rate as it depends on the probability of remaining autonomous.

Comparison to Previous Studies. Table 6 provides a comparison between studies relying on French data and our results concerning the projection of the number of dependant elderly (in million). Two mains conclusions can be drawn seeing this table. First, the more recent the projection is the higher the projected number of disabled is. The projection has to be considered as a lower bound of what we have to take into account for the future when public policies are implemented, in a precautionary principle. It is not a prediction of the future. Second, our projected number of disabled in 2040 is higher than previous studies. Several explanations can be raised. First, our reference year is more recent (2015 against between 2000 and 2010 for previous studies). Second, we consider flows rather than stocks. Lastly, those studies rely on an administrative definition of disability, which is subject to non-take up rate and administrative definition of health.

Table 6 – Comparison of Dependant Elderly's Projection to Previous French Studies

	Ref. year	Year			
		2010	2030	2040	2060
Optimist scenarios					
Bontout et al. (2002)	2000	0.85	0.95	1.1	n.a.
Duée and Rebillard (2006)	2006	0.81	0.95	1.1	n.a.
Lecroart et al. (2013)	2010	1.12	1.37	1.64	1.81
Charpin and Tlili (2011)	2010	1.15	1.40	1.65	1.85
This paper	2015	n.a.	1.28	1.86	2.37
Central scenarios					
Bontout et al. (2002)	2000	0.87	1.10	1.3	n.a.
Duée and Rebillard (2006)	2006	0.86	1.05	1.21	n.a.
Lecroart et al. (2013)	2010	1.12	1.53	1.91	2.26
Charpin and Tlili (2011)	2010	1.15	1.55	1.95	2.30
This paper	2015	n.a.	1.42	2.00	2.84
Pessimist scenarios					
Bontout et al. (2002)	2000	0.90	1.15	1.45	n.a.
Duée and Rebillard (2006)	2006	0.95	1.25	1.57	n.a.
Lecroart et al. (2013)	2010	1.12	1.64	2.12	2.65
Charpin and Tlili (2011)	2010	1.15	1.64	2.15	2.70
This paper	2015	n.a.	1.57	2.28	3.63

Notes: All previous studies define dependency as "being APA recipient". This definition leads to include less individuals than the epidemiological definition "having at least one activity daily living limitation" we used in this Table. Bontout et al. (2002)'s study relies on a baseline in 2000 and forecast 0.85 million elderly with disability in 2010, and 1.1 millions in 2040.

5 Conclusion

This paper aims at forecasting the number of disabled elderly in 2060 in France. Previous studies are twofold. On the one hand, economic studies rely on an administrative definition of dependency (eg: having a disability allowance). These forecasts have three drawbacks. First, these models cannot be used to have information on how a modification of the eligibility criteria changes the number of beneficiaries. Second, it assumes the non take-up rate to be constant across time. It also prevents from estimating the effect of public health policies (an improvement in the recovery rate after a surgery for example). Lastly, it prevent from comparing projection between countries. On the other hand, epidemiological studies rely on a very detailed identification of health status, with a large number of pathologies and dependency states. While providing rich information on future prevalences, and pre-

cise information on health status of individuals, these studies suffer from limitations. First, the allocation of mortality gains between dependency states are assumed constant across individuals since the large number of dependency states prevent from doing otherwise. Second, the projection relies, most of the time, on prevalence evolution giving the evolution of population characteristics. Thus, these models rely on variation in stock rather than flow.

In this paper, we use an epidemiological definition of dependency, based on functional limitation, instrumental activity daily living (IADL) and activity daily living (ADL). We estimate transition probabilities across these dependency states, and then, considering a population of elderly, compute the expected number of dependent elderly. This method relies on the usual demographic scenarios but also on two other ones. First, we assume different demographic scenarios. Second, we test changes in the attribution of the death probability decrease between dependency states. Third, we made hypothesis on the evolution of transition between dependency states across time. This method bridge the gap between economic and epidemiological studies.

We should expect between 2.37 and 3.63 millions elderly in France in 2060, according to the three usual demographic scenarios. the projected number of dependant elderly is not very sensitive to the scenarios. All parameters tested cause a variation in the estimated number of dependant elderly of plus or minus one million. However, we show that the scenarios have an larger impact on the projected morbidity, defined as the disability-free life expectancy over the total life expectancy. Almost all the scenarios project an expansion of morbidity. Moreover, we show that, among the parameter tested, the one having the highest impact on morbidity is the probability to remain autonomous. An yearly increase of this parameter by 1.5% allows for a compression of morbidity, and all highest increase allows for a compression of morbidity.

In a public policy perspective, this paper provide a new tool helping projection of elderly needs and projection of potential impact of public policies that changes the transition probabilities between dependency states. It shows that an efficient public policy probably have to rely on several parameters to have an impact on morbidity. Indeed, Most of the tested parameter, when the only one to vary, leads to an expansion of morbidity. The only parameter that does not lead to this result is the probability to remain autonomous. However, the required increase of this parameter to project a stagnation of morbidity is very high (five time higher than the observed evolution of this parameter from the last decade). Thus, the public policy aiming at increasing the probability to remain autonomous may be one of the public policy to favour in order to limit morbidity expansion. However, it cannot be sufficient to benefit from a stagnation or compression of morbidity.

This study has two main limitations. First, the number of control variables is, for now, limited. Second, the selection on individuals living in the community leads to an underesti-

mation of the forecast. It means excluding individuals mostly in dependency state 2 or 3. For instance, in 2011, around 88% of individuals living in nursing home entered with an evaluation of their disability level between GIR 1 and 4, meaning close to our states 2 or 3. We may suspect that individuals in nursing home have a higher probability to experience autonomy loss, and a higher probability to die. As a consequence, we may underestimate the probability to go from state 2 to 3 and death, and from 3 to death. Thus, we tend to underestimate the number of highly disabled in 2060. This bias is likely to be limited since the share of elderly living in nursing home is small, and half of the stays last less than 1.5 years and 75% last less than four years (Fizzala, 2017). Lastly, one may think that, since the probability to remain autonomous is a key parameter, the definition of dependency states should favour a more subtle dependency definition at the early beginning of the dependency process, by adding, for example, frailty Fried et al. (2001).

Appendix to

Dynamics of the Disability Process in Ageing Populations

A Data Details

A.1 Disability Definition in SHARE and CARE

Available information In SHARE and CARE-M regarding functional limitations, IADL and ADL slightly diverge. In particular, in SHARE, the possible answers to the questions “do you have difficulties in doing the followings activities” are yes or no while in CARE-M, it is “no difficulty at all”; “I have small difficulties”; “I have huge difficulties”; “I cannot perform this task at all”. We consider the equivalent to the “no” in SHARE is “I cannot perform this task at all”. This choice is the one which minimised prevalence differences by age and gender between the two data. Moreover, there is one question differently ask in SHARE and CARE. In CARE, the question is about the ability to walk 500 meters while it is 100 meters in SHARE.

Table A1 – Definition of Dependency in SHARE Data

Scale	Name	Due to health problem, have at least one difficulty with:
State 0	Autonomy	None of the mentioned activities
State 1	Rosow limitation	walking 500 meters climbing one flight of stairs lifting or carrying weight over 5 kg
State 2	IADL limitation	making telephone calls shopping for groceries taking medications managing money For women only: preparing a hot meal For women only: doing work around the house or garden
State 3	ADL limitation	Bathing or showering Dressing, including putting on shoes and socks using the toilet, including getting up or down getting in or out of bed eating, cutting up food
State 4	Death	

A.2 Surveyed Countries

We include 13 countries in our sample. Selected countries are either in all waves, with a large refreshment sample in wave 4 (Austria, Belgium, Denmark, France, Germany, Italy, Spain, Sweden and Switzerland), or in waves 4,5 and 6 (Estonia, Slovenia), or in five waves (Czech Republic and the Netherlands). Each country represents between 4 and 12 percent of the total sample, as sum up in Table A2.

Table A2 – Surveyed Countries

Country	Number	Per cent
Austria	6,386	7.92
Belgium	7,664	9.51
Czech Republic	7,629	9.46
Denmark	4,604	5.71
Estonia	9,383	11.64
France	6,639	8.24
Germany	5,169	6.41
Italy	6,269	7.78
Netherlands	3,198	3.97
Slovenia	5,079	6.30
Spain	7,642	9.48
Sweden	6,264	7.77
Switzerland	4,683	5.81
Total	80,609	100

Source: SHARE Waves 4, 5 and 6.

B Sensitivity Analysis

B.1 Results with and without Control Variables

Our main specification are with controls for age, gender, and country. We assess the sensitivity of our estimated transition probabilities to the inclusion of more control variables. Table B1a presents our main results while Table B1b presents the estimated transition probabilities including additional controls for education, occupational group, marital status, and the number of children. As transition probabilities are almost identical, it confirms that only controlling for age and gender will not affect our projections while allowing us to avoid making assumption on the evolution of potential socio-demographic characteristics.

Table B1 – Transition Probabilities with and without Control Variables

(a) Baseline Transitions						(b) Transitions with controls					
	S0	S1	S2	S3	S4		S0	S1	S2	S3	S4
S0	0,82	0,16	x	x	0,02	S0	0,82	0,16	x	x	0,02
S1	0,34	0,36	0,23	x	0,07	S1	0,34	0,37	0,23	x	0,07
S2	x	0,33	0,27	0,26	0,13	S2	x	0,33	0,27	0,27	0,13
S3	x	x	0,27	0,50	0,23	S3	x	x	0,27	0,50	0,22

Notes: S0, autonomy. S1, functional limitations. S2, IADL limitations. S3, ADL limitations. S4, death.

Sample: All elderly aged 60 and over, in one the 13 countries included (See Table A2) main surveyed in SHARE, respondent at least in two consecutive waves, and respondent to the health questionnaire. Matrix (a) includes only controls for age, gender and country while Matrix (b) includes also controls for education, marital status, children, occupational group.

Source: SHARE waves 4, 5 and 6.

B.2 Sensitivity to the Re-assignment Process

As mention in Section 2, several individuals have “forbidden” transitions in our data (those who move from 0 to 2 and 3; from 1 to 3; and from 2 to 0). This issue mainly arise among individuals in an autonomous state or low disability state (70% of those with forbidden transitions). Thus, drop individuals with forbidden transitions would create a selection bias in our sample. To treat these individuals, we decided to re-assign their transition toward “allowed” transitions (see Table B2).

To test the sensitivity of our estimated probabilities to this choice, we presents in Table B3 the transition matrix allowing for all transitions. it shows small significant changes for few transitions. Figure B1 shows that these differences are significant only for transition from state 0 to 1; from 1 to 2; from 2 to 1; and from 3 to 2. Thus, this re-assignment process may overestimate the remission probabilities of the most dependant, and slightly decrease the probability to move from low to medium disability. Unfortunately, the consequences of this change on the projection cannot be assess since there is statistical power limitation at projecting so many possible transitions. However, we can assume that if our re-assignment process leads to significant differences in the projection, it would be an overestimation of the autonomous individuals.

Table B2 – Share of Changes in Final State through Re-assignment Process

In the data	After re-assignment	Number of observations	Share of observations (in %)
0 → 2	0 → 1	844	1.05
0 → 3	0 → 1	1,037	1.29
1 → 3	1 → 2	1,243	1.54
2 → 0	2 → 1	501	0.621
3 → 0	3 → 2	351	0.435
3 → 1	3 → 2	548	0.680
TOTAL		4,524	5.61

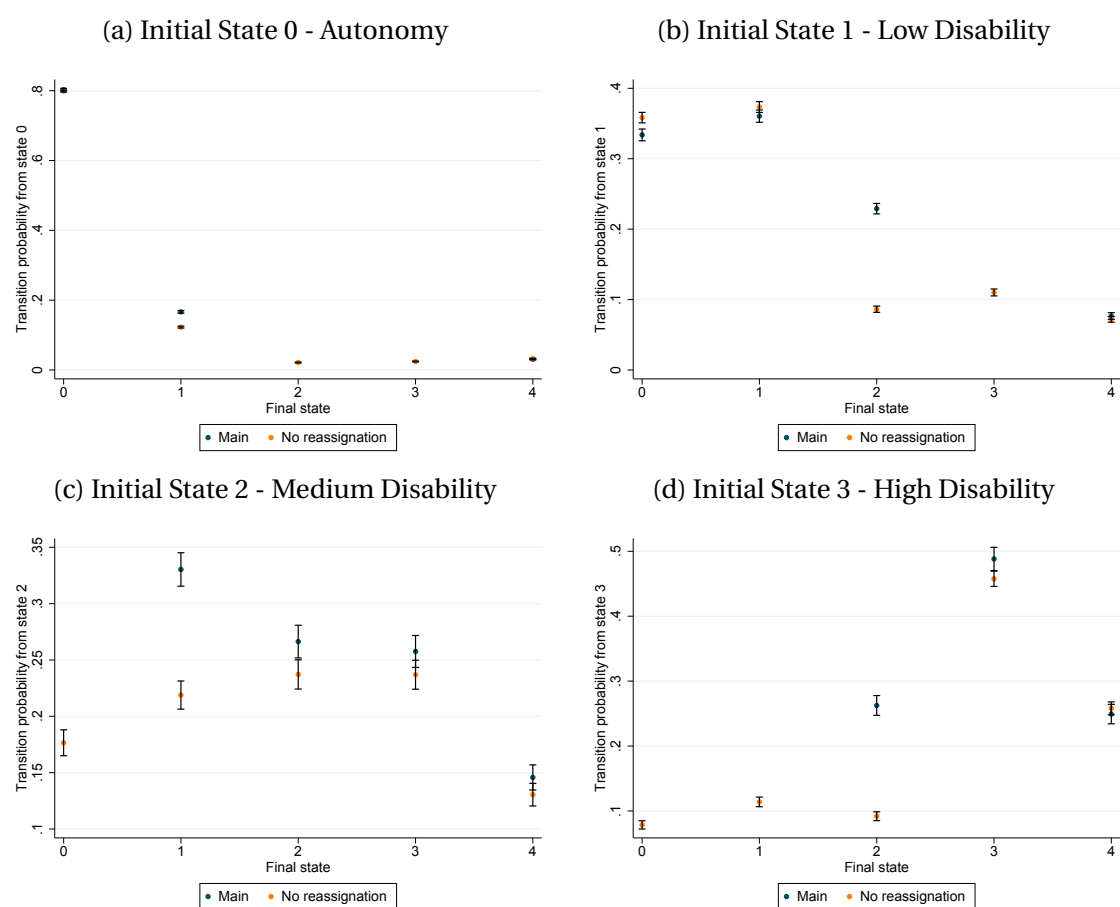
Sample: All elderly aged 60 and over, in one the 13 countries included (See Table A2) main surveyed in SHARE, respondent at least in two consecutive waves, and respondent to the health questionnaire.

Source: SHARE waves 4, 5 and 6.

B.3 Choice of Using Europe instead of France

Estimate transitions over five disability states requires a large sample size to reach an acceptable statistical power. Thus, we use the European data instead of only the French data. To test the sensitivity of this choice, we compare the transition probabilities in France and in Europe. Results are in Table B4. This table shows that there are only slight differences in the probability to stay in the same state Figures B2 show the transition probabilities with confidence intervals for each initial state, in France and in our main sample of 13 European

Figure B1 – Transition Probabilities Allowing All Transitions



Notes: First graph shows the transition probability from state 0 - autonomous to state 0; 1 - low disability; 2 - medium disability; 3 - high disability and 4 - death.

Sample: All elderly aged 60 and over, living in the community, respondent to the health questionnaire. The main sample includes individuals from 13 countries (Austria, Czech Republic, Slovenia, Estonia, Denmark, Netherlands, Sweden, France, Germany, Spain, Italy, Switzerland, Belgium). The dependency states are corrected using a re-assignment process for the main sample (blue circles). The sample without re-assignment (orange squares) allows all transitions.

Source: SHARE, waves 4, 5, 6.

Table B3 – Transition Matrix with and without Re-assignment Process

(a) Baseline Transitions						(b) without Re-assignment					
	S0	S1	S2	S3	S4		S0	S1	S2	S3	S4
S0	0,82	0,16	x	x	0,02	S0	0,81	0,12	0,02	0,02	0,03
S1	0,34	0,36	0,23	x	0,07	S1	0,36	0,38	0,09	0,11	0,07
S2	x	0,33	0,27	0,26	0,13	S2	0,18	0,22	0,24	0,24	0,11
S3	x	x	0,27	0,50	0,23	S3	0,08	0,11	0,09	0,46	0,25

Notes: S0, autonomy. S1, functional limitations. S2, IADL limitations. S3, ADL limitations. S4, death.

Sample: All elderly aged 60 and over, in one the 13 countries included (See Table A2) main surveyed in SHARE, respondent at least in two consecutive waves, and respondent to the health questionnaire.

Source: SHARE waves 4, 5 and 6.

countries. It shows that the only statistically significant difference between both samples is the probability to move from state 1 to 2 and from state 2 to 1. We also check whether the projections using both transition matrix show statistically significant differences in the number of disabled in each state. Figures B3a and B3b shows that we forecast 14,5 millions autonomous elderly in 2060 in Europe, and 14,5 millions using only France.

Table B4 – Transition Matrix by Country – France versus Main Sample

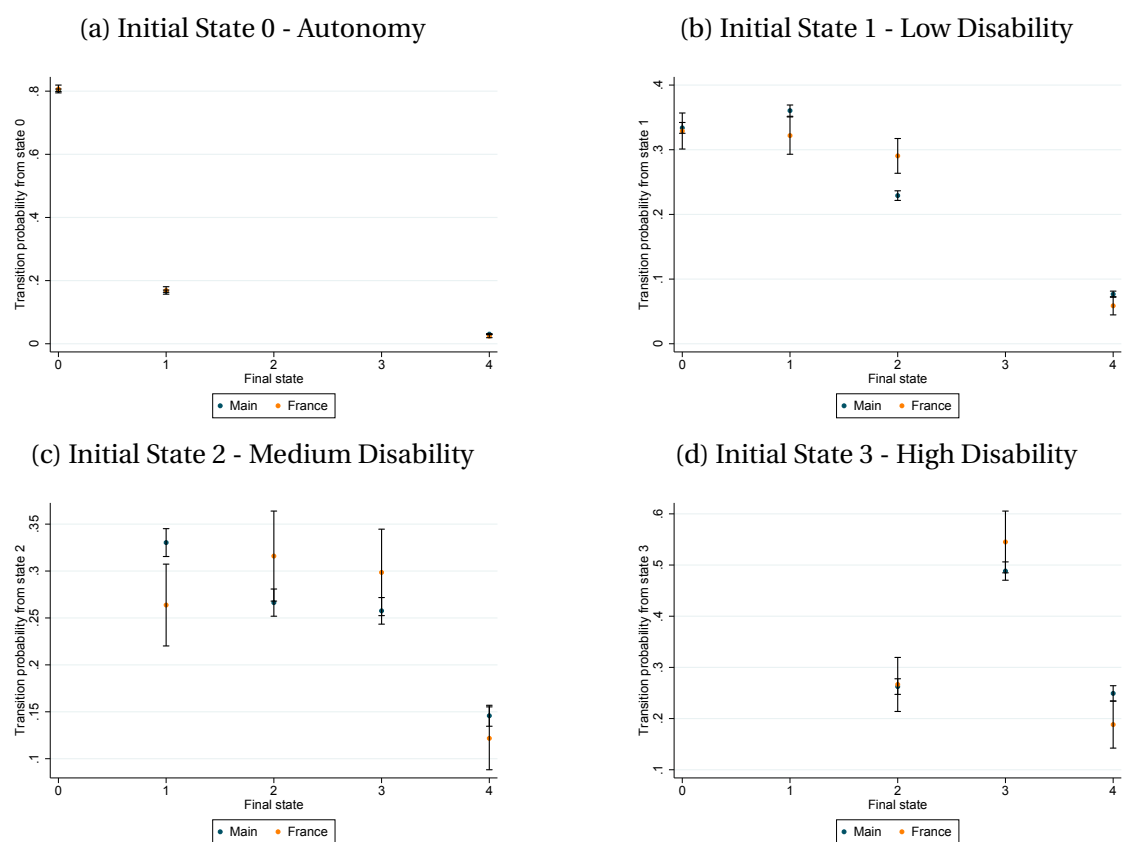
(a) Baseline Transitions						(b) Transitions, France					
	S0	S1	S2	S3	S4		S0	S1	S2	S3	S4
S0	0,82	0,16	x	x	0,02	S0	0,83	0,15	x	x	0,02
S1	0,34	0,36	0,23	x	0,07	S1	0,34	0,32	0,30	x	0,05
S2	x	0,33	0,27	0,26	0,13	S2	x	0,26	0,33	0,31	0,20
S3	x	x	0,27	0,50	0,23	S3	x	x	0,30	0,54	0,17

Notes: S0, autonomy. S1, functional limitations. S2, IADL limitations. S3, ADL limitations. S4, death.

Sample: All elderly aged 60 and over, in one the 13 countries included (See Table A2), respondent at least in two consecutive waves, and respondent to the health questionnaire.

Source: SHARE waves 4, 5 and 6.

Figure B2 – Transition Probabilities in France versus Europe

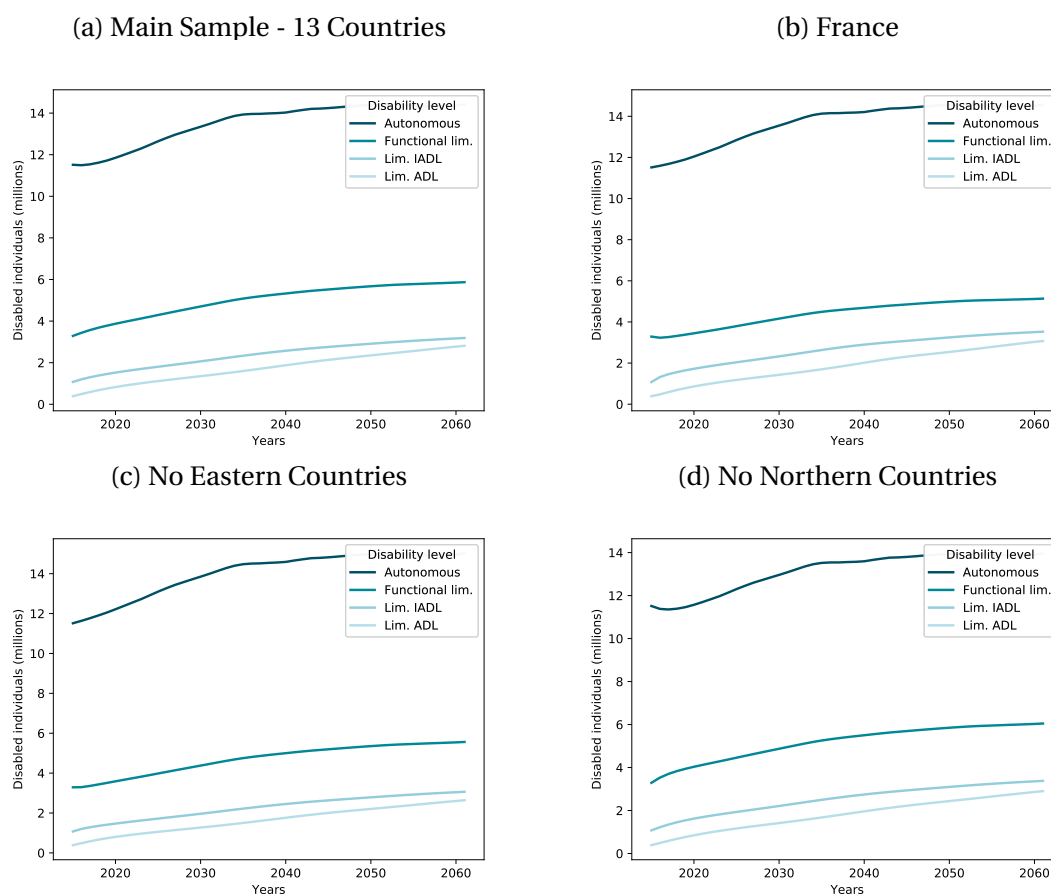


Notes: First graph shows the transition probability from state 0 - autonomous to state 0, 1 - low disability and 4 - death. It shows the probability to stay autonomous is slightly higher than 0.8 for the main sample, and the french sample.

Sample: All elderly aged 60 and over, living in the community, respondent to the health questionnaire. The main sample includes individuals from 13 countries (Austria, Czech Republic, Slovenia, Estonia, Denmark, Netherlands, Sweden, France, Germany, Spain, Italy, Switzerland, Belgium). The second sample includes only individuals from France.

Source: SHARE, waves 4, 5, 6.

Figure B3 – Projection Using Various Samples



Notes: All the projection are based on our main scenario.

Sample: All elderly aged 60 and over, living in the community, respondent to the health questionnaire. The main sample includes individuals from 13 countries (Austria, Czech Republic, Slovenia, Estonia, Denmark, Netherlands, Sweden, France, Germany, Spain, Italy, Switzerland, Belgium). The second sample includes only individuals from France. The third one excludes eastern countries (Austria, Czech Republic, Estonia and Slovenia) and the last one northern countries (Denmark, the Netherlands and Sweden).

Source: SHARE, waves 4, 5, 6.

B.4 Sensitivity of the Number of European Countries in the Sample

One may fear that countries included in the sample creates a very heterogeneous group. Thus, we estimate the transition probabilities for our main sample, and we compare it to the transition probabilities of a sample excluding northern European countries (Denmark, the Netherlands and Sweden) and another excluding eastern European countries (Austria, Czech Republic, Estonia and Slovenia). It shows no statistically significant differences for none of the transition (Figure B4). Moreover, Figures B3c and B3d shows that we forecast 15,0 millions autonomous elderly in 2060 in Europe excluding eastern countries, and 14,0 excluding northern countries. It remain in the same range as the 14,4 millions autonomous elderly projecting in our main scenario.

Table B5 – Transition Matrix by Country – Northern and Eastern Europe Exclusion

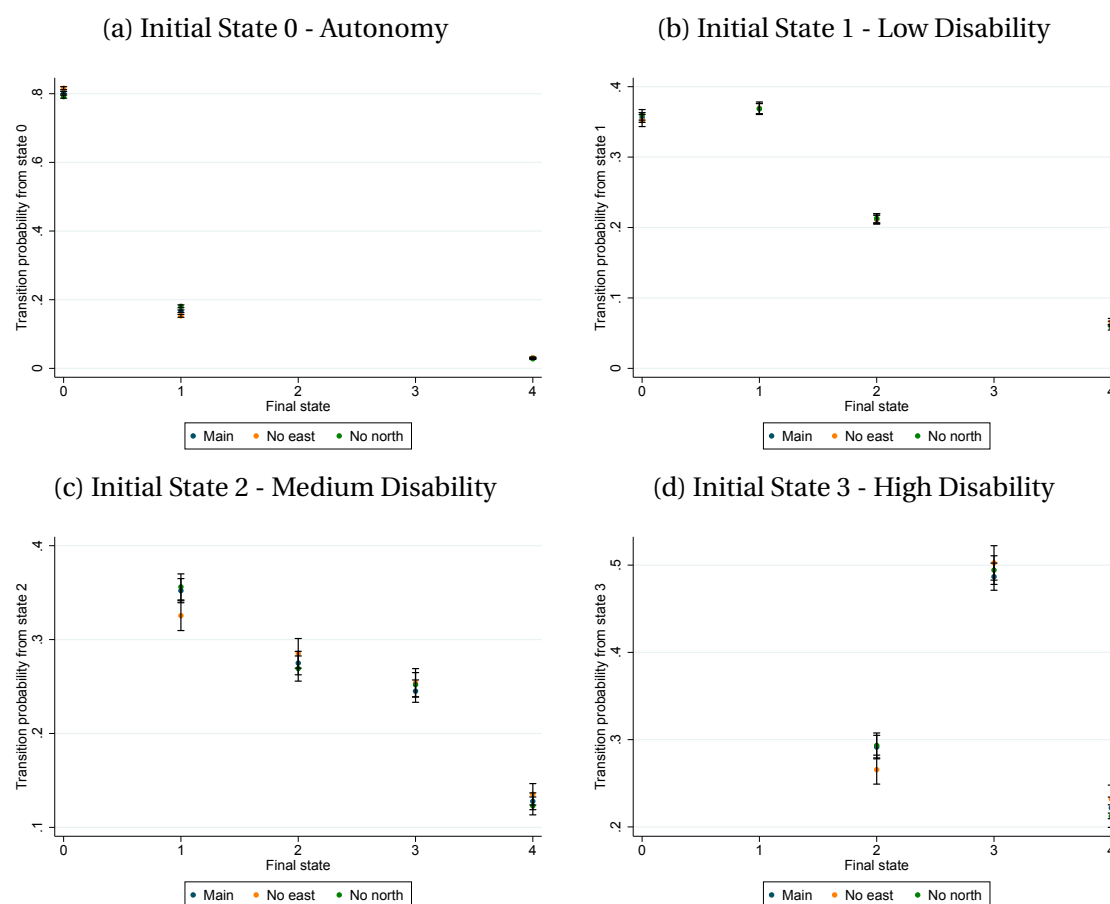
(a) without eastern countries						(b) without northern countries					
	S0	S1	S2	S3	S4		S0	S1	S2	S3	S4
S0	0,84	0,14	x	x	0,02	S0	0,80	0,17	x	x	0,02
S1	0,34	0,36	0,23	x	0,07	S1	0,34	0,36	0,23	x	0,06
S2	x	0,31	0,29	0,27	0,13	S2	x	0,34	0,27	0,27	0,13
S3	x	x	0,25	0,53	0,23	S3	x	x	0,27	0,50	0,22

Notes: S0, autonomy. S1, functional limitations. S2, IADL limitations. S3, ADL limitations. S4, death.

Sample: All elderly aged 60 and over, in one the 13 countries included (See Table A2), respondent at least in two consecutive waves, and respondent to the health questionnaire.

Source: SHARE waves 4, 5 and 6.

Figure B4 – Transition Probabilities with Exclusion of Countries



Notes: First graph shows the transition probability from state 0 - autonomous to state 0, 1 - low disability and 4 - death. It shows the probability to stay autonomous is slightly higher than 0.8 for the main sample, the sample excluding eastern Europe countries and the sample excluding northern Europe countries.

Sample: All elderly aged 60 and over, living in the community, respondent to the health questionnaire. The main sample includes individuals from 13 countries (Austria, Czech Republic, Slovenia, Estonia, Denmark, Netherlands, Sweden, France, Germany, Spain, Italy, Switzerland, Belgium). The sample without eastern countries excludes individuals from Austria, Czech Republic, Slovenia and Estonia. The sample without northern Europe excludes individuals from Denmark, Netherlands and Sweden.

Source: SHARE, waves 4, 5, 6.

C Details of Adjustment Probabilities Method

Once the death calibration is done, we have to adjust other transitions so that probabilities sum to one. There is several way yo adjust other transitions. The implicit assumption in many previous projection models is a reallocation in an homogeneous way. Thus, this assumption is our baseline assumption. The mathematical details of this assumption are sum up in what follows.

The constraint is that all transitions from a given state must sum to one. From state 0, $P_{00}^C + P_{01}^C + P_{04}^C = 1$. We treat transitions to states 0 and 1 symmetrically. We want to find β_0 such that $\beta_0 P_{00} + \beta_0 P_{01} + P_{04}^C = 1$. This gives:

$$\beta_0 = \frac{1 - P_{04}^C}{P_{00} + P_{01}},$$

where $P_{04}^C = P_{04} - \mu(P_{04}^C - P_{04})$, $(P_{04}^C - P_{04})$ is the decrease in mortality, and $\mu \in [0, 1]$.

Similarly, from initial state 1, final states can be states 0, 1, 2 or 4. Using $P_{10}^C + P_{11}^C + P_{12}^C + P_{14}^C = 1$ gives:

$$\beta_1 = \frac{1 - P_{14}^C}{P_{10} + P_{11} + P_{12}}.$$

From state 2, possible final states are states 1, 2, 3 and 4. Thus:

$$\beta_2 = \frac{1 - P_{02}^C}{P_{21} + P_{22} + P_{23}}.$$

From states 3, possible final states are states 2, 3 and 4. Thus:

$$\beta_3 = \frac{1 - P_{03}^C}{P_{32} + P_{33}}.$$

D Reminder Regarding Parameters of the Model

Table D1 – Parameters of the Model : Definitions

Name	Definition	Formula
λ	Weight applied to mortality probabilities.	$\lambda = \frac{P_4^{Insee}}{\sum P_{i4} N_i}$
μ	Proportion of life expectancy gains attributed to autonomy states.	$\mu = 0$ or $\mu = 1$
β	Weight applied to transitions between dependency states.	$\beta = \frac{1 - \lambda P_{i,4}}{1 - P_{i,4}}$
α	Change in the probability to remain autonomous.	$\alpha = 1$ or $\alpha = 1.015$ or $\alpha = 1.03$
θ	Decrease (in %) of the share of dependant 60 years old individuals.	Exogenous, $\theta = 0.1$

Notes: P_{i4} is the probability to die for someone in dependency state i , N_i population in state i , P_4^{Insee} are Insee projections for mortality.

E Additional Results

E.1 Transition Matrix

Table E1 – Transition Matrix by Gender

(a) Women						(b) Men					
	S0	S1	S2	S3	S4		S0	S1	S2	S3	S4
S0	0,79	0,20	x	x	0,02	S0	0,85	0,12	x	x	0,03
S1	0,33	0,37	0,26	x	0,05	S1	0,36	0,36	0,18	x	0,11
S2	x	0,34	0,29	0,28	0,10	S2	x	0,30	0,22	0,22	0,27
S3	x	x	0,27	0,52	0,21	S3	x	x	0,28	0,43	0,29

Notes: S0, autonomy. S1, functional limitations. S2, IADL limitations. S3, ADL limitations. S4, death.

Sample: All elderly aged 60 and over, in one the 13 countries included (See Table A2) main surveyed in SHARE, respondent at least in two consecutive waves, and respondent to the health questionnaire.

Source: SHARE waves 4, 5 and 6.

E.2 Choice of Waves

Table E2 – Transition Matrix by Waves

(a) Transitions Using Waves 1&2						(b) Baseline Transitions					
	S0	S1	S2	S3	S4		S0	S1	S2	S3	S4
S0	0,81	0,17	x	x	0,02	S0	0,82	0,16	x	x	0,02
S1	0,36	0,40	0,19	x	0,05	S1	0,34	0,36	0,23	x	0,07
S2	x	0,42	0,25	0,25	0,07	S2	x	0,33	0,27	0,26	0,13
S3	x	x	0,27	0,54	0,19	S3	x	x	0,27	0,50	0,23

Notes: S0, autonomy. S1, functional limitations. S2, IADL limitations. S3, ADL limitations. S4, death.

Sample: All elderly aged 60 and over, in one the 13 countries included (See Table A2) main surveyed in SHARE, respondent at least in two consecutive waves, and respondent to the health questionnaire.

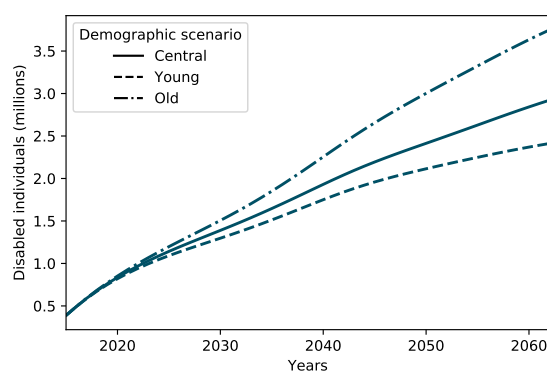
Source: SHARE waves 1, 2, 4, 5 and 6.

E.3 Projections of Disabled for Several Scenarios

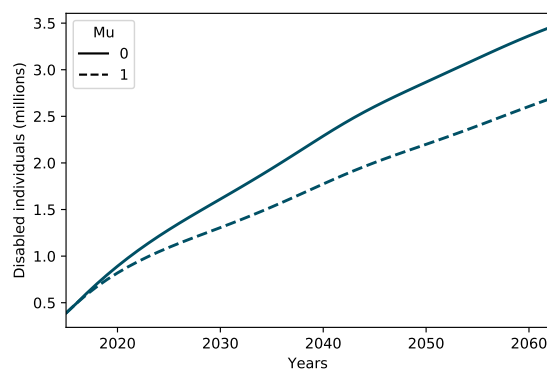
Figure E1 shows the number of disabled individual projected following various demographic scenario (ref E1a), scenario of death gains reallocation (E1b) and scenario of variation in probability to remain autonomous (E1c). It shows that the number of disabled varies by 1.5 millions in the demographic scenario and probability to remain autonomous scenario and by 0.9 million in the death gains reallocation scenario.

Figure E1 – Evolution of the Number of Dependent Individuals

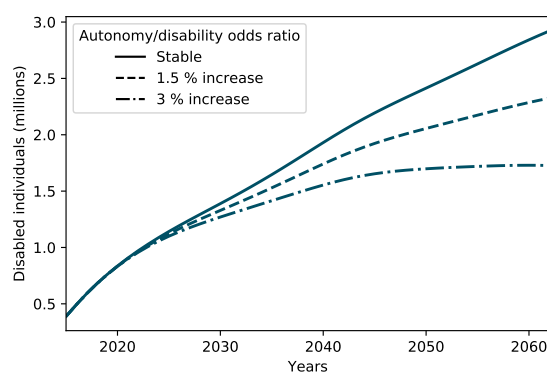
(a) by Insee Scenario



(b) by Allocation of Life Expectancy Gains Scenario
(Varying μ)



(c) by Probability to Stay Autonomous Scenario
(Varying α)

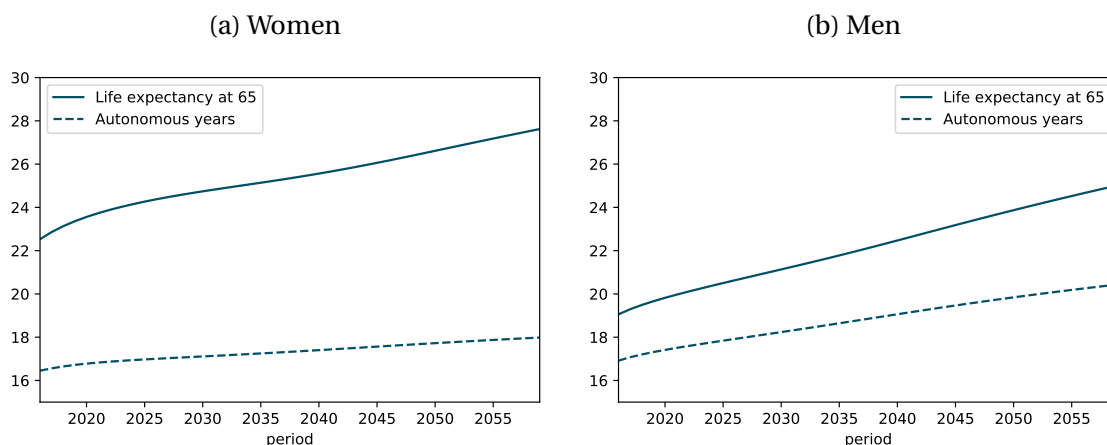


Notes: Figure E1b μ : annual increase of the odds ratio $\frac{P_{00}}{P_{00}+P_{01}+P_{02}+P_{03}}$.

Sample: All elderly aged 60 and over, in one the 13 countries included (See Table A2) main surveyed in SHARE, respondent at least in two consecutive waves, and respondent to the health questionnaire.

Source: SHARE waves 4, 5 and 6.

Figure E2 – Projection of Life Expectancy and Disability-free Life Expectancy at Age 65



Notes: In, 2060, according to the main scenario (central life expectancy gains, homogeneous allocation of these gains), at age 65, women can expect to live 28 years including 18 years without any disability. Men can expect to live 25 years, including 20 in good health.

Sample: All elderly aged 60 and over, in one the 13 countries included (See Table A2) main surveyed in SHARE, respondent at least in two consecutive waves, and respondent to the health questionnaire.

Source: SHARE waves 4, 5 and 6.

Chapter 5

Does an Increase in Formal Care Affect Informal Care?

Summary of the chapter

This paper investigates the causal impact of formal care use on informal care among formal care users. We propose an original instrument for formal care use, using local disparities in the price of formal care providers. Using the French survey *CARE*, we implement a two-part model to show the effect of formal care on the extensive and on the intensive margin of informal care. An exogenous increase in formal care is found to decrease the probability to use informal care, with a low magnitude. Heterogeneity tests show this negative effect is mainly driven by caregiving for daily life activities, provided by women. At the intensive margin, however, informal care is not significantly affected by a formal care increase. Reforms extending the generosity of public policies for formal care use can thus be expected to have a limited effect on informal care arrangements.

This Chapter has been co-authored with Quitterie Roquebert.

1 Introduction

As many European countries, France is experiencing the ageing of its population and public policies have to cope with an increasing demand for long-term care. Long-term care, referring to services for individuals suffering from functional limitations, can be provided by professionals (formal care) and non-professional relatives (informal care). Informal care plays a major role in the provision of domestic help and personal care (Colombo et al., 2011), while it has been shown to have detrimental effects on caregivers's health, labor supply and social life (Bauer and Sousa-Poza, 2015). In France, public policies tend both to encourage the use of professional care services and to support informal caregivers. The main program targeted to the disabled elderly, the APA program (*Allocation personnalisée d'autonomie*), partially finances the use of formal care and at the same time implements measures to alleviate the burden of informal care for relatives. Evaluating such a policy requires to have an insight of the interactions existing between formal care and informal care.

This paper documents the effect of an increase in formal care use on informal care. An increase in formal care may lead to a decrease in informal care if both services are substitutes: the care provided by formal caregivers does not need to be provided by relatives. Conversely, both services could be complement: additional support from informal carers could be needed with increasing formal care use, for instance to cope with administrative costs. Moreover, formal care could have a signalling effect: formal care intensity could signal the importance of the disability for relatives and increase informal care use.

There is a prolific literature on the effect of informal care provision on formal care use and it typically shows that informal care and formal care are substitutes (see Bonsang (2009) for a review). The literature studying the impact of formal care use on informal care is more limited. Several studies have questioned the impact of public subsidies on both formal and informal care consumption (Christianson, 1988; Ettner, 1994; Pezzin et al., 1996; Stabile et al., 2006; Rapp et al., 2011; Fontaine, 2012; Arnault, 2015). They aimed at forecasting the effect of public policies financing formal care on care arrangements. The causal impact of formal care on informal care has been little studied, mainly because of the difficulty to find an instrument for formal care. Carrino et al. (2018) use variations in individuals' eligibility status in Austria, Belgium, Germany and France to instrument formal care consumption (at the extensive and intensive margin) and analyse its effects on informal care. They find that higher formal care provision would lead to an increase in informal care utilisation.

Our paper contributes to this literature by analysing the effect of formal care intensity on informal care. To the best of our knowledge, it is the first paper to concentrate on the effect of formal care intensity on informal care *among formal care users*. Studying the intensive margin of formal care is of interest in a context where long-term care policies are gaining

importance. In 2016, a reform of the French long-term care policy, the so-called ASV law,¹ increased the generosity of subsidies on formal care for individuals already benefiting from the APA program. Evaluating its effects on informal care requires to have an insight on how increasing formal care use affects informal care. Moreover, there is no reason for the extensive margin of formal care to have the same impact as its intensive margin on informal care.

We use the national and cross-sectional French survey CARE (*Capacités, aide et ressources des seniors*), collected in 2015, which is representative of the elderly population at the national level. From this survey, we extract a sample of formal care users. To ensure exogeneity of formal care use, we implement an original instrumental variable strategy that makes use of local variations existing in the prices of the home care sector. We obtain this information from the departmental *SolvAPA* survey. We estimate a two-part model, which highlights the effect of formal care on the extensive and intensive margin of informal care.

Our results show that an exogenous increase in formal care affects the extensive margin of informal care, with a limited magnitude. According to heterogeneity tests, this negative effect is mainly concentrated on caregiving for daily life activities, provided by women, and it affects both primary (spouse and children) and secondary caregivers (friends, neighbours). The intensive margin of informal care is unaffected. Thus, an increase in formal care use as the one planned by the 2016 APA reform can be expected to have a limited effect on the involvement of relatives in the provision of care and concentrated on specific caregivers.

2 Conceptual Framework

To analyse this effect, we use a theoretical framework classically considered in the literature and comprehensively described in Pezzin and Schone (1999). We present here a simplified version of the model. It formalises the utility of the parent (indexed by p) and the child² (indexed by c) denoted $U_i, i \in \{c, p\}$. The child provides a quantity of informal care IC while the parent can also consume hours of formal care FC . Both contributes to produce the well-being of the parent W , and their effect is conditional on the disability level of the parent D . We assume a Cournot-Nash equilibrium where the child chooses unilaterally the informal care quantity, assuming as given the formal care volume; and the parent chooses unilaterally the formal care quantity, assuming as given the informal care volume.

The child is assumed to be altruistic as he/she takes into account the well-being of the

¹*Loi relative à l'adaptation de la société au vieillissement* – Law for the adaptation of society to ageing.

²Since we are not interested in the long-term care arrangement within the family, we only consider the total volume of informal care, whatever if it comes from one or several careers. Thus, we summarise the total number of care received in the model as those from one child, whatever the real number of caregivers.

parent. His/her utility is formalized as follows:

$$\begin{cases} \text{Max}_{X^c, IC, L} U^c(X^c, W(IC, FC; D), L) \\ \text{s/c } V^c + \omega T = X^c + \omega(L + IC) \end{cases}$$

With V^c the nonlabor income of the child, ω is his/her labor wage, T is the total time endowment, X^c is the consumption of private good and L is leisure.

The parent chooses X^p and FC to maximise his/her utility:

$$\begin{cases} \text{Max}_{X^p, FC} U^p(X^p, W(IC, FC; D)) \\ \text{s/c } V^p = X^p + p_{FC}FC \end{cases}$$

Where V^p is the parent nonlabor income and p_{FC} is the price of formal care.

The amount of informal care is chosen by the child while the quantity of formal care depends on the parent's decision. It gives the following reaction functions:³

$$IC^c = f^{IC}(V^c, \omega, FC(p_{FC}; D)) \quad (5.1)$$

$$FC^p = f^{FC}(V^p, p_{FC}, IC; D) \quad (5.2)$$

This theoretical framework gives interesting results for our empirical strategy. Indeed, according to this model, the price of formal care has an impact on informal care only through the formal care function. The price of formal care is thus a potential candidate for instrumenting formal care use.

3 Data and Method

3.1 Data and Sample

This paper takes advantage of two datasets: a national survey on the elderly population in France and a survey on departmental practices regarding long-term care. This last survey is used to obtain our instrumental variable.

The French Survey CARE. We use the French survey CARE (*Capacités, aide et ressources des seniors*), which focuses on the elderly population living in the community in France. This cross-sectional survey, collected in 2015, surveyed close to 11,000 individuals, and is representative of the population aged 60 or more at the national level. It gives exhaustive information on the limitations encountered by individuals and on the formal and informal

³This function came from the first order condition of the utility function. See Appendix A for details and Pezzin and Schone (1999) for further details on the resolution of this maximization program.

care they receive. In particular, when the individual has been able to declare them, we observe the number of hours provided by professional caregivers and relatives.

A Departmental Survey. Our instrument comes from the *SolvAPA* survey (DREES, 2015a). As part of the CARE survey, this departmental survey was implemented by the Ministry of Health in 2015 to document the practices of departmental councils regarding long-term care policies.⁴ This survey offers the opportunity to have information on the way departmental councils implement the APA program and how they regulate the home care sector. Using this survey, however, implies to focus on individuals living in a department that did answer to the survey: 85 over 96 metropolitan departments responded to the survey.

Sample Selection. Our sample of interest is made of individuals living in the community that declare they consume formal care. We more specifically focus on those who consume unskilled formal care, provided by professional housekeepers or non-medical caregivers.⁵ Focusing on formal care users induces a selection: compared to the whole population of elderly, formal care users are more frequently women, living alone and with a low-income (Appendix B.1). Our results are thus relevant for this sub-population of elderly specifically. Considering a broader sample, including individuals not consuming formal care, would limit the selection and would give results on an increase in formal care at both the intensive and extensive margin. Such a sample, however, is not relevant in our framework. First, the regulated price (used as an instrument in our empirical strategy) does not affect the probability to consume formal care (Appendix B.1). As a consequence, our instrument is weaker when considering an extended sample (Appendix B.2). Moreover, including non-consumers raises an additional technical issue, related to the log-form applied when formal care equal zero. The usual way to deal with zero value is to add 1 to the variable, making the assumption that 1 is negligible. Regarding formal care volume, however, 1 is not negligible, and results on extended sample are highly sensitive to the specification of the log-variable.⁶

Finally, our sample is restricted to individuals whose department has responded to the *SolvAPA* survey⁷ and we exclude outliers, defined as the 1% extreme values regarding formal and informal care volumes.⁸

⁴The questionnaire can be found here (in French): <http://www.data.drees.sante.gouv.fr/TableViewer/document.aspx?ReportId=344>.

⁵In CARE Survey, these professionals are referred to as “*aide à domicile*”, “*auxiliaire de vie*”, “*garde à domicile*”, “*femme de ménage*”, and “*aide-ménagère*”.

⁶Results available upon request.

⁷76 departments over the 82 respondents are represented in our sample of elderly. The characteristics of formal care users whose department has not responded to the *SolvAPA* survey (420 observations) are not significantly different compared to formal care users in general.

⁸It corresponds to more than 167 informal hours per week or more than 70 formal hours per week. Appendix B.3 presents alternative estimations modifying the definition of outliers.

Variables of Interest. Our independent variable is the number of formal care hours received by individuals. Our dependent variable is the volume of informal care they receive. This variable takes into account the hours of informal caregivers declared by the individual.⁹ Formal care and informal care volumes are directly declared by the elderly for each caregiver, either at the daily, weekly or monthly level. Since the most frequent unit is the week, we convert daily and monthly volume in weekly hours and expressed, for each individual, the total number of informal or formal care received per week. Appendix B.4 presents the distribution of these variables. They are, in level, relatively skewed while the distributions of the log-variables are better shaped for the econometric model we use. The variables we use are the following: gender, age, living status (alone or not), number of children, education level (having the French *baccalauréat* or not), income level and disability group. We additionally control for the fact that someone else has responded to the questions on the care received (proxy). The disability group corresponds to a synthetic indicator computed from activity limitations declared by individuals. It mimics the *AGGIR* scale, which is used in the APA program to assess the disability level of individuals. More details on the contents of each category are given in Appendix C.

Descriptive Statistics. Table 1 presents summary statistics on the main variables used in the model for our estimation samples: formal care consumers (Column 1), and, among them, those who receive informal care (Column 2). The typical individual of our baseline sample is a woman, living alone, having about two children and with a moderate disability level. Compared to this baseline sample, informal care users are older and have a higher number of children. They are more severely disabled, more frequently APA beneficiaries, and a proxy was more often in charge to answer the questionnaire. As a consequence, they consume significantly more formal care (in average, 6.48 hours by week in the baseline sample and 7.21 hours among the sub-sample of informal care consumers).

3.2 Instrumental Variable

We face the classical endogeneity issues that arise when studying simultaneously formal care and informal care. The first endogeneity threat is reverse causality: we could capture the effect of informal care on formal care use. The second is the omitted variable bias: unobserved determinants affecting both formal and informal care use could yield biased estimators.

To deal with these endogeneity issues, we implement an instrumental variable strategy. Local variations in home care supply provide an exogenous source of variations in the vol-

⁹It means that some caregivers are not taken into account if the individual has not been able to declare the volume they provided. If an individual has not been able to give the volume of care of any of his/her caregivers, he/she is not regarded as informal care recipient. Appendix E.3 provides more details. It reproduces our main results with an alternative definition of informal care reception. Results are robust to this change.

Table 1 – Descriptive Statistics on the Main Samples

	Baseline sample	Informal care consumers	Difference between samples
Consumes informal care	56.57	100.00	-
Consumes formal care	100.00	100.00	-
Hours of formal care	6.48	7.21	***
Hours of informal care	13.35	23.60	***
Woman	77.68	78.30	n.s
Age	82.55	83.85	***
Living alone	71.03	70.69	n.s
Number of children	2.34	2.47	***
Education	13.37	10.75	***
APA beneficiary	44.26	48.53	***
Disability group:			***
1	2.45	3.60	
2	14.24	18.56	
3	13.71	17.36	
4	34.67	33.71	
5	14.46	12.48	
6	20.47	14.29	
Income:			***
< €10,000	25.38	24.97	
€10,000 - €15,000	27.87	30.91	
€15,000 - €20,000	22.05	21.70	
€20,000	24.70	22.43	
Proxy	44.07	58.08	***
Observations	2,648	1,498	

Notes: In the baseline sample (consumers of formal care) 56.57% consume informal care. The average weekly hours of formal care consumed is 6.48 hours. In the sub-sample of informal care consumers, the average weekly hours of formal care consumed is 7.21 hours. The difference between the two samples is significant at the 1% level.

Notes: The test performed is a Student (resp. Pearson χ^2) test if the variable is binary or continuous (resp. categorical). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, n.s not significant.

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

ume consumed. In particular, we may expect the consumption to be higher when available prices are lower, since elder's demand for formal care is sensitive to the price (Roquebert and Tenand, 2017). We use information on prices at the local level rather than individuals prices to guarantee that variations in this price are exogenous.¹⁰ We consider the departmental

¹⁰It is due to the atomicity condition, i.e the fact that one individual's consumption cannot influence the

level, where the home care sector is managed in France (Hegé et al., 2014). Since we exploit local variations, the identification rests on inter-individual variations.

We use as an instrument the lowest regulated price available in the department. In France, both regulated and non-regulated providers¹¹ operate on the home care sector.¹² We focus on regulated prices, for which data are available. Regulated providers are allowed to enter the market by departmental councils, they have to meet quality requirements and their prices are fixed by the departmental council.¹³ The departmental council fixes a price for each structure, which depends on the provision costs of the provider: it is supposedly set at the average hourly provision cost. But it also depends on administrative considerations of the departmental council (Gramain and Xing, 2012). For instance, the departmental council can modulate the importance of qualified caregivers in the workforce through the pricing process. The heterogeneity in regulated prices thus reflects the variations in provision costs as well as departmental variations in pricing practices.

To be valid, our instrument should not affect informal care except through formal care (exclusion restriction). This is what is predicted in the conceptual framework (Equation 5.1). Arnault (2015) underlines this assumption does not hold if informal care is affected by parent's private goods consumption (X^P), which also depend on the price of formal care through the parent's budget constraint. Moreover, in case of financial transfers from parents to children, the price of formal care could affect the amount of the transfers which then modify the non-labor incomes of children (V^C), coming into play in the informal care decision. Strategic behaviors could also come into play: with a high price, children could increase *ex ante* their informal care provision to limit the parent's consumption of formal care and save money for inheritance. We argue such a biased behaviour should be limited since the money engaged for formal care remains relatively low (compared, for instance, to the price of nursing homes) and since such a mechanism should only concern relatively-high income individuals. Arnault (2015) relaxes the hypothesis that informal care depends on the price of formal care only through formal care volume. Thus, he estimates a reduced-form model estimating the cross-price elasticities of formal care and informal care.¹⁴

The exclusion restriction may also be an issue if the departmental price is correlated with departmental characteristics that reflect informal and formal care use of individuals in the department. We verify that this price is not correlated with departmental characteristics

price established at an aggregate level.

¹¹In the home care sector, two regulatory status are existing in 2015: structures can be *authorized* (regulated) or not. In 2016, a reform has required all structures to get regulated; we exploit, however, a national survey collected in 2015, and a departmental survey from 2015, when the distinction was still existing.

¹²Roquebert et al. (2018) provide a detailed presentation of the different types of providers operating on the home care sector in France.

¹³Conversely, non-regulated providers are free to enter the market and only have a constraint on the increase rate of their price.

¹⁴Comparison of results are presented in Section 5.

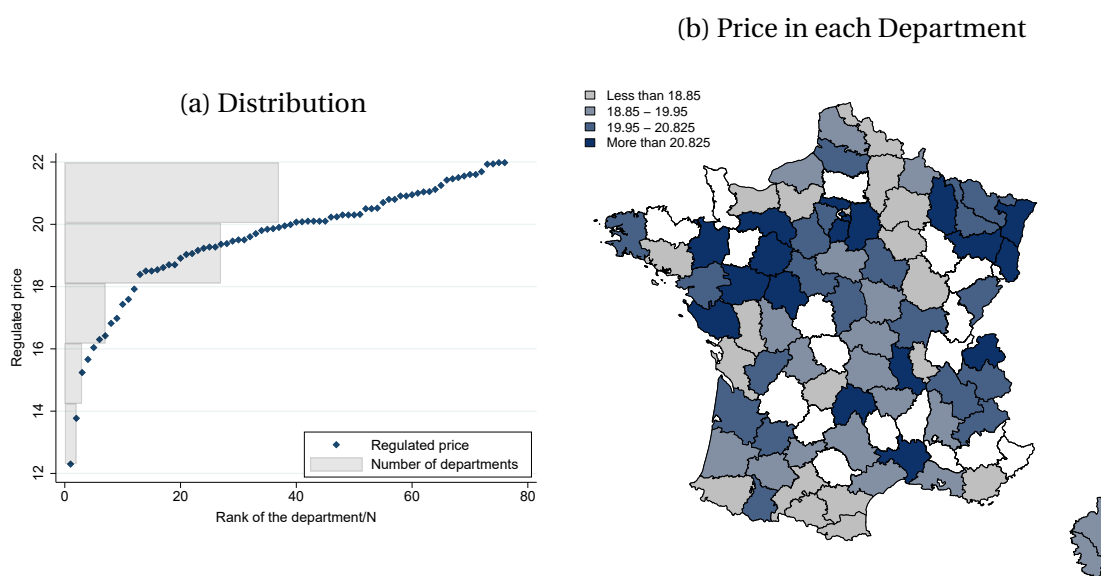
such as demographic characteristics (share of elderly in the population, share of women among elderly, share of elderly living alone), political side of the departmental council, economic characteristics (interdecile ratio, share of taxable households, poverty rate, share of APA beneficiaries), supply characteristics (equipment rate in institutions). None of these variables explain variations in the lowest regulated price at the departmental level (see Table D1).

In the *SolvAPA* survey, departmental councils were asked to give information on prices fixed for regulated providers. We consider the lowest price available in the department, which shows the minimum price that has to be paid to get formal care from a regulated provider.¹⁵ In the 76 departments represented in our sample, this price goes from 12.3€ to 21.98€, with an average share of 19.54€ and a standard deviation of 1.88. Figure 1a illustrates the distribution of the lowest regulated price. Figure 1b maps the lowest regulated price in each department. We have conducted a test of spatial auto-correlation, to see whether the level of the lowest regulated price in one department is correlated to the level of this price in departments nearby (Appendix D.2). We find that there is no spatial auto-correlation between the value of the lowest regulated price and the value of this price in departments nearby. Overall, these tests support the exogenous dimension of our instrument. Lastly, we test the sensitivity of the instrument to the exclusion of departments with the lowest regulated price (Appendix D.3). It shows that our instrument is not sensitive to the departments with extremely low regulated price.

Alternative instruments have been investigated, regarding the characteristics of local policies financing the demand or individual characteristics, but none has been assessed as relevant. Appendix D.4 gives more details.

¹⁵Individuals could potentially obtain lower prices if they are served by non-regulated providers - over-the-counter workers in particular. There is no data, however, on those prices. Moreover, for individuals benefiting from the APA program, departmental councils tend to favor regulated providers: most beneficiaries (75%) have to be served by a regulated provider (Couvert, 2017).

Figure 1 – Description of the Lowest Regulated Price



Notes: Figure (a): Departments are ranked by importance of the lowest regulated price. The department with the lowest price has a price close to 12 euros while the department with the highest price has a price close to 22 euros. 37 departments have a regulated price between 20 and 22 euros. Figure (b): This map shows the lowest regulated price in each department. missing department are in white.

Source: SolvAPA survey, 2015.

3.3 A Two-part Model for Informal Care Use

Two-part Model. We aim at showing the causal impact of a variation of formal care intensity on informal care consumption - both at the extensive and intensive margin. Following Bonsang (2009) and Carrino et al. (2018), we use a two-part model (TPM) combined with an instrumental variable strategy (Duan, 1983).¹⁶

The first part of the model is a binary choice model (Probit model) and focuses on the extensive margin of informal care. With the instrumental variable (IV) strategy, this first part falls into two stages. The first stage corresponds to the variation of log-hour of formal care attributable to a variation in regulated price of the department (Equation 5.3) and the second stage of the first part of TPM is the variation in probability to report informal care attributable to the exogenous variation of log-hour of formal care (Equation 5.4). Equation 5.4 is estimated with conditional maximum likelihood estimation.¹⁷

$$\log(\text{FC}_i) = \pi_0 + \pi_1 T_{d(i)} + \pi_2 X_i + \pi_3 Y_{d(i)} + u_i \quad (5.3)$$

$$\Pr(\text{IC}_i > 0 | \text{FC}_i, X_i, Y_{d(i)}) = \Phi(\alpha_0 + \alpha_1 \log(\text{FC}_i) + \alpha_2 X_i + \alpha_3 Y_{d(i)}) \quad (5.4)$$

with $\Pr(\text{IC}_i > 0)$, the probability for individual i of declaring informal care use; $T_{d(i)}$, the lowest regulated price available in the department d of individual i ; X_i , controls for individuals characteristics; $Y_{d(i)}$, controls for departmental characteristics. Φ is the cumulative density function of the standard normal distribution. We assume that error terms between Equation 5.3 and 5.4 follow a normal joint distribution $((u_i, v_i) \sim \mathcal{N}(0, \Sigma))$.

The second part is a two-stage least square (2SLS) explaining the consumption level for consumers of informal care. It focuses on the intensive margin of informal care.

$$\log(\text{FC}_i) = \tau_0 + T_{d(i)} \tau_1 + X_i \tau_2 + Y_{d(i)} \tau_3 + v_i, \forall i, \text{IC}_i > 0 \quad (5.5)$$

$$\log(\text{IC}_i) |_{\text{IC}_i > 0, \text{FC}_i, X_i, Y_{d(i)}} = \beta_0 + \beta_1 \widehat{\log(\text{FC}_i)} + \beta_2 X_i + \beta_3 Y_{d(i)} + \epsilon_i \quad (5.6)$$

We assume that error terms follow normal distributions. To take into account potential correlations of disturbances among individuals living in the same department, we estimate standard errors clustered at the departmental level (Moulton, 1990).

¹⁶See Mihaylova et al. (2011) for a recent review of econometric tools for healthcare resources and costs and long-term care consumption studies; see Leung and Yu (1996) on the choice between sample selection model and two part model.

¹⁷We use the Stata command “ivprobit” (version 14.0). Two estimators can be obtain: i) the conditional maximum-likelihood estimation (MLE); ii) Newey’s efficient two-step estimator (Newey, 1987). Newey’s estimator is particularly relevant when MLE does not converge. However, it does not make it possible to cluster standard errors. Since we have no convergence issues in our main results, we use the MLE estimation and cluster standard errors at the departmental level (see below).

Covariates. Individual covariates include variables that are likely to correlate with informal care: gender, age, living status (alone or not), having children, education level, disability group, proxy respondent and income level. Regarding departmental variables, for the sake of precision, we only include relevant variables in departmental controls. We define relevant departmental variables as variables that explain informal care consumption at the individual level (at the extensive or intensive margin). To select them, we regress our outcome variables on a set of potentially relevant variables at the departmental level. These variables include demographic and socio-economic characteristics of the population at the departmental level, while controlling for individual characteristics. We select those having a significant effect as departmental controls in our final regression. The final set of departmental controls included ($Y_{d(i)}$) are: the interdecile ratio, the share of elderly population in the departmental population, the share of women among them, the political side of the departmental council, the equipment rate in institutions and the local unemployment rate.

4 Results

4.1 Main Results

Impact of the Regulated Price on Formal Care Use. To be used as an instrument, the regulated price has to be correlated with individual consumption (relevance condition). In our sample, a 1% increase of the regulated price leads to a significant average decrease by 0.733% in the formal care consumption, significant at the 1% level (Table 2, Column (1)). It is also the case when focusing on informal care consumers: a 1% increase of regulated price leads to an average decrease in formal care consumption by 0.696%, significant at the 5% level (Column (3)). In both cases, the F-test is low: our instrument should be regarded as relevant but weak.¹⁸ To cope with this issue, we have estimated in Appendix E.1 the confidence intervals using the conditional likelihood-ratio (CLR) statistic proposed by Moreira (2003). It is expected to be robust to the bias induced by weak instruments in small samples. Results show that the bias induced by our weak instrument is limited on the first part of our model, while it seems to be more important on the second part of our model. Thus, we need to be cautious when interpreting the results at the intensive margin of informal care.

Causal Impact of Formal Care on Informal Care. At the extensive margin, an exogenous increase of formal care consumption decreases the probability that individuals declare they

¹⁸Note that the usual rule of thumb stating that there is a weak instrument issue when the F-test is lower than 10, coming from Staiger and Stock (1997), has been established for the case of IID errors and thus are not relevant in our estimation including clusters (Cameron and Miller, 2015). However, in the absence of alternative thresholds, we consider the weak instrument issue has to be dealt with.

consume informal care by 0.294.¹⁹ (Table 2, Column (2)). This effect is significantly different from zero at the 1% level. At the intensive margin (Column (4)), an exogenous increase in formal care does not significantly affect the volume of informal care declared by individuals.

Size of the Effect. The increase by one of the log-hour is equivalent to the effect of multiplying formal care use by 2.718.²⁰ It represents an increase in formal care by 11.13 hours for an individual who consume 6.48 hours of formal care by week (the average number of hours consumed in our data).²¹ This 11.13 hours increase leads to a decrease in the probability to consume informal care by 0.294. Assuming the effect is proportional, it would be equivalent to a decrease of 0.026²² in the probability to consume informal care for a one-hour increase in formal care volume. Though it is significant, the effect of a formal care increase on informal care probability can thus be regarded as limited.

Underlying Mechanisms. The negative impact we find at the extensive margin could illustrate the eviction of informal care by formal care: when formal carers provide a high volume of care, relatives withdraw from the care provision. Since information on care is from a declarative survey, it could also be due to a declarative bias (“self-assessed” mechanism): the increase in formal care could decrease the propensity of our sample members to recognize informal care as such. Receiving visits from relatives would not be directly associated to the care provision since it is already provided by paid formal caregivers.

4.2 Extensions: Alternative Outcomes

Our data contain rich information on caregivers and the type of care they provide: it makes possible to explore the heterogeneous impact of formal care intensity on informal care. We consider here the heterogeneity according to the characteristics of the care provided (care for daily life activities, moral support, material help) and the characteristics of the caregiver (relationship with the individual, gender). These heterogeneity tests focus on the first part of the model. Indeed, intensive margin can not be studied for some variables (hours are not declared according each type of care) and for others, restrictions to consumers on the second part often threaten the validity of our first stage. We additionally explore, among the

¹⁹By comparison, a naive analysis including directly formal care and informal care would predict no effect on the probability to consume informal care (Appendix E.2. Result using a 2SLS estimator are in Table E4. It shows also a negative significant impact, larger than our main estimate but not significantly different.). It suggests that the negative causal effect we observe with the IV strategy is cancelled out by a reverse causality or an omitted variable bias.

²⁰ $\ln x_2 = \ln x_1 + 1 \Leftrightarrow \ln \frac{x_2}{x_1} = 1 \Leftrightarrow \frac{x_2}{x_1} = e^1 = 2.718 \Leftrightarrow x_2 = 2.718 \times x_1$

²¹ $(2.718 \times 6.48) - 6.48$

²² $\frac{0.294}{11.13}$

Table 2 – Main Results: Effect of an Increase in Formal Care on Informal Care

	First part (All)		Second part (Informal care consumers)	
	(1) Regression $\ln(\text{FC})$	(2) IV-Probit $\Pr(\text{IC} > 0)$ Marg. Eff.	(3) Regression $\ln(\text{FC} \text{IC} > 0)$	(4) IV-regression $\ln(\text{IC} \text{IC} > 0)$
Regulated price (log)	-0.733*** (0.236)		-0.696** (0.294)	
Formal care hours (log)		-0.294*** (0.055)		1.60 (0.975)
F-test	9.70	-	5.62	-
R ²	0.22	-	0.23	-
Individual controls	Yes		Yes	
Departmental controls	Yes		Yes	
Clusters	76		74	
N	2,648		1,498	

Notes: In the first stage of the first part (resp. second part), a 1% increase of the regulated price in the department leads to an average decrease of 0.733% (resp. 0.696%) of formal care hours weekly consumed. An exogenous increase of one log-hour of formal care decreases the probability to receive informal care by 0.294. Among consumers of informal care, an increase of one log-hour of formal care non significantly decreases the volume of informal care.

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses, clustered at the departmental level. Individuals and departmental characteristics are controlled for. The regulated price is the lowest regulated price available in the department. Models of Equations 5.3, 5.4, 5.5, 5.6. “Marg. Eff.” stands for marginal effect.

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

elderly that report receiving informal care, an alternative measure for informal care intensity by considering the number of caregivers reported by consumers.

Type of Care. There is evidence in the literature that the substitution between formal and informal care varies across the type of formal and informal care (Bonsang, 2009). When individuals declare caregivers in the CARE survey, they are invited to specify for which type of care the caregiver operates: in our sample, among the elderly that report receiving informal care, 99.73% report receiving care for daily life activities, 54.81% for moral support and 8.80% for material support. Table 3 shows the impact of an exogenous increase in formal care on the probability to receive these three types of care (Columns 1 to 3). An exogenous increase in formal care significantly decreases the probability to receive informal care for daily life activities. It echoes our main result since mostly all informal care declared is associated with daily life activities. But this increase in formal care intensity leaves unaffected the probability to receive moral support or material help. Thus, the decrease at the extensive margin is concentrated on the activities of daily living, which can be performed by both types of care providers, but not on the type of care that is specific to informal caregivers.

Relationship with the Elderly. The effect of a change in formal care intensity is potentially heterogeneous according to caregivers' characteristics, especially given their relationship with the elderly. In our sample, among those who report receiving informal care, 84.65% of elderly report receiving care from their partner or from a child (what we call primary caregivers)²³ and 25.10% from neighbors, friends or broader-family members (secondary caregivers). An exogenous increase in formal care decreases the probability to report care from both primary and secondary caregivers (Table 3, Columns 4 and 5). The effect on primary caregivers, however, vanishes when studying partners and children separately (Column 6 and 7). The result on secondary caregivers echoes previous findings showing that friends or neighbors are likely to withdraw from informal caregiving in the presence of formal care (Christianson, 1988).

Caregivers' Gender. We are also interested in the heterogeneity of formal care intensity according to the caregivers' gender. In our sample, 66.56% of elderly report receiving care from at least one woman and 53.47% from at least one man. An increase in formal care decreases the probability to report receiving care from women, but not significantly from men (Table 3, Columns 8 and 9). This result echoes the differentiation of tasks performed by men and women (Billaud and Gramain, 2014), with women performing basic activities for domestic help and personal care and men being specialised in administrative or material help. Thus, the tasks performed by women would be substitutes to formal care activities more than those performed by men.²⁴

Table 3 – Extensions: Characteristics of Care and Caregivers

	Probability to receive informal care								
	Marginal effects								
	Daily life activities	Moral support	Material help	Primary caregivers	Secondary caregivers	Partner	Children	Women	Men
Formal care hours (log)	-0.250*** (0.065)	-0.067 (0.119)	-0.064 (0.096)	-0.238*** (0.103)	-0.161** (0.079)	-0.153 (0.123)	-0.184 (0.120)	-0.225** (0.088)	-0.119 (0.152)
Observations	2,648	2,648	2,648	2,648	2,648	2,648	2,648	2,648	2,648

Notes: An increase of one log-hour of formal care decreases the probability to receive informal care for the daily life activities by 0.250.

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses, clustered at the departmental level. Individuals and departmental characteristics are controlled for. Formal care hours are instrumented by the lowest regulated price available in the department. Estimation of IV-Probit models, marginal effects reported.

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

²³ 22.90% from spouse, 66.36% from children

²⁴ Given the frequency of care provided by men and women, the heterogeneous effect we observed cannot be attributed to a lower precision on care provided by men.

Number of Caregivers. Main results show an impact at the extensive margin of informal care but not at the intensive margin. We propose an alternative measure of informal care at the intensive margin by studying the number of caregivers (rather than the total hours of caregiving). In our sample, among those receiving informal care, the average number of caregivers is 1.77. 57% report only one caregiver, 24.37% report two caregivers; 17.75% three caregivers or more. This outcome does not affect our conclusion at the intensive margin of informal care: an exogenous increase in formal care volume does not affect significantly the number of caregivers reported by elderly receiving informal care.²⁵

4.3 Extensions: Results on Subsamples

Heterogeneity by APA status. Informal care reaction to formal care might depend on the disability level on the individual. We estimate our model on the subsample of individuals who benefit from the APA program (Table 4). The effect is similar to our baseline results: an exogenous increase of formal care decreases the probability to declare receiving care, while it does not affect informal care at the intensive margin. Our instrument is stronger than in the baseline sample, suggesting that the regulated price is particularly relevant to explain formal care consumption of APA beneficiaries. It echoes the framework of the policy, in which most beneficiaries (75%) have to be served by a regulated provider (Couvert, 2017). In Appendix B.2, Table B3 shows similar results in subsamples of individuals suffering from instrumental activity daily living limitation (IADL) and activity daily living limitation (ADL).

Table 5 shows the results on the subsample of elderly living alone. The first part shows that an increase in formal care decreases the probability to consume informal care by 0.27. It is similar to our baseline results. The second part cannot be interpreted since the first stage is hardly significant and the F-test is very low. This change in the first stage could be explained by a lower price sensitivity on this subsample of elderly living alone and having informal care, potentially because of a higher disability level.

²⁵The coefficient estimated by our regression is 0.367 with a standard error of 0.564. More details results available upon request.

Table 4 – Effect of Formal Care Volume on Informal Care Use for APA Beneficiaries

	First part (All)		Second part (Informal care consumers)	
	(1) Regression <i>ln</i> (FC)	(2) IV-Probit <i>Pr</i> (IC > 0) Marg. Eff.	(3) Regression <i>ln</i> (FC IC > 0)	(4) IV-regression <i>ln</i> (IC IC > 0)
Regulated price (log)	-0.793*** (0.231)		-1.054*** (0.313)	
Formal care hours (log)		-0.325*** (0.039)		0.913 (0.163)
F-test	11.74		11.31	
R ²	0.14		0.16	
Clusters		75		72
N		1,172		727
Individual controls			Yes	
Departmental controls			Yes	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Notes: In the first stage of the first part (resp. second part), a 1% increase of the regulated price in the department leads to an average decrease of 0.793% (resp. 1.054%) of formal care hours weekly consumed. An exogenous increase of one log-hour of formal care consumed decreases the probability to receive informal care by 32.5 percentage point. Among consumers, an increase of one log-hour of formal care non significantly increases the volume of informal care. Cluster at the departmental level. The regulated price is the lowest regulated price available in the department. Models of Equations 5.3, 5.4, 5.5, 5.6. "Marg. Eff" stands for marginal effects.

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

Table 5 – Effect of Formal Care Volume on Informal Care Use for Individuals Living Alone

	First part (All)		Second part (Informal care consumers)	
	(1) Regression $\ln(\text{FC})$	(2) IV-Probit $\Pr(\text{IC} > 0)$ Marg. Eff.	(3) Regression $\ln(\text{FC} \text{IC} > 0)$	(4) IV-regression $\ln(\text{IC} \text{IC} > 0)$
Regulated price (log)	-0.770*** (0.221)		-0.492* (0.254)	
Formal care hours (log)		-0.271*** (0.059)		1.97 (1.511)
F-test	12.14	-	3.76	-
R ²	0.24	-	0.26	-
Individual controls	Yes		Yes	
Departmental controls	Yes		Yes	
Clusters	76		74	
N	1,881		1,059	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Notes: In the first stage of the first part, a 1% increase of the regulated price in the department leads to an average decrease of 0.770% of formal care hours weekly consumed among the elderly living alone. An increase of one log-hour of formal care consumed decreases the probability to receive informal care by 27.1 percentage point. Among informal care consumers, an exogenous increase of one log-hour of formal care non significantly decreases the volume of informal care consumed. Cluster at the departmental level. The regulated price is the lowest regulated price available in the department. Models of Equations 5.3, 5.4, 5.5, 5.6. “Marg. Eff.” stands for marginal effects.

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

5 Discussion

Population Studied. Our work is centered on formal care users living in the community. This population is selected compared to the whole population of elderly. First, individuals living in the community have on average lower disability levels and more social relationships compared to those living in institutions. Second, we focus on individuals consuming formal care. Our results are thus relevant for this sub-population of elderly specifically. As mentioned in Section 3.1, considering a broader sample raises several issues. Our instrument does not affect the probability to consume formal care (Appendix B.1). It is then weaker when considering an extended sample (Appendix B.2). Including non-consumers raises an additional technical issue, related to the log-form applied when formal care equal zero. Add 1 to zero value is not negligible when considering formal care and results on extended sample are highly sensitive to the specification of the log-variable.

Exogeneity of the Instrument. Our identification rests on the hypothesis that the regulated price is exogenous to individual informal care consumption. The lowest regulated price should not be correlated with unobserved variables that also affect individual informal care use. In our estimations, we control for a set of departmental variables that correlate with informal care use to limit such unobserved determinants of informal care. Moreover, the hypothesis of exogeneity builds on the characteristics of the long-term care system in France. Qualitative studies have shown that the pricing of regulated services results from technical and administrative mechanisms (Gramain and Xing, 2012) and it is not identified as a political issue (in the voting process for instance) (Billaud et al., 2012). Moreover, the elderly and their family are poorly rallied around collective action (Weber et al., 2013) and they are not likely to influence these technical decisions. Finally, Appendix D shows that our instrument is not related to departmental characteristics of the department such as political side of the council or demographic and economic characteristics.

Co-residence Choice. Increasing formal care use could have an impact on cohabitation probability. In our sample, the correlation between the lowest regulated price and the co-residence with children is close to zero (0.008). It shows that our instrument is little related to the probability to live with a child. We have tested if an increasing formal care use, instrumented by the lowest regulated price, affects the probability to live with a child. It shows no effect of formal care use on co-residence with children.²⁶

²⁶Results are available upon request. The marginal effect of formal care volume on the probability of coresidence is 0.088, with a robust standard error of 0.120.

Quantified Informal Care. The outcome variables we consider are the probability to declare receiving informal care and the volume of care received. In order to make the first and the second part of our model consistent, individuals who receives informal care are those who have been able to quantify the number of hours they receive. However, in our sample, 17% of individuals declare they receive informal care but have not been able to give the number of hours they receive. We have estimated the first part of our model, using as an outcome variable a dummy indicating if the individual receives some informal care, even if he/she has not been able to quantify it (Appendix E.3). It shows that our results are robust to this change of definition.

Comparison with Previous Results. Our work follows Christianson (1988); Ettner (1994); Pezzin et al. (1996); Rapp et al. (2011); Fontaine (2012), which aimed at forecasting the effect of implementing public policies financing formal care on care arrangements. To do so, they have analysed the effect of receiving or not public subsidies on formal care (binary treatment), on both the extensive and the intensive margin of informal care. They find a negative effect of receiving a public subsidy on informal care. We are going one step further by analysing the effect of a change in the intensity of formal care on informal caregiving. Our work is thus closer to the studies of Carrino et al. (2018), Arnault and Goltz (2017) and Arnault (2015).²⁷ Using the SHARE data, Carrino et al. (2018) estimate the causal impact of formal care consumption on informal care. They find a positive effect of formal care volume on both the extensive and intensive margin of informal care. Several points could explain these differences with our results. First, Carrino et al. (2018) are considering both consumers and non-consumers of formal care. Thus, they capture the effect of a change in the extensive and in the intensive margin of formal care. Moreover, they focus on a population with several European countries (while we are centered on France), in a earlier time period: our data are from 2015 while they use the SHARE waves from 2004 and 2006, which corresponds in France to the very beginning of the APA policy. Using the French survey *Handicap-Santé Ménages* (2008), Arnault and Goltz (2017) use out-of-pocket expenses for the formal care as an instrumental variable in a bivariate Tobit model. They show that an exogenous increase of formal care is associated with a decrease in informal care use. Though they are focused on a different population,²⁸ our results are consistent with this findings and show that such a decrease is concentrated at the extensive margin of informal care. Using the same data, Arnault (2015) relaxes the IV hypothesis and estimates a reduced-form model identifying the cross-price elasticity of formal care and informal care volumes. He finds that a higher price of formal care in the department²⁹ decreases the volume of formal care consumed but

²⁷Chapter 4 of the thesis.

²⁸Arnault and Goltz (2017) focus on the elderly living alone with ADL and IADL limitations.

²⁹This variable corresponds to the price of the biggest provider in the department.

leaves the informal care volume unaffected. The differences of results focusing on different populations, with alternative measures of formal and informal care, shows the complexity of the relationship between both types of care. It calls for further investigation of the existing heterogeneity among the elderly consuming long-term care.

6 Conclusion

This paper documents the causal impact of an exogenous variation in formal care on informal care use, both at the intensive and the extensive margin. This effect is estimated on formal care users only. To tackle endogeneity issues, we propose an original instrumental variable strategy taking advantage of local disparities in the price of regulated providers. Using a two part model, we show that increasing formal care leads to a significant but small decrease in the probability to receive informal care. Heterogeneity tests show that this negative effect is mainly concentrated on caregiving for daily life activities, provided by women, and affects both primary and secondary caregivers. At the intensive margin of informal care, however, no significant effect is observed. Overall, an increase in formal care use as the one planned by the 2016 APA reform can be expected to have a limited effect on informal care arrangements.

Appendix to

Does an Increase in Formal Care Affect Informal Care?

A Theoretical Framework Details

The child is assumed to be altruistic as he/she takes into account the well-being of the parent. His/her utility is formalised as follows:

$$\begin{cases} \text{Max}_{X^c, IC, L} U^c(X^c, W(IC, FC; D), L) \\ \text{s/c } V^c + \omega T = X^c + \omega(L + IC) \end{cases} \quad (5.7)$$

With V^c the non-labor income of the child, ω is her labor wage, T is the total time endowment, X^c is the consumption of private good and L is leisure.

$$\text{Equation 5.7} \Rightarrow \text{Max}_{X^c, IC} U^c(X^c, W(IC, FC; D), L(IC, X^c, V^c)) \quad (5.8)$$

Considering a Cournot-Nash equilibrium, the child chooses the optimal level of informal care, taking as given the formal care level. Thus,

$$\text{Equation 5.8} \Rightarrow \text{Max}_{X^c, IC} U^c(X^c, W(IC, \bar{FC}; D), L(IC, X^c, V^c)) \quad (5.9)$$

The first order conditions are:

$$\begin{cases} \frac{\partial U^c(X^c, W(IC, FC; D), L)}{\partial X^c} = 0 \\ \frac{\partial U^c(X^c, W(IC, FC; D), L)}{\partial IC} = 0 \end{cases} \quad (5.10)$$

The parent chooses X^p and FC to maximize his/her utility:

$$\begin{cases} \text{Max}_{X^p, FC} U^p(X^p, W(IC, FC; D)) \\ \text{s/c } V^p = X^p + p_{FC}FC \end{cases} \quad (5.11)$$

Where V^p is the parent nonlabor income and p_{FC} is the price of formal care.

$$\text{Equation 5.11} \Rightarrow \text{Max}_{X^p, FC} U^p(X^p(V^p, FC), W(IC, FC(V^p, X^p; D))) \quad (5.12)$$

Considering a Cournot-Nash equilibrium, the parent choose the optimal level of formal

care, taking as given the informal care provision. Thus, the first order condition is:

$$\begin{cases} \frac{\partial U^p \left(X^p(V^p, FC), W(IC, FC(V^p, X^p; D)) \right)}{\partial X^p} = 0 \\ \frac{\partial U^p \left(X^p(V^p, FC), W(IC, FC(V^p, X^p; D)) \right)}{\partial FC} = 0 \end{cases} \quad (5.13)$$

First order conditions of child and parent maximisation program gives the following reaction functions:

$$IC^c = f^{IC}(V^c, \omega, FC(p_{FC}); D) \quad (5.14)$$

$$FC^p = f^{FC}(V^p, p_{FC}, IC; D) \quad (5.15)$$

B Sample Details

B.1 Determinants of Formal Care Consumption

This work concentrate on elderly consuming formal care. Table B1 presents the determinants of formal care consumption, on all individuals surveyed in CARE (Column 1) and, among them, on individuals whose department has responded to the SolvAPA survey (Column 2). This last column makes it possible to include our instrument in the determinants. These estimations show that the probability to consume formal care is higher for women, living-alone individuals, APA beneficiaries and low-income individuals.³⁰ The probability to consume formal care is increasing with age and the disability level, and is decreasing with the number of children. Moreover, the lowest regulated price in the department is not correlated with formal care use at the extensive margin: there is no direct link between our instrument and the selection of formal care users.

³⁰This effect of income has already been observed on French data (Roquebert et al., 2018). It could reflect two mechanisms. First, richer individuals do not apply to the APA program financing home care since the expected value of the subsidy is lower for them (Arrighi et al., 2015). Second, even when controlling for the disability status, income could be associated to unobserved dimensions of health: then, low income would reflect higher needs for care.

Table B1 – Explaining Formal Care Use

	Consumes formal care Probit	
	(1)	(2)
Woman	0.440*** (0.0358)	0.434*** (0.0389)
Age	0.0413*** (0.00193)	0.0409*** (0.00206)
Lives alone	0.464*** (0.0369)	0.459*** (0.0400)
Disability group	-0.409*** (0.0129)	-0.414*** (0.0130)
Has the <i>baccalauréat</i>	0.0712* (0.0413)	0.0811* (0.0446)
Has children	-0.118*** (0.0433)	-0.114** (0.0501)
Income (/1000)	-0.00192 (0.00158)	-0.00178 (0.00165)
Proxy	0.141*** (0.0406)	0.137*** (0.0424)
Regulated price (log)		0.0730 (0.247)
Departmental controls	Yes	Yes
N	10,290	8,882

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Notes: Ceteris paribus, a woman has a higher probability of receiving formal care; while being in low disability group decreases this probability.

Sample: Column (1) 10,920 individuals surveyed by the CARE survey; Column (2) among them, 8,882 whose department has responded to the survey *SolvAPA*.

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

B.2 Sample of Elderly and Subsample of Formal Care Consumers

Our main results are focused on elderly receiving formal care. Table B2 and Table B3 present the results for extended sample, including both consumers and non-consumers of formal care. As we take the logarithm of formal care, the formal care variable is augmented by 1 to deal with zero values. Among each group, we distinguish individuals by disability levels, using the limitations in instrumental activities of daily living (IADL) or essential activities daily living (ADL). An individual is regarded as having IADL or ADL limitations when he/she declares having some or a lot of difficulties in performing an activity, or if she/he needs someone to assist her/him. Table B2 presents the first stage and Table B3 the second stage (both at the extensive and intensive margin of formal care).

Table B2 presents the first stage for both the first part of the model (extensive margin, lines 1 to 3) and the second part of the model (intensive margin, lines 4 to 6). When considering an enlarged sample (all individuals, whatever their care consumption and type of limitations), the regulated price is little correlated with formal care hours and the instrument is weak. Restricting the sample to formal care users shows a higher correlation between the regulated price and the number of hours of formal care hours consumed with higher F-tests. In both cases, smaller samples are associated with lower F-tests.

Table B3 shows the second stage estimates for the same samples. When considering all individuals (including individuals not consuming formal care), an exogenous increase in formal care is found to decrease the probability to consume informal care. Results are similar when focusing on formal care users. There is overall no significant effect on the second part of the model.

Note that to make all the column of these tables comparable, all results use logarithm of formal care plus one. Thus, this result is not directly comparable with our main results, where such a transformation is not required because we exclude the non consumers (and use logarithm of formal care).

B.3 Exclusion of Extreme Values in the Sample

We test whether our results are sensitive to the exclusion of extreme values in the sample (Table B4). In our baseline results, the extreme values for formal care and informal care consumption (beyond the 99th percentile) are excluded from the sample.³¹ Without any exclusion or with a 5% exclusion,³² the coefficient of the second part of our model gains precision to reach the significance level. Overall, our results on the intensive margin of informal care are sensitive to the exclusion of individuals and should then be interpreted cautiously.

³¹Corresponding to more than 167 informal hours per week or more than 70 formal hours per week.

³²Corresponding to more than 24 informal hours per week or more than 84 formal hours per week.

Table B2 – Impact of Regulated Price on Formal Care Use with Different Samples

	All individuals			Formal care consumers		
	All	IADL limitation	ADL limitation	FC consumers	IADL limitation	ADL limitation
Dependent variable: formal care hours						
All individuals						
Regulated price (log)	-0.156* (0.0832)	-0.254* (0.148)	-0.251 (0.209)	-0.564*** (0.188)	-0.578*** (0.190)	-0.572** (0.217)
F-test	3.50	2.96	1.44	9.00	9.28	6.93
N	8,882	5,402	3,420	2,648	2,600	2,001
Dependent variable: formal care hours						
Informal care consumers						
Regulated price (log)	-0.346* (0.202)	-0.356* (0.214)	-0.298 (0.259)	-0.550** (0.238)	-0.551** (0.243)	-0.536* (0.277)
F-test	2.94	2.78	1.39	5.33	5.14	3.73
N	2,966	2,295	2,050	1,498	1,492	1,237

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Notes: Estimation of linear models, clustered at the departmental level. Individuals and departmental characteristics are controlled for.

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

Table B3 – Impact of Formal Care Use on Informal Care with Different Samples

	All individuals			Formal care consumers		
	All	IADL limitation	ADL limitation	FC consumers	IADL limitation	ADL limitation
Dependent variable: probability to consume informal care (Marg. Eff.)						
Formal care hours	-0.410*** (0.0229)	-0.316*** (0.0161)	-0.285*** (0.00887)	-0.375*** (0.0677)	-0.368*** (0.0678)	-0.369*** (0.0533)
N	8,882	5,402	3,420	2,648	2,600	2,001
Dependent variable: volume of informal care hours among consumers						
Formal care hours	1.963 (1.351)	1.830 (1.428)	1.988 (2.348)	2.025 (1.273)	2.163* (1.290)	1.898 (1.497)
N	2,966	2,846	2,050	1,498	1,492	1,237

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Notes: Estimation of linear models, clustered at the departmental level. Individuals and departmental characteristics are controlled for. Formal care volume is instrumented using the lowest regulated price of the department.

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

B.4 Distribution of Formal and Informal Care Variables

Distributions of the number of hours of care in our main sample and in the sub-sample of informal care consumers (Figure B1) have a mass point in zero and a long right tail. Using a logarithm transformation (Figures B2) both for informal and formal care makes it possible to get closer to a normal distribution of our variables of interest.

Table B4 – Sensitivity Tests on Outliers Exclusion

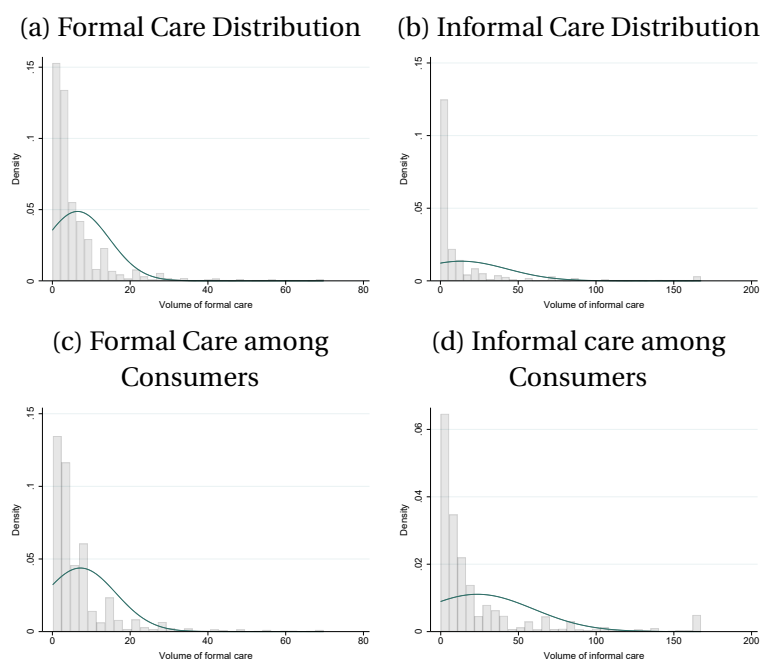
	First part (All)		Second part (Informal care consumers)	
	(1) Regression <i>ln</i> (FC)	(2) IV-Probit <i>Pr</i> (IC > 0) Marg. Eff.	(3) Regression <i>ln</i> (FC IC > 0)	(4) IV-regression <i>ln</i> (IC IC > 0)
No exclusion				
Regulated price (log)	-0.740*** (0.239)		-0.743*** (0.273)	
Formal care hours (log)		-0.279*** (0.056)		1.739** (0.958)
F-test	9.63	-	7.40	-
R ²	0.22	-	0.24	-
N	2,689		1,529	
Exclusion of extreme 5% of formal consumers				
Regulated price (log)	-0.623*** (0.191)		-0.542*** (0.232)	
Formal care hours (log)		-0.335*** (0.290)		2.139* (1.298)
F-test	10.60	-	5.42	-
R ²	0.25	-	0.20	-
N	2,453		1,332	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Notes: Models of Equations 5.3, 5.4, 5.5, 5.6, clustered at the departmental level. Individuals and departmental characteristics are controlled for. The regulated price is the lowest regulated price available in the department. "Marg. Eff." stands for marginal effects. Using our sample without exclusion of outliers on formal and informal care consumption, A 1% increase of the regulated price in the department leads to an average decrease of 0.740% of formal care hours weekly consumed (first stage). An exogenous increase of one log-hour of formal care consumed decreases the probability to receive informal care by 0.279 (second stage). Among informal care consumers, a 1% increase of the regulated price in the department leads to an average decrease of 0.743% of formal care hours weekly consumed (first stage).

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

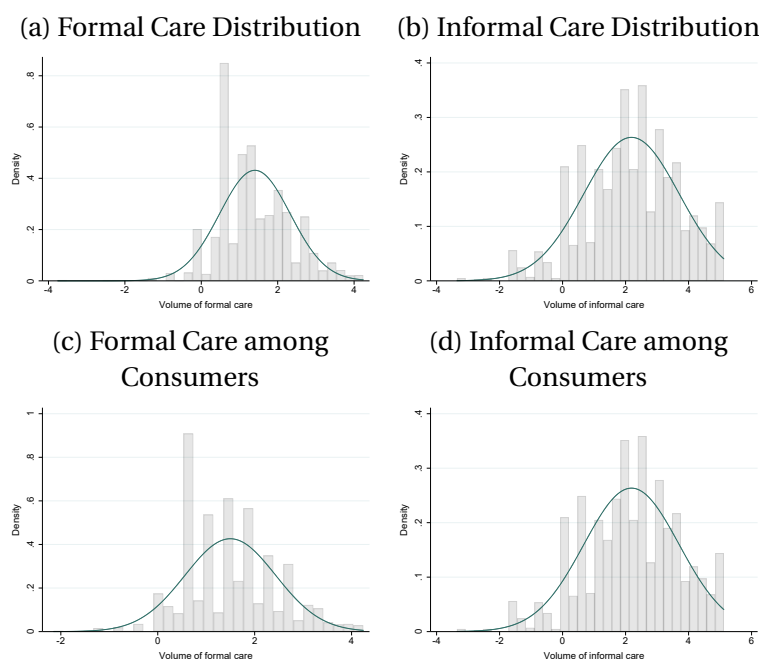
Figure B1 – Weekly Volume of Formal and Informal Care (in Hours)



Notes: Distribution of the number of hour of care in our baseline sample and among the formal care consumers.

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

Figure B2 – Weekly Volume of Formal and Informal Care (in Log-hours)



Notes: Distribution of the number of log-hours of care in our baseline sample and among the formal care consumers.

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

C Details Regarding the Institutional Context

Since 2002, disabled elderly have been entitled to benefit from a specific program: the personalized allowance for autonomy (*Allocation personnalisée d'autonomie*, APA). This program aims at financing formal care consumption for the disabled elderly. This is a central, national program, which is implemented at the local level by departmental councils.

To be eligible, an individual aged 60 or more has to apply to the program and to be assessed as disabled. She receives at home a visit from a medico-social team from the Departmental council in charge of establishing her disability level, using the French administrative scale AGGIR (*Grille autonomie, gérontologie, groupe iso ressource*). This scale aims at assigning individuals to one of the six disability levels of the scale, from GIR 1 (severely disabled) to GIR 6 (independent). Table C1 summarizes the classification and the disabilities associated to each group. All individuals in the same group are supposed to require the same amount of resources to cope with their activity limitations. Thus, each group is assumed to be homogeneous in long-term care needs. Only individuals in GIR 1 to 4 are eligible to the APA.

When an individual is eligible, the team estimates the number of care hours she needs to perform the activities of daily living, referred to as a “care plan” (*plan d'aide*). The monetary equivalent of this care plan must not exceed a given GIR-specific ceiling established at the national level. The APA beneficiary is then free to consume the number of care hours she wants. For each hour under the care plan volume, the hourly price will be reduced by the APA subsidy, which is a decreasing function of income through a copayment rate.

The 2016 reform has extended the generosity of the program through two ways. First, it has modified the computation rule of the copayment rate. It now depends on the income and on the disability level, and, compared with the pre-reform scheme, it makes the policy more generous especially for low-income and/or severely-disabled individuals. Second, it has increased the level of the national GIR-specific ceiling established at the national level, such that care plan volumes in the post-reform scheme are likely to be higher.

Table C1 – Definition of each Disability Level (AGGIR scale)

GIR 1	Invalid individuals (bedridden persons) with important cognitive troubles, who need to be constantly taken care of.
GIR 2	Are invalid but have their cognitive functions less deteriorated than elderly in GIR 1, or are not invalid but have important cognitive troubles. ¹¹¹
GIR 3	Individuals need every-day help for personal care but they do not have any important mental troubles.
GIR 4	Individuals who need some help, either for getting out of bed, or for meal preparation, dressing or undressing.
GIR 5	Individuals who punctually need help for activities of daily living, but not on a regular basis.
GIR 6	No daily activity limitations.

D Instrument Details

D.1 Explaining the Variation in our Instrument

In this section, we estimate the correlation between the lowest regulated price in the department and other departmental characteristics. It makes it possible to document the sources of variation of our instrument and additionally gives an insight of the relevant departmental controls for our main estimations. We have selected departmental variables related to general socio-economic characteristics of the population (share of elderly, interdecile ratio, share of taxable households), variables illustrating the characteristics of the elderly population in the department (share of women, share of living alone, share living in nursing home, poverty rate, among the elderly) and variables reflecting the orientation of social and general departmental policies (equipment rate in institutions, share of APA beneficiaries, political side of the departmental council).

Table D1 presents the estimation results. Estimation is conducted at the departmental level rather than the individual level, since the CARE survey is not meant to be representative at the departmental level. Results show that the level of the lowest regulated price in the department is not correlated with the socio-economic characteristics of the departmental population, nor with the characteristics of the elderly population or the variables related to the orientation of policies in the department. Overall, the departmental variables we consider explain less than 10% of the variation of the lowest regulated price in the department. We have alternatively tested a stepwise procedure to see if excluding some variables without a significant effect could help gaining precision on others. Results are stable. Local characteristics, thus, do little in explaining the variations of our instrument.

D.2 Spatial Autocorrelation

To further document the sources of variation in our instrument, we have investigated the spatial autocorrelation in this variable using Moran's index (Moran, 1948). Moran's index I makes it possible to evaluate if departments that are close tend to have a similar level of regulated price, compared to others. It is computed as follows:

$$I = \frac{N}{S_0} \frac{\sum_i \sum_j w_{i,j} (y_i - \bar{y})(y_j - \bar{y})}{\sum_i (y_i - \bar{y})^2}$$

with N the total number of departments, y_i the lowest regulated price in department i ; \bar{y} the average price computed over all departments available, $S_0 = \sum_i \sum_j w_{i,j}$, $w_{i,j}$ is the spatial weight between department i and j .

In this feature, we use as a spatial weight the distance between the center of the department i and the others. It makes it possible to weight the importance of other departments

Table D1 – Instrument Variations are not Correlated with Departmental Characteristics

	Lowest regulated price in the department
Share of 75+ in the population (2015)	2.148 (17.39)
Interdecile ratio (2014)	0.720 (0.928)
Share of taxable households (2014)	0.0371 (0.0818)
Share of women among 75+ (2015)	1.571 (32.49)
Share of 75+ living alone (2014)	-0.0806 (0.189)
Share of 75+ living in nursing home (2014)	0.299 (0.384)
Poverty rate 75+ (2014)	-0.0628 (0.187)
Equipment rate in institutions - medical beds (2014)	-0.00958 (0.0376)
Share of APA beneficiaries in the 60+ population (2005)	0.0668 (0.226)
Left-wing departmental council (2015)	-0.270 (0.570)
Constant	15.28 (17.70)
R ²	0.087

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Notes: Linear regression model among the 76 departments respondent to the SolvAPA survey and having regulated providers. An increase by one percentage point of the share of 75+ in the department is associated with a non significant increase of the lowest regulated price in the department.

Source: Survey *SolvAPA* (DREES, 2015a).

according to their proximity to the department j . It also takes into account the department size.³³

The Moran's Index with this spatial weight is a measure of the auto-correlation between the distance between departments and the lowest regulated price of the departments. The value of the index is $I = -0.00699$, with a p-value equal to 0.365: it shows that there is no spatial correlation between the lowest regulated price in the department and the localisation of one department compared to another.

³³An alternative measure would have taken into account only the neighbouring departments of department i but such a measure is limited. For instance, it does not account for the similarities between non-neighbouring departments of the same region.

D.3 Exclusion of some Departments with a Low Regulated Price

We test the robustness of our results to the exclusion of a few departments having a regulated price especially low (Table D2) and thus being slightly atypical when looking at the distribution of departments. In the first stages, F-tests are lower when excluding the first or the two first departments with the lowest price. Results on the second stage of the first part are consistent with our baseline results. On the second stage of the second part, the positive coefficient gains statistical significant at the 10% level. Overall, our results on the intensive margin of informal care are sensitive to the exclusion of departments and should then be interpreted cautiously.

Table D2 – Sensitivity to the Exclusion of Department with Low Regulated Price

	First part (All)		Second part (Informal care consumers)	
	(1) Regression $\ln(\text{FC})$	(2) IV-Probit $\Pr(\text{IC} > 0)$ Marg. Eff.	(3) Regression $\ln(\text{FC} \text{IC} > 0)$	(4) IV-regression $\ln(\text{IC} \text{IC} > 0)$
Exclusion of the department with the smallest price				
Regulated price (log)	-0.652** (0.251)		-0.603* (0.326)	
Log of total hours of formal care		-0.321*** (0.0324)		2.349* (1.426)
F-test	6.77		3.42	
R ²	0.22		0.28	
N	2,636	2,636	1,489	1,489
Exclusion of the two departments with the smallest prices				
Regulated price (log)	-0.642** (0.278)		-0.686** (0.354)	
Log of total hours of formal care		-0.321*** (0.0360)		2.520* (1.432)
F-test	5.35		3.76	
R ²	0.22		0.23	
N	2,619	2,619	1,481	1,481

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Notes: Models of Equations 5.3, 5.4, 5.5, 5.6, clustered at the departmental level. Individuals and departmental characteristics are controlled for. The regulated price is the lowest regulated price available in the department. In the first part (resp. second part), a 1% increase of the regulated price in the department leads to an average decrease of 0.652% (resp. 0.603) of formal care hours consumed. An exogenous increase of one log-hour of formal care consumed decreases the probability to receive informal care by 0.321. Among informal care consumers. The first part of the Table corresponds to the estimation excluding the 12 individuals living in the department with the lowest regulated price and the second part additionally excludes 17 individuals from the department with the second lowest price.

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

D.4 Finding an Instrumental Variable for Formal Care Studies

Instrument variables for formal care are relatively scarce in the literature. Using the SHARE data in Austria, Belgium, Germany and France, Carrino et al. (2018) exploit the inter-regional variations in the eligibility rules for formal care subsidies. Such an instrument requires specific hypotheses on the sources of inter-regional variations and can hardly be used when working at the national level. Using French data, Barnay and Juin (2016) use local variations in the eligibility practices of the APA policy to instrument formal care use. The outcome variable is mental health. Their instrumental variable, however, cannot be used when studying the impact of formal care on informal care: it has been shown that departments often take into account informal care provided by relatives to decide on one individual's eligibility (Billaud et al., 2012).³⁴ More generally, any variable that rests on departmental practices regarding the APA policy is likely to be directly related to informal care, not only through the effect on formal care consumption.

To find an instrument for formal care, we have investigated potential individual determinants explaining differences in volume consumed. Socio-demographic variables and health characteristics are not good candidates since they are directly affecting informal care. Proximity to the head office of a professional caregiver could be an exogenous reason explaining variations in formal care consumption. The service we consider is, however, specific: the provider covers a given geographical area, but the head office location gives little information on this area. It explains why we observe that there is no empirical correlation between the intensity of use and the proximity to a professional head office location.

We have also considered, on the supply side, the potential effect of the capacity of formal care providers. Individual consumption could theoretically be influenced by the capacity of formal care providers in the department. The higher the capacity of formal care providers, the more individuals are likely to be able to consume with no restriction on the supply side. There is here a technical issue: data on the home care sector present the number of providers available at the departmental level. This number, however, gives little information on the importance of the supply: one provider can serve a low or a high number of beneficiaries. There is no available data on the capacity of providers.

In this paper, we use the information of the lowest regulated price in the department available in the *SolvAPA* survey. This survey presents three types of regulated price for formal care: the lowest, the highest and the biggest prices of regulated providers in the department. We chose the lowest price as an instrument for formal care since it gives information on the financial availability of formal care. The biggest price could have been a candidate to instru-

³⁴The APA policy is supposedly "care-blind": the APA benefits should be independent of informal care received by the individuals. Field studies, however, have shown that it actually depends on departmental practices.

ment formal care, since it corresponds to the price of the provider covering the majority of formal care users. Technically, however, there are more missing values on this variable (15 missing values vs 9 for the lowest regulated price) and the variance of this variable is lower. Moreover, at the individual level, it is not empirically correlated to formal care consumption, whatever the sample considered (see Table D3).

Table D3 – Impact of the Biggest Provider's Price on Formal Care Use

	All Regression <i>ln</i>(FC)
Biggest regulated price (log)	-0.578 (0.433)
F-test	1.79
R ²	0.215
Individual controls	Yes
Departmental controls	Yes
Clusters	70
N	2,479

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Standard errors in parentheses.

Notes: The price of the biggest regulated providers is non significantly associated with the level of formal care use.

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

E Additional Estimations and Robustness Checks

E.1 Models for Weak Instruments

Our instrument, while being the most relevant we have been able to find, is correlated to the consumption of formal care users but not strongly enough to avoid the weak instrument issue. The first issue with a weak instrument is the precision: a weak correlation between the instrument and the independent variable of interest might substantially lower the precision of the estimations. The second issue lies in the bias that it might create with limited sample size. This is a major concern here given the relatively low number of observations in our sample. Our F-test is above the critical values defined by Stock and Yogo (2005) for 15% maximal IV size bias but is not able to reach the 10% level.³⁵

In this section, we provide tests and confidence intervals robust to weak instrument. Following the guidelines proposed by Cameron and Trivedi (2009), we use the confidence interval based on the conditional likelihood-ratio (CLR) statistic, proposed by Moreira (2003).³⁶

The intuition is the following. In the presence of a weak instrument, the normal approximation of the t-statistic used for the construction of the confidence interval poorly performs. Moreira (2003) proposes a procedure for testing the hypothesis $H_0 : \beta = \beta_0$ with weak instruments. This test is based on critical values that are functions of the data. A confidence region for the parameter robust to weak instruments can then be constructed by inverting the test (Mikusheva, 2010).

The robust confidence interval obtained is only comparable to a confidence interval with a classical IV-estimation: we thus first estimate a IV-regression for the first part (probability to consume informal care) and the second part of our two part model (volume of informal care for consumers). For these two parts, we additionally provide the confidence interval constructed with the CLR test. The comparison of IV-regression models and confidence intervals obtained with the CLR gives an insight of the importance of the bias due to the weakness of the instrument. These results, however, can not be directly compared to our baseline results, since clusters can not be included. These estimations rest on the strong hypothesis of homoskedasticity and may thus be regarded cautiously.

According to Table E1, for the first part of our model, both the 2SLS estimation and the CLR confidence interval make it possible to conclude that an increase in formal care has a significant and negative effect on the probability to consume informal care. Results on the second part of the model are more ambiguous: while the confidence interval obtained with the 2SLS estimation includes zero, it is not the case for the CLR confidence interval. With the CLR approach, an increase in formal care use is found to have a significant and positive effect

³⁵We use the thresholds provided in the Stata command *ivreg2*: 16.38 for a 10% maximal IV size, 8.96 for a 15% maximal IV size, 6.66 for a 20% maximal IV size and 5.53 for a 25% maximal IV size.

³⁶We use the stata command *CONDIVREG*.

on informal care use at the intensive margin. Our interpretation of results at the intensive margin of informal care thus needs to be particularly cautious, since the bias induced by the weakness of our instrument seems to impact our baseline results.

Table E1 – Confidence Intervals Robust to Weak Instruments

<i>Dependent variable</i>	All <i>Pr(IC > 0)</i>	Informal care consumers <i>ln(IC IC > 0)</i>
2SLS	[-0.923 ; -0.140]	[-0.032 ; 3.232]
CLR	[-1.207, -0.225]	[0.441 ; 6.662]
NN	2,648	1,498

Notes: Estimations of IV two stage least squares model with standard confidence intervals ("2SLS") or conditional confidence interval from conditional likelihood ratio ("CLR"). Individual and departmental characteristics are controlled for.

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

E.2 Reduced Form, Naive Analysis and Alternative Specification

Table E2 – Naive Analysis

	First part (All) Probit $Pr(h_{IC,i} > 0)$ Marg. Eff.	Second part (Informal care consumers) Regression $\ln(h_{IC,i} h_{IC,i} > 0)$
Formal care	-0.011 (0.009)	-0.012 (0.032)
N	2,648	1,498

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Notes: Column (1) is the Probit regression of formal care on informal care. Column (2) is the OLS regression of formal care on informal care among informal care users, clustered at the departmental level. “Marg. Eff.” stands for marginal effects. The log-number of formal care hours is instrumented by the lowest regulated price in the department. Individual and departmental characteristics are controlled for. An increase by one log-hour of formal care non significantly decreases the probability to consume informal care. An increase by one percent of formal care decreases non significantly the level of informal care use.

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

Table E3 – Reduced Form

	First part (All) Probit $Pr(h_{IC,i} > 0)$ Marg. Eff.	Second part (Informal care consumers) Regression $\ln(h_{IC,i} h_{IC,i} > 0)$
Regulated price (log)	0.382*** (0.146)	-1.11** (0.467)
R ²	0.12	0.36
N	2,648	1,498

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Notes: Column (1) is the Probit regression of regulated price on the probability to consume informal care. Column (2) is the OLS regression of the informal care hours on the log-regulated price among informal care users, clustered at the departmental level. “Marg. Eff.” stands for marginal effects. The log-number of formal care hours is instrumented by the lowest regulated price in the department. Individual and departmental characteristics are controlled for. An increase by one of log-regulated price increases the probability to consume informal care by 0.382, significant at the 1% level. An increase by one percent of the regulated price decreases the level of informal care use by 1.11% among informal care consumers, significant at the 5% level.

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

As a robustness check, we compute the impact of formal care on the probability to declare informal care using a 2SLS estimator, as describe in the following equation.

$$\log(FC_i) = \pi_0 + \pi_1 T_{d(i)} + \pi_2 X_i + \pi_3 Y_{d(i)} + u_i \quad (5.16)$$

$$\mathbf{1}_{IC_i > 0 | FC_i, X_i, Y_{d(i)}} = \alpha_0 + \alpha_1 \widehat{\log(FC_i)} + \alpha_2 X_i + \alpha_3 Y_{d(i)} + \epsilon_i \quad (5.17)$$

Table E4 show that, using a 2SLS, the impact of one log-hour of formal care on the probability to declare informal care is 0.53 percentage point, significant at the 10% level. The standard errors are large and thus, this result is not significantly different from the marginal effect estimated using probit.

Table E4 – Impact of Formal Care on Informal Care Probability Using 2SLS Regression

	Main sample	APA beneficiaries	Living alone
Formal care hours (log)	-0.532* (0.306)	-0.260* (0.150)	-0.415** (0.198)
N	2,648	1,172	1,881

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Notes: Results are clustered at the departmental level. Individual and departmental characteristics are controlled for. The log-number of formal care hours is instrumented by the lowest regulated price in the department. This Table shows the results in the main sample, sample of APA beneficiaries and sample of elderly living alone, using a 2SLS estimator in a linear model. It shows that an increase by one-log hour of formal care leads to a decrease in the probability to receive informal care by 53 percentage point, significant at the 10% level.

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

E.3 Dealing with Missed Caregivers

The variable we use is built on the individual's declaration: someone who receive informal care has declared informal caregivers and have been able to quantify the volume of care they provide. Such a definition is restrictive: for some informal caregivers, the individual is not able to quantify the care they provide and thus are not taken into account. They could be called "missed caregivers". Three quarters of individuals in our sample (73.6%) haven't any missed caregivers.

The others are divided in two categories. 9.2% have both quantified and non-quantified informal caregivers: thus, they are identified as care recipient but the volume of informal care they receive is underestimated. 17.2% have exclusively missed caregivers and thus are not identified as receiving informal care while they have missed caregivers.

Table E5 presents the determinants of having at least one missed caregiver. Younger and living-alone individuals have a lower probability to be unable to quantify the volume provided by one caregiver. Surprisingly, the disability status has a non-linear effect: the most severely-disabled individuals (disability group 1/2) and those with a low disability level (disability groups 5/6) have a significantly lower probability to have at least one missed caregiver.

We consider an alternative definition of informal care reception: individuals receive informal care if they declared a caregiver – whatever the declaration on the volume. We estimate the first part of our two-part model with this alternative definition (Table E6). Results are consistent with our baseline results: increasing the formal care volume decreases the probability that individuals receive informal care, with a similar magnitude of the coefficient.

In Table E7, we estimate our results while excluding individuals who have at least one missed caregiver. It shows that our baseline results are robust to this exclusion. Note that the probability to have at least one missed caregiver is uncorrelated with the number of formal care hours consumed or with our instrument (estimation of a Probit model controlling for parents' characteristics).

Table E5 – Probability to Have at Least One Missed Caregiver

	Has at least one missed caregiver
Woman	-0.0292 (0.0686)
Age	0.00191 (0.00348)
Lives alone	-0.153** (0.0645)
Disability group	-0.0411* (0.0211)
Has the <i>baccalauréat</i>	-0.00233 (0.0862)
Has children	0.269*** (0.0889)
Income (/1000)	-0.00875*** (0.00316)
Proxy	0.131** (0.0627)
N	2,648

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Standard errors in parentheses.

Notes: Estimation of a Probit model. Living alone is negatively associated with the probability to declare a caregiver without being able to quantify his help.

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

Table E6 – Alternative Definition of Informal Care Use

	Probability to receive some informal care Marg. Eff.
Formal care hours (log)	-0.230*** (0.072)
Individual controls	Yes
Departmental controls	Yes
N	2,648

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Standard errors in parentheses.

Notes: Estimations of an IV Probit model where the log-number of formal care hours is instrumented by the lowest regulated price in the department. Individual and departmental characteristics are controlled for. “Marg. Eff.” stands for marginal effects. An exogenous increase by 1% of formal care volume leads to a significant decrease of the probability to declare receiving informal care by 0.230. In this model, those who declare receiving informal care but cannot quantify it are included.

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

Table E7 – Results on the Subsample Excluding Missed Caregivers

	First part (All)		Second part (Informal care consumers)	
	Regression $\ln(\text{FC})$	IV-Probit $\text{Pr}(\text{IC} > 0)$ Marg. Eff.	Regression $\ln(\text{FC} \text{IC} > 0)$	IV-regression $\ln(\text{IC} \text{IC} > 0)$
Regulated price (log)	-0.913*** (0.243)		-0.821*** (0.267)	
Formal care hours (log)		-0.261*** (0.066)		1.083 (0.695)
F-test	14.08	-	7.52	-
R ²	0.28	-	0.25	-
Individual controls	Yes		Yes	
Departmental controls	Yes		Yes	
Clusters	75		74	
N	1,949		1,255	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Notes: Results clustered at the departmental level. Individuals and departmental characteristics are controlled for. The regulated price is the lowest regulated price available in the department. “Marg. Eff.” stands for marginal effects. In the first stage of the first part (resp. second part), a 1% increase of the regulated price in the department leads to an average decrease of 0.913% (resp. 0.821%) of formal care hours weekly consumed among the elderly living alone. An increase of one log-hour of formal care consumed decreases the probability to receive informal care by 0.261. Among informal care consumers, an exogenous increase of one log-hour of formal care non significantly decreases the volume of informal care consumed.

Source: Survey *Capacités, aides et ressources des seniors* (DREES, 2015b).

General Conclusion

Demographic ageing in France raises sustainability issues on pension system and long-term care allowance. These issues lead to pension reforms that increase claiming age, and to several evolutions of long-term care policies regarding for example the generosity of the allowance and the targeted population. This thesis aims at improving the knowledge regarding these policies and their implications. Thus, a first part focuses on the impact of later retirement on health while a second part focuses on the long-term care policies in France. This conclusion provides a resume of the main results and contributions while a second part presents a discussion and possible extensions of these researches.

1 Main Results and Contributions

Retirement and Health. The first part of this thesis explores the link between retirement and health. As a consequence of demographic ageing, most of the European countries lead reforms that increase claiming age. The first Chapter provides a review of previous researches on the link between retirement and health. It highlights that the results are not as contradictory as it seems to be. Once the results on the impact of the switch from employment to retirement; on the impact of later retirement; and on the impact of earlier retirement are analysed separately, consensual results partly emerges. Thus, almost all studies show that retirement leads to a decrease in healthcare consumption, an increase in self-reported health, a decrease of depressive symptom, but also of cognitive abilities. Most of the studies on the impact of later retirement show no significant results on mortality, pathologies and self-reported health, but find a significant decrease in cognitive abilities. It highlights the usefulness of larger sample size, and the use of minimum detectable analysis to distangle no impact from statistical power limitations. Lastly, an increasing number of studies show heterogeneous impact by gender and occupational groups, showing the importance, once the average effect identified, to explore its heterogeneity.

The second Chapter is on the impact of later retirement on mortality in France. This chapter uses the administrative data of the private sector employees pension scheme (Cnav). The sample of interest has 2 millions observations. To deal with reverse causality issue, the 1993 pension reform is used as an instrumental variable. This reform is the first one that increase the claiming age for private sector workers. The results, precisely estimated, show that an exogenous increase of one year in the claiming age has no significant impact on the probability to die. To test the power of our sample to detect statistically significant effects for rare events like death, we compute minimum detectable effects (MDE). It suggests that, if an

impact of later retirement on mortality would be detectable, it would remain very small in magnitude.

The third Chapter focuses on the impact of later retirement on healthcare consumption in France. The 1993 French pension reform still serves as an instrumental variable. I use HYGIE data, which is a merge of administrative data from the National Health Insurance and pension scheme of private sector. Delayed retirement by one quarter due to the reform significantly decreases both men's probability to have at least one doctor visit between ages 66 and 76 and the number of doctor visits among men consumers. This effect is mostly driven by the consumption of general doctor visits. There is no major change in price, and the negative impact seems to be higher for the youngest.

Long-term Care Policies. The second part focuses on the need for long-term care associated with demographic ageing. Thus, the fourth Chapter uses dynamic microsimulation model to project the number of dependant elderly, and the evolution of morbidity, according to several scenarios. Previous studies on the projected number of French disabled rely on an administrative measure of disability (benefit from a public subsidy). This model relies on an epidemiological measure of disability, and on the computation of transition probabilities from one dependency state to another. Moreover, this model relies on the evolution of flows and not of stocks. This Chapter show that we may expect between 2.37 and 3.63 millions disabled elderly in 2060. All policies relying on a lower increase would violate a precautionary principle. Moreover, a large part of the scenarios tested leads to an expansion of morbidity. It also show that the probability to stay autonomous is the parameter with the highest impact on the morbidity evolution. However, the required increase of this parameter to benefit from a stagnation of morbidity is very high. Thus, It suggests that public policy should focus on policies that delayed the entrance in the disability process, but also play a role on other parameters.

The last Chapter investigates the causal impact of formal care use on informal care among formal care users. To deal with reverse causality, local disparities in the price of formal care providers is used as an instrumental variable. Using the French survey CARE, we implement a two-part model to show the effect of formal care on the extensive and on the intensive margin of informal care. An increase in formal care slightly decreases the probability to report informal care use. Heterogeneity tests show this negative effect is mainly driven by caregiving for daily life activities, provided by women and secondary caregivers. At the intensive margin, informal care is not significantly affected by a formal care increase.

2 Discussion and Future Research

Beyond the discussion and limitations already raised in this thesis, this section point out potential issues and future research associated with these issues. In particular, questions concerning the impact of using administrative versus survey data; the best practice to model healthcare expenditure data; potential extension of the microsimulation model; and lastly, regional disparities in elderly's care.

Administrative Versus Survey Data. The first part of this thesis relies only on administrative data. The main advantage is the large number of observations. When looking at very tiny phenomenon, a large number of observations is required to reach a sufficient statistical power. However, administrative data contain, most of the time, only very few information about socio-economic individual characteristics. Thus, results presented in the first part of this thesis capture an average effect with very few ways to control for heterogeneity across groups. At the reverse, the second part of this thesis relies on survey data. The large range of information on socio-economic characteristics allows for heterogeneity exploration. However, the use of survey data is associated with several limitations: sample size, declarative bias, and the selection bias due to non-response and selection of individuals in the survey (for example, people living in the community, or people having the same location during three years). In this thesis, there is very few options to measure the impact on the results of using administrative data versus survey data.

Most of these potential sources of differences that could impact the results are impossible to test. However, the declarative bias induced by the use of survey data concerning healthcare consumption, income and social benefit could be studied. Thus, the future availability of CARE data merged with administrative data on healthcare consumption and income will allow for such comparison. This comparison could provide a measure of the declarative bias related to healthcare consumption, income and social benefits.

Healthcare Expenditure Data. The third chapter of this thesis requires to think about the way healthcare consumption is modelled. Thus, healthcare expenditure has two specificities. First, the distribution is censored in zero. Second, there is a long right tail that makes the distribution skewed. There are literature reviews about the different methods available to deal with these specificities. However, there is few recommendation concerning how to choose the best method, taking into account sample size, population observed, type of expenditure included, and the shape of the distribution. The main interest of the third chapter was not to provide such answer. However, it would have been of interest.

Thus, one further work could be to compare results that emerge from these several meth-

ods, and to develop a tool to help with the choice of the most appropriate method. This tool could include for example results concerning how to choose the best distribution to fit with the data and How to treat the censoring issue according to the share of zero in the distribution. The answer could be provided using both Monte Carlo method and real data as an illustration.

Lastly, the question of retirement and healthcare requires a fine understanding on the role of age in healthcare expenditure. Thus, age has both an impact on retirement decision, health, healthcare coverage, and healthcare expenditure. This is a confounding factor that has to be taken into account. Further works on the evolution of healthcare expenditure over life cycle could address this question and provide evidence on how to take into account age in the question of the link between retirement and health. In particular, the HYGIE data used in the third chapter could be used to explore this question, since it includes from a large age range healthcare expenditure from 2005 to 2016.

Microsimulation. The major role of population projection is not to predict the future of ageing but to inform on what would be expected under a various range of plausible scenarios. Thus, it provides information on what a prudence principle imposes to anticipate. In particular, the microsimulation of the number of long-term care allowance in France has to be interpreted as the minimum number of beneficiaries we have to take into account.

Thus, the estimations provided in the fifth chapter are probably lower to what we will experience in 2060. One possible extension to this work could be to explore the reason for the underestimation in the previous forecast, and thus provide a real "worst case" scenario.

Second, the microsimulation model enables to disentangle between the share of dependent elderly attributable to demographic ageing and the share attributable to the health conditions in the country. Thus, using survey comparable to SHARE but in other countries (HRS in the Unites States, ELSA in England, TILDA in Ireland, etc.) it is possible to compute the projection of the future elderly in France if the French experiences the health transition of another country.

Disparities of the Long-term Care Policy in France. The French policies supporting long-term care for elderly is managed at the departmental level. Thus, disparities can emerge from this management. These disparities are independent from individual decisions and thus can be used as an instrumental variable in studies (see for example Chapter 5). However, there is few knowledge concerning which factors have an impact on the share of elderly recipient, and at the level of support they benefit between department. One further research is to understand what share of these disparities is attributable to demographic characteristics of local areas, to differences in health, and to differences in public support management.

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Abstract

Abstract: Demographic ageing in France raises sustainability issues on pension system and long term care allowance. These issues lead to pension reforms that increase claiming age, and to several evolutions of long term care policies. This thesis aims at improving the knowledge concerning these policies' implications. A first part focuses on the impact of retirement on health. Chapter 1 sums up evidences from previous studies about the impact of delayed retirement on health. Chapters 2 and 3 respectively focus on the impact of later retirement on mortality and healthcare expenditure. They show that later retirement due to the 1993 French pension reform has no impact on mortality and decreases healthcare expenditure. The second part of this thesis focuses on the long term care policies in France. Chapter 4 uses a microsimulation model to project future needs for long term care. The estimated number of disabled elderly in 2060 reaches 3.63 millions, with a morbidity expansion. Chapter 5 focuses on the impact of a variation of formal care on informal care use. An increase in formal care is found to slightly decrease the probability to report informal care use.

Keywords: Ageing; Retirement; Health; Long-term care; Public policies.

Résumé: Le vieillissement démographique soulève des questions de viabilité du système de retraite et de soutien aux personnes âgées. Ces questions ont conduit à des réformes des retraites et à plusieurs évolutions des politiques de soutien aux personnes âgées. Cette thèse vise à améliorer la connaissance sur les implications de ces politiques. La première partie porte sur l'impact de la retraite sur la santé. Le chapitre 1 résume les résultats des études antérieures concernant l'impact de la retraite sur la santé. Les chapitres 2 et 3 portent respectivement sur l'impact du report de la retraite sur la mortalité et sur les dépenses de santé. Ils montrent que partir plus tard à la retraite du fait de la réforme de 1993 en France n'a pas d'impact sur la mortalité et diminue les dépenses de santé chez les hommes. La deuxième partie de cette thèse porte sur les politiques de soutien aux personnes âgées en France. Le chapitre 4 utilise un modèle de microsimulation pour projeter les besoins futurs d'aide aux personnes âgées. Le nombre de personnes âgées dépendantes est estimé à 3,63 millions de personnes en 2060, avec une expansion de la morbidité. Le chapitre 5 s'intéresse à l'impact d'une variation de l'aide formelle sur le recours à l'aide informelle. Il montre qu'une augmentation du volume d'aide formelle diminue la probabilité de déclarer recevoir de l'aide informelle.

Mots-clefs: Vieillissement; Retraite; Santé; Soins de longue durée; Politiques publiques.

