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The Economics of Mental Health: from Risk Factors to Financing

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Abstract

This thesis investigates the economics of mental health focusing on three dimensions: financing and services organisation, medication adherence, and socio-economic determinants. Part I provides a detailed analysis on the financial incentives to deliver mental healthcare services. It also proposes innovative payment mechanisms to incentivise integrated community-based care, to detect and prevent mental disorders early in life, and to implement a collaborative stepped care model for depression. Part II assesses the socio-economic factors that influence non-adherence rates and investigates how one can use a payment mechanism to induce adherence. Finally, Part III explores the relationship between unemployment and mental health by age group and education level.

Keywords: mental health, financing & organisation, psychotropic drugs & adherence, socio-economic determinants.

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List of abbreviations

ACSS	Administração Central do Sistema de Saúde, I.P.
ACT	Assertive Community Treatment
AHS	Anxiolytics, Hypnotics and Sedatives
AIB	Abnormal Illness Behavior
ALOS	Average Length of Stay
AOT	Assertive Outreach Teams
AP-DRG	All Patient DRG
APE	Average Partial Effect
ARS	Administrações Regionais de Saúde
ATC	Anatomical Therapeutic Chemical
CBT	Cognitive Behavioural Therapy
CCM	Collaborative Care Model
CHLO	Centro Hospitalar de Lisboa Ocidental
CHMC	Community Mental Health Centers
CHPL	Centro Hospitalar Psiquiátrico de Lisboa
CHSJ	Centro Hospital de São João
CMI	Case-Mix Index
CP	Counting Process
CRT	Crisis Resolution Teams
DALY	Disability Adjusted Life-Years
DDD	Defined Daily Dose
DRG	Diagnosis Related Group
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders, 4^{th} Edition

ECT	Electro-Convulsive Therapy
EU	European Union
FFS	Fee-for-Service
FHU	Family Health Units
GDP	Gross Domestic Product
GEE	Generalised Estimation Equations
GLM	Generalised Linear Model
GP	General Practitioner
HoNOS	Health of the Nation Outcome Scales
HRG	Healthcare Resources Group
ICD-9-CM	International Classification of Diseases, 9^{th} Revision, Clinical Modification
ICPC	International Classification of Primary Care
ILO	International Labour Organisation
IPU	Integrated Practice Units
LAI	Long-Acting Injectable
LOS	Length of Stay
MDC	Major Diagnostic Category
MHVS	Mental Health and Vitality Scale
MoU	Memorandum of Understanding
MPR	Medication Possession Ratio
NHS	National Health Service
OLS	Ordinary Least Squares
PbR	Payment by Results
PCT	Primary Care Trust
PDC	Proportion of Days Covered
PH	Proportional Hazard

PHC	Primary Healthcare
PHCU	Personalised Healthcare Units
PHQ-9	Patient Health Questionnaire
PNSIJ	Portuguese National Plan for Child and Youth Health
P4P	Pay-for-Performance
QIC	Quasi Likelihood under Independence Model Criterion
RID	Reduction in Deviation
SC	Stratified Cox
SIARS	Sistema de Informação da Administração Regional de Saúde
SMI	Serious Mental Illness
SF-36	Short Form 36-item Health
UK	United Kingdom
US	United States of America
WCM	Working Correlation Matrix
WHO	World Health Organisation
YLD	Years Lived with Disability

Introduction

The World Health Organisation (WHO) defines mental health as "a state of well-being in which the individual realises his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community" (WHO, 2007*a*, p.1). This definition moves away from the simple concept that mental health is a state of absence of mental illness.

According to WHO, around 450 million people suffer from any mental illness (WHO, 2001). In the United States (US) the 12-month prevalence of any mental disorder among US adults amounts to 18.9% in 2017 (NIMH, 2019). Regarding serious mental illnesses (SMI) among US adults, this rate is 4.5% (NIMH, 2019). The WHO Mental Health Surveys Initiative assessed the prevalence of mental disorders in 10 European Union (EU)-countries (Belgium, Bulgaria, France, Germany, Italy, the Netherlands, Northern Ireland, Portugal, Romania, and Spain) using data collected between 2001 and 2015 (except Portugal, 2008) (Alonso, Chatterji and He, 2013). It was found a 12-month prevalence of any mental disorder among adults of 13.2%. For SMI this rate amounts to 3.3%.

Mental disorders affect not only the patients but also have an impact on society (Trautmann, Rehm and Wittchen, 2016). Specifically, EUWMH (2013) found that 3.1% of individuals with any mental disorder are absent from work 3.1 days per month compared to 1 day per month for individuals without disorder. Also, presenteeism is much higher for individuals suffering from any mental disorder compared to individuals without disorder (2.4 and 0.5 days per month, respectively).

In the top 20 causes of global burden of disease, five are mental disorders: major depression, anxiety disorders, schizophrenia, dysthymia, and bipolar disorder (Vos et al., 2015). In 2013, mental illnesses accounted for 21.2% of years lived with disability (YLD), the highest percentage among other groups of diseases. Using the composite measure, disability adjusted life-years (DALYs), the burden of mental illness accounted for 7.1%, the fifth higher percentage in terms of global burden of disease. However, and by reallocating neurological disorders, self-harm, and chronic pain syndrome, Vigo, Thornicroft and Atun (2016) claim mental illnesses account for 32.4% of YLD and 13% of DALYs. This means that assessments of the global burden of diseases are underestimate the burden of mental illnesses. These estimates rank mental illnesses in the first place in global burden of disease considering YLD and DALYs.

According to Kohn et al. (2004), part of this burden results from the fact that only some individuals receive treatment or/and treatment is delayed for many years (treatment gap). In the US, the treatment gap for moderate to severe mental disorders amounts to 53.2% (Kohn et al., 2018). Using data of WHO Mental Health Surveys, Wang et al. (2011) found a treatment gap between 34% and 69% for SMI, 63% and 83% for moderate disorders, and between 79% and 86% for mild disorders.

The cost of mental disorders does not solely comprise the diagnostic and treatment costs (direct costs). It also includes other costs, such as productivity losses due to work absence and/or early retirement and income losses due to mortality, disability, and care seeking. Therefore, these should be accounted when computing the economic cost of mental disorders (Trautmann, Rehm and Wittchen, 2016). According to Trautmann, Rehm and Wittchen (2016), in 2010, the global direct and indirect economic costs of mental disorders amounted to 2.5 trillion US dollars of which 1.7 refers to indirect costs. For the EU, in 2010, Gustavsson et al. (2011) estimated the cost of brain disorders of 798 billion euros. Approximately, 37% of this cost concerns to direct healthcare costs, 23% to direct non-medical costs, and 40% to indirect costs related to patients' productivity losses. Trautmann, Rehm and Wittchen (2016) believe that these economic costs will double by 2030.

Overall, mental health imposes challenges to local Governments. Improve mental health and reduce the burden of mental disorders should be a priority. Mental health policy "is a government statement specifying values, principles and objectives for mental health" (Zhou et al., 2018, p.2) and, if correctly formulated and implemented, it can reduce its burden and improve mental health (Zhou et al., 2018). The main areas of mental health polices have been: service organisation, service provision, service quality, human resources, legislation and human rights, advocacy, administration, surveillance and research, and financing and budgeting (Zhou et al., 2018).

Economics is "concerned with the use and distribution of resources among the individuals making up a society, and how different ways of allocating resources impacts on their well-being" (WHO, 2006, p.5), and its application to the healthcare sector is important. Given the impact mental disorders have not only on individuals with the disease but also on society, "too much is at stake to ignore this economic dimension of mental health care, whether measured in terms of lost health gains, misallocated monies or unfair financing mechanisms" (WHO, 2006, p.11).

This thesis provides with additional evidence to the literature on economics of mental health. It focuses on three domains: financing and service organisation, adherence to psychotropic medication, and socio-economic determinants. The empirical analyses performed in this thesis use data from Portugal because mental health in Portugal has some specificities which make it a case study.

First, the Portuguese mental health system is essentially centred around inpatient stays and emergency consultations, which consume more than 80% of the resources, coupled with an insufficient provision of community-based services (Almeida et al., 2015). The way mental health services are organised does not comply with the optimal mix of services suggested by WHO (2007*b*). Specifically, it is suggested that most of mental healthcare can be self-managed or managed by informal community-care. However, when additional support and expertise is needed, primary care services should be able to address mental health issues and inpatient stays should be consider as a last resort.

Second, Portugal is one of the European's countries with the highest prevalence of mental health disorders (22.9% compared to 18.4% and 14.9% in France and the Netherlands, respectively) (Almeida et al., 2013). Due to the financial crisis of 2008, these prevalence rates, namely for SMI, increased (Almeida, Antunes and Silva, 2016). Additionally, and according to the last epidemiological study, 33.6% of patients with SMI in Portugal do not receive treatment (Almeida et al., 2013).

Finally, Portugal was strongly affected by the economic crisis, meaning that some socio-economic determinants of mental health (e.g. unemployment and income) were largely affected. Therefore, Portugal provides additional conditions to address the relationship between mental health and socio-economic determinants.

This thesis is divided in three parts: part I focuses on the financing and service organisation; part II on adherence to psychotropic medication; and part III on socio-economic determinants.

Part I includes three chapters. Chapter 1 assesses the incentives of a case-mix based funding system in delivering mental healthcare services. The first step involves using readmissions information as a proxy for quality of care. If readmissions are increasing over time this can indicate a scarcity of community services or early discharges due to lack of beds or shortage staff. On the other hand, if readmissions are decreasing we can state that inpatient settings are providing high-quality care and responses of community services are effective. A second relevant issue is understanding how specific determinants of the current financing system influence delivery of inpatient mental health services. A third element is the magnitude of scale effects. Organisation of inpatient mental health services can be done through concentration of services in a few units or several hospitals proving them. The trade-off to be made is between being closer to patients having several units of low volume activity each or benefiting from economies of scale to obtain better outcomes. Lastly, it is assessed the importance of integrated continuous care services as a complement to inpatient care. We use a diagnosis related group (DRG) dataset between 1994 and 2013 considering all mental health inpatient discharges to perform these analyses.

Using a heteroskedastic fractional probit model, evidence of a negative relationship between readmissions rate and treating more complex cases was found. The quality of care is not affected by the number of treated patients. For hospitals that treat less complex cases, and using a probit model, we find that the current financing system incentivises an increase in the number of equivalent patients through rehospitalisations. Despite this effect might be related to other DRGs, it exacerbates the problem of recurrent readmissions on psychiatric wards. The results provide evidence of a scale effect for each DRG using a conditional risk set model. However, its magnitude does not justify the centralisation of psychiatric services in high-volume hospitals. In terms of long-term care, we find potential savings of 26% of the initial cost for the National Health Service (NHS) if integrated continuous care was in place. Based on these results, we conclude that the focus of mental health system redesign should be on reducing readmissions by introducing a quality measure associated with DRG prices, implementing multidisciplinary teams to provide community services and promoting integrated mental healthcare, with concentration of hospital services not being particularly relevant.

In Chapter 2 it is performed a comprehensive review of healthcare providers payment schemes and their related incentives, and best practices in mental health prevention and care. Then, it is elaborated innovative payment mechanisms, which were further discussed with a large panel of experts. We design a four-dimension model that focused on (i) the prevention of mental disorders early in life; (ii) the detection of mental disorders in childhood and adolescence; (iii) the implementation of a collaborative stepped care model for depression; and (iv) the integrated community-based care for patients with SMI. First, it is recommended a bundled payment to primary care practices for the follow-up of children with special needs or at risk under two years of age. Second, it is proposed a pay-for-performance

(P4P) scheme for all primary care practices, based on the number of users under 18 years old who are provided with check-up consultations. Third, it is proposed a P4P scheme for all primary care practices, based on the implementation of collaborative stepped care for depression. Finally, a value-based risk-adjusted bundled payment for patients with SMI is proposed. By implementing this new mental health payment scheme, it is expected that the Portuguese mental health system will encourage and compensate early prevention and detection of mental health disorders; will create a more efficient and accessible care for depression; and will create a more integrated, community-based care for SMI. The implementation of evidence-based best practices in mental health requires careful attention to payment mechanisms. Other countries facing similar issues can apply the suggested financing model for the Portuguese mental health system.

Chapter 3 estimates the direct treatment costs of SMI in the Portuguese NHS and its cost determinants. Data was collected from two Portuguese general hospitals and one Psychiatric hospital during one year (1^{st} of September 2014 to 31^{st} of August 2015). Schizophrenic and delusional disorders had the highest average cost per patient, of €1,577 and €1,493, respectively. The cost per diagnosis decreased with age and male patients were more costly when diagnosed with schizophrenia and affective disorders. We found some heterogeneity among SMI and patients' characteristics. The treatment cost of SMI in its acute phase is relatively low in comparison with other chronic diseases. As Portugal is a country with tight public health budgets, especially for mental health, an effective resource allocation is crucial and can be done through economic evaluations, which requires evidence on mental health costs. Cost determinants' analysis provides the rationale to introduce risk adjustment measures linked to per patient disease-related payment.

Part II includes two chapters. Chapter 4 analysis the association between primary non-adherence and its main drivers. Using data on prescription in primary care and dispensing of psychotropic drugs between 2009 and 2015, we compute non-adherence rates for counties belonging to the Center region of Portugal. We merge socio-economic characteristics at municipality-level such as unemployment rate and percentage of welfare recipients to build a more complete set of information on patients' context. Using a fractional probit model, it is estimated the association between non-adherence rate and socio-economic determinants, using the pair municipality-year as unit of observation. Between 2015 and 2009, non-adherence rates were about 8.5% and 23.7%, respectively. These results show that an increase of 1 percentage point in the percentage of beneficiaries of social benefits and unemployment rate has a positive impact on non-adherence rate of 1.5 and 1.1 percentage points, respectively. Younger individuals are less adherent to treatment. The number of physicians and average wage in the municipality are negatively associated with non-adherence rate. These results are capturing the effect of adverse economic conditions on non-adherence to psychotropic medication. Specifically, there are two particular groups within the population which are more vulnerable: the unemployed and welfare recipients. Policies focusing on unemployment benefits should not be discarded since they can improve mental health status and may allow individuals to afford medication. Integrating mental health in the benefit system is also of great importance. We suggest the implementation of an additional co-payment for welfare recipients and unemployed, given special attention to the youth. These measures should be coordinated with strategies to enhance mental health. Hence, effective policies ought combine the three key-areas: health, labour market, and social security.

Chapter 5 analysis the physician's payment if treatment non-adherence is a possibility. We design a model with a patient diagnosed with a mental health disease being followed by one semi-altruistic physician. The Government has to decide how to pay the physician so that she provides the proper treatment to the patient, knowing its resources come from taxpayers. The physician receives a bonus if the patient adheres to the treatment and an additional improvement bonus if the patient's health status improves. The patient, who faces an adherence cost, has to decide whether to adhere to the treatment or not. Our results show that when the patient and the physician need to be convinced to turn to the adherence side, the Government decision is based on the level of tax distortion. Specifically, when the tax distortion is low the optimal adherence bonus is zero and the improvement bonus decreases with the level of altruism and with the benefit the patient gets if his health status improves. On the other hand, if the tax distortion is moderate, it does not matter how the optimal adherence and improvement bonuses are distributed as long as the expected payment to the physician does not change. When the tax distortion is too high, it is not optimal to induce adherence. This concludes payment mechanisms can induce adherence. However, and in periods of tight budgets where adherence is not guarantee, the way bonuses are paid to the physician is not relevant as long as the expected payment remains the same. Other reasons like administrative simplicity can dictate which payment system prevails.

Part III provides additional evidence on the unemployment-mental health relationship by allowing the impact of unemployment on perceived mental health to differ by age group and, within each age group, to vary according to the education level of the individual. We use Portuguese data for the period 2014 and 2015. We found evidence of a negative relationship between unemployment and perceived mental health for individuals under 35. The magnitude of this relationship increases with the level of education of the individual. We conjecture that our results may be reflecting the unmet expectations of young individuals who completed more years of schooling as far as labour market outcomes are concerned. That is, well-educated young unemployed appear as a particular vulnerable group of mental health exposed to unemployment in times of economic crises. Our results point to the need of coordinating policies targeting both mental health and unemployment at this age group.

The table below provides a summary description of this thesis.

Table 2: Summary Description of the Thesis

Part	Chap.	Research Question	Findings
I	1	How inpatient mental health services should be organised? What are the incentives that the current financing system is creating?	Mental health system should be redesigned to reduce readmissions by implementing multidisciplinary teams, with concentration of hospitals not being relevant.
	2	What payment mechanism should be designed to promote early prevention and detection of mental disorders and create a more integrated, community-based care?	A four dimensional model is designed in which we implement a P4P mechanism and suggest a value-based risk-adjusted bundle payment to treat SMI.
	3	What is the direct cost of SMI and its determinants?	Schizophrenic and delusional disorders have the highest direct cost. Direct costs are relatively low compared to other chronic diseases. The analysis on cost determinants provides evidence to introduce risk adjustment measures.
II	4	What are the socio-economic determinants of treatment non-adherence?	The welfare recipients and unemployed, namely young adults, are the more vulnerable groups. Measures on unemployment benefits and additional co-payments for welfare recipients should not be disregarded.
	5	How a payment mechanism can improve adherence?	In times of tight budgets, when adherence is not guaranteed, it does not matter how we pay the physician as long as his expected payment remains the same.
III	6	What is the relationship between unemployment and mental health?	Well-educated young unemployed appear to be a vulnerable group of mental health exposure to unemployment. Policies should target both mental health and unemployment focusing on this vulnerable group.

Part I

Financing and Services Organisation

Chapter 1

Delivering mental healthcare inpatient services: incentives of a case-mix funded system

1.1 Introduction

Mental or psychological well-being makes up a valuable part of an individuals' capacity to lead a fulfilling life (Chisholm, Saxena and Van Ommeren, 2006). The latest epidemiological research shows that psychiatric disorders and mental health problems have become one of the main causes of disability in societies nowadays (Almeida, 2009).

According to Knapp et al. (2007*a*), economic costs of mental health disorders are very high. For the former 15 European countries, a conservative estimation of these costs was performed and points to an average cost of 3 to 4% of Gross National Product (Gabriel and Liimatainen, 2000). More recently, and for 30 European countries, Wittchen et al. (2011) estimate the economic cost of mental disorders in about 497 billion euros. This cost not only includes both direct and indirect health costs (e.g. diagnosis and treatment of a disorder, social and informal services) but also indirect costs related to productivity loss.

One of the main challenges European countries are facing is to ensure mental health services receive a fair share of the available health funding (MHE, 2002). Mental health system financing has become a priority for almost all European countries and the US (McDaid, Knapp and Curran, 2005; Garfield, 2011).

The way mental health is financed can create incentives or barriers to system's reform and have long-term consequences on planning and delivery of services (Salvador-Carulla et al., 2006). Hence, assessing the impact of the current financing system on mental healthcare services is crucial.

In this paper we analyse the mental health inpatient and long-term care using data of the Portuguese NHS, a case-mix based funding system, which is currently discussing a new financing model. More specifically, we investigate if the current financing system is creating barriers in delivering mental health services. The first element involves using readmissions as a proxy for quality of care. If readmissions are increasing over time this can indicate ineffective community services' responses or early discharges due to lack of beds or shortage staff. On the other hand, if readmissions are decreasing we claim that inpatient services are providing high-quality care and community services are being effective. Second, we analyse how mental healthcare should be organised since this is the first step in the discussion of a payment design. Suppose unit costs and outcomes of mental healthcare are largely independent of the amount of work performed in each setting. Then, a single payment value, applicable to all units, small and large, would be feasible. Moreover, the size of each unit could be left totally to patients' preferences or patients' geographic concentration. At the other extreme, in the presence of strong size (scale) effects, healthcare facilities of different size may need different unit payments and location of activities of hospitals providing mental healthcare services must be actively planned.

Additionally, and according to the literature, mental health services should be balanced between hospital and community-based services (Almeida and Killaspy, 2011).[1] Thus, the Portuguese government has been approving several decree-laws on integrated continuous care for patients with SMI.[2] These continuous care facilities aim to provide recovery and deinstitutionalisation programmes for patients with SMI and serve as a complement to inpatient care. The rationale is to transfer patients with SMI to these facilities once they are clinically stable which allows, on average, shorter inpatient stays. As the implementation of these services has constantly been postponed, we analyse the potential savings that integrated continuous care can bring to the Portuguese NHS. Identifying these potential savings, along with their clinical benefits, allows to discuss how mental healthcare organisation should be balanced between hospital and integrated care. This topic is relevant also for the payment design as it should reduce incentives for (re)institutionalisation and promote community-based care.[3]

Our results reveal that quality of care, measured by readmissions rate, is not affected by the number of inpatient discharges. Using a probit model, we find that the current financing mechanism is creating incentives for hospitals to increase the number of readmissions.

As far as services organisation is concerned, since we want to model the length of time spent by each patient in a hospital before discharge, we use a duration model, specifically a conditional risk set model. We opt to use this model because it accounts for several specificities of our dataset, such as recurrent readmissions within 30 days of discharge (meaning that patients did not improve their health status) and repeated events for the same patient (he can improve his health status but after a period of time, more than 30 days, he gets sick again). Our results show there is no advantage in centralisation of activities in high volume hospitals. We also identify potential savings for the NHS that range between €4.5M and €13.4M if integrated continuous care facilities were part of the Portuguese mental health

[1] Community mental health services include, among others, supported housing with full or partial supervision, primary care medical services, daycare centers and community mental health centers.

[2] Patients whose diagnosis is one of the following: schizophrenia, bipolar or severe depressive disorders.

[3] One example is England's "Care Pathways and Packages Approaches".

system as a support to inpatient care (about 26% of the initial cost). Transferring patients with SMI to these facilities will reduce, on average, the hospitals' length of stay (LOS). This implies an increase in hospitals' bed capacity allowing hospitals to treat more patients. Based on our results, hospitals would have capacity to treat, on average, 10% to 27% more patients with severe mental disorders per year.

Based on our results, we suggest that the new mental health financing plan should improve quality of care by introducing adjusted payments which reward hospitals for the additional cost/effort towards quality. Also, implementing multidisciplinary teams to provide community care services is crucial. The new financing plan does not need to induce concentration nor to accommodate the fact that high volume hospitals could receive proportionally less because they benefit from economies fo scale. Hence, it would be feasible to have a single payment to all units providing mental health inpatient care. Additionally, and given that the treatment gap in Portugal for severe mental disorders is about 33.6% (Almeida et al., 2013), the new mechanism should consider integrated continuous care as part of the Portuguese mental health system since hospitals will have greater capacity to treat more patients besides all the clinical benefits of these facilities.

We believe that our results and methodology might be extended to other NHS where mental health services are being financed using a case-mix based funding system.

The remainder of this chapter is as follows. The next section briefly describes the Portuguese health financing system and reviews the literature on the topic. Section 1.3 presents the dataset used throughout our analysis and the descriptive statistics, while the methodological approach is described in Section 1.4. Section 1.5 presents the main results from our analysis, which are then discussed in Section 1.6. Sections 1.7 and 1.8 provide the robustness checks and limitations of our analysis, respectively. Finally, Section 1.9 concludes.

1.2 Literature Review

1.2.1 The Portuguese National Health Service

The Portuguese health system is organised around a NHS, which is managed by the Ministry of Health. The Portuguese NHS was set to comply with the Constitution disposition that establishes the right of all citizens to health protection, regardless of their economic and social background (Barros and Simões, 2007; Simões et al., 2017).

Hospitals belonging to the NHS are not paid episode by episode. There is a global contract, *contratos-progama*, between each hospital and Administração Central do Sistema de Saúde, I.P. (ACSS) that bundles together all prospective episodes.[4] The total amount a hospital h receives is equal to

$$F_h = I_h + O_h + Ha_h \tag{1.1}$$

where I_h, O_h and Ha_h stand for inpatient care, outpatient care and other hospital activities,[5] respectively.

Concerning inpatient care, a hospital h is paid according to the following formula:

$$I_h = \mathit{price} \times ep_h \times cmi_h \tag{1.2}$$

where ep_h stands for the number of equivalent patients and cmi_h is the case-mix index.

The *price* is computed using the price and weight of each DRG for a hospital h.[6] The number of *equivalent patients* not only considers the normal acute inpatient episodes which have a LOS between an inferior and a superior limits defined for each DRG, but also the

[4]The NHS' financial and human resources, facilities and equipment, systems and information technology is managed by ACSS.

[5]E.g.: Scientific Research.

[6]The prices and weights of the DRG are stipulated by decree-laws.

episodes with a LOS below or above the above mentioned limits,[7] respectively. The equivalent patients formula converts these last two types of episodes in equivalent normal acute inpatient episodes. Also, the number of days in-hospital of transferred patients are converted in equivalent episodes. A normal acute episode corresponds to one equivalent patient.

The case-mix index (*cmi*) is a measure of relative cost or resources needed to treat the mix of patients. It reflects the diversity and complexity of all patients treated in a hospital. To compute the *cmi* we need to weight the number of equivalent patients by the relative weight for each DRG. The relative weights reflect the national "average hospital resource consumption" by patient for that DRG relative to the national "average hospital resource consumption" of all patients. Until 2014, the *cmi* was computed separately for medical and surgical DRGs but from 2014 onwards, there is a unique *cmi*, comprising medical and surgical activities. It should be highlighted that the price and weights set for DRGs are not based on analytical cost. They have an historical origin with subsequent adjustments being made mostly *ad-hoc* to the external researcher.[8]

Regarding hospital rehospitalisations, there is no additional payment if they occurred 72 hours after the last discharge.[9] There are exceptions namely for psychiatric patients. In this case, mental health patients that are readmitted within 60 days after last discharge are paid using a daily price.[10]

As far as organisation is concerned, the public infrastructures for healthcare provision have been restructured in the recent past. Most of the Portuguese hospitals are now administratively part of health units called hospital centers (Centros Hospitalares). In some regions, the government has been grouping together the local primary care health centers

[7]These boundaries are stipulated by decree-laws.

[8]No information has been publicly disclosed on the reason for these price changes.

[9]It is defined as multiple inpatient stays within a specified time period by the same patient.

[10]This price is defined by decree-law and it is the price paid to "other health care centers with inpatient care". In 2013 this price refers to the daily price paid to midterm rehabilitation care unit of the Portuguese National Network for Integrated Care. In 1994 and 1995 the decree-law does not provide any price for rehospitalisations.

and the hospitals located in the same region into a single administrative unit known as local health units (Unidade Local de Saúde). The main idea behind this restructure was to promote efficiency gains from integrated care. This reorganisation did not imply the closure of a hospital but instead the reconfiguration of acute services. This means that only in a few number of cases, duplicated services within different hospitals of the same hospital center were closed.

As far as mental health is concerned, Portugal is currently shifting from psychiatric hospitals to a network of services based on the community. The rationale is to keep patients in their respective residential communities instead of staying in psychiatric hospitals (Almeida, 2009). Thornicroft and Tansella (2003) argue that when deinstitutionalisation is carefully planned, patients who are discharged to community care present better outcomes. Since 2007, Portugal closed two psychiatric hospitals which were replaced by community-based services and mental health units in general hospitals. Due to this service reorganisation, the mental health referral network was modified and new psychiatric services within general hospitals were developed (DGS, 2004). The aim of this reorganisation is to provide services closer to the population by developing community-based services (Almeida, 2009). Empirical evidence shows that community care services not only promote better continuity of care but also increase treatment compliance (Almeida and Killaspy, 2011).

However, Portugal still relies on inpatient care since it lacks of community care services, domiciliary services and primary care services oriented towards mental healthcare. One possible reason for this fact is the way mental healthcare is funded (Almeida, 2009).[11] Budget rigidity, absence of financial incentives and lack of explicit funding for community services are some factors that have been restraining the progress of mental health services (WHO, 2003*b*).

[11] In A.1.1 we present some of the arguments that have been put forward for a new mental health financing plan.

Still, no empirical study was performed on the organisation of inpatient mental health services nor on community-based services, highlighting the need for evidence that can guide policy making.

In 2010, and in order to solve a long-existing gap in social support and healthcare in Portugal, the government established, by the decree-law 8/2010,[12] the integrated continuous care for patients with SMI (Portuguese National Network for Integrated Care for mental health patients, RNCCISM). These services are a set of sequential interventions in mental health and/or social support, focusing on rehabilitation and recovery of patients with SMI. In the light of family and social integration, integrated continuous care conducts an active and continuous process of rehabilitation and social support by promoting self-sufficiency and improving patients' outcomes. The rationale is to transfer patients from inpatient care to these healthcare facilities, after they are clinically stable. The provision of these services includes three types of residential units (maximum support, intermediate support and minimum support), social integration facilities (day centers) and home support teams. In 2011,[13] the government defined the prices that should be paid to these integrated continuous care units.

The implementation of these services has been postponed. Despite several studies stating the clinical benefits of these facilities on patients' outcomes (Almeida and Killaspy, 2011), there is no study providing empirical evidence on savings for the NHS if integrated care was in place.

1.2.2 Mental Health Financing

Mental healthcare is characterised by diversity in provision, which covers long-term and acute care, and medical, mental, rehabilitative and social services (Mason and Goddard,

[12] Updated version is given by the decree-law 22/2011.

[13] Decree-law 183/2011.

2009). For a successful mental health system it is essential for patients to have access to good physical and human capital resources. Many countries found limitation on resources which restrict access and constraint health improvements. Policy-makers not only have to decide on the distribution of funding within mental health system but also on the allocation of resources between regions, services and programs (WHO, 2003*b*). The concepts of equity,[14] effectiveness,[15] and efficiency can help policy-makers to make such decisions.[16] One way to affect these elements is to use the financing and payment system.

When designing a mental health payment system, governments should take into consideration the issues related to supply- and demand-side. On the supply side, financing and reimbursement mechanisms affect the provision and availability of mental health services. On the demand side, utilisation rates by people with mental disorders is low.[17] Considering the purchaser side, such as governments, they may "disinvest" in mental health when budgetary pressures arise. Hence, depending on how a payment system is design, it can "exacerbate or ameliorate imbalances between supply and demand" (Mason and Goddard, 2009, p.1).

For most European countries, mental healthcare is financed in the same way as other healthcare services, using either national, regional or local budgets (MHE, 2002). Therefore, general decisions about such financing may not be in line with mental health policy-maker or planner (WHO, 2003*b*).

The WHO proposes four ways to purchase mental health services: global budget, capitation, the case rate and fee-for-service (FFS). The global budget allows the purchaser to predict with certainty the level of expenditures on mental health in a given year. Capitation

[14] No particular segment of the population is favoured. Equity can be measured in terms of healthcare status, utilisation of services, resources and access.

[15] Achieve the expected outcome which is measured by "how well results are produced" (WHO, 2003*b*, p.12).

[16] Related to the resources required for effectiveness.

[17] This fact namely reflects the stigma and financial barriers (Mason and Goddard, 2009).

is based on a fixed fee for each enrolled person. In this case, a specific level of healthcare is covered, regardless of the amount of services provided. In the case rate (or bundled payment), purchasers pay a fixed amount to cover the average costs of all services needed to achieve a successful outcome for a pre-defined episode of care. Finally, the FFS pays a fixed fee each time a patient accesses the system, that is, the payment is based on the number of procedures or the number of services provided. This mechanism gives economic incentives to physicians to provide more units of care to increase reimbursement (WHO, 2003*b*).

Most of the empirical work regarding the innovative mental health system financing is based on evidence from the US. Some of the studies found that FFS provides incentives for over utilisation (Menon, 2014). The most relevant studies about this topic found that moving from a FFS reimbursement to a capitation payment system lower inpatient and outpatient costs without patients becoming sicker (Dwyer et al., 1995; Bloom et al., 1998; Chou et al., 2005; Bloom et al., 2011). However, capitation *per se* may not increase prevention (Catalano et al., 2000).

In the Netherlands it was introduced a new reimbursement schedule in mental healthcare based on discontinuous discrete step function. That is, providers receive a fee according to the treatment duration but this fee is flat and only increases after the next threshold is reached. The authors found that this system increased the total costs since the unintended effects offset efficiency gains (Douven, Remmerswaal and Mosca, 2015). Specifically, treatments were shifted to a next threshold resulting in an increase of costs. The table in appendix A.1.2 summarises the most relevant works on this topic.

Less research has been performed on the case-mix based funding in mental health (Mason and Goddard, 2009). Based on evidence from the US, Jennison and Ellis (1986) found that the rate of visits per mental health provider per month increased when they shift from a salaried basis to a FFS reimbursement mechanism. Rosenthal (2000) examined the effects of risk sharing with mental health providers. The introduction of a case-rate payment system resulted in a reduction of outpatient visits compared to a FFS system.

The DRG system can be effective to ensure that sufficient resources are transferred to mental health services. Nevertheless, and for some countries such as Italy and Austria, this system under-funds mental healthcare (Mason and Goddard, 2009). A possible explanation relies on the reimbursement rates which "have not always fully taken into account all the costs associated with chronic mental health problems" (Knapp et al., 2007*a*, p.86). In Austria, the DRG system was reformed to take into account the additional problems associated with mental healthcare and to allow adjustments in the LOS for different levels of clinical need. This reform has been allowing psychiatric wards to cover their costs (Knapp et al., 2007*a*).

In the United Kingdom (UK), payment by results (PbR) is the mechanism used to pay for NHS's hospital service. PbR does not "reward results, in the sense of paying for health outcomes, but remunerates "activity" using Healthcare Resource Groups (HRGs) as the payment units" (Mason and Goddard, 2009, p.3). The classification system created for mental health is based on a model of care cluster. Care clusters are reference groups used to link service users with similar needs and problem severities. The focus of this new classification system relies on patient need and severity. This model "moves away from purely diagnostic descriptions of people (though not wholly) to one of broadly described needs" (Clark, 2011, p.72).

In Australia, the National Casemix & Classification Centre found that mental health major diagnostic category (MDC) had the worst performance when compared to other DRGs in terms of differences in resource consumption between patients. Specifically, the performance is assessed using the Reduction in Deviation (RID) statistic. The higher the RID, the better. This statistic is applied to several performance outcomes such as the LOS. For mental health MDC, the LOS RID is about 16% while for the best performing MDC is 76%, and considering all MDCs is approximately 61% (UOW, 2012). It was recommended a new classification of mental health disorders to be used in the specialist mental health sector.

One of the weaknesses in this vast literature is that the main empirical studies focus on the analysis of the impact of changing the payment system from a FFS to capitation using data from the US. Since the US has a "decentralised, multi-payer system with mixture of private and public finance" (Mason and Goddard, 2009, p.14), the results cannot be fully extended to a NHS.

Overall, mental health financing needs to be carefully analysed, the first step being the assessment of incentives provided by the current financing system. Therefore, our paper adds evidence to the literature on the incentives a case-mix funded system creates in delivering mental health inpatient services.

1.2.3 Services Organisation

A mental healthcare system assumes a multidisciplinary approach to psychiatric disorders (Knapp et al., 2007*a*). Evidence points to a balanced care between community-based and modern hospital-based care (Thornicroft and Tansella, 2003). Frontline services are based in the community but hospitals play an important role as specialist providers. When inpatient care is required, LOS should be as brief as possible whilst supported by a good community mental health services (WHO, 2003*b*). Empirical studies found that, after a discharge, the risk of readmission decreases when a good clinical practice within the community is offered (Zhang, Harvey and Andrew, 2011). Hence, organisation of inpatient care reveals to be an important issue for the system's efficiency and readmissions can be used as a proxy for quality of care.

In the US, managed care is a system that integrates financing and delivery of appropriate healthcare using a comprehensive set of services. Its major role is to control spending levels using specific financial parameters. Managed care comprises many types of organisations and insurance options. Also, "it includes systems of financing service delivery such as capitation and putting providers at risk for the cost of delivery" (WHO, 2003*b*, p.47). Empirically, Bernstein and Fox (2000) found that implementing managed care to patients with SMI is an effective way to achieve cost efficiency.

In the UK, assertive outreach teams (AOTs) and crisis resolution teams (CRTs) have been introduced as part of the community mental healthcare system. They aim to assess all patients being considered for acute hospital admission, to offer intensive home treatment rather than hospital admission (if feasible), and to facilitate early discharge from hospital (Chisholm and Ford, 2004). Several empirical studies have been performed to understand the impact of these service models on inpatient admissions (Wane et al., 2007; Barker et al., 2011; Jacobs and Barrenho, 2011; Hamilton et al., 2015), LOS (Barker et al., 2011), and service cost (McCrone et al., 2009). Except in the study of Jacobs and Barrenho (2011), all these studies found a reduction on inpatient admissions, LOS, and in service cost. Jacobs and Barrenho (2011) did not find a statistically significant difference between admissions before and after the implementation of CRTs. However, this study was carried at primary care trusts which might have underestimated the impact of CRTs that operate in a smaller geographic area. Also, and as pointed out by Werbeloff et al. (2017), there are several risk factors that may explain admissions in acute mental health facilities after contact with AOTs and CRTs, such as older age and being diagnosed with non-affective psychosis.

In appendix A.1.3 it is presented a table that briefly describes some of the empirical studies on managed care, AOTs, and CRTs.

Since a large debate about financing mental health is taking place in the literature, it is important to understand if there is any gain in terms of efficiency from centralising activities in higher volume hospitals. The rationale for this analysis relies on the fact that hospitals, which treat more patients, are able to "spread their fixed costs across a wider activity base, thereby reducing the average cost per patient" (Freeman, Savva and Scholtes, 2016, p.7). So, larger hospitals may be more cost-effective than smaller ones. This catchy argument requires a clear empirical background which is currently absent. Policy makers need to account for the possibility of concentrating activities in some hospitals or at least accommodate the fact that some hospitals may receive proportionally less as they benefit from economies of scale.

The literature is vast in what concerns hospital efficiency since hospitals consume a significant share of health resources in most countries (OECD, 2012*a*). Specifically, analysis on the economies of scale, stating whether larger hospitals are more or less efficient than smaller ones, has gained importance (Posnett, 1999; Weaver and Deolalikar, 2004; Morikawa, 2010). The empirical work performed on this topic focuses on the analysis at a hospital-level (Morikawa, 2010) and on specific medical treatments (Gaynor, Seider and Vogt, 2005).

As far as hospital-level is concerned, the results are consistent among studies on this topic.[18] Evidence points to a scale effect for small hospitals (less than 200 beds), a constant scale effect for the average hospital with about 200-300 beds and an average cost increase for hospitals with more than 400-600 beds (Aletras, Jones and Sheldon, 1997; Kristensen et al., 2008).

The work performed on specific medical treatments reports a relationship between hospital volume and outcomes such as mortality rates or other proxies (LOS, physician volume) (Hamilton and Hamilton, 1997; Gaynor, Seider and Vogt, 2005). Logistic and probit regression models, accounting for fixed effects at hospital level, are the most common methodologies applied in these volume-outcome studies.

Regarding studies on services organisation at a medical speciality level, Peltokorpi et al. (2011) found potential savings of 35.3% when applying the economy of scope and scale in vascular surgery operations. However, these concepts applied to services organisation at a medical speciality level have not received much attention in the literature. Hence, we add to the literature an analysis of economies of scale in mental health departments within general hospitals. We also provide evidence on potential savings that integrated continuous care

[18] Most of the studies focus their analyses on a specific country and use different methodologies such as the estimation of the total factor productivity (Morikawa, 2010) or the estimation of the short-run cost function to determine the long-run scale economies (Kristensen et al., 2008).

may bring to the mental health system (besides all clinical benefits), which so far has not been done.

1.3 Data

We use the DRG dataset of hospital discharges, which is organised by ACSS. It includes all inpatient discharges at the NHS and the diseases are classified according to the International Classification of Diseases, 9^{th} Revision, Clinical Modification (ICD-9-CM).[19] We only consider mental health diseases (i.e. DRGs 424 to 432) using observations from 1994 to 2013, excluding Psychiatric Hospitals.[20] We exclude these hospitals from the analysis because not only they have more long-term care beds than general hospitals but because they have speciality units which cannot be fully compared with the services provided by general hospitals. Moreover, psychiatric hospitals are planned to be excluded from the mental health system as the Portuguese government aims to develop a mental health system balanced between inpatient care, provided by general hospitals and community-based services.

This dataset comprises information about patients characteristics such as age and gender. We merge hospital level information data (annual data) — case-mix index (*cmi*),[21] beds, average yearly LOS (*lstay*), discharged patients (*dp*), and total cost (*totalcost*),[22] — from ACSS and hospital reports, available at ACSS.[23] This information is only available from 2001 onwards. 74 hospitals do not have complete information over these variables. To overcome this problem, we use information of the following year whenever a gap exists. In addition, we do not have information regarding the year 2013 on the hospital-level variables and,

[19] For the cost analysis we use All Patient DRG (AP-DRG) grouper, version 21.

[20] In appendix A.2.1 we provide the description of each DRG code.

[21] Through our analysis, the computation of *cmi* slightly change. However, these changes are not significant enough to undermine its use since the key element that we aim to capture is the cross-section differences.

[22] This cost comprises operational, financial and extraordinary costs gathered from the financial statements.

[23] In appendix A.2.2 we present the sources of information used.

therefore, we use 2012 information as a proxy.

We found eleven cases of rehospitalisation, in the same DRGs, that had an admission date previous to the last discharge. These cases were removed from our dataset as they were a registration error. We also dropped 7,685 observations of patients aged 15 and younger since they are treated in Child and Adolescent Psychiatric inpatient units.[24] The dataset, including all discharges from 1994 to 2013, has 209,415 observations.

Observations of some hospitals were combined due to the creation of hospital centers and local health units. Given to this merge, in 2011, the data of Centro Hospitalar e Universitário de Coimbra includes the discharges of the psychiatric hospital Sobral Cid. We are not able to disentangle the information of this psychiatric hospital. In appendix A.2.3 we present a summary of the hospital mergers occurred in the NHS.

1.3.1 Descriptive Statistics

The number of mental health inpatient discharges increased by approximately 4% between 1994 and 2013 which is slightly higher compared to the overall discharges in the NHS (3%). DRGs 426 (Depressive neuroses), 429 (Organic disturbances and mental retardation), and 430 (Psychosis) are the codes with more cases registered, representing together approximately 82% of all mental health discharges. The histogram is presented in appendix A.2.4. DRG 430 is the most heterogeneous group within mental health DRGs since it comprises different diseases such as schizophrenia, schizo-affective, and bipolar disorders. 98% of all inpatient discharges whose diagnoses are severe mental disorders were registered in DRG 430. These disorders account for 43% of all mental health inpatient discharges.

Almost all hospitals registered cases in all DRGs — DRGs 424 and 427 were recorded in 83.3% of all hospitals, DRGs 425, 426, and 429 in 98.3%, DRG 428 in 79.2%, DRG 430 in 95.8%, DRG 431 in 77.5% and DRG 432 in 89.2%.

[24] Patients aged 16 and older may be treated in adult mental health inpatient units.

Given the number of cases treated per year, we consider that a small capacity hospital treats less than 302 cases per year, whereas a high capacity hospital treats more than 542 cases per year.[25] In our dataset, 72% of the hospitals treated less than 302 cases per year and 9.2% treated more than 542 cases per year. To what concerns the overall dimension of the hospital (measured by the number of beds), 52% of all inpatient discharges were treated in hospitals with less than 650 beds. However, more than half of these observations were treated in hospitals with a number of beds that range between 400 and 650.

To analyse a possible correlation between hospital capacity and the treatment of complex cases (considering complex cases the ones that are more costly), we analyse the average total cost per hospital associated with mental health DRGs and year. This "cost" range between eight hundred euros and four thousand euros, approximately.[26] We excluded from this analysis the surgical DRG (DRG 424) since not only has a higher price when compared to the other DRGs but also the number of cases recorded in this DRG is small. In Figure A.2, appendix A.2.5, we present the average "cost" by hospital capacity. The "outlier" in the small capacity hospitals group concerns to a hospital that treated only one case in 2011. Regarding the medium and high capacity hospitals, we consider there are three distinct groups in terms of costs. This is explained by the DRG prices update. Overall, this figure allows one to say that both small and medium capacity hospitals treat complex cases.

In mental health inpatient care, the key important variables are the LOS and rehospitalisations (Gaynes et al., 2015). Since these variables will be used in our analyses, we provide a detail descriptive statistics in subsections 1.3.1.1 and 1.3.1.2, respectively. Additionally, special attention should be given to DRG 430 as it comprises approximately 51% of all mental health inpatient discharges. Subsection 1.3.1.3 discriminates a detail analysis

[25]These values correspond to the 25^{th} and 75^{th} percentiles, respectively.

[26]As mentioned before, price and weight of DRGs are not based on analytical cost. Therefore, the best we can do is to use the DRG prices as a proxy of the cost. The price can be obtained using the decree-laws that were in force in the period under analysis.

on the diagnoses recorded in DRG 430. In appendix A.2.6 we provide a description of all the variables included in our analysis, their respective designations and summary statistics for DRG 430 — Psychosis. For the remaining DRGs, this information is presented in a web appendix.[27] In subsections 1.3.1.4 and 1.3.1.5 we perform a patient analysis and determine the level of complexity in mental health, respectively.

1.3.1.1 Length of Stay

In the period under analysis, approximately 98.7% of all discharges have a LOS less than 90 days (mean and standard deviation amount to 22.2 and 135.4 days, respectively) and, within 90 days, we have approximately 67.3% of cases with a LOS between 1 and 20 days (Figure A.3, in appendix A.2.7).

The total LOS increased by approximately 2.9% between 1994 and 2013 due to an increase in the number of discharges with LOS of less than 40 days. During this period, the percentage of cases with a LOS above 120 days decreased, with exception of 2013. In addition, 0.14% of all discharges have a LOS of more than 360 days registered in all DRGs. More than 80% of these cases were registered in DRGs 430 and 429. In our data there are 146 cases with a LOS higher than 1,000 days.

The LOS can in part explain hospital costs, as there is a strong, although not perfect, correlation between LOS and hospital costs (Polverejan et al., 2003). Therefore, it is important to understand the outliers in our sample. We use the method applied by Freitas et al. (2012) where LOS outliers are defined as episodes with a LOS that exceeds the geometric mean plus two standard deviations of all inpatient stays registered in the same DRG per year. This method seems reasonable as LOS distribution is approximately log-normal and "it could lead to a high level of agreement between costs and LOS, identifying the majority of extreme costs" (Freitas et al., 2012, p.3). Outliers account for 2% of total discharges distributed as

[27] `https://meocloud.pt/link/28843095-7089-400d-b320-5a26a6a528b7/Web_Appendix/`

follows: DRG 426 (33.9%), DRG 430 (20.4%), and DRG 425 (13.5%). Approximately 54% of all outliers were registered in eight hospitals.

Considering the average length of stay (ALOS), DRG 430 has the highest ALOS (26.3 days) among the others DRGs (not considering DRG 424 as it is a surgical one — its ALOS amounts to 38.6 days).

Figure A.4, presented in appendix A.2.8, conveys a considerable increase in the ALOS from 1999 to 2000 which is explained not only by a decrease in the number of discharges in 2000 but also due to an increase in the LOS of most DRGs, with exception of DRGs 425, 426, and 428.

The ALOS per hospital range between 4.5 and 70.2 days from 1994 to 2013, respectively. Comparing the ALOS between hospital centers and hospitals *per se*, we can state that around 73.5% of hospital centers have a higher ALOS.

1.3.1.2 Rehospitalisations

Hospital readmissions are defined as multiple inpatient stays within a specified time period by the same patient. They are an important indicator of patient health outcome and healthcare system performance. They are also regarded as an indicator of poor care or lack of coordination of care services. In the US, data from Medicare hospitalisations collected in 2005 shows that 37% of Medicare expenditures concern to inpatient care. Readmissions account for a significant share of this cost: 18% of Medicare patients are readmitted within 30-days of discharge, accounting for $15 billion (Minott, 2008).

Despite shorter stays tend to be more service intensive and more costly *per* day, too short LOS could also cause adverse effects on health outcomes, or reduce the comfort and recovery of the patient. If these outcomes lead to a greater readmission rate, costs per episode of illness may fall only slightly, or even rise (OECD, 2011). Recent research shows that hospital ALOS is positively associated with lower readmission rates (Mark et al., 2013).

In our data we have 27,622 cases of rehospitalisation from 1994 to 2013 and about 64.2% and 12.6% of these rehospitalisations occur in DRGs 430 and 426, respectively. All these cases happen within a year.[28] Nearly 42.8% of all rehospitalisations (corresponding to 11,821 cases) occur within 30 days and 1.3% (347 cases) happen within the same day.

Rehospitalisations registered within the same DRG amount to 21,345 (corresponding to approximately 77.3% of all rehospitalisations). About 74.1% and 10% of these cases are coded as DRGs 430 and 426, respectively. The average time to rehospitalisation amounts to 68.1 days in DRG 430 and 74.8 days in DRG 426. Approximately 21.5% of these rehospitalisations were registered in the last three years — from 2012 to 2013, it increased 6.5%. The ALOS of the first inpatient admission has been decreasing in the last three years, namely between 2011 and 2012 (approximately 16.5%). The same trend is identified for the ALOS of the rehospitalisations, with exception of 2012.

Analysing readmissions,[29] they amount to 9,434 (corresponding to 44.2% of all rehospitalisations within the same DRG). Approximately 51% of these readmissions occur in 10 hospitals.

We identify a pattern in readmissions, which consists in a seven-day peak. This pattern is characterised by having a large number of readmissions in every seven-days.

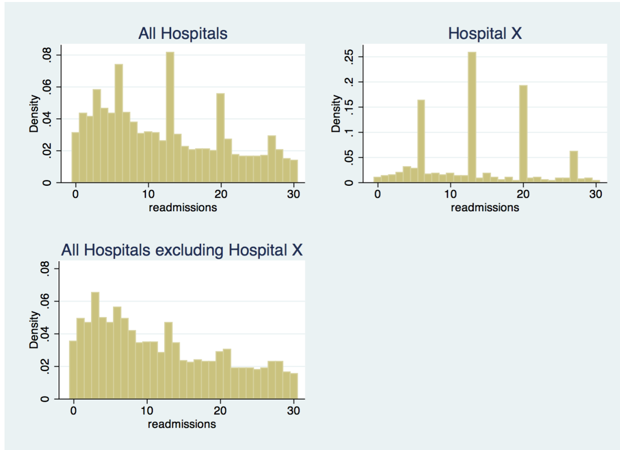
These peaks are in part explained by the readmissions registered in one hospital, which we call Hospital X (Figure 1.1).[30] According to psychiatrists, both the third and fourth peaks are explained by the fact that some patients who receive maintenance electro-convulsive therapy (ECT) need to stay in the hospital for at least one day. However, and excluding from our analysis the readmissions occurred in this hospital, in weeks 3 and 4, we still

[28]The number that identifies each patient is different every year which means that it is possible to have rehospitalisations occurred between years but we are not able to identify them. Only from 2012 onwards we are able to follow the patient between years.

[29]Individuals being rehospitalised within 30 days of last discharge from hospital and registered in the same DRG.

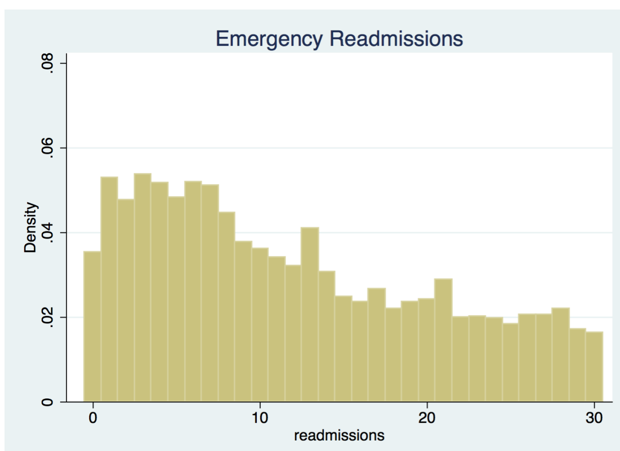
[30]We are not authorised to specify the hospitals' name in our analysis.

Figure 1.1: Histogram – Readmissions



have three peaks — 6, 13, and 21 days.[31] In our dataset, we have a variable that allows us to distinguish between both emergency and non-emergency readmissions. Based on this variable, in Figure 1.2 we present the histogram of emergency readmissions which allows to conclude that the peaks we identified earlier concerns to non-emergency readmissions. The

Figure 1.2: Histogram – Emergency Readmissions



unplanned readmissions amount to 68% of the total readmissions within the same DRG. This means that non-emergency readmissions account for a significant share of the total

[31]We have another peak corresponding to 3 days after the last discharge which cannot be explained by the fact that some patients left the hospital on Friday and were readmitted on next Monday, as the number of these cases is not significant.

readmissions (32%). Regarding the readmissions occurred in days 3, 6, 13, and 21 after last discharge, 50% concerns to planned readmissions.

Comparing the number of readmissions before and after the merge, approximately 77.8% of the hospital centers have a lower number of readmissions when compared to hospitals *per se*. Nevertheless, in the cases in which the hospital centers have a higher number of readmissions, this number is significantly high.

Another important aspect is that nearly 68.1% of the readmissions are registered as episodic mood disorders (39.6%) and schizophrenic psychoses (28.5%). Bodén et al. (2011) identified two potential risk factors for rehospitalisation of people with schizophrenic and schizoaffective disorders: short duration of initial hospitalisation (less than two weeks) and early non-adherence to medication. According to our data, the ALOS of these diagnoses amounts to 27.3 days.

Since readmissions *per se* may not be very informative as we are not taking into consideration the total number of discharges, it is important to analyse the readmission rate. Namely, the 30-day readmission rates after an admission for SMI is considered in the literature as one of the key indicators of mental health quality (OECD and WHO, 2012). This measure is cited as a main undesirable outcome of healthcare systems. Therefore reducing readmission rates should be one of the top strategic priorities (WHO, 2005*a*).

The 30-day readmission rate ranges between 0 and 40% between 1994 and 2013. The DRG 430 has the highest readmission rate among others DRGs with an average of 11%. For all DRGs, we find a negative correlation between the ALOS of 30-day readmission and the readmission rate. Meaning, for longer ALOS we have lower readmission rates. The same evidence was found when considering the first inpatient stays, except for DRGs 425, 429, and 432.[32]

[32] We also considered as first inpatient stays the readmissions occurred in 30-days but registered in a different DRG, and all the readmissions registered in the same DRG above 90 days.

This analysis show that readmissions are main issue in mental health. Thus, it is important to determine the cost of emergency readmissions and determine the potential incentives the current financing mechanism provides.

1.3.1.3 DRG 430 — Psychosis

DRG 430 is the most heterogeneous group within mental health DRGs since it includes different diseases such as schizophrenic disorders, schizoaffective psychoses, and bipolar disorders.

Performing an analysis on the main diagnoses, we can state that approximately 56.5% of these cases, from 1994 to 2013, are registered as episodic mood disorders (25.5%), schizophrenic disorders (18.1%), and anxiety, dissociative and somatoform disorders (12.9%). For this analysis we have comprised the diagnoses into main categories.

Chronic schizophrenia is a severe and disabling disorder. According to the study about Global Costs of Schizophrenia conducted by Knapp, Mangalore and Simon (2004), the impact of schizophrenia on healthcare budgets is considerable, ranging between 1.5% and 3% of total national healthcare expenditures. Because it is a chronic disease its cost tends to persist. The study further reveals that approximately one third to two thirds of the total healthcare cost of schizophrenia is for hospitalisation, even in countries that have already substantially reduced their inpatient care. The authors also bring to attention the costs this disease has in other care organisations and public sector bodies, mainly social service agencies, housing departments, and the criminal justice system. In our dataset, the weight of cases registered as schizophrenic disorders has not been changing over time and its ALOS is 34.6 days.

1.3.1.4 Patient Analysis

The mean age of the patients is forty-nine years and about 58.3% of all patients are women. Costs are not available at a patient level. As mentioned in subsection 1.2.1, price and weight of DRGs are not based on analytical accounting cost. Hence, we use the DRG prices as a proxy of the cost.

To estimate the "cost" per patient, we use all the decree-laws that were in force during the years under analysis. In these decree-laws we have the price of each DRG, which can be assumed as the "cost" of an inpatient stay when the LOS is between an inferior and a superior limit. If the LOS is below the inferior limit, the "cost" is computed by multiplying the LOS by a daily price. When the LOS is above the superior limit, the "cost" is then computed by adding to the DRG price a daily price (which is multiplied by the difference between the superior limit and the LOS). This daily price decreased approximately 34.4% between 2012 and 2013. This was an administrative decision with no explanation.

The "cost" of rehospitalisation is computed by multiplying the LOS by a daily price.[33] The total "cost" amounts to 496,061,211 € from 1994 to 2013. Around 56% of this total "cost" was incurred in the last 7 years (Table 1.1):

Table 1.1: Treatment "cost" per year

Year	"Cost"
2006	31,602,388 €
2007	34,240,380 €
2008	32,939,646 €
2009	35,535,352 €
2010	33,659,596 €
2011	36,778,748 €
2012	37,588,428 €
2013	35,340,496 €

Analysing the "cost" per patient of the outliers, the mean and standard deviation amount to 13,626.5 € and 63,075.7 €, respectively. The sum of this "cost" over all patients is about 56,999,668 € and represents approximately 11.5% of the total cost.[34]

[33] For psychiatric departments, patients who are readmitted within 60 days after discharge are consider a rehospitalisation.

[34] In the appendix A.2.8, Figure A.5 depicts the "cost" per patient split between outliers and non-outliers.

The average "cost" per patient sums up to 2,368.8 € and DRG 430 has the greatest average "cost" (2,769.5 €), excluding DRG 424.

1.3.1.5 Mental Health Complexity

In order to estimate the level of complexity in mental health, I_j, we take the average weights of all discharged patients, multiply the relative weight of each DRG (w_i) by the number of cases in each DRG ($n_{i,j}$) and then divide by the total number of discharges, as follows:

$$I_j = \frac{\sum_i w_i * n_{i,j}}{\sum_i n_{i,j}} \tag{1.3}$$

The higher this index is, the more complex cases we have, and more resources are needed. In our case this index amounts to 1.24. According to Freitas et al. (2012), the increasing complexity "may be the single most important determinant of high LOS outliers" (p.8).

1.4 Methodology

Descriptive statistics give a general overview of the key variables one should take into consideration when designing a new financing model. This analysis *per se* is not sufficient to pursue our aim in analysing the mental health system. A more sophisticated investigation is needed concerning rehospitalisations and services organisation since they are the main issues in a mental health system.

Regarding rehospitalisations, we first analyse treatment outcomes (subsection 1.4.1.1). We describe the method to determine the effect of treating a high number of patients on the quality of medical care. We also investigate if the current financing system is creating unintended consequences on readmissions and estimate the cost of emergency readmissions (subsections 1.4.1.2 and 1.4.1.3, respectively).

As far as services organisation is concerned, and given the recent developments in the Portuguese system,[35] we focus on hospital services organisation and integrated continuous care. Specifically, we discuss if organisation of mental health services should be done with concentration of services in a few hospitals or with several units providing them (subsection 1.4.2.1). We describe the method used to estimate the potential savings that integrated continuous care can bring to NHS (subsection 1.4.2.2).

All the analyses were performed using Stata®12.

1.4.1 Rehospitalisations

1.4.1.1 Treatment Outcomes

Our first variable of interest is the 30-day readmission rate as it can be considered a proxy of the quality of medical care (Fischer et al., 2014). This rate is computed as the ratio between the number of patients admitted to the hospital within 30 days after an inpatient stay and the total number of discharges. It includes all the unplanned readmissions within the same DRG. We exclude from this analysis the planned readmissions since they are usually part of clinically proper care (Horwitz et al., 2011).

Considering we want to assess the volume effect on quality of care, our independent variable of interest is the current total number of discharges by DRG, hospital, and year (*volume*). As covariates we include the hospital characteristics (*cmi*, *beds*, *dp*, *lstay* and *totalcost*).[36]

The relevant equation is:

$$rehosp\_rate_{h,j,t} = \alpha_0 + \alpha_1 * volume_{h,j,t} + \alpha_2 * \chi_{h,t} + \alpha_3 * \zeta_{h,t} + \epsilon_{h,j,t} \tag{1.4}$$

[35] Please see subsection 1.2.3.

[36] In appendix A.2.6 we provide a detail description of each variable.

where h, j and t indexes the hospital, the DRG, and the year, respectively. χ is a vector of hospital characteristics: *cmi*, *beds*, *dp*, *lstay*, and *cost*. ζ is a vector of dummy variables (*dumcmi*, *dumtotcost*, *dumlstay*, *dumdp*, and *dumbeds*) that were created to control the procedure of using 2012' information for the year of 2013 (when no information was available) and for using information of the following year when there was no available information for the remaining years. We estimate the above equation separately for each DRG using time fixed effects.

Because the readmission rate ranges between $[0, 1)$ we decide to use a fractional response model. Particularly, we use a fractional response generalised linear model (fractional probit model), which accommodates the zero values of the dependent variable and also allows for heteroskedasticity (Wooldridge, 2011; Williams, 2016).[37]

To interpret the results we compute the marginal effects. We also estimate equation (1.4) using a non-heteroskedastic model, since Wooldridge (2011) recommends the comparison of the results of average marginal effects between ordinary fractional probit and heteroskedastic fractional probit. If there are some modest differences in the average marginal effects estimated by the two models, we can be almost sure the heteroskedastic model is the appropriate one (Williams, 2016). The comparison *per se* is not sufficient to claim one model is better than the other. We perform a Wald test to determine whether the coefficients in the heteroskedasticity equation are significantly different from zero (Williams, 2016). In cases where we fail to reject the null hypothesis (coefficients are equal to zero), the preferable model is the non-heteroskedastic.

We did not use the Ordinary Least Squares (OLS) method because it predicts impossible values (i.e. values below 0 or above 1), produces non-normal errors, and only provides linear effects (the effect of the explanatory variables tends to be non-linear) (Buis, 2010). We did

[37] We decide to use the probit function since it "leads to computationally simple estimators in the presence of unobserved heterogeneity or endogenous explanatory variables"(Papke and Wooldridge, 2008, p.123).

not consider models such as logit, probit, or heteroskedasticity probit because they do not allow for fractional response variables. Additionally, despite the generalised linear models *per se* can estimate some fractional dependent variables, they do not allow for heteroskedasticity (Williams, 2016). Hence, we opt to use a more flexible model.

1.4.1.2 Financing determinants

Considering how hospitals are being financed in terms of inpatient care,[38] the case-mix index (cmi) and the equivalent patients days are the relevant determinants. In order to determine the variables that may influence rehospitalisations, we use a probit regression model to estimate the following equation:

$$\begin{aligned} dum\_rehosp_{n,h,j,t} &= \alpha_0 + \alpha_1 * volume_{h,t} + \alpha_2 * age_n + \alpha_3 * gender_n \\ &\quad + \alpha_4 * \chi_{h,t} + \alpha_5 * \zeta_{h,t} + \alpha_6 * weight_{j,t} + \epsilon_{n,h,j,t} \end{aligned} \tag{1.5}$$

where n, h, j and t indexes the patient, the hospital, the DRG and the year, respectively. The dum_rehosp is a binary variable such that:

$$dum\_rehosp_{n,h,j,t} = \begin{cases} 1 & \text{if the patient was readmitted in the same DRG within 60 days (unplanned)} \\ 0 & \text{otherwise} \end{cases}$$

Volume is the current total number of discharges by hospital and year. χ and ζ have the same meaning as before. *weight* stands for the relative weight of each DRG code.[39] In this analysis we consider both short-term (less than 30 days) and medium-term rehospitalisations (between 31 and 60 days) as the latter rehospitalisations may reflect the influence of factors beyond inpatient care such as availability of community and family supports (CIHI, 2008).

[38]For further detail see subsection 1.2.1.

[39]This variable can be consider as a proxy of the average relative amount of hospital resources required to treat patients within each DRG category.

In this analysis, we did not consider patients who were discharged in November or December (except if it was a readmission) as we are not able to follow these patients between years.

Another important aspect of the financing system is how it pays mental health rehospitalisations occurred within 60 days after last discharge.[40] Between 1996 and 2013,[41] the daily prices have been changing, and therefore it is important to estimate the impact of these changes on rehospitalisations.[42] Applying the same reasoning as before, but now being the price of rehospitalisation the variable of interest, we perform a probit regression model:

$$\begin{aligned} dum\_rehosp_{n,h,j,t} &= \alpha_0 + \alpha_1 * volume_{h,t} + \alpha_2 * age_n + \alpha_3 * gender_n \\ &\quad + \alpha_4 * \chi_{h,t} + \alpha_5 * \zeta_{h,t} + \alpha_6 * price\_rehosp_t + \epsilon_{n,h,j,t} \end{aligned} \tag{1.6}$$

where the indexes are the same as before. The variable *price_rehosp* is the daily price that is defined by decree-laws.

1.4.1.3 Cost of emergency readmissions

According to physicians, it is common to schedule a consultation between weeks one and two after a patient is discharged (clinical practice guidelines). Rehospitalisations may be due to medication adherence or treatment adjustment patients. Hence, identifying a large number of readmissions between weeks one and two after a patient has been discharged does not mean that we are dealing with unplanned readmissions. To estimate the cost of emergency readmissions, we need to eliminate from the analysis the non-emergency readmissions. In our dataset, and as reported in subsection 1.3.1.2, we are able to disentangle the planned readmissions from the unplanned ones. Assuming that we did not have such variable (which is the case in most datasets), we use an econometric model to estimate planned readmissions.

[40] Please see subsection 1.2.1

[41] In 1994 and 1995 the decree-law does not provide any price for rehospitalisations.

[42] This daily price increased about 3.8% in the last 18 years. The price decreased approximately 13.3% between 2012 and 2013.

We perform such analysis in order to add additional evidence on how one can estimate unplanned readmissions when it is not possible to disentangle both readmissions. Also, we are able to check if our approach estimated well the planned readmissions as we are able to compare the estimated results with the true values of these readmissions.

Since we need to estimate the "excesses" given by the peaks identified in subsection 1.3.1.2, we use a negative binomial regression model. The dependent variable is a discrete variable defined as the number of days between the date of admission and the last discharge (*readmission*).

$$\begin{aligned} readmission_{n,h,j,t} = \alpha_0 + \alpha_1 * age_n + \alpha_2 * gender_n \\ + \alpha_3 * \chi_{h,t} + \alpha_4 * \zeta_{h,t} + \alpha_5 * dumread3 + \alpha_6 * dumread6 \\ + \alpha_7 * dumread13 + \alpha_8 * dumread21 + \epsilon_{n,h,j,t} \end{aligned} \tag{1.7}$$

where n, h, j and t indexes the patient, the hospital, the DRG and year, respectively. χ and ζ have the same meaning as before. *dumread3*, *dumread6*, *dumread13*, and *dumread20* are dummy variables to control for the four peaks (3, 6, 13 and 21) that remain after excluding readmissions occurred in Hospital X in weeks 3 and 4.

After estimating the model, we generate predicted probabilities. We use those predictions to estimate the non-emergency readmissions. To determine the cost of emergency readmissions we drop the observations corresponding to non-emergency cases and use the "cost" per patient computed in subsection 1.3.1.4.

1.4.2 Services Organisation

1.4.2.1 Economies of scale

Our dependent variable is the LOS per episode, hospital, year, and DRG. *Volume* and *volume*^{2} are the independent variables of interest. As covariates we include patient characteristics (*age*, *gender*) and hospital characteristics (*cmi*, *beds*, *dp*, *lstay*, *totalcost*).[43] We perform the regression analysis separately for each DRG since it classifies a patient under a particular group where those assigned are likely to need a similar level of hospital resources for their care.

To compute the scale effect we use a duration model to model the length of time patients spend in the hospital. The model adopted is the conditional risk set model (Box-Steffensmeier and Jones, 2004; Cameron and Trivedi, 2005). We did not use OLS method because it does not account for several specificities of our dataset which influence the results.

Since our dataset consists of discharged patients, the model needs to be an univariate duration model (transition from "sick" to "stable")[44] but with multiple spells (patients may be readmitted). We have recurrent/repeated events, which arises when several events of the same type are registered for each individual. Our dataset only has completed spells since we do not have individuals that stay "sick" (Box-Steffensmeier and Zorn, 2002).[45] Spells for the same individual cannot be considered independent and therefore we need to account for correlated unobservables.

We assume entry into the state being modelled is exogenous, meaning there are no initial conditions problems. Otherwise, the model of survival times in the current state would also have to take into account the differential chances of being found in the current state in the first place (Box-Steffensmeier and Zorn, 2002).

The survival time data is an outflow dataset in which data collection is based on those leaving the state of interest. We also have information on when the spell began. If one has information about the day, month, and year in which a spell began, and also the day, month, and year, at which subjects were last observed — so survival times are measured in days

[43] We also introduce dummy variables to control for the procedure of using 2012 information for the year of 2013 and use information of the following year whenever a gap exists.

[44] We only have a single state.

[45] Our dataset consists on inpatient discharges. This means that the likelihood function is simply the multiplication of the density function from period 1 to N.

— and the typical spell length is months or years, then it is reasonable to treat survival times as observations on a continuous random variable (not grouped). But if spells length is typically only a few days long, then recording it in units of days implies substantial grouping. It would then make sense to use a specification that accounts for the interval censoring. In our data around 18% of all observations regarding DRG 430 (Psychosis) have a duration spell between 1 and 30 days. Therefore, we can use days as unit of the LOS. We assume a continuous model since $\{T = t\}$ is interpreted as an observation from a continuous process, contributing a density function term to the likelihood.

An important issue that we should take care of concerns "tied" survival times — more than one individual in the data set with the same recorded survival time. A relatively high prevalence of ties may indicate that the banding of survival times should be taken into account when choosing the model specification (Box-Steffensmeier and Zorn, 2002; Cleves and StataCorp, 2009).

Overall, the duration model that we have to consider must take into account the following items: continuous time; outflow sample; no time-varying characteristics (explanatory variables are fixed over time and have only cross-section variation); completed spells; recurrent events (multiple spells); correlated unobservables (state dependence); unobserved heterogeneity; and "tied" survival times.

We do not have time-varying characteristics since our control variables are: gender, age, volume and hospital characteristics (which change between years but not within the same year and because we cannot follow a patient between years — due to *id* changes — this is not a concern. These variables are time-invariant within each spell.).

First, we need to understand which model accounts for multiple spells and correlated unobservables. There are two different approaches to deal with recurrent events: the Counting Process (CP) and the Stratified Cox (SC) model (Box-Steffensmeier and Zorn, 2002; Cleves and StataCorp, 2009). In the CP model, different lines of data are treated as independent even though several outcomes are from the same subject. This model uses the standard Cox proportional hazard (PH) method to analyse the data. In the SC model, recurrent events are treated as not identical and the strata are the time interval numbers. Within this model we have three different approaches: Conditional 1, Conditional 2 and Marginal models.

Conditional means that a subject is assumed not to be at risk for a subsequent event until a prior event has occurred. The difference between these two conditional models is the time scale. Specifically, the Conditional 1 approach uses the same data layout as the CP approach, but a SC model is used instead of a standard Cox PH model. In this model, the time until the first event influences the risk of the set for later events. The Conditional 2 model uses a different data layout: the start value is always 0 and the stop value is the time interval length. The time until the first event does not influence the following events since the clock determining who is at risk gets reset to zero after each event.

The Marginal approach uses the standard data layout. It considers each event as a separate process. Time for each event starts at the beginning of follow-up for each subject. There is no start time column but only a stop time column. All subjects are considered to be at risk for all events, regardless of how many events they actually had.

If the order of the events is not important, then we should choose the CP model. Otherwise, we need to decide between the three approaches of the SC model. If the time interval of interest is the time from the study entry then Conditional 1 approach is the correct choice. We should choose the Conditional 2 model if the time interval of interest is the time between two events. If there are different types of events, then we should use the Marginal model.

In our case, the more suitable approach is the Conditional 2 model, as the time a patient stays in the first episode influences the time he stays in the second time, and so on (order matters). What we have seen from the descriptive analysis is that the LOS of the first episode has been decreasing and the number of readmissions within the same DRG has been increasing with a LOS higher when compared to the first episode.

Thus, the appropriate model is the conditional risk set model (variance-correction models) considering elapsed time, where estimates are provided for the effect of covariates on the hazard of the k^{th} event since the beginning of the observation period.

The Cox model is a proportional hazard model, its specification can be written as:

$$h_q(t) = h_{0q}(t) \times e^{X\beta} \tag{1.8}$$

where X is the vector of time-independent covariates (*volume*, *volume*^{2}, *age*, *gender*, *cmi*, *beds*, *dp*, *lstay*, *totalcost*, and the dummy variables) and $h_{0q}(t)$ is the baseline hazard function at time t for a subject in group q. The baseline hazard function describes the risk for individuals with $x_i = 0$, who serve as a reference cell and $exp(X\beta)$ is the relative risk, a proportionate increase or decrease in risk, associated with the set of characteristics x_i. In this model, the coefficients are assumed to be the same, regardless of the group, but the baseline hazard can be group specific. The baseline hazard function can take any shape as a function of t. The only requirement is that $h_{0q}(t) > 0$.

The characterisation of the distribution of time can also be provided by the survival function. This function gives the probability that the event has occurred by duration t. Both hazard and survival functions provide alternative but equivalent characterisation of the distribution of time. There is a mathematical relationship between these two functions. The survival function is the baseline survival function, raised to the power of the exponent of the linear prediction (Clayton, 2012).[46] Thus, the effect of the covariate values on the survivor function is to raise it to a power given by the relative risk $exp(X\beta)$.

Maximum likelihood estimates of β for the above model is obtained by maximizing the partial log-likelihood function:

[46]The exponent of the linear prediction is the hazard ratio for that combination of covariates.

$$logL = \sum_{j=1}^{D} \left[\sum_{i \in D_j} \mathbf{x_i}\beta - d_j log \Big\{ \sum_{k \in R_j} exp(\mathbf{x_k}\beta) \Big\} \right] \tag{1.9}$$

where $\mathbf{x_i}$ is the row vector of covariates mentioned before for the time interval $(t_{0i}, t_i]$ for the i^{th} observation in the dataset $i = 1, ..., N$. j indexes the ordered failure times $t(j)$, $j = 1, ..., D$; D_j is the set of d_j observations that fail at $t(j)$; d_j is the number of failures at $t(j)$; and R_j is the set of observations k that are at risk at time $t(j)$, that is, all k such that $t_{0k} < t(j) \leq t_k$. The estimator $\hat{\beta}$ has been shown to be a consistent estimator for β (Lin, 1994).

To estimate this model we consider the exit rate (event) as a variable that is 1 if the patient leaves the state, and 0 if not. In addition, and in order to build a timeline, we create two variables: one for entry time and other for exit time. To adjust for repetitions and for dependence of spells, we generate a variable that stratifies our data and is based on episode sequences for each patient. Hence, the estimation of the partial log-likelihood function (1.9) is obtained by forming the ordered failure times $t(j)$, the failure sets D_j, and the risk sets R_j, using only those observations within that stratum.
Finally, and in order to account for "tied" events, this model uses the Efron method which takes consideration on how the risk set changes depending on the sequence of tied events (Box-Steffensmeier and Jones, 2004).

There are economies of scale if $exp(X\beta)_{high\_volume} > exp(X\beta)_{low\_volume}$ as the baseline survivor function ranges between 0 and 1. Specifically, to determine if there is a scale effect, we convert the estimation results in number of days by obtaining the adjusted survival curve for low and high volume hospitals for each DRG.[47] This is done by combining the baseline survivor function with the linear prediction of the covariates. It is worth recalling that the adjusted survival at time t is the baseline survival at time t, raised to the power of the

[47]The mean difference between these two curves gives the scale effect measured in number of days.

exponent of the linear prediction.

The difference between these two curves is the predicted value of the variable *volume*. We consider high/low volume hospitals are the ones with a volume greater/less than the median value. To obtain the adjusted survival curve for the high/low volume hospitals we then use the mean volume for each volume group.[48] For the remaining control variables (*age*, *gender* and hospital characteristics) we use their mean value for each DRG.

We estimate the scale effect for each DRG but, because DRG 430 comprises 51% of the total observations, we pay special attention to the results of this DRG.

1.4.2.2 Potential savings for NHS from integrated continuous care

Our approach is to use the DRG dataset to analyse which inpatient stays of patients with SMI are eligible to be transferred to these institutions and compute the potential savings (difference between the current "cost" and the potential "cost" if integrated continuous care units were in place).[49]

First, we analyse the LOS. According to psychiatrists,[50] and based on their clinical expertise, the LOS that on average a patient with SMI needs to stay in the hospital to be stabilised is approximately 24 days (Scenario 1).[51] We claim all inpatient discharges which had a LOS higher than this ALOS could have been transferred to these facilities.

The integrated continuous care cost is computed by multiplying the time that a patient needs to stay in those facilities (the difference between the total LOS and ALOS) by the daily price defined in the decree-law, which amounts to 26.62€.[52] Since we have no information

[48]For robustness purposes we perform this analysis considering different predicted values for *volume* using the percentile 75.

[49]As mentioned before only patients with SMI are eligible for integrated continuous care facilities.

[50]The auhtors would like to thank Ricardo Gusmão from Instituto Nacional de Saúde Pública do Porto and Teresa Reis from Nova Medical School.

[51]This ALOS is very similar to the one we find if we compute the ALOS for SMI patients using our dataset (23.6 days).

[52]This price can be considered as the "cost" of treating a patient in continuous care housing: "Residência de apoio moderado com complemento de unidade sócio-ocupacional". So far, no changes have been made to

on the LOS a patient, on average, needs to stay in integrated care, we assume equal quality of treatment which is reflected in the same LOS, independently where the patient is treated.

As psychiatrists claim that the ALOS for patients with SMI can range between 15 and 30 days we create two additional scenarios based on the lower and upper bound of this interval (Scenarios 2 and 3, respectively).

We perform this analysis for the period between 2011 and 2013. The daily price paid per patient to these units was defined in 2011.

It is worth recalling that these facilities not only aim to support inpatient care but also to provide social integration of individuals with psychosocial disability. In our analysis, we are not considering the benefits from social integration, due to lack of information.

1.5 Results

1.5.1 Rehospitalisations

1.5.1.1 Treatment Outcomes

Table A.4 in appendix A.3.1 presents the estimation results for the model specification (1.4) for each DRG. The results were estimated using the heteroskedastic fractional probit regression, except for DRGs 425 and 432 in which we use the ordinary fractional probit model. According to the Wald tests, we reject the null hypothesis for all DRGs. For DRGs 425 and 432, it was not possible to estimate equation (1.4) using the heteroskedastic fractional probit model since convergence is not achieved.

The variable of interest, *volume*, is statistically significant for all DRGs, except for DRG 432 in which the coefficient is not statistically significant (first column of Table 1.2). *Volume* increases readmission rate suggesting that quality of medical care is affected by the number

the prices stipulated in 2011.

of inpatient discharges. However, the average marginal effects are approximately zero for all DRGs. For DRGs 425, 426, and 430, if we increase the number of inpatient discharges by 100, it will lead to a 2 percentage points increase in the readmission rate. Regarding DRGs 427 and 429, if we increase the number of inpatient discharges by 100, the readmission rate increase by 3 percentage points. For the remaining DRGs, 428 and 431, an increase in the number of inpatient discharges by 100 will lead to a 6 and 14 percentage points increase in the readmission rate, respectively.

Table 1.2: Treatment Outcomes — Average Marginal Effects

	volume	*cmi*
DRG425	0.0002	NS
DRG426	0.0002	-0.0286
DRG427	0.0003	NS
DRG428	0.0006	NS
DRG429	0.0003	-0.0244
DRG430	0.0002	-0.0206*
DRG431	0.0014	0.0424
DRG432	NS	NS

NS: Not statistically significant
*statistically significant at 0.1

On the impact of the remaining covariates, namely complexity of cases *(cmi)*, Table 1.2, second column, presents the average marginal coefficients of this variable. For all DRGs, with the exemption of DRGs 427 and 431, treating more complex cases decrease the readmission rate. For DRG 431, *cmi* was found to be positively associated with readmission rate. The average marginal effects linked to *beds* are approximately zero and not statistically significant.

1.5.1.2 Financing determinants

Tables A.5 and A.6, in appendix A.3.2, present the results for the regression equations (1.5) and (1.6). The first column presents the results for the full model, whereas the second column presents the results of a restricted model, in which the variables that were found not to be statistically significant were recursively eliminated. The results in Table A.5 show patients are more likely to be rehospitalised in DRGs with higher weight and in hospitals with a lower *cmi*. Higher average length of hospital stays increase the probability of patients being readmitted by 0.0054. The remaining control variables bear the expected signs. In particular, patients discharged from small hospitals (small number of beds) or from hospitals with a high number of discharged patients are more likely to be readmitted. However, the magnitude of the marginal effect of *beds* and *volume* is approximately zero.

According to the model specification (1.6), the price of readmissions does not have an impact on the probability of readmissions. The marginal effect is almost zero and it is not statistically significant. As for the remaining variables, the results are similar to the ones obtained in the previous model specification, in terms of both statistical significance and marginal effects.

1.5.1.3 Cost of emergency readmissions

In appendix A.3.3 we present the estimation results of equation (1.7). This regression model is used as a means to determine the planned readmissions.

Plotting the observed proportion of each count and the mean probability for the negative binomial model (Figure A.6 in appendix A.3.3), we can state the negative binomial regression model as reasonable predictions. Using these predictions, we estimate the non-emergency readmissions as follows:

Table 1.3: Non-emergency readmissions

Readmission	Predicted Probability	Frequency	Number of cases	Non-emergency readmissions
3	0.0537896	406	546	140
6	0.057382	433	697	264
13	0.0383559	289	771	482
21	0.0170736	129	253	124

According to our results, the non-emergency readmissions corresponds to approximately

11% of the total readmissions (excluding the readmissions registered in Hospital X in weeks 3 and 4). Also, of the readmissions occurred 3, 6, 13, and 20 days after the last discharge, 43% correspond/concern to planned readmissions.. Comparing these results with the planned readmissions that actually occurred, which represents approximately 50% of the readmissions occurred in the seven-day peaks, we can state that our methodology provides good predictions for the peaks.

Using the estimation results, the total cost of the emergency readmissions is 10,464,023 €. If we consider the unplanned readmissions that effectively occurred, this cost is slightly smaller and amounts to 9,247,645 €.

1.5.2 Services Organisation

1.5.2.1 Economies of Scale

Tables A.9 and A.10 present the estimation results of the conditional risk set model for each DRG (appendix A.3.4.2).

Since we have a quadratic term in our regression model, it is not straightforward to determine if we have a scale effect or not, only by looking at the volume's marginal effects presented in tables A.9 and A.10. Hence, we convert the estimation results in potential days saved using the methodology described in subsection 1.4.2.1.[53] The scale effect ranges between 0 and 6 days (Table 1.4).

For DRGs 427, 430 and 432 we identify a scale effect. DRGs 428 and 429 present zero potential days saved. For the remaining DRGs, we find diseconomies of scale.[54] The results are very similar if we consider the top 25% as the high volume hospitals.

It is worth highlighting the impact of the remaining covariates, namely *beds* and complexity of cases (*cmi*). Table 1.5 presents the marginal effects of both variables. Specifically,

[53]In appendix A.3.4.1 we present the median and pctl75 of the variable *volume* for each DRG.
[54]The results are very similar if we drop the variable $volume^2$.

Table 1.4: Economies of scale — Volume

	# days saved (pctl 50)	# days saved (pctl 75)
DRG425	-0.01	0
DRG426	-0.02	-0.02
DRG427	1.05	1.06
DRG428	0	0
DRG429	0	0.01
DRG430	0.08	0.08
DRG431	-1.1	-1.1
DRG432	6.33	6.33

we present the unexponentiated coefficients (i.e. hazard rates).

Table 1.5: Marginal effects — *beds* and *cmi*

	Marginal effect (*beds*)	Marginal effect (*cmi*)
DRG425	-0.0013	0.426
DRG426	-0.0010	0.392
DRG427	-0.0011	NS
DRG428	-0.0016	-0.319
DRG429	-0.0003	0.361
DRG430	-0.0004	0.528
DRG431	-0.0004	NS
DRG432	NS	NS

NS: Not statistically significant

The coefficient of *beds* is statistically significant for almost all DRGs (except DRG 432). The negative sign indicates that those treated in hospitals with a high number of beds have a lower hazard rate *ceteris paribus* (i.e. lower conditional "stable" rates and hence longer LOS). Regarding *cmi*, the associated coefficients are positive and statistically different from zero for all DRGs, except for 427, 431 and 432. The positive coefficient estimates indicate that patients who are treated in high *cmi* hospitals have a smaller LOS. Only for DRG 428 we find a negative relationship between *cmi* and LOS, suggesting diseconomies of scale.

Based on these results, we can say there is no justification to centralise psychiatric services in high volume hospitals.

1.5.2.2 Inpatient Care and Integrated Continuous Care

The table below (Table 1.6) presents, for the three scenarios, the current "cost" (before transferring) of treating patients eligible to be transferred to integrated continuous care and the potential "cost" if these facilities were in place (after transferring). We also report the number of patients eligible and the ALOS in these healthcare facilities under the three scenarios.

Table 1.6: Potential Savings for NHS of Integrated Continuous Care

	Scenario 1	Scenario 2	Scenario 3
# patients	6,149	11,382	3,978
ALOS_CC	23.03	19.50	27.79
Before transferring			
Cost hospital	24,215,920 €	41,109,184 €	17,085,424 €
After transferring			
Cost hospital	14,002,497 €	21,783,754 €	9,645,127 €
Cost CC	3,770,430.3 €	5,907,430.5 €	2,942,628 €
Total cost	17,772,927.3 €	27,691,184.5 €	12,587,755 €
Potential savings	6,442,992.7 €	13,417,999.5 €	4,497,669 €
% of initial cost	26.6%	32.6%	26.3%

Under these scenarios it is expected potential savings that range between 4,497,669 € and 13,418,000 € (about 26% and 33% of the initial cost, respectively). If continuous care facilities were in place, hospitals would have capacity to treat, on average, 10% to 27% more patients with severe mental disorders per year.

1.6 Discussion

Our results show the number of readmissions has increased in the last three years. This trend can be explained by the fact that the ALOS of both readmissions and first inpatient discharge have been decreasing. According to recent literature on management strategies to reduce psychiatric readmissions (Gaynes et al., 2015), psychiatric hospital stays have become too brief with a negative consequence on the number of readmissions. We conjecture that patients are leaving the hospital not fully recovered. There are several reasons that might explain this result. First, hospitals may be under pressure to discharge patients specially because of lack of beds or shortages of staff (RCPsych, 2009). Second, and according to Gaynes et al. (2015), in order to avoid readmissions, hospitals should render sufficient inpatient care to stabilise the patient's psychiatric status. It should also ensure an adequate discharge plan and the mental health system should provide support services to allow a successful transition from inpatient to outpatient care. In addition, the mental health system ought to deliver an effective outpatient services so that patients remain in the community. Our result might be due to lack of adequate discharge plans and effective community mental health services. To test this conjecture we need information on the number of community mental health units and the geographical area where they provide such services. Having this information we could compare readmissions pattern between hospitals where these units exist and hospitals where they do not.

On the other hand, the current financing mechanism provides incentives for hospitals with a lower *cmi* to increase the number of equivalent patients using rehospitalisations. Although this effect might be related to other DRGs, it exacerbates the problem of recurrent readmissions on psychiatric units. As far as the daily price of rehospitalisations (*price_rehosp*) is concerned, we did not find evidence to sustain the fact that this variable increases the likelihood of subsequent psychiatric admission.

When analysing the readmission rate, we find the number of inpatient discharges increases the readmission rate for all DRGs, except for DRG 432 in which the variable *volume* is not statistically significant. The magnitude of the marginal effect is approximately zero suggesting quality of medical care is not affected by the number of inpatient discharges.

As for the slightly negative effect of treating more complex cases, on average, *cmi*, we put forward the hypothesis this variable is capturing best practices since larger hospitals get sicker and more expensive patients (Morikawa, 2010). According to information provided by psychiatrists about hospitals providing community mental health services (we do not know the extension of these services), we believe this result may also be explained by the fact that hospitals with higher *cmi* provide more community care services than their counterparts. Since in our dataset hospitals that treat, on average, more complex cases are the ones providing mental health home care and have day centers, this fact can be one possible explanation for our finding. According to ACSS (2015), a governmental report on mental healthcare delivery, Portugal still lacks of community care services. The literature has been reporting a positive relationship between readmissions and hospital case-mix index (Frost et al., 2009; Ammar et al., 2013). The rationale is that hospitals with a higher *cmi* are probably dealing with more complex cases, which may result in a higher readmissions rate due its complexity .

Regarding DRG 431, where we find a positive relationship between readmission rate and *cmi* (0.0424), it comprises childhood mental disorders. Two possible reasons can explain this result. First, despite patients ageing 16 and older can be treated in adult psychiatric departments, the paediatric hospitals with childhood and adolescent wards are specialised in treating those disorders, particularly the complex ones. In Portugal there are few units specialised in treating those patients and are inserted in hospitals with higher *cmi*. This result is in line with previous literature. That is, more complex cases are treated in hospitals with higher *cmi* which result in higher readmissions rate. Second, and given that only few units are specialised in treating childhood and adolescent disorders, our result may reflect the weakness of general hospitals with only adult psychiatric wards to effectively treat these disorders, which can possibly increase readmission rate. To validate these two conjectures, we would need to know which hospitals have a specific unit to treat children with psychiatric disorders or have protocols with child psychiatrists to provide care on a regular basis.

As for the remaining control variables, the average marginal effects are very small. Specifically, the number of hospital beds (*beds*) has a negative relationship with readmission rates for almost all DRGs. Despite this result not being statistically significant, it is in line with recent literature. Brown et al. (2014) claim larger hospitals may be able to address strategic issues such as readmissions since they are likely to have more resources.

Overall, treating complex cases plays an important role not only on the likelihood of being readmitted but also on the readmission rate. Combining this fact with our conjecture that patients are leaving the hospital not fully recovered, policy makers should implement measures to reduce unplanned readmissions. To do so, the mental health system should provide enough outpatient resources to allow a successful transition from inpatient to outpatient facilities. In 2012, the US established the Hospital Readmissions Reduction Program (HRRP), which reduced the payment to hospitals with excessive readmissions. These readmissions are determined by a risk-adjusted computation of a hospital's actual readmissions compare to a national benchmark. This program only includes patients with acute myocardial infarction, heart failure, pneumonia, chronic obstructive pulmonary disease, and elective primary total hip and/or total knee replacement. However, and according to McGarry, Blankley and Li (2016), despite readmissions have been decreasing, this decline may not be attributable to HRRP. One of the biggest concerns regard the overall financial impact of this program on hospitals' bottom lines. Reducing readmissions implies hospitals to invest in services that may help prevent readmissions, such as follow-ups and discharge plans. Since these services are not reimbursed and hospitals have less revenues from reduced readmissions, it is not clear if it is cost-effective for hospitals to try and avoid penalties (James, 2013). To overcome this problem, the Centers for Medicaid and Medicare Services provide additional funding for strategies that aim to reduce readmissions such as the Community-based Care Transitions and the Partnership for Patients.

We consider a new mental health financing plan should provide incentives to reduce readmissions. This plan should implement a quality measure, which should be associated with the reduction of DRG prices. Specifically, hospitals should be rewarded for the additional cost/effort involved in raising quality (Busse, Geissler and Quentin, 2011). Specific financial incentives should be provided to hospitals reporting a set of quality information. These financial incentives can be related to DRG prices. Also, the mental health system should promote effective services to improve care transitions from hospital to other settings. Meaning, the financing mechanism should incentivise community care rather than inpatient stays. Community based multidisciplinary teams should also be created and able to provide intensive and highly integrated community mental health services for people with SMI. These multidisciplinary teams should include nurses, psychiatrist, psychologists, occupational therapists, and social workers. According to Gaynes et al. (2015), a long-term approach to reduce readmissions for people with SMI is the Assertive Community Treatment (ACT). This approach was developed in the US and provides treatment, rehabilitation, and support services to patients who are diagnosed with SMI. Most ACT contacts are provided in community settings (Bond et al., 2001). It worth highlighting that community-based services also have impact on patient's outcomes. As Almeida and Killaspy (2011) state, these services provide significant better outcomes on treatment compliance, clinical symptoms, quality of life, housing stability, and vocational rehabilitation.

As far as service organisation is concerned, our results show there is a scale effect for DRGs 427 (Neuroses except depressive), 430 (Psychosis) and 432 (Other mental disorder diagnosis). For DRG 430 the economic magnitude of the scale effect in number of days amounts to 0.08 per year (our temporal unit of reference). This value is rather small to justify the centralisation of psychiatric services in high volume hospitals. For DRGs 427 and 432, we find potential gains of 1 and 6 days if patients were treated in high volume hospitals, respectively. The ALOS of both DRGs 427 and 432 is 14.85 and 7.87 days, respectively. Transferring treatments to high volume hospitals can only bring potential savings of 2.8% for the NHS as these two DRGs account for 5% of total hospital mental health discharges.

For the remaining DRGs, the scale effect is negative suggesting diseconomies of scale.[55] One possible explanation for our findings is that DRG 427 comprises more common and straightforward diagnoses and, consequently, high volume hospitals are more effective in treating these diseases (e.g.: adjustment disorders and obsessive-compulsive disorders). Regarding DRG 432, it includes diagnoses that normally need special treatment such as sleep disorders. These treatments are often provided by high volume hospitals. Therefore, patients with these disorders treated in these facilities need less inpatient care than the ones treated in hospitals with no such treatments.

When deciding on the centralisation of activities in high volume hospitals, policy-makers should not rely only on potential savings. The literature has reported a negative relationship between usage of services and the distance of the patient from the hospital (the so-called *distance decay* effect) (Mungall, 2005). This effect is more pronounced for patients with low incomes, poor access to transport and the elderly and disable. Balancing the potential gains that we find against the arguments on access to care, we conjecture the former argument is not strong enough to justify the centralisation of psychiatric services.

Since inpatient care for mental disorders is indicated specially for people with SMI our results may be reflecting the fact that this type of diseases has on average a length of treatment of 24 days in Portugal, regardless of hospital volume. This value was provided by psychiatrists and is based on their clinical expertise since no formal study was performed on the ALOS of patients with SMI in Portugal. In the literature there are several studies focusing on SMI inpatient ALOS based on evidence from the US. Lee, Rothbard and Noll (2012) found a confidence interval for the ALOS of 10 ± 3 days. However, we need to be cautious when comparing these values across countries. This is due to the fact that inpatient LOS is influenced by the availability of community health services (WHO, 2003*b*) and also

[55] The most prominent result concerns to DRG 431. As this DRG comprises childhood mental disorders, the effect of treating more cases is potentially offset by the fact that we are not considering patients aged 15 or younger.

by the increased pressure to discharge patients earlier (Auffarth et al., 2008). Systema, Burgess and Tansella (2002) found evidence of a shorter LOS in a community-based system than in a hospital-based system. As for Portugal, it has been relying on inpatient care, and community services did not have the desirable development. Meaning, these services were not implemented in the majority of general hospitals that belong to the NHS (Almeida, 2009).[56] Therefore, and since the US is more community-based oriented than Portugal, the results provided by empirical evidence need to be read carefully.

It is worth highlighting that we find economies of scale for hospitals that treat, on average, more complex cases (*cmi*). Specifically, hospitals with higher *cmi* have a smaller LOS. This result may be explained by the same reason we describe in treatment outcomes: larger hospitals treat, on average, more difficult cases (patients are more complex) (Morikawa, 2010), we believe this might be capturing best practices.

We also find diseconomies of scale for larger hospitals (with higher number of beds), which is in line with previous literature (Posnett, 1999). Our results may be reflecting the reorganisation of public infrastructure for healthcare provision which inserted the Portuguese hospitals into common management health units. This reorganisation did not imply a hospital merge but instead only administrative services were merged. In addition, combining this result with the finding that larger hospitals have lower readmission rates, enhances the importance of the LOS. According to Gaynes et al. (2015), one advantage of longer stays is that patients are provided with additional monitoring which increases the likelihood of a patient being stabilised via treatment, reducing the readmissions. On the other hand, and as the authors pointed out, longer stays have disadvantages such as unintended consequences of hospitalisations (infections, job loss). Also, and as mentioned before, longer LOS can imply lack of community health services. Policy-makers aim to “move away from a mental health

[56] One reason is the low funding of general hospitals with community focus (WHO, 2003*b*; Almeida et al., 2015).

system dominated by institutional care alone towards one whereby the main emphasis is on providing care and support within the community" (McDaid and Thornicroft, 2005, p.12). Hence, the LOS should be brief and supported by multidisciplinary teams in the community.

Our results on integrated continuous care show these facilities should be considered as part of the Portuguese mental health system. They serve as a complement to inpatient care as many mental disorders are "better managed by services that adopt a continuing care model" (WHO, 2003*c*, p.48). The ability of inpatient care to help patients with SMI may depend on the availability of comprehensive continuous care services (WHO, 2003*c*). Additionally, and according to the literature, once these services are available, they may help reduce hospital readmissions (Systema, Burgess and Tansella, 2002), and also provide social integration for these patients (Wait and Harding, 2006) which can bring long-term gains.[57] If these facilities were available, hospitals would have the capacity to treat, on average, 10% to 27% more patients with SMI per year. In Portugal, Almeida et al. (2013) estimated a treatment gap (difference between population in need of services and the proportion that actually receives such services) of 33.6% for SMI. This result provides additional grounds to implement such facilities for SMI patients.

According to Porter and Lee (2013), the healthcare delivery system design can improve patient value. Organising care into Integrated Practice Units (IPUs) around patient medical conditions can efficiently maximise the patient's overall outcomes (Porter, 2012). As integrated continuous care facilities are patient-centered and bring together providers and staff who address severe mental disorders, they can improve patient outcomes at both medical care and social integration.

It should be highlighted that the recent governmental report on mental healthcare delivery (ACSS, 2015) identifies as an urgent need the creation of continuous care facilities. It is the

[57]This social integration promotes greater personal autonomy and independence and also employment integration for patients with SMI.

social sector that has been the main provider of psychiatric rehabilitation but it cannot be considered as a substitute for these facilities.[58] Moreover the social sector has been at almost full capacity (ACSS, 2015).

Given the current economic and financial situation, Portugal has launched several reforms in its healthcare sector not only to "introduce more efficiency into the health system" (Barros, 2012*a*, p.10) but also to reduce the costs regarding the NHS. Implementing continuous care facilities could bring potential savings to NHS and should, therefore, be considered by policy-makers.

In terms of the methodology used to determine the unplanned readmissions and its cost, we consider that our approach, the negative binomial regression, is appropriate since it fits quite well the 30-day readmissions distribution. Comparing these results with the real unplanned readmissions,[59] we believe this methodology can be used as a guide to determine unplanned readmissions when it is not possible to distinguish between planned and unplanned.

Comparing the methodology used in determining the scale effects with the main common methods used in the volume-outcome empirical works, mainly the logistic and probit regression models, we believe our approach is the most appropriate because it accommodates the fact that patients may leave the hospital not fully recovered, a very important aspect in mental health (Zhang, Harvey and Andrew, 2011), particularly in our dataset. We must refer that data on hospital characteristics about mental health departments were not available.

Regarding the computation of potential savings, we assume a benchmark with an ALOS for all patients with SMI. As mentioned before, this ALOS is the number of days that a patient with SMI needs to stay at the hospital in order to be stable (which approximately coincides with the ALOS of these patients in our dataset — 23.6 days). The cases in which

[58] The social sector is financed by the Ministry of Labour and Social Security.

[59] As mentioned before, in our dataset we have a variable that distinguish both the planned and unplanned readmissions.

patients may need to stay longer in the hospital are the ones in which patients have comorbidities. The patients considered in the analysis are diagnosed with a SMI. Thus, we believe these patients could have been transferred to an integrated continuous care facility.

It is worth noting that transferring patients to these units will allow the ALOS to decrease mainly in DRG 430 (it comprises 98% of all mental health inpatient discharges whose diagnosis is severe mental disorders). As these cases are treated mostly in high volume hospitals we conjecture that potential scale effects could emerge from integrated continuous care, *ceteris paribus*. After the implementation of integrated continuous care, we suggest scale effects should be reassessed. If the magnitude of the scale effect is sufficiently high, the government should promote the centralisation of inpatient services in high volume hospitals. In this scenario, decentralisation is not affected, as integrated continuous care is provided closer to patients' geographic concentration.

Another important issue is to understand if the current DRG financing mechanism for mental health inpatient care is the right one. This mechanism encourages hospital activity such as more inpatient stays and emergency visits, and also discourages the implementation of a more balanced care (Almeida et al., 2015; CTARSM, 2017; Perelman et al., 2018). In 2009, the WHO compared the optimal mix of services for mental health (WHO pyramid framework (WHO, 2007*b*)) with the Portuguese mental health services structure (WHO, 2009*b*). That comparison clearly showed the Portuguese mental health system relies heavily on hospital settings, community services are underdeveloped, and fragmentation of care occurs. We identify DRG 430 as an heterogeneous code which comprises diagnosis with different ALOS. Like in the UK, an alternative financing mechanism based on clusters can be considered. Each care cluster group people with similar mental health needs and difficulties and also take into consideration the period of care. An algorithm was created to support physicians in accurately allocating patients to clusters. Patients are re-assessed and re-clustered periodically (NHS, 2016). These clusters are then used to pursue the PbR mechanism for commissioning mental healthcare. Hence, we suggest policy-makers should rethink the payment mechanism in order to reflect the different resources needed to treat similar diseases. We should highlight that since 2015, ACSS implemented a new classification system (All Patients Refined DRG) which classifies patients according to their reason of admission, severity of illness and risk of mortality. In this classification, the DRG 430 was disaggregated and some diagnoses such as schizophrenia and bipolar disorders were assigned to a specific DRG. Therefore, despite the mechanism by which the Portuguese hospitals are financed remains the same, this new classification might bring different incentives to mental health inpatient than the ones we found when AP-DRG, version 21, was in place. As future research, we will determine if this new classification system had impact on some of the main key issues of mental health (length of stay and readmissions).

Overall, the Portuguese mental health financing system should create incentives for hospitals to reduce their readmissions rates by introducing a quality measure associated with the reduction of DRG prices. Also, the mental health financing plan should be designed in order to account for the implementation of integrated continuous care and to establish specific multidisciplinary teams. Specifically, the financing mechanism should allocate a significant part of the budget to community care rather than to inpatient care. Providing such facilities and multidisciplinary teams not only will reduce readmissions but also will improve patient outcomes (Almeida, 2009; Almeida and Killaspy, 2011). In terms of organisation, we do not find any advantage in centralise inpatient services and, therefore, the financing system does not need to induce concentration. Also it does not need to accommodate the fact that high volume hospitals could receive proportionally less because they benefit from economies of scale. A single payment value, applicable to all units is adequate.

1.7 Robustness Checks

We estimated the regression model described in subsection 1.4.2.1 using a multiple OLS. In this analysis we create an unique observation for patients who were readmitted within 30 days by adding the LOS of the different admission episodes. The results are different from the ones we obtain using a duration model, as in this case volume is not statistically significant, specifically for DRG 430 (Tables A.11 and A.12 in appendix A.4). Hence, to have a correct view of economies of scale, it is crucial the way data specificities are accommodated by each estimation method.

In terms of efficiency measures, some authors state that one should use the ALOS instead of LOS. The argument is the LOS is influenced by patients' characteristics, but even after controlling for those covariates, there is still unexplained variations in the LOS between hospitals (Cooper et al., 2010). For robustness purposes, we estimated the regression model described in subsection 1.4.2.1, using ALOS as the dependent variable instead of LOS. We opt to use the OLS regression model since in this case the observation unit is the hospital and not the patient. Tables A.13 and A.14 in appendix A.4 present the results of this analysis. We find a scale effect for most DRGs, exception being DRGs 425, 426, and 431. The sign and magnitude of the coefficients are similar to the ones we obtain considering as efficiency measure the LOS.

1.8 Limitations

It is worth highlighting some limitations of our analysis. The first one is related to the fact that we are not able to follow the patients between years in the DRG dataset. Second, we did not analyse the social sector which constitutes an important part of the Portuguese mental health system (financed by the Ministry of Social Security), specially in terms of long term care for patients with SMI. A governmental report on mental healthcare delivery (ACSS, 2015), identified the social sector as the main provider of psychiatric rehabilitation.

Additionally, we were limited to conducting an analysis on outpatient care. The ACSS provided this information, namely the monthly accumulated number of mental health consultations between 2008 and 2013 for all hospital centers (Centros Hospitalares) and local health units (Unidades Locais de Saúde) belonging to the NHS. However, this information is not very informative as we were not able to disentangle the services provided in the community from outpatient consultations. We consider that policy-makers should gather all information on community mental health services provided by hospitals in order to be possible to analyse the impact of these services on inpatient care and also understand the current state of the art.

1.9 Conclusion

Our paper assesses the incentives of a case-mix based funding system in delivering mental healthcare services. Since organisation of services is relevant for the mental health system financing, we determine the existence of a scale effect from concentrating activities in high volume hospitals. This study is performed for Portugal between 1994 and 2013 and uses a DRG dataset. Also, potential savings for NHS from continuous care were computed since these facilities can work as a complement to inpatient care.

The current financing mechanism provides incentives for hospitals treating, on average, less complex cases to increase the number of equivalent patients using rehospitalisations. Despite this result might be related to other DRGs, we believe it exacerbates the problem of recurrent readmissions on psychiatric wards.

We find evidence of a negative relationship between readmission rates and treating more complex cases. Our results also show quality of care, measured by readmissions rate, is not affected by the number of patients treated.

As far as organisation of services is concerned, we find a scale effect for some DRGs, specially DRG 430 which comprises about 51% of total mental health inpatient discharges. Despite this result, the economic magnitude of the scale effects found is rather small and does not justify the centralisation of psychiatric services in high volume hospitals. The potential savings that this centralisation could bring is about 2.8% of the total cost of mental health inpatient care (likely to be smaller than costs of transport and convenience to patients).

We also find potential savings for inpatient care if integrated continuous care was in place that range between 4.5€M and 13.4€M (about 26% and 33% of the initial cost, respectively). Transferring patients to these facilities could allow inpatient care to treat, on average, 10% to 27% more patient with SMI per year. This is an important issue given that 33.6% of the Portuguese population with SMI do not receive treatment (treatment gap).

Our results provide information to the Portuguese policy-makers designing a new mental health financing plan. The focus should be on reduction of readmission by introducing quality measure, on implementation of multidisciplinary teams and on promotion of integrated mental healthcare with concentration of services not being relevant.

Chapter 2

Reforming the Portuguese mental health system: an incentive-based approach[1]

2.1 Introduction

To promote an effective mental health system, the WHO has made several recommendations, namely, a larger involvement of primary healthcare (PHC) in prevention and treatment of mild diseases, community-based care for SMI, more integrated care, better access to care, and less discrimination (WHO, 2009*a*). An evaluation of the Portuguese Mental Health Plan carried out in 2017 stated that Portugal is failing to achieve such recommendations (CTARSM, 2017).

The Portuguese mental health system is essentially centred around inpatient stays and emergency consultations, which consume more than 80% of the resources, coupled with an insufficient provision of community-based services (Almeida et al., 2015). A cross-country

[1]The co-authors of this paper are Pedro Chaves, José Caldas de Almeida and Julian Perelman.

comparison has shown that Portugal is below other European countries in terms of development of community-based mental health centres and mental health teams (Almeida et al., 2015).

These weaknesses are especially worrisome when considering that the prevalence of lifetime mental disorders is above 30% (Almeida et al., 2013), that mental health disorders represent 11.7% of disease-adjusted life years lost, and that Portugal experiences a high prevalence of depression (7.9%), anxiety (16.5%), impulse disorders (3.5%), and substance abuse (1.6%) in comparison with other European countries (Almeida et al., 2013). Several ambitious and evidence-based plans have been proposed over the last decades, but none of them has been able to convincingly tackle these issues. We documented, in a previous contribution (Perelman et al., 2017*b*), that this failure was partly due to the inadequate payment mechanisms of Portuguese mental health care providers, which did not encourage best practices. Among these mechanisms we highlighted the volume-based hospital financing system, which does not encourage the continuity of care or community-based interventions; and the capitation-based model for PHC, which favours long lists and short consultations, completed by a P4P scheme that does not include a single mental health indicator.

Based on this perspective this study designs a new payment model for mental health care providers in Portugal, focusing on the prevention and detection of mental health disorders early in life, on the treatment of moderate depression in PHC, and on the community-based follow-up of SMI. The prevention and detection dimensions were selected as major issues because of the large burden of mental disease in Portugal, in comparison with neighbour countries: for example, the 2017 Global Burden of Disease study indicates that major depressive disorders represented the third cause of years lived with disability in Portugal, 40% than predicted according to the country's socio-demographic context, while it is the fifth cause in Western Europe, 10% higher than predicted (Vos et al., 2017). The second reason for selection was the extreme weakness of mental public health in the country. As mentioned in the 2017 evaluation of the National Mental Health Plan, "so far, Portugal has no integrated strategy for promotion and prevention in mental health" (CTARSM, 2017, p.57). In regard to treatment of moderate depression in PHC, WHO (2011*b*) mentioned that "unless primary care services can treat the large minority of people with anxiety and depression, specialist services will be paralysed due to the demand, unable to focus on people with severe and ongoing needs" (p.9). The same mission observed that "the financing system has created unintentional disincentives to establish community based services, rewarding hospital admissions and medical interventions" (WHO, 2011*b*, p.9). We further detail the rationale for selecting these dimensions as priorities for reforming the payment system.

The remainder of this chapter is as follows. The next section provides the conceptual background of our analysis, which briefly reviews the literature. Section 2.3 presents the methodological approach. Section 2.4 presents the main results from our analysis, which are then discussed in Section 2.5. Section 2.6 provides the limitations of our study. Finally, Section 2.7 concludes.

2.2 Literature Review

In the health economics literature, the physician (the agent) is viewed as making decisions on behalf of the patient (the principal), because he has more knowledge and information about diagnoses and treatments. However, the physician is rarely a perfect agent for the patient because he also cares about his own interests (income, leisure time, reputation, etc.). The physician's objectives of patient well-being and own interest may conflict, which may result in the physician not always making the best decisions for the patient. This agency problem exists because of the impossibility for the patient to adequately monitor the physician's effort and competence due to lack of knowledge and information, and the uncertainty surrounding treatments' outcomes. The fact that patients lack information about their mental health disease and possible treatments is especially acute because of the stigma surrounding these diseases, which inhibits open discussions and information search, while the uncertainty about treatments' effectiveness is greater than in other clinical domains. These difficulties are amplified by the physicians' own lack of information and knowledge for mental health. For example, a focus group with general practitioners (GPs), conducted in the UK, observed that SMI is "too specialised for routine primary care and felt they lacked sufficient skills and knowledge" (Lester, Tritter and Sorohan, 2005, p.2). Payment mechanisms are of particular importance to align physicians' objectives of patient health and own well-being.

All traditional payment mechanisms have advantages and drawbacks. The fixed salary avoids incentives to discriminate against patients but limits the physicians' motivation, introducing a risk of lower quality. FFS motivates physicians to increase the volume of care, but may encourage an excess provision, leading to higher expenditures. Capitation, which reimburses practices on the basis of a list of potential users, promotes efficient use of resources but may lead to selecting the healthiest users, and to under-provision. The bundled payment, which reimburses providers for treating diagnosed patients for a given period regardless of services provided, creates incentives similar to those in capitation, except that it does not encourage the selection of healthy patients because it finances patients with a given disease. Finally, P4P rewards high quality care but may cultivate a practice centred exclusively on indicators, and the selection of patients who are more likely to help attain the targets. Let us mention also that FFS is more trusted by patients than other payment models, because they feel that under FFS physicians put the patients' health and well-being above cost considerations (Kao et al., 1998).

Internationally, alternative reimbursement models have been tested in mental health, with limited success, as shown in Chapter 1. Recalling, in the US, the "Colorado Medicaid Capitation" replaced the traditional FFS system in 1995, which led to a reduction in the use of more complex resource-consuming services and lower expenditures (Bloom et al., 1998), a greater integration of services (Chou et al., 2005), consultations replacing inpatient stays among youths, but no change in prevention (Catalano et al., 2000).

The per case payment system, using DRG, was demonstrated to reduce institutionalisation of SMI (Zechmeister et al., 2002) but increased hospital debts, possibly because of the inadequacy of DRG as a classification system for mental health, which are more oriented to short acute stays than long-term uncertain ones (Knapp et al., 2007*b*). In Austria the creation of specific categories for mental health allowed hospitals to cover their costs while increasing community-based care (Zechmeister et al., 2002).

Finally, in the UK, characterized by an NHS with strong similarities to the Portuguese one, a payment per activity was implemented based on HRG. However, it was observed that this payment model offered few incentives to mental health providers to respond efficiently to mental health needs (Jacobs et al., 2016), so that episode-based payments were introduced, based on Mental Health Clusters. These clusters group patients into 21 categories, according to their needs, and providers are paid a fixed amount for each treatment period according to the patient's cluster. Jacobs et al. (2016) analysed this payment model, showing a high variation between providers in terms of costs, treatments, and lengths of stay within clusters, making the adequate pricing and services of each cluster difficult. These authors concluded that the payment should not be abandoned, as it was the most adequate for mental health treatment, but that clusters should be revised in order to make them more homogeneous.

To summarise, theory suggests using payment systems that combine various reimbursement schemes in order to attenuate their weaknesses, while the evidence is poorly conclusive about which system functions best in mental health. Hence, our proposal is more grounded on theoretical considerations, adopting the following options:

1. When there was evidence that a specific service was a good practice, we opted to encourage it specifically through FFS.

2. Capitation and bundled payments were favoured because they encourage efficiency, continuity of care, and prevention, but we completed these schemes with P4P in order to limit the risk of under-provision.

2.3 Methodology

Our goal is to create payment mechanisms that encourage the evidence-based best practices in mental health, not to define these best practices. This is why we perform a narrative review of the literature, in the four selected domains of action, to identify the best practices with proven effectiveness and cost-effectiveness. The option for a non-systematic review was guided by the fact that best practices have long been identified in systematic reviews, and reported in national and international guidelines, so that a duplication of this task was not deemed necessary.

Thereafter, we elaborate payment mechanisms, which we further present to a large panel of experts in the field, who comment on the proposal and make suggestions. We interview 22 experts with different backgrounds and experience, and from Southern and Northern Portuguese regions. The list of experts includes ten psychiatrists, four hospital managers with an economics background, two psychologists, two nurses, one hospital manager with a health science background, one social assistant, one public health specialist, and one GP. There were 13 men and nine women, and the average experience as professional in the area was 22 years (ranging from 3 to 42) (Table B.1 in appendix B.1).

Our study cannot be considered as a qualitative analysis in a traditional way, which was beyond our scope and competences. However, we proceed in a way that is close to the Delphi technique, with two rounds, as follows. We design an alternative payment model, on the basis of the literature, and then we present it individually, through face-to-face interviews, to the panel of experts, asking them to comment on the model and provide suggestions.

Then, after a first round of interviews, and a collection of highly important and numerous comments and suggestions, we revise our model, which we present it to experts again for their approval, and provide new suggestions and comments, if deem necessary. The consultation rounds occurred between 29 February 2016 and 18 March 2016.

This approach is indeed close to what is generally known as the Delphi technique, although it was not applied in a rigid way, and our objective is more about improving our initial model by obtaining new ideas and measuring its feasibility in the Portuguese context, than to make it fully consensual (contrary to the principle of the Delphi technique, which aims at reaching consensus by way of statistical analysis (Jones and Hunter, 1995)). This is why our paper also does not display results of the expert panel.

The results of the final model, which derive from our literature review and the inputs from experts, are reported.

2.4 Results

We detail here the four dimensions of the proposal, describing the rationale for choosing one as a priority; the type of intervention that we choose to encourage, and why; and the proposed payment mechanism. The final proposals for each dimension are summarised in Table B.2 in appendixB.2.

2.4.1 Prevention early in life

- ***Rationale***

There is vast evidence that early life adversities affect health in the long run (Case, Fertig and Paxson, 2005). This is particularly true for mental health. Kessler et al. (2010) estimate that parental mental health disorders, parental criminality, family violence, and physical or sexual abuse, are all related to a higher likelihood of mental health disorders during childhood, adolescence, and adulthood. Interventions early in life in socially deprived contexts have also been demonstrated to be highly effective in preventing physical and mental illnesses (Muennig et al., 2011).

- ***Intervention***

The Portuguese National Plan for Child and Youth Health (PNSIJ) acknowledges this point, suggesting that it is crucial to evaluate the adaptation to pregnancy, the emotional status of the mother, and psychosocial factors (DGS, 2013). The text mentions, "the assessment of family dynamics should be a concern for the PHC team at each contact with the child/youth/family. During the first year of life, special attention should be devoted to the emotional status of the mother (due to the risk of post-partum depression), referring to the identified cases that may interfere in the child's development" (DGS, 2013, p.12). The plan suggests personalised care for children at risk or special needs, with a higher frequency of consultations, and the possibility of at-home visits. These visits have been proven to be effective in avoiding mental health disorders later in life (Olds et al., 2004; Peacock et al., 2013).

These proposed guidelines seem to represent an adequate response, but their implementation has been limited by the insufficient human resources and by the absence of a clear signal and compensation to PHC teams for whom early prevention of mental health disorders should be a priority.

- ***Payment model***

We propose the creation of a bundled payment to the PHC team for the follow-up of children at risk or with special needs during the two first years of life, with the registration of these children on a central platform, including information/justification for these children being considered at risk or with special needs, on the basis of a diagnosis evaluation grid (CNSM, 2009). The presence of a psychologist available for consultation in PHC practices is also recommended (he/she does not need to be physically present full time, being preferably part of a specialized mental health team).

2.4.2 Early detection of mental health disorders

- ***Rationale***

Kessler et al. (2005) observe, on the basis of a cohort, that half of mental health disorders (Diagnostic and Statistical Manual of Mental Disorders, $4th$ Edition (DSM-IV)) have their onset before 14 years old, and 75% before 24 years old. This study also observe that the median age of onset of anxiety and impulse disorders was 11 years old. However, Burnett-Zeigler et al. (2012) conclude that only a third of adolescents attending a PHC consultation receive a psychological evaluation.

- ***Intervention***

PHC practices are the best setting to tackle this issue. In Portugal, since individuals have easy access to PHC, due to universal coverage, very low co-payments, and wide geographical distribution, the GPs can easily reach children and youth.

Also, the PNSIJ includes guidelines for the evaluation of children and youths, indicating at which ages they must be evaluated and how. Eleven consultations are recommended between the first week and the third year of life, and eight consultations between three and 18 years old. The contents of the mental health evaluation are clearly stated, mentioning affective relationships, behaviours and disorders, life at home, at childcare, and at school, substance abuse, violence, and physical abuse. Guidelines are widely available, but are poorly followed because of GPs' lack of time, and also because the implementation of these guidelines is not clearly signalled and compensated. In practice, the evaluation of children is essentially centred on physical health, while adolescents often do not appear at these vigilance consultations.

- ***Payment model***

We suggest adding an indicator in the P4P scheme for PHC practices, namely the "percentage of users in the key-ages of the PNSIJ who have effectively attended the vigilance consultations, according to the diagnosis evaluation grid".

Given that vigilance consultations are specific services that need to be encouraged, and that mental health evaluation is more time consuming, we suggest the payment of an additional fee to GPs for each follow-up consultation including mental health evaluation, using the diagnosis evaluation grid.

2.4.3 Stepped collaborative model for depression

- ***Rationale***

According to WHO (2011*b*), PHC is the main pillar supporting high-quality mental health care. PHC has the capacity to identify and treat mental health disorders, refer more severe cases to specialists, and carry out prevention and promotion activities. In particular, the treatment of common mental disorders by PHC services has several advantages over the treatment provided by specialized teams in Portugal. Specifically, easier access related to the wide geographical distribution of PHC practices and the very low co-payments, holistic view of the patient, allowing the treatment of co-morbidities, and a more efficient treatment, avoiding the use of more expensive specialized care.

- ***Intervention***

According to Gilbody et al. (2006), there is strong evidence that the intervention of PHC in the treatment of depression is effective and cost-effective. We therefore opt to focus on this disease as a priority, which may be extended later to other mental health diseases. The collaborative stepped care model has been demonstrated to be an effective response for the treatment of depression. Thirty-seven studies measured this effectiveness, showing improvements in terms of patient adherence to treatment, quality of life, and depression outcomes (Mitchell et al., 2013). The model has been implemented differently in various places, namely in the UK (NICE, 2009), the Netherlands (Franx et al., 2012), the US (Bartels, Gill and Naslund, 2015), and Chile (Araya et al., 2003).

Based on the international experience, we suggest the implementation of a model in four stages:

- 1^{st} stage: Depression diagnosis in PHC, using a pre-defined symptoms grid (e.g., Patient Health Questionnaire, PHQ-9), by a GP or a nurse.

- 2^{nd} stage: Treatment of mild depression in PHC, on the basis of self-help, cognitive-behavioural therapy, and physical exercise, by a specialised mental health worker.

- 3^{rd} stage: Treatment of moderate depression in PHC, on the basis of medication, psychological interventions, and social support, by a GP or psychologist.

- 4^{th} stage: Treatment of severe, atypical, or psychotic depression, or with suicide risk, on the basis of medication, complex psychological interventions, and combined treatments, by a specialised mental health team including a psychiatrist.

The current payment scheme for PHC does not, however, provide incentives for their involvement in mental health care. The capitation payment favours long patient lists, and thus leads to excess referral and overloading, and short consultations, which are not appropriate for mental health therapies; finally, the P4P scheme does not include a single indicator related to mental health.

- ***Payment model***

Following Miller et al. (2017), we propose the inclusion of the following indicator in the P4P scheme for PHC: "proportion of users with depression whose condition has been diagnosed with PHQ-9 and treatment has been initiated in the adequate phase of the collaborative stepped care model".

We also suggest nominating a reference GP in the PHC team and a reference psychiatrist in the specialised mental health team of catchment area, to enhance the collaboration between primary and specialised care. We suggest the payment of a fixed monthly fee to compensate these physicians for the extra work. The availability of psychologists in PHC practices should also be considered.

2.4.4 Integrated community-based care for SMI patients

- ***Rationale***

There is substantial evidence suggesting better outcomes for SMI when treated in the community, while inpatient stays are associated with poorer health outcomes and risk of readmissions (Knapp et al., 1995). Despite this evidence, there are few community-based mental health teams in Portugal, while the current hospital financing model is volume-based, favouring more frequent consultations and inpatient stays.

- ***Intervention***

The model to be favoured is that of community-based mental health teams, which are expected to improve access to care because of their proximity to patients' homes and lower stigma; to improve reinsertion because the community-based setting allows better contacts with social care, families, and employers; to improve follow-up, which leads to better health outcomes and efficiency through reducing inpatient stays and emergency visits.

- ***Payment model***

We suggest the implementation of a per period payment, according to which the hospital receives an annual payment for each patient registered with SMI, covering all healthcare services.

The rules for the payment attribution are the following:

- Diagnosed with SMI according to the ICD-9-CM: 292 (drug-induced mental disorders), 295 (schizophrenic psychosis), 296 (affective psychosis), 297 (delusional disorders), or 298 (non-organic psychosis).
- The number and type of patients are contracted at the beginning of the year, with the payment being attributed according to this estimated volume.
- The payment covers all SMI-related services, namely inpatient stays, day care, medications, consultations, lab tests, and exams.
- The payment does not cover the non-acute treatment phase, i.e., long-term care services.

Also, the participation in the new payment scheme is conditional on the following:

- The payment is attributed to the mental health department, which has full autonomy and responsibility in managing funds, being the residual claimant.
- The mental health department disposes of community-based mental health teams, with protocols with PHC practices, residential units, patients and families associations, rehabilitation units, nursing homes, social services, and local authorities.

Also, the payment includes a P4P component:

- A bonus (resp. penalty) for the hospitals in the lowest (resp. highest) decile of the distribution in terms of inpatient stays.
- A bonus (resp. penalty) for the hospitals in the lowest (resp. highest) decile of the distribution in terms of post-discharge consultations up to 30 days after discharge.
- A budget penalty in case the hospital does not contribute and update a national registry of SMI, specifically created within this new payment model.

Finally, we suggest an implementation phase of this new payment scheme, in order to smooth the adaptation, collect new data, and evaluate its impact.

The implementation should be limited to three hospitals in year 1, six hospitals in year 2, and nine hospitals in year 3. The selection of hospitals for this pilot phase should be made using a random sampling method, from the universe of Portuguese NHS hospitals with a mental health department from the Lisbon, Coimbra, and Porto regions, where most patients are treated. We suggest selecting three hospitals used as “treatment group”, and three others as “control group”. Then, the same process will be replicated for the three following in year 2, and for the three last in year 3.

In their first implementation year, we suggest a 25% higher bundled payment, in order to favour the necessary changes in structures and teams. During the first three years, data will be collected on resource use, pathologies, and functionality, in order to refine the payment value and their risk-adjustment for functionality. Afterwards, the new payment model and its values will be designed, and the implementation will be extended to all the hospitals belonging to the Portuguese NHS.

2.5 Discussion

This paper proposes an innovative payment model for the Portuguese public mental health system. This system departs from the hypothesis that failures of previous plans, which have been largely highlighted in recent national and international evaluations (WHO, 2011*b*; CTARSM, 2017), are the result of the neglecting of implementation processes, especially in ensuring that suggested guidelines are properly financed and motivated. This is why in this project we focus on a payment model, as a means to implement best practices in mental health.

Much has been written about the influence of payment models on healthcare providers' practices (Rice, 2006; Ettner, Schoenbaum and Williams, 2012). Surprisingly, only few studies have addressed the impact of reimbursement schemes in mental health. This is why the proposal was mainly based on theoretical and empirical studies not specifically oriented towards mental health, validated by mental health experts. This resulted in the view that all payments have serious limitations, so that "payment innovations that blend elements of fee-for-service, capitation, and case rates can preserve the advantages and attenuate the disadvantages of each" (Robinson, 2001, p.150). In other terms, it appears clearly that blended payments are the most promising option, combining several advantages of various payment schemes, in order to diminish their adverse effects. In the meantime, we selected the areas and types of interventions that best correspond to the current weaknesses of the Portuguese mental health system, and for which there was more evidence.

This proposal needs to be tested in practice, to confirm whether the expected benefits will materialize in practice, and not be compromised by unexpected adverse effects. It should be highlighted that preliminary meetings have taken place at the ACSS, the Portuguese institution that defines and implements the financing of NHS healthcare providers, in order to implement pilot projects following our recommendations. This is a promising step because these pilot projects include a close evaluation of their effectiveness and cost-effectiveness. Thus, we will be able, in the following months, to produce outcomes that we expect to be useful for Portugal and for other mental health systems facing similar difficulties.

As our proposal is largely centred around implementing new financing mechanisms for mental health providers, a major issue is its sustainability, in a country marked by a relatively low GDP per capita compared to other European countries, and tight public health budgets.

Some of our suggestions are neutral from a budget viewpoint, as they merely redistribute money from low performers to high performers, in the case of P4P (dimensions 1, 2, and 3), or redistribute the money paid on the basis of volume into per-patient payments (dimension 4).

However, in dimension 1 we propose a bundled payment to the PHC team for the follow-up of children at risk or with special needs during the first two years of life; in dimension 2, we suggest the payment of an additional fee to GPs for each follow-up consultation; and in dimension 3 the payment of a fixed monthly fee to compensate these physicians for the extra work, respectively. Considering an estimated number of 4,722 children at risk and prices of each type of consultations, the annual budget impact of dimension 1 may vary between 1.3 and 2.4 million euros. Considering 1,964,862 children in the ages for the follow-up consultations, and a fee of 15 euros per consultation, the annual budget impact of dimension 2 would be of 29.5 million euros. Finally, considering the 857 primary care centres and 110 hospitals, and a monthly fee of 124 euros to GPs and specialists, the annual budget impact of dimension 3 would be of 1.2 million euros. In other terms, the budget impact of the proposal would be of 33.1 million euros per year, that is, 0.36% of the total public health expenditures (9,130 million euros in 2017).

Note, however, that providers' payment mechanisms are only one among other possible instruments to promote best practices in mental health, so that it should be accompanied by investments in community-based care facilities, continuous training and support for GPs, a greater autonomy for primary care and mental health department managers, and the reinforcement of primary care teams with psychologists. These investments also require an increasing awareness on the part of the population and decision-makers about the burden of mental health disease, which financing models cannot achieve.

2.6 Limitations

Our proposal suffers from some limitations that should be mentioned. First, the proposal was presented to and validated by only a limited group of experts, selected by convenience. If, as expected, the project creates interest in policy-makers for its implementation in practice, we suggest diffusing the proposal through formal channels, and opening a period for public discussion.

Second, there is a vast literature on the effects of payment schemes on physicians' practices, which inspired our model, but the literature is scarce on the empirical testing of their impact, and even much scarcer in the field of mental health. This is why we also suggest implementing the model progressively, in order to measure its effects carefully, before expanding it to the whole country.

Finally, we must repeat that all payment schemes have their weaknesses, and even combining various models through blended formulas may not succeed in mitigating them. In particular, we propose to use in some way the P4P in all dimensions, which might be associated with excessive focus on incentivised indicators, crowding-out intrinsic motivation, or cheating on performance reporting (Doran, Maurer and Ryan, 2017). Although the evidence is ambiguous for these adverse effects, they may be considered in the implementation process, through limiting the weight of the P4P in the physician remuneration.

2.7 Conclusion

The Portuguese mental health system suffers from various weaknesses, and has failed to implement WHO recommendations on best practices. This failure is largely related to inadequate payment and incentives to providers. To overcome this problem, we design an alternative payment model for primary care and hospitals on the basis of the literature and experts' consultation.

The model focuses on prevention and detection of diseases early in life, stepped care collaborative model for depression, and community-based care for SMI. This alternative financing model for mental healthcare providers, aimed at incentivising best practices, is expected to contribute to a better quality of all mental health financing systems that are facing the same challenges as the Portuguese one.

Chapter 3

Direct treatment costs of Serious Mental Illnesses among adults and their determinants: the Portuguese National Health Service[1]

3.1 Introduction

For people with SMI, defined according to their duration and impact on the disability (Bachrach, 1988), evidence suggests that community-based care (e.g.: community-based rehabilitation and mobile crisis teams) should be available and inpatient stays should be consider as a last resort since evidence points to better outcomes when patients are treated by community services instead of inpatient treatment (Thornicroft and Tansella, 2003; WHO, 2007*b*). Also, treating patients with SMI implies a strong coordination between services and continuity care. It is important for patients with SMI that mental health services guarantee

[1]The co-author of this paper is Julian Perelman.

the coordination of different services such as social, psychological, and medical, as patients with mental health disorders find it difficult to access several essential services (Thornicroft and Tansella, 2003). Therefore, mental health services should avoid fragmentation of care (Funk and Pathare, 2003). Several countries such as the UK, the US, and Canada have been shifting their mental health services to a more community-based system in which inpatient care, based in general hospitals, is the last resort (Drake and Latimer, 2012; MHT, 2016). This transition should be carefully planned, however, since the lack of community services may increase problems of marginalization and homelessness, which occurred in the US (Raphael and Stoll, 2013).

Recently, and as already mentioned, Portugal has been discussing how mental health services should be organised and how the financing mechanism can help achieve good practices. Currently, the Portuguese health system relies heavily on a NHS, and mental health disorders are mostly treated at NHS hospitals (Almeida, 2018). Hospitals receive an annual budget calculated on the basis of expected complexity adjusted activity, using DRGs (for a detailed description of the financing system please see Chapter 1, subsection 1.2.1). However, the current financing mechanism encourages hospital activity such as more inpatient stays and emergency visits, and also discourages the implementation of a more balanced care (Almeida et al., 2015; CTARSM, 2017; Perelman et al., 2018). In 2009, the WHO compared the optimal mix of services for mental health (WHO pyramid framework (WHO, 2007*b*)) with the Portuguese mental health services structure (WHO, 2009*b*). That comparison clearly showed that the Portuguese mental health system relies heavily on hospital settings, that community services are underdeveloped, and that the fragmentation of care occurs.

In order to favour greater continuity and coordination of care, to promote prevention, and make inpatient care less profitable in favour of more efficient care (e.g. community), a new mechanism based on a per patient disease-related payment has been proposed to finance the treatment of patients with SMI (Perelman et al., 2018). To implement the payment scheme, cost measurement is needed in order to define a fair payment to compensate costs and reduce the risk of patient selection and under provision. Measuring direct treatment costs for the Portuguese NHS is important because Portugal is a country with a low Gross Domestic Product (GDP) per capita within the European context, and tight public health budgets, especially for mental health, which imperatively calls for careful attention to resource allocation. Decision-making about resource allocation (e.g., through economic evaluations) requires sound evidence about mental health costs. Our paper seeks to fill in the lack of evidence in this field. The main goal is to assess the direct cost of treating SMI in psychiatric wards and determine its main drivers in the Portuguese NHS.

The remainder of the chapter is as follows. The next section 3.2 presents the dataset used throughout our analysis and a descriptive statistics, while the methodological approach is described in section 3.3. Section 3.4 presents the main results from our analysis, which are then discussed in section 3.5. Sections 3.6 and 3.7 present the limitations of our work and suggestions for future research, respectively. Finally, section 3.8 concludes.

3.2 Data

Our data was collected between 1^{st} of September 2014 and 31^{st} of August 2015 from a convenience sample of three public hospitals: one psychiatric hospital located in Lisbon (Centro Hospitalar Psiquiátrico de Lisboa (CHPL)) and two general hospitals located in Lisbon and Porto (Centro Hospitalar de Lisboa Ocidental (CHLO) and Centro Hospital de São João (CHSJ), respectively). In 2015, these hospitals accounted for 13% of all inpatient discharges in the NHS.

The data was collected through revision of paper registries at CHLO, by psychiatrists, and using electronic databases at CHSJ and CHPL, by psychiatrists and administrative staff. At CHLO, despite the diagnoses were already codified, psychiatrists had to review the paper registries since the electronic databases did not contain all the interventions performed per patient. The data collection was approved by the hospital boards and Ethical Committees, and the data collection process was designed in close collaboration with hospital and mental health department boards.

The data comprises all patients diagnosed with an SMI, during the acute phase of disease, aged 18 or older and who received any treatment during the period under analysis. We used the ICD-9-CM to select the patients with an SMI: 291, alcohol-induced mental disorders; 292, drug-induced mental disorders; 295, schizophrenic disorders; 296, affective disorders; 297, delusional disorders; and 298, non-organic psychosis. In appendix C.1 we provide a list of the 3-digit codes considered in our analysis. We follow the definition of Bachrach (1988), who suggests that people with chronic mental disorders can be defined according to their diagnosis, disability, and duration of their diseases. If a patient was diagnosed with more than one SMI diagnostic procedure, we considered the most recent one.

Note that some diagnoses were not included, on the basis of the Bachrach (1988) definition, which might be considered as SMI by some authors. This is the case, for example, of ICD 294, which includes organic psychosis such as dementias and amnestic disorders that were not classified in other ICD-9 codes. Regarding people suffering from dementia, they have specific programs and are followed by other medical specialities (neurology, internal medicine, geropsychiatry, etc). Only a minority of these cases are followed in Psychiatry's outpatient settings. This is also the case of patients coded with ICD 299 (pervasive developmental disorders), who are followed in specific centres that treat such disorders.

Our dataset included six patients who died during the period under analysis. We dropped those observations since the cause of death could not be directly related to mental health. The total number of patients amounted to 2,928. The total number of resources provided by the three hospitals during the year under analysis was 30,532.

3.2.1 Cost measurement

The dataset contains information on all resources provided by the hospitals on outpatient and community settings, day care and emergency ward. We also have information on inpatient stays such as the length of stay and the DRG. Information on the year in which patients started to be followed by the hospital is also available. The dataset comprises information on patients' characteristics such as age and gender. Data on level of education, employment status, and degree of disability were provided only by one hospital and, therefore, we disregarded this information.

Unit costs are not available at a patient level. The best proxy to evaluate the unit cost of resources provided to patients with SMI is the official tariffs that are stipulated by decree-law. It should be highlighted that these tariffs are not based on analytical costs. They have an historical origin with subsequent adjustments being made *ad-hoc* to the external researcher, and are used as prices in hospital financing.

More specifically, and regarding inpatient care, we use the DRG prices, which are stipulated by decree-law. Between 2014 and 2015 those prices changed and, therefore, we use the decree-laws number 20/2014 and 234/2015 for discharges occurred in 2014 and 2015, respectively. For the remaining types of care, that is, community and emergency services, outpatient care and all the resources provided on those settings, the official tariffs did not change during the year under analysis. It should be highlighted that there is no official tariff for day care. The only thing that is paid is all the services and resources provided in this setting.

Finally, the medication administered in the hospital setting is fully supported by the hospital. Hence, the medications cost was provided by hospitals.

3.2.2 Descriptive Statistics

About 74% of the patients in our dataset were diagnosed with schizophrenic psychosis (ICD 295) or affective disorders (ICD 296) as presented in Table C.2 in appendix C.1.1. Given the residual number of patients recorded with alcohol-induced disorder (ICD 291), we did not consider those observations in our analysis.

Outpatient care and emergency services represented about 42.5% and 32% of the total services provided. Inpatient care accounted for 3.4% of the total services (Figure C.1 in appendix C.1.1).

The average length of stay amounted to 21.7 days and 15% of total inpatient stays regarded readmissions. The average number of consultations per patient was 4.4. Concerning individual information, 59% of the patients are male and the mean age is 49 years old.

3.3 Methodology

To analyse the main drivers of the costs we estimate the following equation for each ICD-9-CM:

$$cost_{i,j} = \beta_0 + \beta_1 age_i + \beta_2 gender_i + \beta_3 treat\_phase_i + \alpha_h + \epsilon_{j,i} \tag{3.1}$$

where i, j, and h stand for patient level, ICD-9-CM code, and hospital level, respectively. Gender is a dummy variable that is 1 if male and 0 if female. The treatment phase is also a dummy variable that assumes the value 1 if patients have been followed for more than 3 years by the hospital, and 0 otherwise. We included this variable as a potential cost driver since evidence suggests that treatment costs can vary according to phase of care and stage of disease (Jo, 2014).

Equation (3.1) was estimated using a generalised linear model (GLM), with gamma distribution and *log* link function. We have controlled for hospital fixed effects (α_h). We chose the gamma distribution because our dependent variable is strongly skewed to the left. Having said that, we did not use the OLS because it will lead to less precise estimates of the means and marginal effects. This method does not produce robust results to tail problems unless for large samples (Cameron and Trivedi, 2005), which is not our case. Since GLM allows to specify a distribution that reflects the mean-variance relationship and a link function that can handle linearity in the sense of no systematic misfit, we opted to use such regression model (Cameron and Trivedi, 2005). We use the statistical software Stata®13 to perform this analysis.

3.4 Results

3.4.1 Direct treatment costs

Schizophrenic psychosis and delusional disorders are the most costly diseases, €1,577 and €1,493, respectively. The cost of treating a patient with non-organic psychosis amounts to €933, which is the least expensive disorder (Table C.3 in appendix C.2.1).

The average cost per patient of treating patients with SMI amounts to €1,289. The most costly resources were the day center (services and resources provided in such setting) and inpatient care (Table C.4 in appendix C.2.1).

The density function of the cost considering all ICD-9-CM was heavily skewed and the extreme values concerned patients who had longer inpatient stays, several readmissions, and were administered with second generation of antipsychotics in outpatient settings (Figure D.5 in appendix C.2.1).

3.4.2 Cost determinants

The cost per patient decreased with age in all ICD-9-CM, with the exception of drug-induced mental disorders (ICD 292) (Table (C.5) in appendix C.2.2). Being male increased the cost of schizophrenic psychosis (ICD 295) and of affective disorders (ICD 296). On the other hand, a female patient is more costly than a male patient when the diagnosis was one of the following: drug-induced mental disorders (ICD 292), delusional disorders (ICD 297), and non-organic psychosis (ICD 298).

The treatment phase was not statistically significantly linked to cost for the diagnoses ICD 295 and ICD 297. The treatment for patients diagnosed with delusional disorders or non-organic psychosis and followed by the hospital for more than three years was more costly compared to patients who have been followed for less than three years. Regarding drug-induced mental disorders, the initial treatment phase was more costly.

3.5 Discussion

The average yearly cost of treating SMI in the Portuguese NHS is €1,289. Schizophrenic psychosis (ICD 295) and delusional disorders (ICD 297) were more costly than the remaining SMI, amounting to €1,577 and €1,493, respectively. Although inpatient care accounted for only 3.4% of the total services, its cost per diagnosis represented more than 50% of total cost.

Age was negatively related to cost in almost all diagnosis. Male patients were more costly when diagnosed with schizophrenia psychosis and affective disorders. Female patients experienced higher costs when diagnosed with drug-induced mental disorders, delusional disorders, and non-organic disorders. Finally, the treatment phase (i.e. for patients treated for more than 3 years) was positively related to cost for affective disorders and non-organic psychosis.

The cost could not be directly compared to earlier evidence as most studies considered both direct and indirect costs, and presented results only for the burden of disease, which combines costs with prevalence (Insel, 2008; Gustavsson et al., 2011; Neil et al., 2014). However, and for schizophrenia, a recent study determined the direct treatment cost of disease for various European countries. The authors reported an annual cost per patient that ranged between €3,211 in Poland and €13,704 in the Netherlands (Kovács et al., 2018). Compared to this international evidence, the values for Portugal are quite low (€1,577). This may be explained by two factors. On the one hand, we used the prices that are paid by the NHS, and not the real costs supported by hospitals; in a context of recognized under-financing (EC, 2019), these prices may be very low, compared to those practices elsewhere. On the other hand, also due to under-financing, NHS hospitals have suffered severe financial difficulties, with high levels of debts and arrears (EC, 2019). This may have prompted hospitals to cut in resource use, which our study likely reflects. This reduction might have consequences on the quality of care, which we did not assess and was beyond the scope of the study.

Regarding other diseases, as studies generally report mental health disorders aggregated into broader categories, this imposes an additional challenge for comparison (Gustavsson et al., 2011). However, and based on international evidence, there are other chronic conditions with higher direct treatment costs when compared to SMI. For example, in the US, Williams et al. (2011) compared the direct treatment cost of bipolar disease with other chronic conditions, and found that diabetes and coronary artery disease were more costly.

Regarding cost drivers, individual characteristics play an important role. Given that many adult mental health disorders begin in adolescence (Jones, 2013) and preventive interventions have the capacity to generate economic benefits when compared to interventions later in life (Australia, 2016), we conjecture that treatment costs are higher early in life because they have an additional component regarding prevention. In contrast, for drug-induced mental disorders, the treatment cost varies positively with age. On one hand, the use of cannabis, which may induce SMI such as bipolar disorders with psychotic features, occurs at young ages (Bally, Zullino and Aubry, 2014; Carrà et al., 2014; Gibbs et al., 2015); on the other hand, however, some mental health consequences of substance abuse, such as severe depression, usually occur later in life, explaining the higher needs (Ganzini, Walsh and Millar, 1993).

Treating male patients with schizophrenic psychosis or affective disorders (bipolar disorder and depression) is more costly when compared to female patients with the same diagnosis. Evidence from the literature points out that incidence of schizophrenia is higher in men, and that they usually suffer more negative symptoms (Ochoa et al., 2012). Evidence suggests in this sense that "until menopause illness onset is delayed and severity of illness is reduced by oestrogen on the level of gene expression and transmitter functioning" (Häfner, 2003, p.1). Regarding bipolar disorder, the literature shows that men with bipolar disorder present more obsessions/compulsions and suicidality than women, while women present more weight gain and insomnia (Goel, Terman and Terman, 2002). Hence, the cost of treating affective disorders may be higher for men given the more severe symptoms when compared to women. Another hypothesis is that men tend to recognise their mental health condition with greater difficulty, or face a greater perceived stigma, with a subsequent delay in searching for care. There is evidence, for example, that men have a significantly lower use of any mental health treatment (Wang et al., 2005; Roy-Byrne et al., 2009), so that they access treatment at a more severe stage of disease.

Regarding drug-induced mental disorders, despite these diseases being more prevalent in men (Almeida et al., 2013), women experience greater risk of depression and histories of abuse when compared to men (Caton et al., 2014). This fact may explain the higher cost of treating female patients diagnosed with drug-induced mental disorders. Delusional disorders are more prevalent among women (Soyka, Zingg and Baumgärtner, 2011), and no gender differences were found in the prevalence of non-organic psychoses (Petkari, Mayoral and Moreno-Küstner, 2017); however, we did not find any evidence that severity, needs, or healthcare use are higher among women, probably related to the very scarce literature on these issues.

Our results also show that patients who are being treated for affective disorders or non-organic psychosis for more than three years are more costly compared to patients in the initial treatment phase. There are two main treatments for affective disorders: medication and psychotherapy. The former plays an important role in the prescribed treatment. However, the high rate of non-adherence to psychotropic medication (Bulloch and Patten, 2010) may lead to treatment adjustments, which possibly translate into a more costly treatment over time. We must highlight that patients can recover from these disorders with the appropriate long-term treatment (Muneer, 2013). Non-organic psychosis is a very comprehensive category, which allows physicians to avoid making specific diagnoses straight away. Also, diagnoses are likely to change according to the changes in symptoms and relapses (Chaturvedi and Sahu, 1986). Therefore, the specific diagnosis may likely be identified later, which can explain the higher cost for patients followed for a longer period.

Additionally, and from a more general perspective, that the way services are organised plays an important role on the treatment cost (Funk and Pathare, 2003). Since Portugal strongly relies on inpatient care, and community services are underdeveloped and continuity of care is weakly promoted (Almeida, 2009), costs may be higher than those that would be observed if balanced care model was implemented and continuity of care promoted. This is particularly likely to hold in the Portuguese case because of the high number of mental health readmissions (Chapter 1).

Note finally that we did not consider the role of social and private sectors because the scope of our work is to determine the direct treatment costs of SMI in its acute phase, under the NHS perspective. However, it is worth highlighting the important role of the social sector for providing rehabilitation and continuing care (WHO, 2009*b*).

3.6 Limitations

First and foremost, we only considered a convenience sample of three hospitals, which were not totally representative of all NHS practices, using a limited number of variables for a limited period of time. This was problematic especially because the sample was too small to evaluate alcohol-induced mental disorders, which were less prevalent. Also, and being located in urban areas and being quite similar in terms of dimension, our analysis may not reflect the practices of smaller and rural settings. It was beyond our material possibilities to perform a data collection in a larger sample of settings that would be more representative of the NHS mental health practices. Further research, which would require more means and greater support from public and/or private institutions, should replicate the study on a larger scale, for a longer time period, and with a broader data collection scope. Note, however that despite not being representative of all NHS hospitals, these three hospitals accounted for 13% of all inpatient discharges in 2015.

Second, the resource valuation was based on official tariffs rather than on analytical costs. As mentioned above, unit costs are not available and official tariffs were the best proxy. Stated differently, we based our estimates on NHS prices paid to hospitals, which may under- or over-estimate true costs. A close monitoring of hospital activities should be performed in order to check which services are incentivized or de-incentivized when a per-patient payment is implemented, in order to verify which of these services are over- or under-paid.

Third, we followed patients over one year, which is a relatively short time frame. However, we were able to collect information on new patients and patients followed by the hospital over many years. We were therefore able to collect heterogeneous types of treatment. We must also highlight that, in this analysis, we considered patients with SMI in their acute phase only.

Finally, more research should be performed on the disability and socio-economic cost drivers. The data collection protocol included data on socio-demographic (level of education and employment status) and clinical (degree of disability) characteristics. Unfortunately, only one hospital was able to provide this information on a useful scale, so we could not use this information in multivariate analysis, due to the high proportion of missing data. Consequently, and as further research, we aim to collect additional information to refine our analysis.

3.7 Further Research

In 2018, and following our financing proposal (Perelman et al., 2018), ACSS implemented a pilot study in which a per period payment was introduced, according to which the hospital receives an annual payment for each patient registered with SMI, covering all healthcare services. Only five hospitals entered in this study: CHLO, Hospital Magalhães Lemos, Centro Hospitalar Universitário de Coimbra, CHSJ, and Hospital Espírito Santo de Évora. The selection criteria was the availability of community services. The price paid per patient was computed using our data but without controlling for possible risk factors. Specifically, the prices that were used to pay for schizophrenic psychosis, affective disorders and non-organic psychosis amounted to €1,519, €1,035, and €799, respectively.

So far, no study has evaluated this pilot study. Therefore, we proposed to ACSS to evaluate this study in order to assess if the prices correctly cover the treatment cost of those diagnoses and also if this new financing mechanism improved community-based mental health teams, "which are expected to improve access to care because of their proximity to patients' homes and lower stigma; to improve reinsertion because the community-based setting allows better contacts with social care, families, and employers; to improve follow-up, which leads to better health outcomes and efficiency through reducing inpatient stays and emergency visits" (Perelman et al., 2018, p.7).

3.8 Conclusion

Our paper assesses the direct treatment costs of SMI and its determinants in the Portuguese NHS. We found that schizophrenic disorders are the most costly disease. Age, gender, and treatment phase play important roles as cost determinants.

As Portugal is a country with a low GDP per capita among other European countries and with tight public health budgets, especially for mental health, effective resource allocation is crucial. Decisions on this allocation, which can be done through economic evaluations or cost-effectiveness programmes, require clear evidence about mental health costs.

Since Portugal is currently discussing a new mental health financing plan based on a per patient disease-related payment to finance the treatment of patients with SMI, our cost determinants' analysis provides a rationale to introduce risk adjustment measures when defining a new payment scheme. Finally, direct treatment costs were substantially lower that those observed in other European countries, possibly related to under-financing and cuts in resource use, with possible consequences on the quality of care, which remains to be evaluated.

Part II

Adherence to Psychotropic Medication

Chapter 4

Non-adherence to psychotropic medication in Primary Care: the role of socio-economic determinants

4.1 Introduction

Psychotropic drugs are medications that aim to improve an individual's mood, emotions and behavior. They play a central role in the treatment of mental health disorders along with psychotherapies (Kovess et al., 2004). Over the past years, an increase in utilisation of psychotropic drugs has been reported. In the US, Moore and Mattison (2017) found one in six American adults filled one or more prescriptions for psychiatric drugs, namely, antidepressants, antipsychotics, anxiolytics, hypnotics and sedatives (AHS). In Australia, the antipsychotic and sedative dispensing increased by 85.2% and 26.4% between 2010 and 2011, respectively (Stephenson, Karanges and McGregor, 2013). Regarding European countries, Kovess et al. (2004) reported a mild-increase in consumption of antidepressants from 2000 to 2002. More recent studies found an increase of 6.8% per year between 1998 and 2010 in psychotropic prescriptions in England (Ilyas and Moncrieff, 2012). In Portugal, Matias et al. (2015) reported an increasing trend in utilisation of psychotropic medication from 2003 to 2009 and a downward trend from 2010 onwards. The most prominent result of this study is the extremely high utilisation of AHS. The authors found that, in 2012, approximately 12.5% of the population, on average, receives daily treatment with these drugs.

Patients with mental health disorders can improve their health status by adhering to the prescribed treatment. Treatment non-adherence can be defined as "failure to enter in a treatment programme, premature termination of therapy and incomplete implementation of instructions (including prescriptions)"(Nosé et al., 2003, p.197). Despite treatment non-adherence being a challenge in all fields of medicine, it is a matter of particular importance in mental health. Psychiatric disorders have the highest percentage of patients who do not comply with the treatment (20-50% of any patient population is at least partially non-adherent compared to 70-80% of patients with schizophrenia and related psychotic disorders). Several reasons can explain this difference such as lack of insight of the disease, namely for SMI patients, and frequency of treatment-related side-effects (Nosé et al., 2003). Also, socio-economic factors have been pointed out as important determinants of non-adherence (Lesén, 2011; Sundell et al., 2013).

Non-adherence to psychotropic drugs has been reported as a public health issue (Farooq and Naeem, 2014) but it also has important implications in economic terms. Not adhering to the prescribed treatment may result on decompensation of patients with mental illnesses. In fact, patients with SMI who do not adhere to the treatment are more likely to be (re)hospitalised with more severe symptoms and, normally, with longer inpatient stays (Dilla, Ciudad and Alvarez, 2013). A systematic review on economic costs of medication non-adherence by disease groups, reports an annual adjusted total cost per mental health patient between $3,252 and $19,363 (Cutler et al., 2018).

Mental health patients are not treated only by psychiatrists and other mental health professionals but also by primary care physicians. Primary health services play an important role in delivering mental health care (Clatney, MacDonald and Shah, 2008). According to WHO (2007*a*), providing mental health services in primary care involves not only diagnosing and treating people with mental illnesses but also providing follow-up consultations and strategies to prevent mental health disorders. In addition, primary care is a crucial component in most of the collaborative care models (CCMs) for mental health (Goodrich et al., 2013). These models provide integrated mental health and general medical care in primary care units. Jacob et al. (2012) and Woltmann et al. (2012) found evidence on cost-efficiency of CCMs to improve health outcomes for several mental health disorders considering different primary care settings and population study.

Most of mild-to- moderate mental disorders are treated in primary care. Only when patient's problem is too complex, the GP should refer to a primary care mental health provider, or directly to secondary care (Kravitz et al., 2006). Consequently, patient's non-adherence to psychotropic treatment is an issue that is faced not only by psychiatrists and other mental health professionals but also by GPs.

Portugal is one of the European's countries with the highest prevalence of mental health disorders (22.9% compared to 18.4% and 14.9% in France and the Netherlands, respectively) (Almeida et al., 2013). Due to the financial crisis of 2008, prevalence of mental health disorders, namely the severe ones, increased (Almeida, Antunes and Silva, 2016) and socio-economic conditions deteriorated (Pedroso, 2014). Primary care settings have been recognised by the government as a cornerstone of the Portuguese mental health system. However, there are important features on primary care services that make treatment non-adherence even a more serious problem. First, and according to the National Health Plan for 2011-2016, the treatment of mental health disorders in primary care has mainly been relying on prescription of psychotropic medication (Miguel and Sá, 2010). This characteristic is itself a problem since the literature has been reporting the importance of psychotherapies provided in primary care to treat patients with mental health illnesses, particularly, depression (Cuijpers et al., 2009). Second, there are no incentives for GPs to provide continuous care for people with mental disorders (Perelman et al., 2017*a*). If patients are not monitored in a continuous basis, they might not fulfil with the prescribed treatment (Mert et al., 2015).

This chapter assesses the link between treatment non-adherence to psychotropic medication in primary care and socio-economic factors in central region of Portugal, which comprises approximately 17% of all the Portuguese population (ARS Alentejo et al., 2016). This region is very heterogeneous as it comprises urban and rural municipalities with distinct socio-economic characteristics.

We have data on electronic prescriptions and dispensing of psychotropic medication between 2009 and first semester of 2015. We define non-adherence when patients do not fill the prescriptions. We perform this analysis at a municipality level as we do not have individual information on socio-economic characteristics. We add to our dataset socio-economic variables such as the number of physicians per 10,000 inhabitants, percentage of beneficiaries of social benefits and unemployment rate. Since our dependent variable is a proportion, meaning it is bounded between zero and one, we use a fractional probit model (Papke and Wooldridge, 2008) to estimate the impact of socio-economic variables on the percentage of patients who did not adhere to the prescribed treatment. We perform the same analysis for specific pharmacological subgroups such as AHS and antidepressants since Portugal has the highest prevalence of depression among European countries.

We find that between the first six months of 2015 and 2009 the non-adherence rates were about 8.5% and 23.7%, respectively. AHS and antidepressants were the pharmacological subgroups with higher average non-adherence rate, amounting to 19.9% and 22.5%, respectively. Our results show an increase of 1 percentage point in the percentage of beneficiaries of social benefits and unemployment rate has a positive impact on non-adherence rate of 1.5 and 1.1 percentage points, respectively. Younger individuals are less adherent. The number of physicians and average wage are negatively associated with non-adherence rate.

Our results are capturing the effect of adverse economic conditions on non-adherence rate to psychotropic medication. There are two particular groups within the population which are more vulnerable: the unemployed and welfare recipients. These findings call for policies to promote employment and to support welfare recipients combined with integration of mental health. Within those groups, the youth are the most vulnerable. We believe policies focusing on unemployment benefits should not be discarded since they can improve mental health status and may allow individuals to afford medication. Integrating mental health in the benefit system is also of great importance. We suggest the implementation of an additional co-payment for welfare recipients and unemployed, given special attention to the youth. Also, and given the high non-adherence rate, these findings call for coordinated strategies to enhance adherence and promote mental health. Strategies to tackle non-adherence can range from psychosocial and cognitive interventions to electronic reminders or family interventions. Based on the literature, the success of these strategies will depend on the degree of involvement of GPs in the treatment process (Thompson and McCabe, 2012). Hence, GPs should be incentivised to treat mental health disorders and monitor mental health patients on a regular basis.

The remainder of the chapter is as follows. The next section reviews the literature on treatment non-adherence. Section 4.3 briefly provides an overview on the Portuguese prescription drug system. Section 4.4 presents the dataset used throughout our analysis and a descriptive statistics, while the methodological approach is described in section 4.5. Section 4.6 presents the main results from our analysis, which are then discussed in section 4.7. Section 4.8 and 4.9 provide the robustness checks and suggestions for future research, respectively. Finally, section 4.10 concludes.

4.2 Literature Review

4.2.1 Definition of adherence

Non-adherence with medication is a complex problem affecting most of health care systems. However, it is important to clarify the concept of adherence. "Adherence" and "compliance" are terms related to the extent in which patients follow the prescribed treatment. As Hugtenburg et al. (2013) reported, these terms are used interchangeably but their meaning is slightly different. The difference relies on the relationship between the patient and the health care provider. Compliance was defined by Blackwell (1992) as "the extent to which a person's behaviour in terms of taking medications, following diets or executing lifestyle changes coincides with medical or health advice". In other words, compliance is used when patients follow the recommendations of the practitioner. On the other hand, adherence implies a more proactive role of the health care provider in the "compliance with recommendations made in a therapeutic relationship" (Breen and Thornhill, 1998, p.459). The literature has been using patient compliance and adherence as synonyms (Hugtenburg et al., 2013). However, in recent years, authors prefer to use "treatment adherence" rather than "treatment compliance" since the latter term has been linked to the idea that patients are subservient to health providers (Hugtenburg et al., 2013). In this study we use adherence to refer to patients' compliance to the prescribed medication.

4.2.2 Treatment non-adherence

The body of literature on treatment non-adherence is vast and has different approaches. Some authors focus their analysis on identifying the causes and consequences of patient's non-adherence to the prescribed treatment. Others analyse the prevention side.

The reasons for non-adherence are related to patient-, practitioner-, and/or medication-specific factors. Examples such as a complex treatment plan, lack of communication between patient and physician, patient's belief that treatment is not necessary, and patient's inability to follow the treatment due to its costs may explain non-adherence (Jimmy and Jose, 2011; Hugtenburg et al., 2013; Farooq and Naeem, 2014).

The consequences of non-adherence go beyond patient's poor outcomes. It is expected that costs increase for the health care system and also for the society. According to Iuga and McGuire (2014), poor health outcomes increase services utilisation, and consequently health care costs. It is estimated the avoidable health care costs due to medication non-adherence among patients with hypercholesterolemia, hypertension, diabetes type 2, osteoporosis, HIV, and congestive heart failure in the US amounts to $105 billion (Aitken, Valkova et al., 2013) in 2012, about 3.9% of the total health care costs. This estimation was performed by comparing the difference between health care utilisation costs of patients with complications due to treatment non-adherence and patients with the same disease who did not have any complication. In addition, non-adherence's phenomenon has important consequences on productivity and absenteeism (Iuga and McGuire, 2014).

Several prevention guidelines have been proposed to prevent non-adherence. Among them, we highlight patient counselling, family support, reminders, simplify medication prescription and availability of team based care (Jimmy and Jose, 2011; Iuga and McGuire, 2014). But before adopting any of these measures, the practitioner should understand the causes of non-adherence. Only by recognising such reasons, an effective strategy can be implemented (Iuga and McGuire, 2014).

To perform studies on treatment non-adherence, it is crucial to know how to assess adherence to medication. Depending on the available information, there are direct and indirect measurements. The former comprises direct observation, and drug levels and markers (Iuga and McGuire, 2014). To what concerns indirect measurements, there are specific measures used in research and administrative settings such as Medication Possession Ratio (MPR) which is the ratio between the total days supplied and the number of days between the first and last refill; and the Proportion of Days Covered (PDC) which considers the number of days in refill interval (Iuga and McGuire, 2014). Regarding inpatient settings, pill counting, technology-assisted monitoring, self and interviewer rating measures and dose counting device are some of the indirect measurement tools (Iuga and McGuire, 2014; Sajatovic et al., 2010).

There are some issues that we have to take into account when selecting the adherence's measurement (Sajatovic et al., 2010). First, the relationship between adherence and patient's outcome should be considered. That is, if we are studying pharmacological classes in which the effects of missed doses can only be assessed several weeks after discontinuation, we do not need a frequently measure of adherence. On the other hand, if we are analysing drugs such that a missed dose have an immediately impact on patient's outcome than a regular measure for adherence is required. Also researchers have to balance between costs of measure adherence and its precision. Finally, Sajatovic et al. (2010) suggest to combine complementary adherence measurements.

It is worth mentioning that non-adherence can be classified into the following three types: a primary type, known as non-fulfilment adherence or primary non-adherence, in which practitioners prescribe medication but patients never fill or initiate the treatment; a second type, named persistence, refers to event when patients discontinue the treatment when health providers did not tell to do so; and a third type, known as non-conforming, and happens when patients do not take the medication as prescribed (e.g. skipping doses; take medication at incorrect times) (Jimmy and Jose, 2011).

4.2.3 Treatment non-adherence in Mental Health

Non-adherence is common in all fields of medicine but it takes special relevance in mental health. According to Breen and Thornhill (1998), between 20% and 50% of any patient population is likely to be partially non-adherent. In the treatment of psychotic disorders this percentage can be as high as 70% or 80%. In primary care, non-adherence can reach 60% for patients diagnosed with depression.

As mentioned above, and also for mental health disorders, there are three main reasons for non-adherence: medication-, patient- and provider-specific factors. Regarding medication-specific factors, antipsychotic and antidepressants medications induce one or more adverse effects. Breen and Thornhill (1998) provide a detailed discussion on the possible side effects that can occur with psychiatric medication, explaining why they might induce non-adherence. But briefly, most of the adverse effects, such as sedation, impaired sexual functioning and acute dystonia, have a large impact on patient's daily routine.

In addition, the cost of psychotropic medicines and complex medication regimens have also been pointed out as inducing non-adherence. Most of the second generation antipsychotics are costly and patients may be unable to afford the prescribed medication. As reported by Breen and Thornhill (1998), in South Carolina (US), low income patients have medications that exceed 25% of the mental health disability income. Moreover, and given the fact the US has a health care system based on insurance coverage, patients who require multiple medications, can exceed the limits set by their health care insurance.

Mental health patients, particularly the ones suffering from a SMI, can be prescribed with more than one medication to treat a single disorder. Regimen complexity such as higher dosing frequency and complicated instructions can increase the probability of non-adherence (Haddad, Brain and Scott, 2014).

Age, psychiatric symptoms, abnormal illness behavior (AIB) and family/patient attitudes have been cited by Breen and Thornhill (1998) as patient-specific factors for non-adherence. A qualitative review performed by Jin et al. (2008) shows, depending on the disease, elderly patients can be more compliant than younger ones. More specifically, the rate of non-adherence for antidepressants and anxiolytics decrease with age (Bulloch and Patten, 2010). On the other hand, there is a positive relationship between non-adherence and age for patients with schizophrenia (Eticha et al., 2015).

The nature of psychiatric disorders also plays an important role on non-adherence. As mentioned by Breen and Thornhill (1998), a patient diagnosed with psychosis may not have the ability to understand a medication complex regimen. AIB is characterised by “the persistence of an inappropriate or maladaptive mode of perceiving, evaluating or acting in relation to one’s own state of health” (Pilowsky, 1993, p.62) despite the fact that a physician has provided a precise explanation of the disease. In psychiatric disorders, AIB affects adherence namely when patients are in denial of illness in maniac states or when they refuse to accept the diagnosis, commonly in personality disorders (Pilowsky, 1993).

In psychiatric disorders, family and patient attitudes towards the disease have an important impact on adherence. According to Breen and Thornhill (1998) some family members tend to react to visible adverse effects of medication and may discourage patient to take it. Furthermore, the degree of family support is also an important determinant. Patients with a high family support tend to be more adherent than the ones with less or even without such support (Perkins, 2002).

Patients may become non-adherent to the prescribed treatment if their views about the disease are not in line with the practitioner’s own view (Breen and Thornhill, 1998). In addition, communication between physicians and patients has also been pointed out as a practitioner-specific factor. If physicians are not available to answer to all the questions a patient or his family might have or/and if he does not provide all the information about possible side-effects, patients are more likely to be non-adherent (Breen and Thornhill, 1998).

There is a vast literature on strategies to increase adherence among patients with mental health disorders. For instance, Haddad, Brain and Scott (2014) suggest patients should be aware of the side-effects when starting medication and practitioners, whenever possible, should simplify the treatment regimen. Involving the patient on the decision of their medication can increase the likelihood of adherence. In addition, there are several psychosocial interventions, which should be combined to increase effectiveness, such as psycho-education (patients are provided with more information about their disease), behavioural approaches (it comprises "skills building, practising activities, behavioural modelling, and reinforcement strategies" (Haddad, Brain and Scott, 2014, p.53)) and cognitive interventions (it includes neurocognitive remediation). Services interventions, in which mental health care providers ensure patients can easily access the clinical services, and electronic reminders are also possible strategies that can improve adherence (Haddad, Brain and Scott, 2014).

The studies that assess the degree and main drivers of non-adherence to psychotropic medication are different in terms of design and adherence measures. Using prescription data, Sundell et al. (2013) assess the socio-economic factors that influence early discontinuation of antidepressant treatment in Swedish patients aged 20-34 years. Early discontinuation was defined as filling only one antidepressant prescription within a 6-month period. The authors found that approximately 26.1% of all patients discontinued the treatment early. Using a multiple logistic regression analysis, it was found that being an immigrant, receiving social assistance and being a men increases the likelihood of early discontinuation. On the other hand, having at least two years of higher education was found to have a negative relationship with early discontinuation.

Also in Sweden, Mårdby et al. (2016) describe the adherence pattern of antidepressants among women and men using trajectory models. A prescribed drug dataset was used and it includes patients aged between 18 and 85 years old who were followed for two years. To estimate adherence, the authors use a continuous measure of medication acquisition which is the ratio between the number of days' supply and the number of days in the observation period. The adherence pattern was determined using a group-based trajectory models. These models use "finite mixture models to identify clusters of individuals who have similar pattern of progression over time" (Mårdby et al., 2016, p.1383). It was found five different patterns: a first pattern where women and men were adherent to the prescribed treatment during two years of follow-up (women: 28.6%; men: 27%); a second in which patients were adherent up to six months from the date of first purchase (women: 16.6%; men: 16.3%); a third group which had an initial period of low adherence but after month 10, the adherence increased (women: 14.5%; men: 14.3%); in trajectory 4 there is a steep decline in the adherence pattern until patients drop the treatment in month 10 (women: 29.4%; men: 31.2%); and, finally, in trajectory 5 (women: 11%; men: 11.1%) patients were not adherent from the first month after purchasing the antidepressant. Patients with lower education, on welfare/social assistance, and unemployed have a higher probability of developing a non-adherent pattern. The authors claim the need to intervene during the first few months of antidepressant treatment. Specifically, both women and men with lower education or income should be capable to develop and maintain an adherence pattern over time. Finally, and given the high proportion of individuals belonging to trajectories that describe early discontinuation, the authors conclude additional support to patients in the early stages of the treatment could enhance adherence.

Freccero et al. (2016) provides evidence on primary-adherence to prescribed antidepressants in primary health care facilities in Stockholm and middle part of Sweden. Authors linked data from prescription and dispensing of antidepressants between 2005 and 2007. Non-adherence rate was defined as a collection of a prescription within 30 days. A total of 11,624 patients were included in the analysis. Primary non-adherence to antidepressants amounted to 14.9%. Using logistic regressions they found that immigrants, younger and divorced patients had a lower primary adherence. Income, gender, education, and diagnosis were not statistically significant.

Braunstein et al. (2017) study adherence of older patients to antidepressant medications. Adherence was measured in several ways: proportion of days covered, discontinuation periods, persistence treatment and dose dispensed. Authors also combined those measures using a mixed clustering method in order to obtain clusters with similar individuals but with different characteristics. To conduct this study, the authors use the French National Health Insurance reimbursement database from 2010 to 2011 in which they include individuals with more than 65 years old. The authors follow the individuals during 18 months, and based on the clustering analysis, they found five distinct groups. The first group, which represents 26.9% of all patients, were fully adherent according to the clinical guidelines. A second group, amounting to 15.8%, was adherent but had several periods of discontinuation. The remaining groups, representing 57.3%, were non-adherent to the treatment and their differences were related to dispensing frequency and treatment discontinuation. Several hypotheses have been put forward to explain non-adherence such as possible side-effects, patients not consulting their physicians to renew their prescription and possible inefficacy of antidepressants. Based on clustering analysis, it was found patients who frequently attended to medical appointments were more likely to adhere to the prescribed treatment.

In Canada, Bulloch and Patten (2010) estimate the degree of non-adherence for the general population. Using the Canadian Community Health Survey of 2002, which was carried out to produce population-based estimates on non-adherence, it was found that, among all individuals, about 34.6% were non-adherent to antipsychotics, 34.7% to sedative-hypnotics, 38.1% to anxiolytics, 44.9% to mood stabilizers, and 45.9% to antidepressants. Age was found to have a negative relationship with non-adherence. In addition, educational status, rural/urban residence, employment status and income were not statistical significant.

In the US, a recent study assesses the risk of discontinuation of long-acting injectable (LAI) antipsychotics for schizophrenia and the relationship between discontinuation rates and socio-demographic variables (McCreath et al., 2017). The dataset refers to ambulatory services provided by a large general hospital mental health center. It includes patients aged between 18 and 81 years who received at least one LAI from January, 2014 to October, 2015. Patients were followed until September, 2016. The authors assume a patient is not adherent to treatment if he did not receive additional injections after October, 2015. To evaluate the risk of discontinuation, it was performed a hazard analysis for single-decrement, non-repeatable events. From this analysis, it was found that the highest proportion of discontinuation happened within 16- and 19-month interval. To determine the relationship between discontinuation rate and socio-demographic variables, it was used χ^2 tests. The authors did not find significant effects of patient's age, gender and race in continuation rates. On the other hand, prescribed frequency (twice a month, monthly, and multiple) was found relevant in explaining continuation rates. Patients who received monthly injections have higher adherence rates than those receiving biweekly injections. One possible explanation may be related to the time commitment of attending to more frequent injections.

Most of the literature only presents the relationship between non-adherence rate and socio-economic conditions for a specific disease and uses subjects sampled from clinical settings. Only Canada presented estimates of non-adherence rates to psychotropic medication but they are based on self-reported adherence and dated 2002.

Having information on prescription and dispensing of all psychotropic medication for approximately seven years (2009 to June 2015) we are able to provide a pattern of non-adherence rates and relate it to socio-economic characteristics. Our analysis allows to perform comparisons between major pharmacological subgroups. Therefore, this study provides information that could be used for any future attempts to enhance adherence. Also, and being Portugal one of the countries with the highest prevalence of mental health disorders it is crucial to know the rate of non-adherence to psychotropic medication and its link to socio-economic conditions. Moreover, and due to the financial crisis of 2008, the Portuguese socio-economic determinants have been changing throughout the years.

4.3 The Portuguese prescription drug system

The Portuguese prescription drug system has been changing over the last years. Until 2011, electronic and manual prescriptions coexist in the Portuguese NHS. That is, physicians were allowed to use both type of prescriptions. Also, during this period, electronic prescription was not paperless. That is, in order for a patient to fill the prescribed medication, the physician needed to print and sign the prescription.

In 2011, the financial assistance program for Portugal and the associated Memorandum of Understanding (MoU) imposed changes to the pharmaceutical market. Regarding prescription, the MoU required a compulsory electronic prescription system. It was also demanded an improvement of the monitoring system of prescription of medicines. In addition, and in order to provide clear rules for the prescription patterns, the MoU required the adoption of international prescription guidelines (Barros, 2012*b*). Therefore, in 2011, the government made electronic prescriptions mandatory. There are some exemptions such as failure of the system, prescription in a domiciliary setting and for physicians with a volume of prescriptions of at most 50 prescriptions per month.

In Portugal, prescriptions can be renewable (no more than three times) for long-term treatments, in which psychotropic medication is included. Renewable and single prescriptions are valid for six months and 30 days from the date on the prescription, respectively. It it worth highlighting that, before 2011, a single prescription was valid only for 20 days.[1]

The prescription rules are determined by decree-law. In the same prescription, a physician can only prescribe a maximum of four distinct medicines of a total of four packages. For the same medicine only, at most, two packages can be prescribed. Regarding single-dose drugs, physicians cannot prescribe more than four packages of the same medicine. Until

[1] The decree-law 242-B/2006 established the due date of 20 days for single prescriptions, as before 2006 they were valid for 10 days. The ordinance 193/2011 established the current due date of 30 days.

2016, patients did not have the option to fractionate the dispensing, even if they buy only one of the prescribed drugs, as the prescription become invalid.

According to an official report issued by the Ministry of Health, in the last six months before electronic prescriptions became mandatory, about 94% and 78% of all the prescribed drugs in primary care and hospital settings, respectively, were issued electronically (MS, 2011).

In 2015, the government established the rules to implement paperless electronic prescriptions (de-materialisation). With this new system, the government aims to enhance the monitoring system and combat fraud. These prescriptions are compulsory for the NHS since April 2016. However, they coexist with both materialised electronic and manual prescription (only for the exemptions mentioned before).

With paperless electronic prescription, there is no limit to the number of medicines in each prescription. Patients can opt to buy only some medicines without the prescription become invalid (SPMS, 2016*c*). Renewable and single prescriptions still have the same validity date.

In Portugal it is not possible to buy any psychotropic drug without prescription. The government reimburses part of the psychotropic drugs expenditures. According to the reimbursement rate, there are four categories: category A, which includes all pharmacological groups and subgroups with a reimbursement rate of 90%; category B, with a reimbursement rate of 69%; category C, which includes all medicines with a reimbursement rate of 37%; and category D, that comprises all drugs with a reimbursement rate of 15%. For pensioners and for patients with specific diseases such as bipolar disorders there is a special reimbursement regime in which the reimbursement rate for drugs included in category A is 95%, and for categories B, C, and D the government add an additional amount of 15%. Antipsychotics are included in category A and antidepressants and AHS belong to category C. It should be highlighted that these reimbursement rates are in place since 2010. Previously, all the pharmacological groups and subgroups belonging to category A were reimbursed by 95%.[2]

4.4 Data

Our dataset comprises information on all prescription and dispensing of psychotropic drugs in primary care for the Center region of Portugal between 2009 and June 2015. This information was provided by Administração Regional de Saúde do Centro (ARS Centro).

To gather this information, we submitted a research protocol to the Ethic Commission for Health of ARS Centro, in which we state the purpose of our study. We required information on the following pharmacological classes, using the Anatomical Therapeutic Chemical (ATC) Classification System: N03A (antiepileptics); N05A (antipsychotics); N05B (anxiolytics); N05C (hypnotics and sedatives); N06A (antidepressants); N06B (psycho-stimulants and nootropics); N06C (psycholeptics in combination); N06D (anti-dementia drugs); and N07B (drugs used in additive disorders).[3]

In the protocol we asked for prescription and dispensing information between 2005 and 2015. According to ARS Centro, the required information is only available since 2007, but information for 2007 and 2008 is not reliable. Hence, ARS Centro granted information from 2009 onwards.

To perform our study, ARS Centro provided information at a patient level (id number, age, gender, municipality and main diagnosis using the International Classification of Primary Care (ICPC) – Second Edition); and at prescription level (id prescription number; prescription date; cost of reimbursement for NHS; price supported by the patient; number of pills; number of packages; dosage; active ingredient; and if it is a generic drug). Using

[2]For the remaining categories the reimbursement rates slightly change. The reimbursement rates for categories B, C, and D amounted to 70%, 40%, and 20%, respectively.

[3]We submitted the same research protocol to the remaining Administrações Regionais de Saúde (ARSs) in order to obtain information on prescription and dispensing of psychotropic medication for Portugal. Despite our protocol have been accepted in all ARSs, we did not receive the information.

the id prescription number we are able to identify prescriptions that are single or renewable. All this information was collected from Sistema de Informação da Administração Regional de Saúde (SIARS) and was anonymized by ARS Centro.

Since we do not have socio-economic characteristics at a patient level, our analysis is performed at a municipality level and no merge with other databases is possible. The Center region of Portugal comprises 77 municipalities that are very heterogeneous as it includes rural and urban areas. This region represents about 17% of the total population in Portugal. We merge annual socio-economic variables at municipality level — unemployment rate (*unemp_rate*), average wage (*avg_wage*),[4] percentage of beneficiaries of social benefits (Rendimento Social de Inserção, RSI) (*pct_rsi*), number of physicians per 10,000 inhabitants (*nr_phys*), pharmacy index (*pharm_index*) and mean age (*avg_age*).[5] The latter variable was computed using individual information at municipality level.

ARS Centro provided information on prescription and dispensing separately. We merge the datasets using the statistical software Stata®13. During this process we found some inconsistencies particularly in early years. In the prescription dataset, each row corresponds to one prescription. However, we found the same prescription several times. Considering the dispensing data, we found cases in which the same prescription was filled multiple times. According to ARS Centro these two inconsistencies concern to fraud schemes and were communicated to the relevant Authorities. In our analysis we drop duplicated observations.

Based on the Portuguese prescription rules, section 4.3, we found some prescriptions with a number of packages higher than one allowed by law. These observations are an error in the dataset, so we have dropped them. We also drop observations related to patients who live in municipalities which are not part of ARS Centro. It is possible that a patient might

[4]We only have information from 2009 to 2013. We use 2013's information to fill the missing values for 2014 and 2015.

[5]In appendix D.1.1 we provide detailed information on these variables as well as on the sources of information used.

be prescribed in primary care settings that belong to ARS Centro (for example in cases in which the patient lives in a parish closed to the administrative border of ARS Centro) and fill the prescription in a pharmacy located outside the administrative region of ARS Centro. In each year we have approximately 2.5 million observations and, for each year, we dropped 0.5% of observations.

Our final dataset considering all psychotropic drugs is a balanced panel. That is, we have 77 municipalities with all of them having information on non-adherence rates and socio-economic conditions.

4.4.1 Adherence measure

The information collected by ARS Centro does not provide any socio-economic determinant at patient level. Therefore, adherence rate needs to be measured at a municipality level. With such information, we determine the proportion of individuals, at a municipality level, who did not buy the prescribed medicines following the prescription rules stated in section 4.3. That is, we assess the non-fulfilment adherence (primary type of adherence) between 2009 and the first six months of 2015 as follows:

$$pct\_n\_adher_{jt} = \frac{\sum non\_filled\_prescriptions_{jt}}{\sum prescriptions_{jt}}$$

, where j and t indexes the municipality and year, respectively.

4.4.2 Descriptive Statistics

The total number of patients who have been prescribed with psychotropic drugs in primary care between 2009 and the first six months of 2015 amounts to 782,316. The years in which more patients were prescribed with psychotropic medicines were 2012 (383,759) and 2011 (382,238), as described in Figure D.1, appendix D.1.2. The total resident population covered by ARS Centro did not fluctuate much between 2009 and 2015. On average, ARS Centro comprises about 1.7 million individuals. Therefore, and in 2012, approximately 22.5% of the population was prescribed with this type of medication. The average age change slightly through years and it ranges between 61.8 and 63.6 in 2009 and the first semester of 2015, respectively. It should be highlighted that in all years we have patients of all ages. Approximately 40% of the patients aged between 18 and 37 years. On average, 72.6% of patients prescribed with psychotropic medication are women.

From individual data, the percentage of patients who, at a given year, were prescribed with psychotropic drugs in the year before, is decreasing over time. Specifically, that percentage amounts to 53% and 32% in 2009 and the first semester of 2015, respectively. We did not identify a non-adherence pattern among patients. This means, patients who did not adhere to the prescribed treatment in a given year may not be the ones who did not adhere in another year. It should be highlighted that non-adherence rate differs between years for the same patient.

Between 2009 and the first half of 2015, the total number of psychotropic prescriptions amounted to 13 million. In appendix D.1.2, Figure D.2 we present the prescription rate by year. It should be pointed out the decrease verified between 2014 and 2015 is due to the fact that we only have information for the first six months of 2015.

Performing the analysis by ATC codes, more than half of all prescribed medicines corresponds to anxiolytics (N05B; 37.7%) and antidepressants (N06A; 27.8%). In appendix D.1.2, Figure D.3, we present the prescription rate by ATC codes. Performing the analysis by the three main codes (anxiolytics (N05B), antidepressants (N06A) and antiepileptics (N03A)) by year, we can see the prescription pattern did not change much over the years (Figure D.4, appendix D.1.2), except for anxiolytics and antidepressants from 2012 onwards.

The non-adherence rates range between 5.9% and 52.3% considering all the years. In appendix D.1.2, Figure D.5, we present the kernel density for non-adherence rate by year and by the whole period under analysis. The latter distribution presents three peaks which concerns to different non-adherence rates between years. The first peak regards to first semester of 2015 and the last peak concerns to 2013. The average non-adherence rate amounts to 21.3% with a standard deviation of 10%.

The non-adherence rate per year was 23.7% in 2009 and 8.5% in the first six months of 2015 (Figure D.6, in appendix D.1.2). Non-adherence rates for all municipalities are much higher in 2013 when compared to remaining years.

AHS (N05B and N05C), and antidepressants (N06A) were the prescribed medicines by ATC code with higher non-adherence rates, on average (Figure D.7, in appendix D.1.2). The average non-adherence rate amounts to 19.9% and 22.5% for AHS and antidepressants, respectively. In this analysis we exclude psycholeptics in combination (N06C) and drugs used in additive disorders (N07B) given their residual prescription volume.

In appendix D.1.2, Figure D.8, we present the top and bottom 10% of municipalities with higher and lower average of non-adherence rates, respectively. There is not a strong positive correlation between non-adherence rates and prescription volume. That is, municipalities with highest non-adherence rates are not necessarily the municipalities with highest prescription rates (Figure D.9, in appendix D.1.2).

It is worth highlighting non-adherence rates are more dispersed between years (standard deviation of 0.097) than between municipalities (standard deviation of 0.023). Meaning, non-adherence rates are more variable over time than across municipalities.

A detailed description of all variables included in the model, their respective designations, and summary statistics is presented in appendix D.1.

4.5 Methodology

Our variable of interest is the annual non-adherence rate by municipality ($pct\_non\_adher_{jt}$). We want to estimate the impact of socio-economic characteristics on treatment non-adherence at municipality level, as follows,

$$\begin{aligned} pct\_non\_adher_{jt} = \beta_0 + \beta_1 unemp\_rate_{jt} + \beta_2 nr\_phys_{jt} + \beta_3 pharm\_index_{jt} \\ + \beta_4 avg\_wage_{jt} + \beta_5 pct\_rsi_{jt} + \beta_6 avg\_age + \epsilon_{jt} \end{aligned} \tag{4.1}$$

, where j and t indexes the municipality and year, respectively.

Because non-adherence rate is bounded between zero and one, standard linear models, as the one presented in equation (4.1), may not be accurate since they can generate predictions outside the unit interval. The appropriate model must take into consideration our dependent variable is a proportion, $0 < pct\_non\_adher_{jt} < 1$. In addition, the regression model should incorporate the fact that our data is a balanced panel, meaning, we have information on non-adherence rate for 77 clusters (municipalities) over seven years.

Because our analysis is performed at municipality-level, unobserved heterogeneity and its possible correlation with the explanatory variables should be accounted for by the regression model. In other words, the regression model should allow unobserved time-constant municipality effects, which captures differences between municipalities, to be related to municipality's socio-economic characteristics.

An approach suggested by Papke and Wooldridge (2008) is to use a generalised estimation equations (GEE) model. The GEE is an extended version of the generalised linear model to account for within-subject correlations. The GEE characterises the marginal expectation, average response for observations sharing the same explanatory variables, as a function of covariates (Wooldridge, 2010). The marginal regression model with unobserved effect is given by,

$$g\left(E\left[y_{jt}|x_{jt},c_j\right]\right) = x'_{jt}\beta + c_j \tag{4.2}$$

, where j and t denote the municipality and year, x_{jt} is a $1 \times K$ vector of covariates, β consists of the K regression parameters of interest, $g(.)$ is the link function, y_{jt} denotes the response variable that is allowed to range between 0 and 1, and c_j is the unobserved effect. In our case, y_{jt} is the non-adherence rate and x_{jt} is a vector containing the following variables: *unemp_rate*, *avg_wage*, *pct_rsi*, *nr_phys*, *pharm_index*, and *avg_age*. We also add a year dummy for 2013 in order to control for the higher non-adherence rate when compared to the remaining years.

Estimation of equation (4.2) provides the direction of the partial effects which is given by the elements of β. As the partial effects depend on the level of covariates and unobserved heterogeneity, and since the latter is not observed, one way to measure the importance of the covariates is to average the partial effects across the distribution of c_j. By doing so, we obtain the average partial effects (APEs). In our model we impose the conditional normality assumption,

$$c_j|x_{jt} \sim Normal(\psi + \bar{x}'_j\xi, \sigma_a^2)$$

, where $\bar{x}_j$ is a $1 \times K$ vector of time averages ($\bar{x}_j = \frac{1}{T}\sum_{t=1}^{T} x_{jt}$), and σ_a^2 is the conditional variance of c_j.

Additionally, and in order to guarantee that β and APEs are identified (the former up to a positive scale factor) (Wooldridge, 2010), we assume strict exogeneity of x_{jt} conditional on c_j. That is,

$$E\left(y_{jt}|x_{jt},c_j\right) = E\left(y_{jt}|x_j,c_j\right)$$

, where x_j is the vector of all covariates in all time periods. Given our model, this assumption is likely to hold. As Papke and Wooldridge (2008) pointed out, this assumption "is common in unobserved effects panel data, but it rules out lagged dependent variables in x_{jt}, as well as other explanatory variables that may react to past changes of y_{jt}"(p.123).

Given both assumptions, we can solve equation (4.2) and get,

$$g\left(E\left[y_{jt}|x_{jt}, c_j\right]\right) = \psi_a + x'_{jt}\beta_a + \bar{x}'_j\xi_a \tag{4.3}$$

, where subscript a denotes the division of the original coefficients by $(1+\sigma_a^2)^{1/2}$. Papke and Wooldridge (2008) and Wooldridge (2010) provide a more detailed explanation.

As mentioned before, one important feature of the GEE model is that it accounts for correlation between subjects. Therefore, we have to choose the working correlation structure. The literature provides seven possible structures: exchangeable, independent, unstructured, autoregressive, stationary, non-stationary, or user-specified. According to Horton (2001), we should use the exchangeable structure if observations have no logical order (clustered data) and small number of time periods; if the number of clusters is small then independent matrix is recommended; the unstructured matrix is appropriate if the number of time periods is small and data is balanced and complete; and if observations are mistimed, the correlation should vary with time, so stationary or autoregressive matrices are preferrable.

Since we have clustered data followed during 7 years and there is high variability within municipalities than between them, we assume an exchangeable (compound symmetry) working correlation matrix (WCM) defined as

$$\mathbf{R}_{t,s} = \begin{cases} 1 & if \quad t = s \\ \alpha & otherwise \end{cases} \tag{4.4}$$

where t and s are two different time points and α is the correlation parameter. This structure assumes that within a cluster any two observations are equally correlated, $Corr(y_{jt}, y_{js}|x_j) = \alpha$, but no correlation between observations from different clusters. Also correlations do not depend on x_j. This structure is similar to the assumption on the correlation matrix under a random effects linear model (Wooldridge, 2010).

One of the features of GEE is the consistency of parameter estimates even when WCM is not correctly specified. But, and as highlighted by Agresti (2013), choosing carefully the working correlation model will improve the efficiency of the estimates namely for small samples. In the presence of large samples (more than 100 clusters), GEE method provides consistent parameter estimates, regardless of the choice of working correlation structure (Jang, 2011). Since in our case we have 77 clusters, choice of the working correlation structure is important. In section 4.8 we provide a sensitivity analysis on the WCM structure.

To estimate equation (4.3), and as suggested by Papke and Wooldridge (2008), we assume that non-adherence rate follows a binomial distribution and, as the link function, we use the probit model. We estimate equation (4.3) considering all psychotropic drugs and then separately for AHS and antidepressants. To perform the analysis we use Stata®13.

4.6 Results

In appendix D.2, Table D.2, we present the estimation results of equation (4.3). All estimations contain time averages of the six explanatory variables.

Considering all psychotropic drugs, all the coefficients bear the expected sign except pharmacy index. The percentage of beneficiaries of social benefits and unemployment rate are positively related to non-adherence rate. More specifically, the estimated effect of a 1 percentage point increase in rate of beneficiaries of social benefits and in unemployment rate, is 1.5 and 1.1 percentage points on the non-adherence rate, respectively.

The number of physicians per 10,000 inhabitants, the average wage and age have a negative impact on non-adherence rate. Our results show that increasing the number of physicians by 1 per 10,000 inhabitants per municipality, non-adherence rate decreases by 0.6 percentage points. If the average wage of a municipality increases by €100 and the average age by 10 years, the non-adherence rate decreases by 3 and 9 percentage points, respectively.

The pharmacy index is positively related to non-adherence rate, which means, increasing the pharmacy index by 0.1‰, non-adherence rate increases 0.9 percentage points. However, this relationship is less significant when compared to other socio-economic determinants.

Performing the analysis by pharmacological subclass, namely, AHS and antidepressants, the effect of almost all socio-economic determinants is higher when comparing to all psychotropic drugs. Only for *pct_rsi* and *nr_phys* the effect is almost the same.

It should be highlighted that, for AHS, *pharm_index* and *avg_wage* lose their statistical significance. Additionally, unemployment rate has a negative impact on non-adherence rate. That is, if unemployment rate increases by 1 percentage point, we estimate that non-adherence decreases by 0.4 percentage points.

4.7 Discussion

Our results reveal, approximately, one in four adults living in the Center region of Portugal was prescribed with psychotropic medication per year. Figures from 2013, show one in six American adults reported taking a psychiatric drug (Moore and Mattison, 2017) and for French population, this percentage is higher and amounts to approximately 33% (France24, 2014).

Mental health care in primary care is defined as the provision of preventive and curative care by a GP, or nurse, who can refer complex cases to secondary care (WHO, 2007*a*; WHO and WONCA, 2008). According to Wittchen, Mühlig and Beesdo (2003), depression and anxiety are the most common mental health disorders treated in primary care facilities.

In Portugal, it is estimated that about 23.7% of individuals who have any mental health disorder are treated in primary care (Almeida et al., 2013). More specifically, individuals who were diagnosed with anxiety (22%) and mood disorders (37.4%) were treated by GPs (Almeida et al., 2013), which might explain the fact that, among all psychotropic drugs, AHS and antidepressants were the most prescribed drugs in primary care representing about 44.4% and 27.8%, respectively.

The prescription pattern did not change except for AHS and antidepressants from 2012 onwards. Particularly, since 2012, GPs have been prescribing more antidepressants and less AHS. There are two possible reasons. First, it was published in last quarter of 2011, a clinical guideline addressing the symptomatic treatment of anxiety and insomnia with benzodiazepines and similar drugs (DGS, 2011). This guideline provides a detail description on the use of antidepressants and AHS in which it is clearly stated that AHS should be used only as a temporary measure. This guideline might have increased awareness of the negative effects of long-term treatment with AHS. Second, society and health care providers have been progressively aware of the burden of mental health disorders, namely mood disorders, which has been supported by international literature (WHO, 2003*a*) and also by the implementation of the Portuguese Mental Health Plan in 2008 (Almeida, 2009). This fact might have promoted, prevented, and helped manage mental health disorders.

More than half of prescriptions were prescribed to female patients. According to Almeida et al. (2013), Portuguese women have a higher risk of suffering from depression and anxiety disorders compared to men. Also, Portuguese women have a much higher rate of lifetime health services utilisation due to mental health disorders than do men (Almeida et al., 2013). This result is line with other international studies that report higher prevalence of prescribing in women compared to men. In the US, Medco (2011) analysed prescription claims data from 2.5 million insured Americans from 2001 and 2010 and found that one in four women is dispensed with psychotropic medication compared to 15% of men. An analysis performed for five European countries (Spain, Germany, the UK, the Netherlands, and Denmark) on the prevalence of antidepressant prescribing shows it is in women than in men (Abbing-Karahagopian et al., 2014).

The average non-adherence rate among patients prescribed with psychotropic drugs in primary care amounts to 21.3% between 2009 and 2015. During this time period, non-adherence rate presents three distinct patterns: for all municipalities, 2013 is the year in which non-adherence rate is higher (mean 41.6%), 2015 is characterized by lower non-adherence rate (mean 8.4%), and for the remaining years non-adherence rate did not change much (mean between 16.1% and 22.6%). ARS Centro did not provide any justification for these differences. However, we put forward the hypothesis these differences might be related to some failures of the software used to record all prescriptions and dispensing. More specifically, since electronic prescription became mandatory after 2011, we believe the system has been adapting to meet demand over the years. According to an official report issued by the Ministry of Health, there have been failures of the system namely in primary health care facilities located in urban and rural areas (MS, 2012). Recently, announcements on temporarily software shut-downs were issued by the Ministry of Health (SPMS, 2016*a*,*b*), which we conjecture that some problems have not been solved yet.

Regarding the average non-adherence rate for AHS and antidepressants it amounts to 19.9% and 22.5%, respectively. Comparing our values with results from the study of Freccero et al. (2016) in which primary non-adherence amounts to 14.9%, this difference calls for urgent strategies to enhance mental health and promote adherence.

Regarding the drivers of non-adherence rate, we find a negative relationship between this rate and average age. That is, municipalities with oldest population have lower non-adherence rates. This finding is similar to the results found by Valenstein et al. (2004); Bulloch and Patten (2010), and Freccero et al. (2016) but it contradicts Miasso et al. (2016) in which elderly patients are less adherent than their younger counterparts. Forgetfulness has been pointed out as a risk factor for poor adherence regardless of age group (Bulloch and Patten, 2010; Miasso et al., 2016). The negative relationship between non-adherence and age can be explained by the careless nature of young individuals (Gadkari and McHorney, 2012). On the other hand, cognitive impairment and complex medication regime (frequency of dosing) are found to be related to poor adherence among elderly people (Jin, Kim and Rhie, 2016). In our case, we believe our result not only translates forgetfulness and carelessness but also self-stigma around mental health that persists among younger adults (Kamaradova et al., 2016; YMCA, 2016). In Portugal, Silveira et al. (2011) relates stigma to poor adherence among undergraduate students. Also, the Portuguese NHS provides additional benefits to afford medication for individuals above 65 whose annual income is less than €5,175.82 per year ("complemento solidário para idosos"). These benefits translate into an additional 50% co-payment of the value that was not covered by the NHS (decree-law 232/2005). This additional benefit might increase primary adherence among the elderly. Overall, combining our results with the fact that mental disorders have an earlier age of onset (Jones, 2013), strategies to enhance adherence among young adults should not be disregarded.

Our results provide additional evidence on a strong relationship between non-adherence rate and socio-economic factors such as unemployment rate, percentage of beneficiaries of social benefits, and number of physicians per 10,000 inhabitants.

Considering all psychotropic drugs, we find that increasing unemployment rate by 1 percentage point, non-adherence increases by 1.1 percentage points. This result is in line with previous literature. As Hibdye et al. (2015) and Mårdby et al. (2016) find, individuals with low socio-economic status are more likely to develop a non-adherent pattern. This positive relationship can indicate the poor financial capacity to afford medication by unemployed individuals (Chandra et al., 2014). Moreover, and given the negative relationship that has been established in the literature between unemployment and mental health (Paul and Moser, 2009; Berchick et al., 2012; OECD, 2012*b*; Matias et al., 2016), this finding gains additional importance. Individuals who have lost their jobs are at greater risk of developing mental health disorders, namely anxiety and depression (Goldsmith and Diette, 2012).[6] However, and based on our results, we expect that this vulnerable group might not improve its health status due to poor financial capacity to afford the prescribed medication. As jobless individuals with mental disorders might return to work if adequate treatment is prescribed (OECD, 2012*b*), we believe those individuals might not return to the labour market within a short period of time, deteriorating their mental health status and maintaining their employment status. Given that long-term unemployment has large negative effects on mental health (Goldsmith and Diette, 2012), we suppose that additional costs are being imposed to society (e.g: treatment costs, loss of income).

Performing the analysis by pharmacological subclass, and for antidepressants, unemployment rate has a larger positive effect on non-adherence rate. We think this result might reflect the fact that unemployment individuals are more likely to develop anxiety and depression disorders (Goldsmith and Diette, 2012), and following the international and national guidelines, these disorders should be treated using antidepressants rather than AHS (DGS, 2011).

Regarding AHS, we find a negative relationship between unemployment rate and non-adherence but this effect is almost zero. We put forward the hypothesis that given the lower average cost of AHS (Furtado, 2013) and being more additive compared to antidepressants (AddictionCenter, 2018), jobless individuals have additional incentives to be adherent.

This result is exacerbated if we consider the following facts. First, Portugal has been continuously among the worst performers in the European Union in terms of youth unemployment. According to ILO (2015) this rate exceeds 30% in some countries, including

[6] It is worth mentioning that it is difficult to establish a causal relationship between mental health and unemployment. That is, causality may run in both directions: on the one hand, it may be that unemployment acts as a stressor thus affecting the mental health of the individuals; on the other hand, those individuals might be unemployed precisely due to their poorer mental health status. Given the scope of this chapter, we just focus on the relationship between unemployment and poor mental health.

Portugal (34.8%), which is very high comparing to the usual 23% in the euro zone (Banerji et al., 2014).[7] Second, there is a positive association between youth unemployment and mental diagnosis requiring inpatient care (Eliason and Storrie, 2010) and a negative link between youth unemployment and self-reported mental health (Matias et al., 2016). Combining both facts with our finding that municipalities with youngest population have higher non-adherence rates, we believe young unemployed individuals are worsening their mental health condition, which prevent them from entering in the labour market, consequently, depleting their skills (OECD, 2012*b*).

The non-adherence rate increases by 1.5 percentage points when the percentage of beneficiaries of social benefits increases by 1 percentage point. In Portugal, these benefits are granted to individuals who are in social and financial need and at risk of social exclusion (EC, 2018). As mentioned before for jobless individuals, this result translates the low financial capacity of this group to afford medication. Additionally, the prevalence of mental health disorders, namely depression and anxiety, is higher among welfare benefit recipients than their counterparts (Butterworth, 2003). Therefore, these individuals are worsening their mental health status by not adhering, which might impose additional costs to society. According to Cree, Kay and Steward (2012), illiterate individuals are more likely to be on welfare benefits than their counterparts. Illiteracy is associated with poor insight of one's chronic condition(s) (Parker, 2000), and therefore, a major factor of poor adherence (Parker, 2000; Clayton et al., 2012). Hence, we consider along with low financial capacity, non-adherence might be driven by low health literacy of these individuals, thus, perpetuating their poor mental health status (Lucca et al., 2015).

The similar result between antidepressants and all psychotropic drugs is explained by high prevalence of depression and anxiety among individuals receiving social benefits (But-

[7]The youth unemployment rate is defined as the number of unemployed youth (typically between 15 and 24 years old) divided by the youth labour force.

terworth, 2003). The difference might rely on the fact that the analysis on all psychotropic drugs includes medications with a higher average cost compared to antidepressants such as antipsychotics (Furtado, 2013). Regarding AHS, and as mentioned before, we believe non-adherence rate is less affected (0.8 percentage points compared to 1.5) given the low average cost of these medicines (Furtado, 2013) and their addictive nature when compared to antidepressants (AddictionCenter, 2018).

It is worth highlighting that despite unemployed individuals and beneficiaries of social benefits are intrinsically tied in (Reid, 2009), in our data the correlation between unemployment rate and percentage of beneficiaries of social benefits is low (0.3).

To what concerns average wage and number of physicians, both variables bear the expected sign. In other words, if average wage increases €100 and number of physicians increases by 1 per 10,000 inhabitants, non-adherence rate decreases by 3 and 0.6 percentage points, respectively. Our result on average wage is in line with previous literature in which income is a key factor for non-adherence (Mishra et al., 2011; Lucca et al., 2015). For patients with multiple comorbid chronic diseases, income reveals to be a major factor of non-adherence. More specifically, low-income patients reported to have to choose what medication was the most important given their limited budget (Mishra et al., 2011). Considering patients with mental illness are less likely to perceive benefits of medication combined with the stigma around mental health (Shrivastava, Johnston and Bureau, 2012), we acknowledge patients do not consider psychotropic drugs as one of the most important medication. Regarding the number of physicians, we conjecture this result may reflect the lack of time GPs have to treat mental health patients. According to Farooq and Naeem (2014), monitoring and encourage patients to take medication can tackle non-adherence. However, to do so, GPs need time and motivation since different patients might need different approaches.

Pharmacy index is positively associated with non-adherence, except for AHS which is not statistically significant. For diabetes mellitus and skin diseases, Syed et al. (2016) and

Moo-Young, Suarez and Adamson (2018), respectively, find no significant differences between adherent and non-adherent patients in distance to pharmacy. Authors claim there are a number of personal barriers to non-adherence, which makes distance to pharmacy less relevant as a risk factor for non-adherence. In Portugal, new community pharmacies or relocation of existing ones must fulfil certain distance and population criteria defined by decree-law.[8] There are some exemptions to these rules. A new community pharmacy can be established if a health care service is present but there is not a pharmacy in the vicinity, that is, less than 3km. We hypothesise that in municipalities with lack of community pharmacies, there is a pharmacy located near to primary health care units driving patients to buy the medication after leaving the primary care facility. In municipalities with more community pharmacies, patients may postpone their buying decision, which may influence their primary adherence. We must refer the relationship between pharmacy index and non-adherence rate is less significant compared to the other socio-economic determinants we have considered.

Given the period covered in our analysis, results may be reflecting the consequences of the economic crisis. Indeed, variables such as unemployment, beneficiaries of social benefits, and income, three of the main determinants of poor mental health, were largely affected by the economic downturn (OECD, 2012*b*).

Despite unable to draw conclusions on Portugal's pattern on primary adherence, our data is very heterogeneous as it comprises municipalities with distinct socio-economic characteristics. Therefore, we believe our conclusions will be similar when considering the remaining regions of Portugal.

Given our definition of non-adherence, which is, the percentage of individuals who were prescribed with psychotropic medication in primary care but did not fill the prescription (primary non-adherence), we are aware that our results might be underestimated since patients can fill the prescription but not take the medication or they can discontinue the treatment

[8] Decree-law 936-A/99 established general rules for the location of community pharmacies.

(non-persistence). Despite most of the literature focuses on secondary adherence, it is important not only to present values for primary non-adherence but also to identify its main drivers since this is the first step towards implementation of effective strategies to improve adherence.

It is worth highlighting that our work differs from the study of Freccero et al. (2016). First, we are using more recent data and our definition of non-adherence respects the Portuguese prescription rules (section 4.3). Second, there are important differences between both Portuguese and Swedish mental health systems that may influence non-adherence rates. More specifically, cognitive behavioural therapy (CBT) is available at Swedish primary care whereas Portugal does not provide such therapy in primary care and the current financing system does not incentivise continuous care (Almeida, 2009; OECD, 2014; Perelman et al., 2017*a*). According to Chapman and Horne (2013) and Haddad, Brain and Scott (2014), CBT can improve adherence, and therefore its availability may influence adherence rates. Third, our analysis comprises all psychotropic medication while the Swedish study only focus on antidepressants. Finally, our analysis is performed at municipality level while Freccero et al. (2016) analysis primary adherence at individual level.

Combining our results with data from treatment gap in mental health care, that is, individuals with psychiatric disorders that remain untreated although effective treatment exist (Kohn et al., 2004), we may explain the high prevalence of mental health disorders in Portugal. According to Almeida et al. (2013), about 81.8% and 33.6% of patients with mild and severe mental health disorders, respectively, are left untreated. Therefore, additional challenges are imposed to society as patients who do not adhere to the treatment and those who do not seek for help are deteriorating their mental health status which might increase health care utilisation and costs.

Given our results, adherence should be promoted. Several strategies such as psychosocial and cognitive interventions, electronic reminders (e.g.: text messages, phone calls), and family intervention (Haddad, Brain and Scott, 2014) are suggested in the literature as a way to enhance medication adherence. On the pharmacological side, the literature suggests that drug treatment should be carefully design to suit the individual patient (Farooq and Naeem, 2014). More specifically, Farooq and Naeem (2014) suggest that GPs can simplify the treatment regime, switch when treatment is not effective, adjust doses, and treat side effects. However, authors claim the success of these strategies will depend on the degree of involvement of GPs in the treatment process. In particular, policies aiming to create incentives to treat mental health patients and provide continuous care by GPs could engage physicians in the treatment process. Fleury et al. (2012) identify inappropriate GP payment model as a barrier to enhance GPs in managing mental health disorders. GPs spend little time assessing and addressing the adherence problem. According to Farooq and Naeem (2014), clinicians need time and patience to keep patients engaged in treatment. Currently, Portugal has two types of primary health care centers: Personalised Health Care Units (PHCU) and Family Health Units (FHU). The main difference between both units is the number of patients enrolled in a FHU, the payment mechanism of GPs working in FHU, and the voluntary creation of multidisciplinary teams in FHU (Simões et al., 2017; Barros, Machado and Simões, 2011). GPs are paid a salary in PHCUs but in FHUs, there are incentive mechanisms based on performance (Simões et al., 2017; Barros, Machado and Simões, 2011). However, there is only one mandatory indicator related to mental health, "Percentage of patients aged 65 or older without being prescribed with AHS". Therefore, additional indicators that could promote adherence should be implemented. Also, and as suggested by Fleury et al. (2012), the role of mental health care providers should be extended in order to enhance the ability of GPs to treat their patients with mental disorders and promote integrated care.

Finally, policies aiming at enhancing mental health and improving the key main drivers of non-adherence should be coordinated. In particular, promote employment, and support welfare recipients should be a priority combined with integration of mental health. These policies ought to account for the fact that there are two particular groups within the population which are more vulnerable. These groups consist of unemployed and welfare recipients. Within those groups, the young adults are the most vulnerable. As reported by McKee et al. (2005), individuals living in countries with generous unemployment benefits experience higher well-being during unemployment than those living in less generous countries. Therefore, policies focusing on unemployment benefits should not be discarded since they can improve mental health status and may allow individuals to afford medication. Integrating mental health in the benefit system is also of great importance. Particularly, benefit system needs to be designed to respond to people's need (JA MH-WB, 2016). Financial incentives for medication adherence are controversial. However, Highton-Williamson et al. (2015) implemented a "descriptive and thematic analyses of semi-structured interviews with the clinicians of patients assigned to receive incentives within a randomized controlled trial"(p.120) in which adherence was improved. Also, positive results on symptoms, insights, and social functioning were reported. Therefore, the implementation of an additional co-payments for welfare recipients and unemployed, namely for young adults, can be a possible strategy to promote adherence.

Nonetheless, and as mentioned before, these measures should be coordinated with strategies to enhance mental health. Effective policies should combine the three key-areas: health, labour market, and social security. This approach was already put forward by the WHO and CGF (2014), which suggested several combined strategies, such as the protection of mental health of the unemployed through social and re-employment programs. In practice, Portugal has been implementing several measures targeting youth unemployment. Most of these were recommended by the European Union to all member-states. To the best of our knowledge, there are no strategies to enhance adherence.

4.8 Robustness Check

Our data does not comprise the full year of 2015. Therefore, we check if prescription rate has any seasonal pattern. To do so, we analysed the prescription rate per month and quarters using a trend model and a *periodogram*. We conclude prescription rate does not have any seasonality.

In addition, and given the higher rate of non-adherence in 2013, we performed the analysis without considering this year. The results did not change. Furthermore, the direction of the relationship between non-adherence rate and socio-economic variables is the same. All variables still remain statistically significant. The magnitude of the APEs has changed slightly but the difference in the coefficients is not statistically significant.

In our model, and because of possible options for the WCM (independent, autoregressive, stationary, non-stationary, and unstructured), only the independent WCM is suitable.[9] As the goal of choosing the WCM is to estimate the coefficients more efficiently, misspecification of the correlation structure can affect the efficiency of the estimates. Generally, GEE method is robust to incorrect specification of the WCM (Liang and Zeger, 1986). However, if the WCM does not "incorporate all of the information on the correlation of measurements within the cluster, we can expect that inefficient estimators will result" (Ballinger, 2004, p.133). Therefore, a selection criteria for the WCM is useful.

The literature suggests the use of Quasi Likelihood under Independence Model Criterion (QIC) to properly select the WCM (Ballinger, 2004). However, we did not use such method because, according to Wooldridge (2014), the way QIC was designed, estimates under independence structure will always be preferrable than the ones using an exchangeable WCM. As Wooldridge (2014) pointed out, large differences between estimates under exchangeable and

[9]As mentioned before, and given the nature of our data, only the exchangeable or independent WCM might be selected.

independent working structures might indicate a misspecification of the probability model or explanatory variables might not satisfy the strict exogeneity assumption. Therefore, and as a sensitivity analysis, we estimate equation (4.3) assuming an independent WCM (Table D.3). The results using both exchangeable or independent WCM are almost the same. In terms of the APEs, the results are the same. Having said that, we can assure our probability model is not misspecified and the explanatory variables satisfy the strict exogeneity assumption.

The literature recommends the use of year dummies when dealing with panel data (Wooldridge, 2010). Also, Papke and Wooldridge (2008) state the desirability of including such dummies in the fractional response models for panel data. In Table D.4 we present the estimation results of equation (4.3) when introducing year dummies. Almost all socio-economic determinants lose their statistical significance. Only both *pct_rsi* and *nr_phys* remain significant but the former is now negatively related to non-adherence rate. The impact of these socio-economic variables is smaller when compared to our original model (without year dummies). It should be mentioned that for AHS, average age remain significant but the magnitude of the APE is small.

These results show the potential problem that can arise when including year dummies. Since we are controlling for municipalities specific characteristics (time averages of the explanatory variables) and now for year dummies, which can capture the economic environment, there is not much left to explain. We conjecture that explanatory variables in regression model with year dummies might only be capturing disturbance. More specifically, as our socio-economic variables might incorporate not only municipalities specific characteristics but also the economic environment over the years, including both time averages and year dummies will expurgate most of variability of these variables.

Given the fact that in our panel data there is a higher variability between years rather than between municipalities, we believe our initial specification, that is, the model that does not consider year dummies, is more appropriate.

It is worth mentioning that Wooldridge (2010) points out several approaches to estimate fractional responses but none of them seem to apply to our data.

One possibility is to use the log-odds transformation. Nevertheless, it may not produce accurate results, even if the dependent variable is strictly within the unit interval (as in our case). This means, "we cannot recover the expected value of the fractional response from a linear model for the log-odds ratio unless we make strong independence assumptions"(Papke and Wooldridge, 2008, p.122).

Another approach is the two-limit Tobit model as it is possible to determine the expected value. However, this model can only be applied if the response variable has a mass point at zero and one. We cannot apply this because our case does not meet the criteria.

The beta regression model might also be a possibility but the main drawback is the inconsistency of all parameters if the distribution is misspecified. In our case, and despite non-adherence rate being continuous on (0,1), it does not follow a beta distribution (Wooldridge, 2010).

Additionally, and suggested by Hardin, Hilbe and Hilbe (2007), one can introduce explicitly municipalities-specific intercepts in the fractional model when the entire population is observed. In our case we have information on the entire population but just a small number of time periods (seven years) compared to the number of cross sectional observations (77 municipalities). Therefore, by applying this methodology, we can incur in the so-called incidental parameters problem which leads to inconsistent estimates of the common slope coefficients (Wooldridge, 2010).

Finally, both pooled Bernoulli quasi-maximum likelihood estimation and pooled non-linear least squares are alternatives but "fully robust inference should be used because the variance associated with the Bernoulli distribution is likely to be wrong, and the variance is unlikely to be constant. More important, there is neglected serial correlation" (Wooldridge, 2010, p.768). Thus, we opt to use the GEE approach.

4.9 Further Research

As further research, we will extend this analysis for the remaining regions of Portugal. This analysis will allow to draw conclusions for Portugal and also to make comparisons between regions. It is important to highlight we have submitted the same research proposal for all the remaining Administrações Regionais de Saúde and they were accepted. So far, we did not receive any data.

We will also extend the analysis for depression disorders. According to international clinical guidelines, patients diagnosed with depression should be treated with antidepressants for at least 6 months (NICE, 2009; DGS, 2012). Hence, we will perform a specific analysis for this pharmacological subgroup considering non-adherence as not only buying the prescribed medicines but also discontinuing the treatment during the first 6 months. To determine the continuity of treatment we will compute the defined daily dose (DDD) (WHO, 2017).

This analysis will consider patients who were diagnosed with depression (ICPC P76 and P74) and were prescribed with antidepressants since 2010 and do not appear in the prescription dataset in 2009. By doing so, even if a patient was treated with antidepressants before 2010, we assume that he discontinued the treatment, and therefore, he started the treatment when we first observe him in our dataset. We are aware this analysis will suffer from the so-called "gap in data availability" (Braunstein et al., 2017). In other words, our data will suffer from time bias because our data does nor provide information on prescribed medication during inpatient stays. It will not be possible to estimate the impact of this effect but we will be able to know if this bias will under- or over-estimate non-adherence rate by assuming long periods of interruption might correspond to unobservable inpatient stays (Braunstein et al., 2017).

Finally, and if policy-makers decide to implement strategies to tackle non-adherence, particularly in the more vulnerable groups, we could test their effectiveness. Specifically, we can check the pattern of non-adherence before and after the strategies have been implemented to verify for differences not only on primary non-adherence but also on patients that are more likely to discontinue treatment. Also, and by performing a qualitative study, we may be able to assess the main reasons for primary and secondary non-adherence, which will allow policy-makers to implement more patient-oriented adherence interventions.

4.10 Conclusion

This chapter provides additional evidence on the socio-economic drivers of non-adherence to psychotropic medication in primary care using information on prescription and dispensing of these drugs for the Center region of Portugal between 2009 and 2015. Non-adherence rate is defined as patients who do not fill the prescribed medication according to the Portuguese prescription rules (primary non-adherence). As our dataset does not provide socio-economic characteristics of individuals, we perform this analysis at municipality-level. We use a fractional probit model to assess the impact of socio-economic variables on non-adherence rate.

Our results provide evidence of positive relationships between non-adherence rate and unemployment, and percentage of beneficiaries of social benefits. More specifically, if unemployment rate and the percentage of individuals receiving social benefits increase by 1 percentage point, non-adherence rate increases by 1.1 and 1.5 percentage points, respectively. On the other hand, increasing average wage and number of physicians improves adherence. In line with previous literature, municipalities with a low average age have smaller adherence rates than their counterparts.

These results call for coordinated strategies to enhance adherence, promote employment, and support low-income families who receive social benefits. Such policies should give special attention to young adults.

Chapter 5

How to improve a mental health patient status when treatment non-adherence is a problem? A payment mechanism approach.[1]

5.1 Introduction

In Chapter 4 we illustrate the importance of adherence, particularly in Psychiatry. As mentioned before, increasing adherence in mental health patients implies, among others, an effective community services (Herbeck et al., 2005), provision of intensive case management to SMI patients (Dieterich et al., 2017) and frequently consultations and psycho-education (Nelson, Maruish and Axler, 2000). The degree of involvement of physicians in the treatment process is crucial for its success (Farooq and Naeem, 2014). Physicians need to have frequent contact with patients in order to induce adherence and improve their mental health status.

[1]The co-authors of this paper are Pedro Chaves and Pedro Pita Barros.

Several factors influence physicians decisions such as ethical concerns, social incentives, and payment mechanisms (Hurst et al., 2005; Biller-Andorno and Lee, 2013; Kazungu et al., 2018). There is a vast literature on physician responses to various payment mechanisms. Empirical work focus on the impact of payment mechanisms on physicians' activities measured by length of stay, volume of services or readmissions (Échevin and Fortin, 2014; Innes et al., 2018). According to Herbeck et al. (2005) the way physicians are paid has an impact on patients' adherence problems. Specifically on mental health, Douven, Remmerswaal and Mosca (2015) conclude that mental health providers react to financial incentives.

Theoretical models focus on the payment model and the physician response. Ellis and McGuire (1986) developed a model of provider response to prospective payment (based on the quality of services provided). They conclude that the weight that a physician places on a patient's benefits (altruism) influences the provision of services. Chalkley and Malcomson (1998) work is an extended version of Ellis and McGuire (1986) where they assume that costs depend not only on the provision of quality care but also on the effort level exerted by the physician. This paper can be seen as the examination of the second best of the Ellis and McGuire (1986) model. Jack (2005) derives the conditions for the optimal payment mechanism in the presence of asymmetric information about altruism. There are extensions of this work which considered that quality has two dimensions (Eggleston (2005) and Kaarboe and Siciliani (2011)). Choné and Ma (2011) introduce asymmetric information not only about altruism but also about patient's valuation for health care. Recently, Fichera et al. (2018) analyse the patient's response to physician's effort. Specifically, they model a joint production of health in which the patient's and the physician's effort can be either complements or substitutes. The goal is to find how P4P responds to the degree of complementarity and substitution of physician and patient efforts. They show that when the physician's and patient's efforts are complements, the power of P4P scheme is higher.

In this paper we analyse the physician's payment if treatment non-adherence is a possibility. We design a model in which treatment non-adherence is a possibility and the physician's payment depends on the patient's health status. Specifically, the patient attends to one consultation and decides whether to adhere or not to the prescribed treatment. If he decides to adhere, he comes back to a second consultation. The semi-altruistic physician has to choose the effort level she will exert in both consultations. On the other hand, the Government decides on the payment mechanism. That is, the physician receives an adherence bonus if the patient adheres to the treatment. Besides that, if the patient's health status improves, the physician receives an additional improvement bonus.

Our results show that when the patient adheres to the treatment for any effort level exerted by the physician, the Government may find optimal to induce the physician to exert a high effort level. In this case the optimal adherence bonus is zero and the optimal improvement bonus increases with the level of altruism and with the benefit the patient gets if his health status improves. On the other hand, the optimal improvement bonus decreases as the tax distortion increases. This result also applies when the patient may not adhere but the physician may always prefer adherence.

In the situation in which not only does the patient need to be convinced to turn to the adherence side, but so does the physician, the Government needs to assure adherence (if it is socially optimal) and guarantee the optimal effort level. The Government's decision is based on the level of tax distortion. Specifically, when the tax distortion is low the optimal adherence bonus is zero and the improvement bonus decreases with the level of altruism and with the benefit the patient gets if his health status improves. On the other hand, if the tax distortion is moderate, we may have multiple equilibria, in which the distribution of the bonuses is irrelevant, as long as the expected payment of the physician does not change. When the tax distortion is high, the optimal adherence and improvement bonuses are zero and there is no adherence. In all the above situations the first-best is only attained when there is no tax distortion.

We conclude that using payment mechanisms can induce adherence. However, and during periods of tight budgets where adherence is not guaranteed, it does not matter the way the physician receives her bonuses as long as the expected payment does not change. That is, multiple equilibria are attained combining both adherence and improvement bonuses or just using one of them. That is, if the adherence bonus can be seen as a proxy of FFS while the improvement bonus can be assumed as a P4P mechanism, the choice between these two payment schemes relies on other reasons like administrative simplicity. It will come as no surprise if we find the payment structure irrelevant in empirical terms.

The remainder of the chapter is as follows. Section (5.2) presents the basic structure of the model and study the decision of each agent separately. Section (5.3) studies the equilibria. We first study what would be socially optimal if the Government could decide the actions of all agents (first-best), and then turn to the situations where patient may adhere or not to the treatment. Section (5.4) discusses the results and section (5.5) provides ideas for further research. Section (5.6) concludes and appendix E collects proofs.

5.2 Model

In this section, we present the basic structure of our model and study the decision of each agent separately.

5.2.1 Setup

There is one patient diagnosed with a mental health problem, who is being followed by one physician. The Government has to decide how to pay the physician so that she provides the proper treatment to the patient, knowing that its resources come from tax payers. In society, there are multiple patients and physicians, but we focus on only one of each, because the Government can apply this individual framework to all of them. We want to focus on the patient-physician relationship and not at system-level equilibrium.

The patient attends a first consultation and decides whether or not to adhere to the prescribed treatment. Let us define $d \in \{n, a\}$ as the patient's adherence decision, where n represents non-adherence and a stands for adherence. In this consultation, the physician has to choose an effort level $x_1 \geq 0$. If the patient decides to adhere to the prescribed treatment, and only in this case, he comes back for a second consultation, where the physician exerts an effort level $x_2 \geq 0$. In this case, at the end of the treatment, his health status is assessed. We assume that, throughout the model, only the sum of the two effort levels x_1 and x_2 matters for the functions which depend on the effort level. So, we define $x = x_1 + x_2$. Furthermore, we assume that, when, at the first consultation the patient sees x_1 he can anticipate what x_2 will be in the second consultation, if he returns. So the patient reacts to x when deciding to adhere or not. The patient's final health status may remain the same or improve, and is defined by $h \in \{0, 1\}$, where 0 stands for remaining the same and 1 for improving. He knows that the probability of improving depends on his adherence decision and on the effort level chosen by the physician, x. This probability, p, is defined in the following way:

$$p(d, x) = \begin{cases} p_n(x) & , \quad d = n \\ p_a(x) & , \quad d = a \end{cases}$$

We assume that $\forall d \in \{n, a\}$, p_d is a C^3 function and, for all x,

$$0 \leq p_d(x) \leq 1 \tag{5.1}$$

$$p_a(x) \geq p_n(x) \tag{5.2}$$

$$p'_a(x) \geq p'_n(x) > 0 \tag{5.3}$$

$$p''_d(x) < 0 \tag{5.4}$$

$$p'''_d(x) < 0 \tag{5.5}$$

Assumption (5.1) is related to the definition of probabilities. Assumptions (5.2) and (5.3) state that the patient's health status will improve with a higher probability if he adheres to the treatment, for any effort level of the physician and, moreover, that the marginal contribution of the effort level for the probability of improving is higher when there is adherence. Assumptions (5.4) and (5.5) are technical.

Regarding his health status, the patient gets a benefit of $b \geq 0$ if it improves and 0 otherwise. The patient's adherence cost is $k \geq 0$. The patient has to choose whether to adhere or not and his utility function, u, is given by:

$$u(d,x) = \begin{cases} u_n(x) = p_n(x)\,b & , \quad d = n \\ u_a(x) = p_a(x)\,b - k & , \quad d = a \end{cases}$$

As mentioned before, the physician chooses to exert a certain effort level. She does so for two reasons. First, the payments she receives from the Government depend on the patient's adherence decision and health status.[2] In case the patient adheres to the treatment, the physician receives an adherence bonus, $w_1 \geq 0$. If, besides that, the patient's health status improves, the physician receives an additional improvement bonus, $w_2 \geq 0$. The wage vector

[2]Remember that the patient's health status is only assessed if he attends the check-up session, which only happens if he adheres to the treatment.

is $w = (w_1, w_2)$. We can define the total payment received by the physician in the following way:

$$m(d,h) = \begin{cases} 0 & , \quad d = n \\ w_1 & , \quad d = a \wedge h = 0 \\ w_1 + w_2 & , \quad d = a \wedge h = 1 \end{cases}$$

When choosing her effort level x, the physician anticipates whether, or not, the patient will adhere, but has no way of knowing if his health status will improve. Therefore, she focuses on the expected value of her total payment, which is:

$$E[m(d,h)\,|x] = \begin{cases} 0 & , \quad d = n \\ w_1 + p_a(x)\,w_2 & , \quad d = a \end{cases}$$

Second, she is semi-altruistic, in the sense that the patient's health status enters directly into her utility function (Chalkley and Malcomson, 1998; Jack, 2005; Choné and Ma, 2011; Liu and Ma, 2013). She benefits from the improvement of the patient's health status in the same way the patient does. The physician's total benefit is modelled as a weighted average of the payment she receives and the expected benefit she gets from the patient's health status, with $\theta \in \,]0,1]$ and $1-\theta$ being the weights:[3]

$$\theta\left(E[m(d,h)\,|x]\right) + (1-\theta)\,p(d,x)\,b$$

For an easier reading, we normalize the weights, dividing the total benefit by θ and defining $\alpha = \frac{1-\theta}{\theta}$. By doing this, we can say that $\alpha \geq 0$ is the level of altruism of the physician. To exert a total certain effort level x, the physician incurs in a cost $c(x)$. We assume that c is a C^3 function and, for all x,

[3]Throughout the model, we assume that benefits and costs are measured in monetary terms.

$$c(x) \geq 0 \tag{5.6}$$

$$c'(x) \geq 0 \tag{5.7}$$

$$c''(x) > 0 \tag{5.8}$$

$$c'''(x) > 0 \tag{5.9}$$

Assumptions (5.6) and (5.7) imply that the cost is non-negative and increases with the effort level. Assumption (5.8) implies an increasing marginal cost. Assumption (5.9) is technical.

The physician knows how the patient makes his decision and only has to choose the effort level. Therefore, her utility function, v, is defined in the following way:

$$v(x, w) = E[m(d, h)|x] + \alpha p(d, x) b - c(x) \tag{5.10}$$

The Government is a benevolent social planner, that is, it aims to maximize social welfare. We consider the Government to be utilitarian, in the sense that it views social welfare as the sum of individual utilities. Besides the patient and the physician, taxpayers, who finance the physician's payment, are also a part of society (Chalkley and Malcomson, 1998). For each monetary unit of taxes collected, there is a cost of $\lambda \geq 0$, which may be interpreted as the cost associated with generating a distortion in the markets where the tax is collected from. Taxpayers also have to face a cost of $l \geq 0$, in case the patient does not adhere. If this happens, society has to bear the cost of readmissions, new consultations and the use of emergency rooms, for instance. However, these treatments only target the patient's stability and do not increase the probability of improvement of his health status. The problem of the Government is to choose the values of w_1 and w_2 that maximize the following expected social utility function, where $\mathbb{1}_{\{n\}}(d)$ is 1 in case of adherence, and 0 otherwise:

$$s(w_1, w_2) = u(d, x) + v(x, w) - (1 + \lambda) E[m(d, h) | x] - \mathbb{1}_{\{n\}}(d) l \tag{5.11}$$

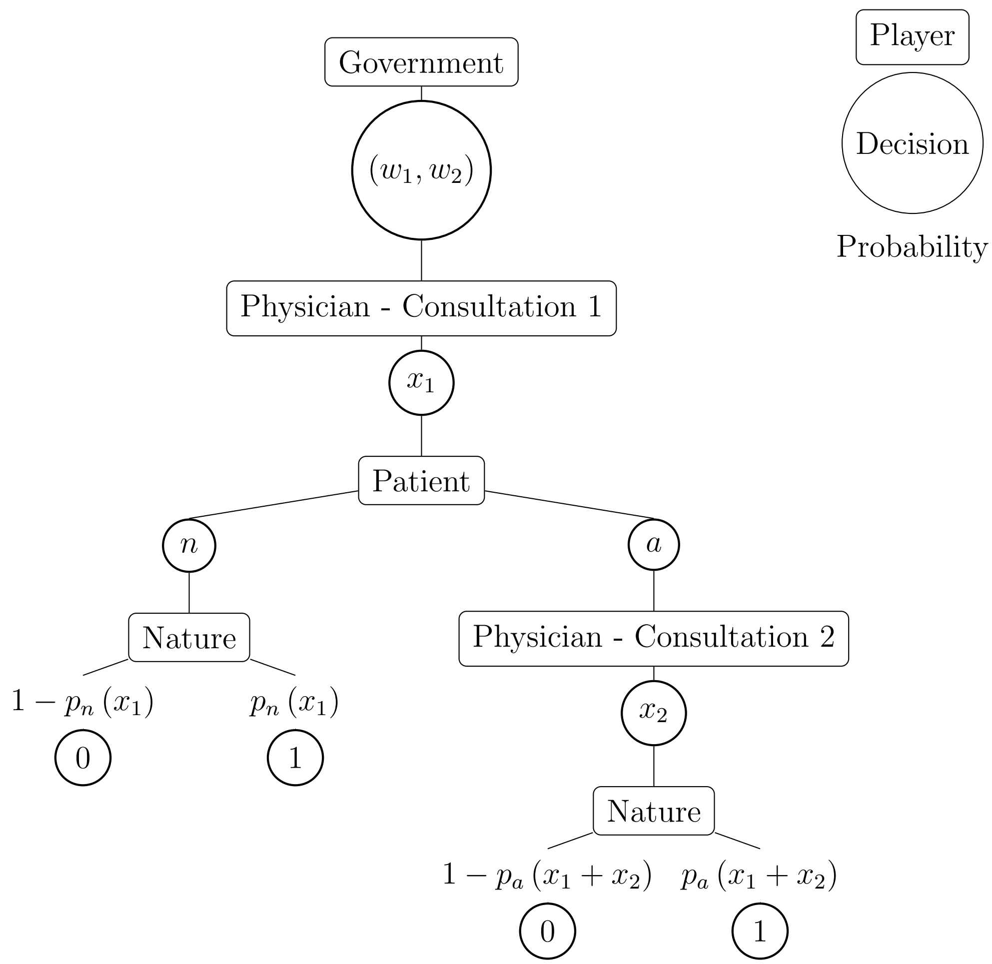


Figure 5.1: Timeline

Figure 5.1 provides the timeline of moves. First, the Government chooses the adherence and improvement bonuses, respectively w_1 and w_2. Then, the physician chooses the effort level for the first consultation x_1, knowing w_1 and w_2. When she does so, she knows the patient will observe this effort and make a rational decision. Such decision will take into account the impact the adherence decision will have on the effort the physician will make in the second consultation, if it takes place. That is, when the physician chooses x_1, she and the patient can infer the value of x_2 which means that, even though this effort level is only seen in the second consultation, it is decided in the first one. That is why it is possible, throughout the paper, to only focus on $x = x_1 + x_2$ as the physician decision to which the patient reacts. After the first consultation, the patient adheres or not. In the first case, the second consultation takes place and the physician puts the anticipated x_2 into practice. The optimal x_2 if the physician can revisit it is the one decided in the first consultation, so that no inter-temporal inconsistency is present. In the second case, there is no second consultation. Nature dictates if the patient's health status improves, and this happens with a higher probability if the patient adheres to the treatment. This model is solved by backward induction: the patient decides to adhere or not, given the effort level exerted by the physician; the latter knows this and incorporates it in his decision, which is affected by w_1 and w_2; the Government knows both the patient's and physician's decisions and, based on those, selects the optimal bonuses.

5.2.2 Patient

The patient has to compare, given the effort level exerted by the physician, the utility he gets if he adheres or not. Although, at the time he decides to adhere or not, he has only seen x_1, he can infer what x_2 will be chosen, given his adherence decision. Therefore, he only focuses on x. He adheres if and only if $u(a,x) \geq u(n,x)$.[4] That is,[5]

$$d^*(x) = \begin{cases} n \quad , \quad (p_a - p_n)(x)\, b < k \\ a \quad , \quad (p_a - p_n)(x)\, b \geq k \end{cases} \tag{5.12}$$

By looking at (5.12), we know that the patient adheres to the treatment when the increase in benefit from changing from not adhering to adhering (the increase in the probability of

[4]In case of indifference, we assume that the patient adheres.

[5]We represent the optimal value of each choice variable with an $*$.

improving) outweighs the increase in cost (which arises because the adherence cost is added). It is important to note that this decision depends on the effort level chosen by the physician, as can be seen in $(p_a - p_n)(x)$. As $p_a - p_n$ is an increasing function of x, we can say that $d^*(x) = a \Leftrightarrow x \geq \underline{x} = (p_a - p_n)^{-1}\left(\frac{k}{b}\right)$.[6] Specifically, as k and b are exogenous to the patient or physician decisions, the choice of x will lead to adherence if it exceeds the threshold $\underline{x}$.

5.2.3 Physician

The physician knows the impact her decision has on the patient's. That is, she knows the patient follows (5.12) and therefore which effort levels make the patient adhere or not. Besides, she is aware of the payment scheme the Government designs. Hence, (5.10) may be rewritten as,

$$v(x) = \begin{cases} v_n(x) = p_n(x)\,\alpha b - c(x) & , \quad 0 \leq x < \underline{x} \\ v_a(x) = w_1 + p_a(x)(w_2 + \alpha b) - c(x) & , \quad x \geq \underline{x} \end{cases} \tag{5.13}$$

We can look at the physician's problem dividing it in two. She needs to find the optimal effort level in v_n and v_a and then choose one of them. That is, in her perspective, it may be optimal that the patient adheres or not. A stationary point of v_n, $\hat{x}_n$, respects the following condition:

$$p_n'(\hat{x}_n)\,\alpha b = c'(\hat{x}_n) \tag{5.14}$$

Equation (5.14) shows that, in an interior solution, the marginal benefit of the effort level equals its marginal cost. Furthermore, as v_n is strictly concave, $\hat{x}_n$, if it exists, is unique, and the optimal effort level in v_n, x_n^*, is $\hat{x}_n$. However, it is possible that (5.14) has no solution in $[0, \underline{x}[$. Using the strict concavity of v_n and assuming that (5.14) has a solution, we can say

[6] To assure that there is a $\underline{x}$, we assume that $\lim_{x\to+\infty}((p_a - p_n)(x)) > \frac{k}{b}$.

that:

$$x_n^* = \max\left\{0, \min\left\{\hat{x}_n, \underline{x}\right\}\right\} \tag{5.15}$$

Note that, in (5.15), $\underline{x}$ can never actually be chosen because it does not belong to the domain of v_n. However, this is not a problem since, in the case in which $v_n(\underline{x})$ is the hypothetical maximum of v_n, it is lower than $v_a(\underline{x})$, which means the physician prefers undoubtedly the patient to adhere.

A stationary point of v_a, $\hat{x}_a$, respects the following condition:

$$p_a'(\hat{x}_a)(w_2 + \alpha b) = c'(\hat{x}_a) \tag{5.16}$$

Observing equation (5.16), we can see that, in an interior solution, the logic which was present in (5.14) still applies, with the difference that w_2 also contributes to the marginal benefit. This means that, in opposition to what happens in v_n, there is the possibility that the Government has the ability to influence x_a^*. Assuming that (5.16) has a solution, and applying the same arguments as before, and the fact that, because of the bound on p_a and the absence of bound on c, v_a must eventually decrease, we can conclude that:[7]

$$x_a^* = \max\left\{\underline{x}, \hat{x}_a\right\} \tag{5.17}$$

Having solved these two sub-problems, the physician should compare the two obtained maxima. Let us define $v_m(x) = w_1 + p_a(x)w_2$ and $v_u(x) = p_a(x)\alpha b - c(x)$, respectively, the monetary and non-monetary parts of the physician's utility, that is, $v_a(x) = v_m(x) + v_u(x)$. It is useful to define $\Delta_v(x_n, x_a) = v_n(x_n) - v_u(x_a)$, the difference in non-monetary utility the physician gets when the patient does not adhere and adheres, and the effort levels chosen are x_n and x_a, respectively. The physician's optimal effort level, x^*, is x_a^* whenever:

[7]As c is increasing and convex, $\lim_{x\to\infty} c(x) = +\infty$.

$$v_m\left(x_a^*(w)\right) \geq \Delta_v\left(x_n^*, x_a^*\left(w\right)\right) \tag{5.18}$$

Equation (5.18) says that, if the Government wants to induce adherence, it has to pay enough to the physician, so that she prefers to exert effort level x_a^*. More specifically, the expected wage the physician receives must be at least as high as the difference between the optimal physician's utility when the patient does not adhere and the optimal physician's non-monetary utility when the patient adheres. This comparison leads us to analyse some different cases separately, which we do in Section 5.3.

5.2.4 Government

The Government is aware of the way it can influence what happens in society. In the end, as it knows both the patient's and the physician's decisions, it can decide, when possible, what is the effort level chosen and the adherence decision, by selecting the appropriate w_1 and w_2. As, for some w's, the Government induces adherence and, for others, it does not, (5.11) may be rewritten as:

$$s\left(w\right) = \begin{cases} s_n = u_n\left(x_n^*\right) + v_n\left(x_n^*\right) - l & , \quad v_m\left(x_a^*\left(w\right)\right) < \Delta_v\left(x_n^*, x_a^*\left(w\right)\right) \\ s_a\left(w\right) = u_a\left(x_a^*\left(w\right)\right) + v_u\left(x_a^*(w)\right) - \lambda\left(w_1 + p_a\left(x_a^*\left(w\right)\right) w_2\right) & , \quad v_m\left(x_a^*\left(w\right)\right) \geq \Delta_v\left(x_n^*, x_a^*\left(w\right)\right) \end{cases} \tag{5.19}$$

Notice that the Government is incapable of indirectly influencing the value of the social utility when there is no adherence, which means it should focus on $s_a\left(w\right)$ when it is choosing w_1 and w_2.

If, with no Government intervention, society is better off without adherence, then $w_1^* = w_2^* = 0$. This is because forcing adherence would lower the non-monetary social utility and still generate a monetary cost. Otherwise, depending on the level of tax distortion, it may be optimal for the Government to induce adherence with positive wages. In the latter case, the Government should find the maximum of $s_a(w)$ and compare it to s_n.

If there was no cost of collecting taxes, then the Government would simply pay the physician the amount needed for her to exert the socially optimal effort level. However, the presence of λ in the model forces the Government to compare the optimal utilities of the patient and physician in case of adherence and non-adherence. Let us define $\Delta_{u+v}(x_n, x_a) = (u_a(x_a) + v_u(x_a)) - (u_n(x_n) + v_n(x_n))$. Then, it is socially optimal that the Government induces adherence whenever $\lambda \leq \bar{\lambda}$, with:

$$\bar{\lambda} = \frac{\Delta_{u+v}(x_n^*, x_a^*(w^*)) + l}{w_1^* + p_a(x_a^*(w^*))\, w_2^*} \tag{5.20}$$

Equation (5.20) tells us that the higher the difference between non-monetary social utilities when there is adherence and not, the higher the maximum tax distortion that makes adherence socially optimal. On the other hand, the higher the payment the physician needs to induce adherence, the lower this threshold is. The social cost of non-adherence increases it.

5.3 Equilibria

In this section, we study the possible equilibria, for each combination of parameters that produce situations which require different types of analysis.

5.3.1 First Best

To have a reference point, it is useful to study what would be socially optimal if the Government could decide the actions of all agents. In such situation, both w_1^{FB} and w_2^{FB} would be zero, because payments to the physician have a social burden and generate no net benefit to society.[8]

We have to compare two possible situations, adherence and non-adherence. Let us define $s^{FB}(d,x)$ as the first best social utility function when the patient makes decision d and the physician exerts effort level x. We then have:

$$s^{FB}(d,x) = \begin{cases} s_n^{FB}(x) = (1+\alpha)\, bp_n(x) - c(x) - l & , \quad d = n \\ s_a^{FB}(x) = (1+\alpha)\, bp_a(x) - c(x) - k & , \quad d = a \end{cases} \tag{5.21}$$

If, after fixing l, k is left unbounded, there are situations in which we have non-adherence in the first best. However, the goal of our paper is to study the payment mechanisms that induce adherence. Hence, we assume $k \leq l$, which assures that, in the first best, the patient always adheres. In fact, notice that, if this is the case, s_a^{FB} is not lower than s_n^{FB} for all effort levels. The first best effort level, x^{FB}, if positive, is then defined by the following first order condition:

$$(1+\alpha)\, bp_a'(x) = c'(x) \tag{5.22}$$

As we want to focus on the impact of the effort exerted by the physician in the patient's adherence decision and health status, we assume the following, which is enough to guarantee that $x^{FB} > 0$:

$$(1+\alpha)\, bp_a'(0) > c'(0) \tag{5.23}$$

Assumption (5.23) states that, at a zero effort level, the social marginal benefit of increasing it is higher than its social marginal cost. The concavity of s_a^{FB} and the fact that the marginal effort cost eventually becomes higher than the marginal benefit imply that the first best effort is positive and unique. In order to make clear the meaning of (5.22), let us

[8] FB stands for first best.

state a result about $\hat{x}_a$, as defined in (5.16):

Proposition 1. The optimal effort level chosen by the physician is increasing in the improvement bonus (w_2).

Proof. See Appendix E. $\square$

Proposition 1 says that, as w_2 goes up, so does x_a^*. When $w_2 = b$, the optimal effort level coincides with the first best one. This is because, when the physician makes her decision, she ignores the positive externality she creates on the patient. A payment in case of adherence equal to the benefit the patient gets in case of improvement aligns the physician's incentives with the ones society has when there is no tax distortion. In addition, notice that $w_2^* \leq b$, because paying an improvement bonus higher than the one that leads to the first best implies a lower social non-monetary utility and a higher expected payment than the ones verified when $w_2 = b$. Combining all of these, we can see that the increase of w_2 has two effects: both the non-monetary social utility and the expected payment increase.[9] When the tax distortion is low, the first effect dominates, which leads to a high improvement bonus and an effort level close to the first best one. Otherwise, it is the second effect that dominates, implying a low improvement bonus, and, therefore, an effort level distant from what would be chosen in the first best. As we shall see in the next sections, the first best optimal effort level is only attained when $\lambda = 0$, meaning that, unless there is no cost in redistributing money, the non-monetary social utility is always lower than it could be.

5.3.2 The patient always adheres

The first situation we are going to study is the one in which $(p_a - p_n)(0)\, b \geq k$. In this case, as $p_a - p_n$ is an increasing function, the patient prefers to adhere for any effort level

[9] Notice that s_a^{FB} is concave.

exerted by the physician, that is, $d^* = a$.[10] This could happen for three reasons: either the adherence cost, k, is very low; or the patient highly benefits from seeing his health status improve; or, even when the physician exerts no effort, the probability of the patient's health status improving is significantly higher when he adheres. Figure 5.2 illustrates the patient's decision in this case: adhering is so beneficial to him that, even if the physician exerts no effort, he prefers to incur in the adherence cost and adhere.

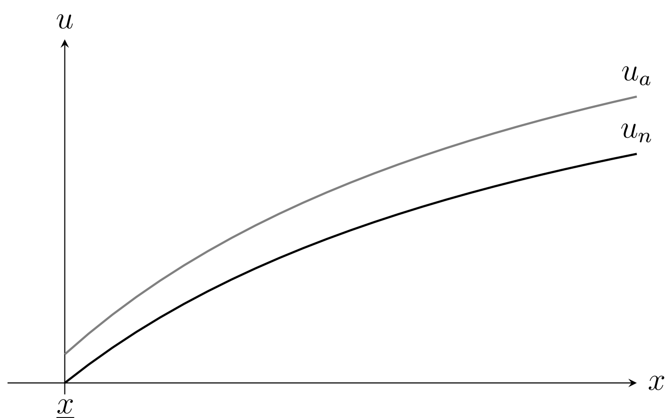


Figure 5.2: Patient's utility functions when $\underline{x} = 0$

The physician does not need to exert any effort to make the patient adhere but, as she is altruistic, her optimal effort level may be positive. Her decision is given by (5.17), with $\underline{x} = 0$. The Government does not need to induce adherence, but it may decide to pay positive wages if the socially optimal effort level is higher than the one the physician would choose by herself. That is, its utility function is reduced to the second branch of (5.19).

In this situation, no positive adherence bonus is paid in equilibrium, that is, $w_1^* = 0$. This happens because w_1 is a constant in (5.13) and, therefore, does not have the power to change x_a^*, only to increase $v_a(x_a^*)$. That is, in the perspective of the Government, the only role w_1 plays is making adherence more attractive to the physician. As adherence is guaranteed, w_1 serves no purpose and, as its collection is costly, its optimal level is 0. Therefore, we only

[10]From (5.3), $(p_a - p_n)'(x) \geq 0, \forall x \geq 0$.

need to focus on one of the Government's decision variables, w_2.

Let us define the physician's optimal effort level when she receives no bonuses, among the ones which induce adherence, as x_a^I. If $x_a^I = 0$, the physician is reluctant, without a monetary compensation, to make any effort, which may happen because she is not very altruistic, the effort cost is high, or the impact of effort on the probability of the patient's health status improving or the benefit of this happening is low. In this case, small values of w_2 do not change the physician's decision, which means they are never optimal for the Government.[11] Hence, in this case, there is a minimum value of w_2, $\underline{w_2}$, which is a possible optimal improvement bonus. If $x_a^I > 0$, $\underline{w_2} = 0$, because, even with no bonuses, the physician is choosing an interior solution, which is affected by any positive w_2. Figure 5.3 illustrates the effect w_2 has on the optimal effort level chosen by the physician. In Figure 5.3a, the Government only considers improvement bonuses in $\{0\} \cup \left[\underline{w_2}, b\right]$, whereas in Figure 5.3b, the set of possible equilibrium values for w_2 is $[0, b]$. In the former case, the physician is not naturally inclined to make a big effort, in opposition to what happens in the latter. In general, $\underline{w_2}$ depends negatively on the benefit generated by the improvement of the patient's health status and on the altruism level of the physician. In fact, if b or α are low, the physician does not care too much about the patient's improvement, thus needing a high monetary incentive to make an effort.

The Government has to choose the optimal w_2, knowing it has an implication on the money it needs to collect and on the effort level chosen by the physician and, consequently, on the physician's and patient's utilities. Figure 5.4 shows what may happen, depending on λ. When $\lambda = 0$, there is no cost in collecting the funds to pay for the physician's bonuses, which may, therefore, be as high as needed.[12] Thus, in this situation, the Government simply

[11]There is one case in which $x_a^I = 0$ and any positive w_2 increases the optimal effort level: when $x_a^I = 0$ is the unconstrained maximizer of v_a and not just the maximizer of v_a subject to $x \geq 0$.

[12]Notice that, if $\lambda = 0$, the sum of the physician's and taxpayers' utilities, net of the tax collection cost, is the same for any (w_1, w_2).

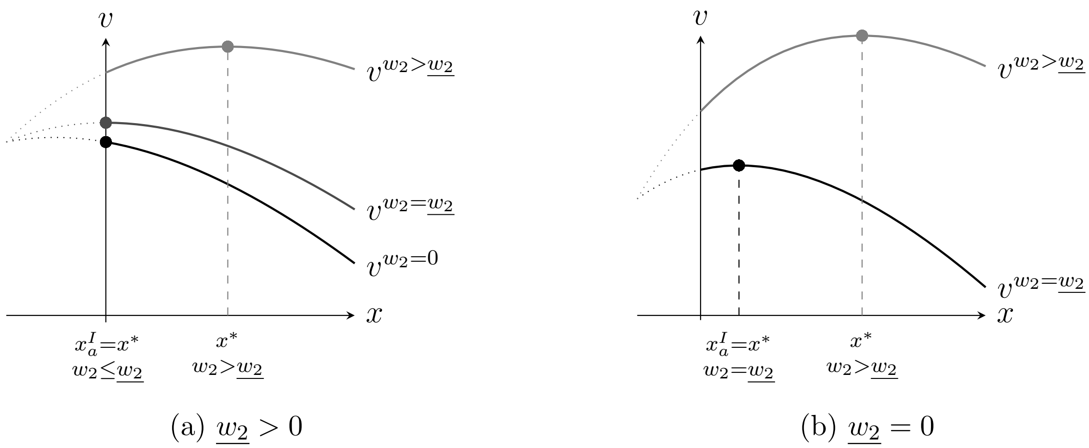


Figure 5.3: Physician's utility function when $\underline{x} = 0$

chooses $w_2^* = b$ which leads the physician to choose x^{FB} and the sum of the patient's and physician's utilities attains its maximum. However, when $\lambda > 0$, there is a trade-off in the choice of w_2, as high values of w_2 lead to a high effort level, but also to a high tax collection cost. In these cases, w_2 is never in $\left]0, \underline{w_2}\right[$, as they imply the same effort level as $w_2 = 0$ and a higher tax collection cost. When λ is low enough, there are values of w_2 higher than $\underline{w_2}$ which generate a higher social utility than the one that results from paying no treatment bonus. However, if λ is higher or equal to a cut-off value, $\overline{\lambda}$, the collection of taxes needed to foster high effort levels is so high, that it is better to simply not pay anything to the physician and let her choose x_a^I.

If $\lambda \geq \overline{\lambda}$, the Government's decision is $w_2^* = 0$. But, otherwise, its characterisation is more complex. In this case, the physician is choosing an effort level different from x_a^I, which means (5.16) is respected. Also, the Government chooses a positive w_2 and the first-order condition for the second branch of (5.19) is fulfilled (for an easier reading, we omit the arguments):

$$p_a^{'} x_{aw_2}^{*\prime} b + x_{aw_2}^{*\prime} \left(p_a^{'} \alpha b - c^{'}\right) = \lambda \left(p_a^{'} x_{aw_2}^{*\prime} w_2 + p_a\right) \tag{5.24}$$

The left hand side of equation (5.24) is the marginal benefit of increasing w_2: when

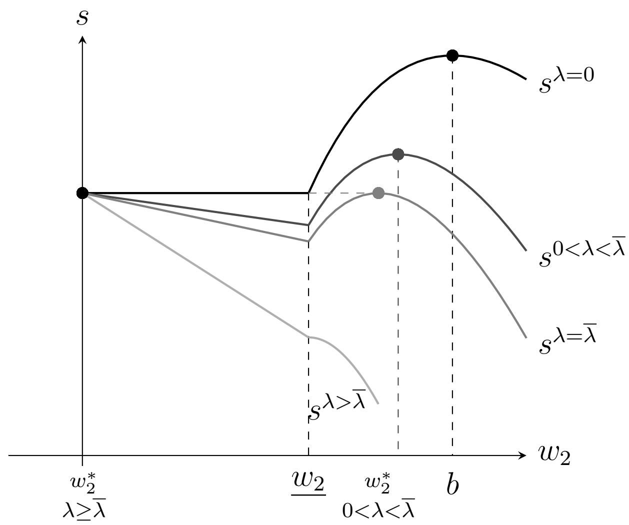


Figure 5.4: Government's utility function when $\underline{x} = 0$ or $\underline{x} > 0$, $v_a\left(x_a^I\right) \geq v_n\left(x_n^*\right)$ and $(1+\alpha)\, bp_a'\left(\underline{x}\right) \geq c'\left(\underline{x}\right)$

w_2 increases, so do the patient's and physician's non-monetary utilities, because the effort level becomes higher. The right hand side is the marginal cost of increasing w_2: when w_2 increases, the probability of the payment occurring goes up and so does the value paid in case of improvement of the patient's health status, and both these effects are weighted by the tax distortion. Introducing (5.16) into (5.24), we obtain the following:

$$w_2^* = \frac{b}{1+\lambda} - \frac{\lambda}{1+\lambda} \frac{p_a\left(x_a^*\left(w^*\right)\right)}{p_a'\left(x_a^*\left(w^*\right)\right) x_a^{*\prime}\left(w^*\right)} \tag{5.25}$$

Although (5.25) does not give us a closed solution to w_2^*, it helps us understand the impact the parameters of the model have on it. We already knew that w_2^* is not greater than b, but now we can add that it never exceeds $\frac{b}{1+\lambda}$. As b or α increase, so does w_2^*, because the higher the benefit associated with the improvement of the patient's health status, the more valuable it is for society that the patient gets better and, therefore, the higher the value of w_2 the Government is willing to pay to induce the physician to exert a high effort level. On the other hand, if λ increases, then it is more costly to transfer money between taxpayers and the physician, which implies a lower value of w_2^*. Proposition 2 summarises the Government's decision in the conditions of this subsection.

Proposition 2. When the patient adheres to the treatment for any effort level chosen by the physician, the following statements are true:

1. The optimal adherence bonus, w_1^*, is 0.

2. The optimal improvement bonus, w_2^*, is in $\{0\} \cup \left[\underline{w_2}, b\right]$, where $\underline{w_2} \in [0, b]$ decreases with b and α.

3. When there is no tax distortion, that is, when $\lambda = 0$, $w_2^* = b$ and the optimal effort level, x^*, is x^{FB}.

4. x^* and w_2^* increase with b and α and decreases with λ.

Proof. See Appendix E. □

In this particular situation, the single objective is the optimal effort to generate better outcome (but not adherence, since it is already guaranteed) and w_2 is the instrument to guide decisions.

5.3.3 The patient may adhere or not

We now focus on the situation in which $\left(p_a - p_n\right)(0)b < k$, that is, when a zero effort level will induce non-adherence. In this case, the physician needs to exert at least a certain positive effort level in order to lead the patient to adhere. This means that w_1^* may be positive and, therefore, in equilibrium, v may depend on both bonuses.

5.3.3.1 The physician always prefers adherence

It is possible that, even if the patient considers non-adherence, the physician does not. That is, even receiving no bonuses, the optimal effort level of the physician is such that the patient adheres. If we define $x_a^*(w_1, w_2)$ as the physician's optimal effort level when the adherence and improvement bonuses are, respectively, w_1 and w_2, this is the case when $v_a\left(x_a^I\right) \geq v_n\left(x_n^*\right)$, or $\Delta_v\left(x_n^*, x_a^I\right) \leq 0$. Once again, the Government does not need to induce adherence and $w_1^* = 0$. As for w_2^*, it is characterised much in the same way as in the previous section. Specifically, we have a single objective (x) and one instrument (w_2).

In opposition to what happens in the previous section, the patient does need to be convinced to adhere. If the physician exerts no effort at all, the adherence cost is high enough so that the patient prefers not to adhere. However, from a certain effort level on, the increase in the probability of improvement of the patient's health status caused by adherence makes the patient want to adhere. This is depicted in Figure 5.5.

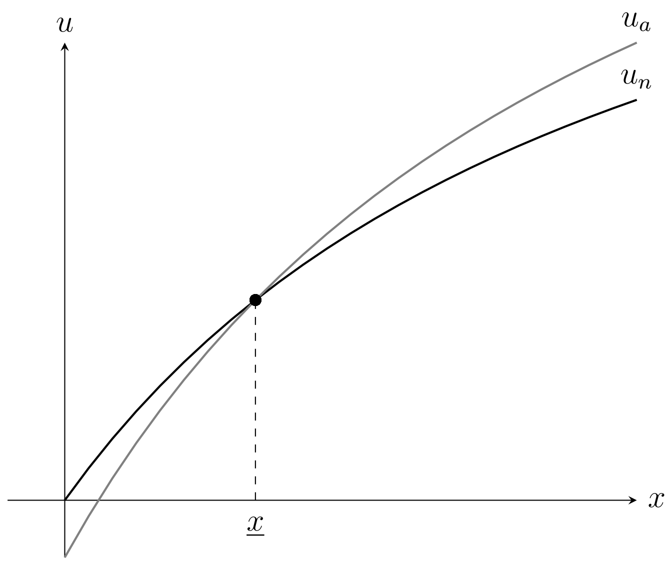


Figure 5.5: Patient's utility functions when $\underline{x} > 0$

As for the physician, although knowing that effort levels below $\underline{x}$ induce non-adherence, she never chooses them, because she is better off when there is adherence. This happens because she highly benefits from the improvement of the patient's health status, or because the difference in the probability of this improvement occurring when the patient adheres and does not is very high. In this case, even if, with $w_2 = 0$, adherence is guaranteed, $\underline{w_2}$ may still be positive. As in the previous section, when the physician is very eager to contribute to the improvement of the patient's health status, she decides for an effort level higher than $\underline{x}$ even when she receives no bonus. Otherwise, when $w_2 = 0$, she chooses $\underline{x}$, the minimum effort level that leads to adherence, and $\underline{w_2} > 0$. The situation is similar to the one in the previous section, but now $\underline{x} > 0$. Figure 5.6 illustrates the physician's decision.

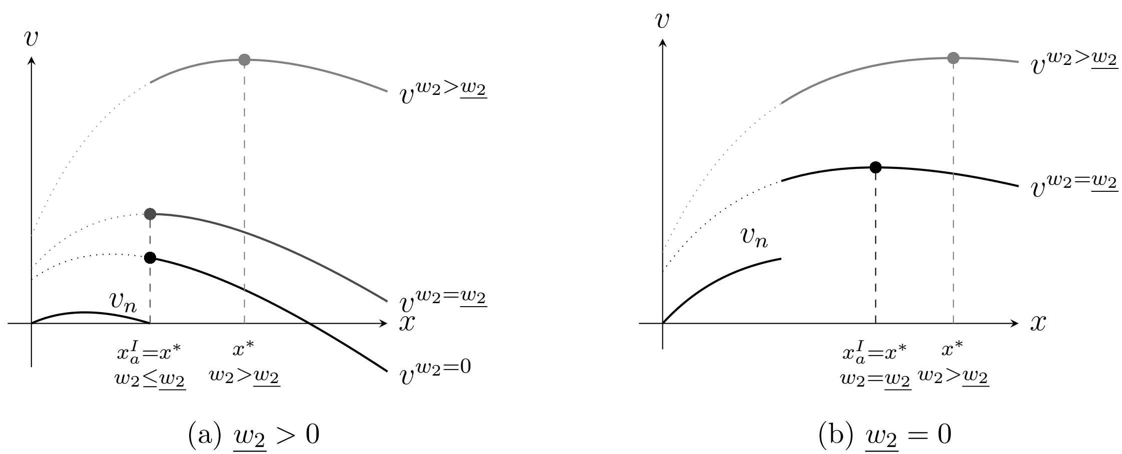


Figure 5.6: Physician's utility function when $\underline{x} > 0$ and $\Delta_v \left(x_n^*, x_a^I\right) \leq 0$

In the perspective of the Government, almost everything is the same as in the previous section. When $w_2 \in \left[0, \underline{w_2}\right]$, the physician's decision may not be changed and, in the presence of $\lambda > 0$, the only possible optimal value for w_2 in this interval is 0. For $w_2 > \underline{w_2}$, the physician chooses an interior optimal effort level, which, in the previous section, meant that, if λ is low enough, social utility is increasing at $\underline{w_2}$. However, when $\underline{x} > 0$, it may happen that $(1+\alpha)\, bp_a'(\underline{x}) < c'(\underline{x})$. If this is the case, the social marginal benefit of $\underline{x}$ is lower than the correspondent social marginal cost and, as the difference between this marginal benefit and marginal cost is decreasing in the effort level, $\underline{x}$ is socially better than any effort level higher than it. In this situation, the Government decision is straightforward: whatever the value of λ, the best decision is to pay no bonuses whatsoever. In the more interesting case, which happens when $(1+\alpha)\, bp_a'(\underline{x}) \geq c'(\underline{x})$, the Government prefers to pay a positive improvement bonus when the tax collection cost is low enough, but, when collecting taxes becomes too costly, $w_2^* = 0$. Figure 5.4 applies to this case. In the cases in which $w_2^* > 0$, as the social utility function suffers no changes relatively to the previous section, w_2^* is still characterised by (5.25). Finally, in the most interesting case, all the conclusions in Proposition 2 are still valid.

Proposition 3. When the physician always prefers adherence to non-adherence, and the social marginal benefit of $\underline{x}$ is not lower than its social marginal cost, all statements in Proposition 2 are true.

Proof. See Appendix E. □

5.3.3.2 The physician may prefer non-adherence

Finally, we are left with the case in which not only does the patient need to be convinced to turn to the adherence side, but so does the physician. This happens when $v_a\left(x_a^I\right) < v_n\left(x_n^*\right)$, or $\Delta_v\left(x_n^*, x_a^* I\right) > 0$, that is, when paying no bonuses to the physician leads her to exert an effort which induces non-adherence. This is the most interesting case because the Government now has two objectives to balance: assure adherence (if that is socially optimal) and guarantee that the optimal effort level is chosen by the physician. And this, as we will see, makes room for a positive w_1^*.

When the Government chooses the bonuses to induce adherence, he may leave the physician indifferent between adherence and non-adherence (and, in this case, we assume that adherence is attained) or strictly preferring adherence. Before continuing, let us state an important result:

Proposition 4. If $\left(p_a\left(x\right) - p_n\left(x\right)\right) b < k$, $v_a\left(x_a^I\right) < v_n\left(x_n^*\right)$ and $x^* > \underline{x}$, then $v_a\left(x^*\right) > v_n\left(x_n^*\right)$.

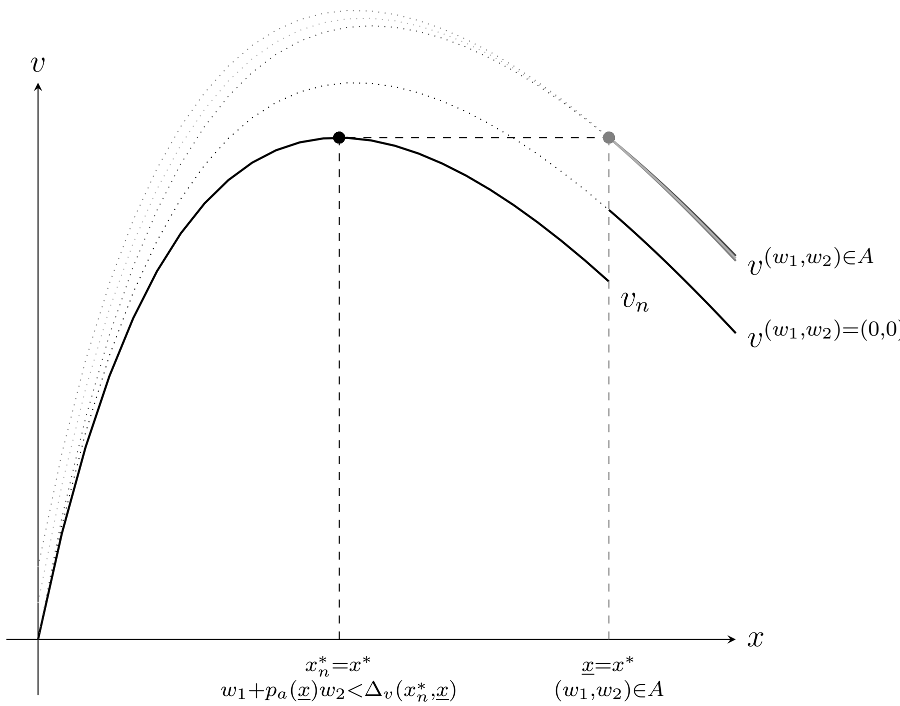
Proof. See Appendix E. □

Proposition 4 has more implications than it may seem. It tells us not only that, if the physician is optimally exerting an effort higher than $\underline{x}$, she must be strictly better off with adherence, but also that, when she is indifferent between adherence and non-adherence, she exerts $\underline{x}$. It is still possible that the physician is exerting $\underline{x}$ and strictly preferring adherence, but this is never socially optimal. This is because, in this case, it is possible to pay less to the physician, still assuring that she exerts $\underline{x}$, which does not change the non-monetary utilities of the patient and the physician and reduces the cost of collecting taxes. Hence, we get that, in equilibrium, either the physician is exerting $\underline{x}$ and is indifferent between non-adherence and adherence, or is exerting a higher effort level and strictly prefers adherence.

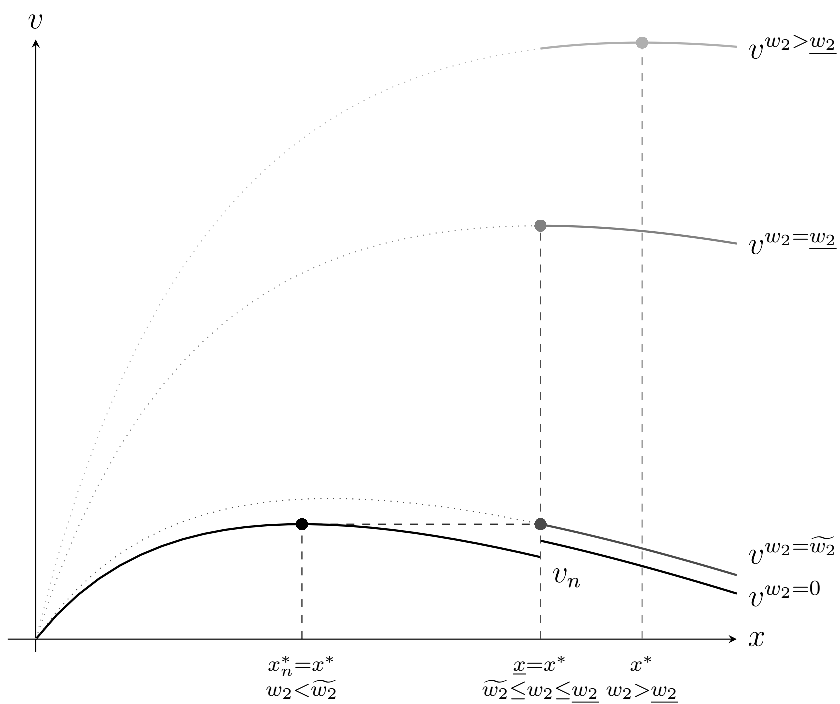
Let us focus on the former situation. The utility of the physician, if she gets no bonuses and chooses to induce non-adherence is $v_n\left(x_n^*\right)$. But, if she is paid enough to be indifferent between adherence and non-adherence, her non-monetary utility is $v_u\left(\underline{x}\right)$. This means that her expected total bonus, $w_1^* + p_a\left(\underline{x}\right) w_2^*$, has to make up for the difference between these two utility levels. Formally, in this type of equilibrium, $\left(w_1^*, w_2^*\right)$ belongs to the following set:

$$A = \left\{ \left(w_1, w_2\right) \in \left(\mathbb{R}_0^+\right)^2 : w_1 + p_a\left(\underline{x}\right) w_2 = \Delta_v\left(x_n^*, \underline{x}\right) \right\} \tag{5.26}$$

Analysing (5.26), we can see that, in this type of equilibrium, w_1 and w_2 are substitutes, that is, if the Government decides to increase one of them, it has to decrease the other, so that the total expected bonus is still in A. So, if it is socially optimal that the Government simply induces adherence, assuring that the physician exerts the minimum effort that leads to it, the way it designs the payment scheme, defining the adherence and improvement bonus, does not make much difference, as long as adherence is guaranteed. In this case, both bonuses have the same role: convince the physician to go that extra mile which assures that the patient adheres. In what refers to the adherence bonus, this is expected, because that is the main reason for its existence. But the improvement bonus, in this case, works like a



(a) The Government only wants to induce adherence



(b) The Government wants to induce adherence and a high effort level

Figure 5.7: Physician's utility function when $\underline{x} > 0$ and $\Delta_v\left(x_n^*, x_a^I\right) \leq 0$

decoy: it is meant to attract the physician to $\underline{x}$, because she knows that the probability of improvement is higher with $\underline{x}$ than with x_n^*. Figure 5.7a illustrates this type of equilibrium. When $(w_1, w_2) = (0, 0)$ and, more generally, when $w_1 + p_a(\underline{x})\, w_2 < \Delta_v(x_n^*, \underline{x})$, the best the physician can do is to exert x_n^* and the patient does not adhere. To make sure that adherence occurs, expecting to pay as little as possible, the Government has several options. Three of them are depicted in the figure: one in which only an adherence bonus exists, one in which only an improvement bonus exist, and one in which there is a combination of both bonuses. Although they influence the physician's utility function in different ways, their impact is the same: in equilibrium, $x^* = \underline{x}$. We may still add that there are maximum levels of w_1 and w_2 the Government may choose when trying to induce this type of equilibrium, respectively:

$$\widetilde{w_1} = \Delta_v\left(x_n^*, x_a^I\right) \tag{5.27}$$

$$\widetilde{w_2} = \frac{\Delta_v\left(x_n^*, x_a^I\right)}{p_a(\underline{x})} \tag{5.28}$$

Both of them depend positively on $\Delta_v\left(x_n^*, x_a^I\right)$ because the more comfortable the physician is with non-adherence, the more the Government has to spend to convince her to make an effort which assures adherence. The maximum improvement bonus, $\widetilde{w_2}$, depends negatively on $p_a(\underline{x})$ because, in opposition to what happens with the adherence bonus, its payment is probabilistic and, the more probable it is, the lower it needs to be. Notice that $\widetilde{w_1} \leq \widetilde{w_2}$ because they both correspond to situations in which the one of the bonus is given and, while w_1 is paid with certainty, w_2 may be or not.

In the other type of equilibrium that may arise, the Government pays the physician not only to induce adherence, but also to assure the effort level is higher than the minimum that guarantees it. And, in this case, the role for w_1 is lost and its optimal level is 0. This happens because it does not change the effort level chosen by the physician, just her utility. Therefore, if there was an equilibrium of this type, in which the physician strictly prefers adherence, and w_1^* is positive, w_1 could be reduced in a way that would not change the physician's decision and the cost of collecting taxes would decrease, hence benefiting society. We are thus left with the study of w_2^*.

Let us define $\underline{w_2}$ in this context as the highest value w_2^* may be so that the physician still chooses $\underline{x}$. Note that $\underline{w_2} \geq \widetilde{w_2}$. No improvement bonus in $\left]\widetilde{w_2}, \underline{w_2}\right]$ is ever socially optimal because it leads to the same effort level as $\widetilde{w_2}$ and to a higher cost of collecting taxes. Hence, the optimal w_2 chosen by the Government is higher than $\underline{w_2}$ (the highest one which leads to an effort of $\underline{x}$) and lower or equal to b (the one that leads to the first best effort level). The set of optimal bonus packs the Government may choose in this type of equilibrium is then:

$$B = \left\{(w_1, w_2) \in \left(\mathbb{R}_0^+\right)^2 : w_1 = 0 \wedge \underline{w_2} < w_2 \leq b\right\} \tag{5.29}$$

Figure 5.7b illustrates this type of equilibrium. Gathering both types of equilibrium, we can define the optimal adherence bonus, given the improvement bonus chosen. If $w_2 \leq \widetilde{w_2}$, only the first type of equilibrium is possible, and w_1^* is such that $(w_1^*, w_2) \in A$. Otherwise, only the second type of equilibrium is possible and $w_1^* = 0$. In sum, we have:

$$w_1^*(w_2) = \begin{cases} \Delta_v\left(x_n^*, \underline{x}\right) - p_a\left(\underline{x}\right) w_2 & , \quad w_2 \leq \widetilde{w_2} \\ 0 & , \quad w_2 > \widetilde{w_2} \end{cases} \tag{5.30}$$

Figure 5.8 shows what may be the optimal choices of the Government when it is trying to induce adherence. In A, we have $w_1 = w_1^*(w_2)$, the physician is indifferent between choosing x_n^* and $\underline{x}$ and the Government is indifferent between all points in the line segment (because all imply the same effort level and expected payment). In B, $w_1 = 0$ and the physician is choosing an effort level higher than $\underline{x}$. If there were no cost of collecting taxes, the Government would simply select point $(0, b)$ which would induce the first best effort level and adherence. However, taxes are (in general) costly which means the Government has to settle with a social utility lower than the first best one, paying an improvement bonus lower than b. As we shall see, the higher the cost of collecting taxes, the more attractive A is, relative to B.

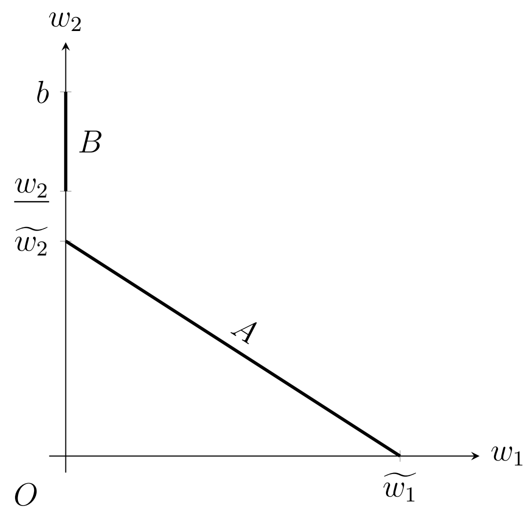


Figure 5.8: Possible optimal bonus packs which induce adherence when $\underline{x} > 0$ and $\Delta_v\left(x_n^*, x_a^I\right) \leq 0$

In Figure 5.9, the horizontal axis is relative only to w_2, even though w_1 may also affect the Government's utility. This is because w_1 is assumed to be $w_1^*(w_2)$. That is, for each w_2 the Government may possible choose, only the optimal w_1 that corresponds to it is considered. In this figure, we may see, in the case in which $(1+\alpha)\, bp_a'(\underline{x}) \geq c'(\underline{x})$ (that is, when the socially optimal effort level is higher than $\underline{x}$), the impact λ has on the equilibria attained. For any λ, if $w_2 \leq \widetilde{w_2}$, it is combined with $w_1^*(w_2)$, the expected payment to the physician is always the same and she always chooses $\underline{x}$, which means the Government's utility is constant. If $w_2 \in \left]\widetilde{w_2}, \underline{w_2}\right]$, $w_1^* = 0$ and the physician is still choosing $\underline{x}$. Hence, the higher the w_2 in this interval, the lower the Government's utility. Finally, if $w_2 > \underline{w_2}$, $w_1^* = 0$ and the physician is choosing an effort level higher than $\underline{x}$. If collecting money is costless, the Government simply pays the physician what she needs (b) to choose the first best effort level. However, as λ increases, it becomes more and more difficult for the Government to induce high effort levels.

Eventually, at high levels of λ, paying the physician only to induce adherence or not paying anything at all and let non-adherence be a reality is preferrable to paying her to make an effort higher than $\underline{x}$. In Figure 5.9, we depict a situation in which there is a transition from effort levels higher than $\underline{x}$ to $\underline{x}$ to x_n^*. When λ reaches a first cut-off level, $\underline{\lambda}$, inducing high effort levels is worse than inducing $\underline{x}$, but the latter is still preferrable to not paying anything to the physician. However, when λ reaches a second cut-off level, $\overline{\lambda}$, collecting taxes is so costly that the Government should just abstain from intervening and give up from inducing adherence.

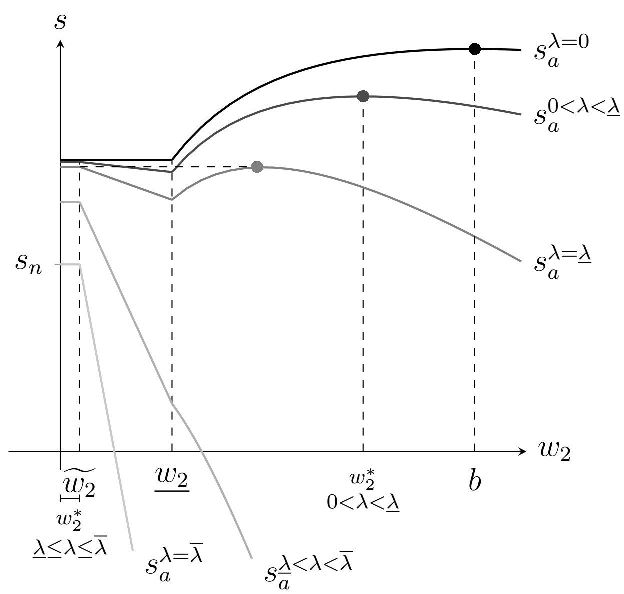


Figure 5.9: Government's utility function when $\underline{x} > 0$, $v_a\left(x_a^I\right) < v_n\left(x_n^*\right)$ and $\left(1+\alpha\right)bp_a'\left(\underline{x}\right) \geq c'\left(\underline{x}\right)$

As for the characterisation of w_2^* when $\lambda < \underline{\lambda}$, the same reasoning used in Subsection 5.3.2 applies: both the physician and the Government are choosing interior solutions, and we may insert (5.16) in (5.24) to get (5.25). In Proposition 5, we have a description of the Government's decision in the conditions of this subsection.

Proposition 5. When the physician does not induce adherence in the absence of bonuses and the social marginal benefit of $\underline{x}$ is not lower than its social marginal cost, the following statements are true:

1. When the tax distortion is low, the optimal adherence bonus, w_1^*, is 0, and the optimal improvement bonus, w_2^*, is in $\left]\underline{w_2}, b\right]$, where $\underline{w_2} \in [0, b[$ decreases with α and b and increases with k.

2. When the tax distortion is high, the optimal adherence and improvement bonuses are 0 and there is no adherence.

3. When the tax distortion is moderate, we may have multiple equilibria, in which the distribution of bonuses is the same, as long as the expected payment to the physician does not change.

Proof. See Appendix E. □

5.4 Discussion

Payment mechanisms play an important role in aligning the physician's incentives with the ones society has. The most common mechanisms of physician payments are salary, FFS, capitation, and P4P (Grignon et al., 2002). The remuneration of a physician can mix one or more type of payments as in the case of the UK, the US (Kazungu et al., 2018), and Portugal (Simões et al., 2017). Briefly, under salary the physicians are paid an annual amount to work a set number of hours per week per year (Gosden et al., 2000). On the other hand, capitation reimburses practices on the basis of a list of potential users and FFS reimburses each item of service provided and occurs after care has been provided (Gosden et al., 2000). As for P4P, it rewards or penalise health care providers according to their performance on measures of quality.

These payment mechanisms have been used by Governments to improve the delivery of evidence-based care and health outcomes (Ettner, Schoenbaum and Williams, 2012; WHO, 2014). In mental health, evidence suggests that continuous care should be provided in order to enhance and monitor adherence (Balon, 2002). However, it is not clear how policy-makers can improve adherence using payment mechanisms.

In our model it is possible to improve a mental health patient status through a payment mechanism. That is, we introduce two types of payment mechanisms: an adherence bonus (w_1) which is received by the physician if the patient adheres to the treatment; and an improvement bonus (w_2) which is paid if the patient's health status improves. Our results show that what is relevant is not the type of incentives that are in place but how hard is to collect money from taxpayers. Specifically, and analysing the situation in which patient may not adhere and the physician may prefer non-adherence, the Government cannot induce adherence if collecting taxes is too costly. On the other hand, if the cost of collecting taxes is moderate then it is not relevant the type of payment mechanisms that are in place because it is possible to induce adherence only by using the adherence bonus, or the improvement bonus, or a combination of both. When the cost of collecting taxes is low, the Government finds optimal a positive improvement bonus and a zero adherence bonus. This last result applies when the patient always adheres or when he may adhere or not but the physician always prefers adherence.

The adherence bonus can be seen as a proxy of FFS while the improvement bonus can be assumed as a P4P mechanism. Despite the implementation of financial incentives to the physicians being country specific, most studies report a combination of FFS and P4P since it is a way of overcoming some of the weaknesses of those payment mechanisms (Conrad, 2015). It is discussed that FFS *per se* induces high volume namely in practices that provide a high net income per unit of service. However, if FFS is complemented with P4P incentives it may improve quality of care (Conrad, 2015).

Specifically on mental health, in Part I, Chapter 1, we have described several reimbursement models tested in mental health but with limited success, and therefore, making evidence poorly conclusive about which system functions best for mental health. Recently, Perelman et al. (2017a) propose an innovative payment model for mental health providers by incentivising best practices. Based on theoretical considerations, the authors argue that FFS should be opted when there is evidence that a specific service is a good practice. On the other hand, capitation and bundle payments are favoured as they promote efficiency, continuity care, and prevention but the authors complemented these schemes with P4P. Particularly, and for the Portuguese mental health system, authors suggest the inclusion of a P4P indicator and an additional fee for each follow-up consultation to be paid to general practitioners (Perelman et al., 2018). However, based on our results and given the tight budgets Portugal has been facing, we believe that what matters is to keep the expected payment of physicians constant and not how the incentives are provided to them. The choice between which payment mechanism prevails will rely on other reasons such as administrative simplicity.

Additionally, the literature has been arguing that a successful P4P scheme depends on the ability to measure performance (Ettner, Schoenbaum and Williams, 2012). In cases in which assessing performance is hard, and Governments face tight budgets, our model suggests that policy-makers can rely on the FFS payment instead of the P4P. It is worth mentioning that innovative measures to evaluate and improve quality of mental health care are being implemented in several countries (Kilbourne et al., 2018).

Our results can be tested empirically. Particularly, the physician's effort level can be proxied by indicators that assess the degree of involvement of the physician in patient's treatment such as the number of medical procedures. Regarding patient's adherence cost, we can use as proxy the number of prescriptions not filled. To assess the patient's improvement health status several patient health questionnaires are available namely the PHQ-9 or the Health of the Nation Outcome Scales (HoNOS). Finally, and regarding to the degree of altruism, Jack (2005) suggests that physicians with higher values of α can be the ones that admit more patients for secondary care since they perceive a great benefit of admission.

Overall, when adherence is not attractive to patients and physicians, what matters is not the payment mechanism itself but how costly it is to collect money from taxpayers. Hence, when Governments face tight budgets, policy-makers can choose the payment mechanism that best suits mental health needs knowing that if assessing performance is hard, FFS can be the optimal option.

It is worth highlighting that the optimal adherence and improvement bonuses decrease with the level of altruism and with the benefit that the patient gets from improving. This result emphasises the work of Godager and Wiesen (2013), where authors found evidence of different levels of altruism towards patient's health benefit using behavioural data.

Finally, in our model, the first-best is never attained unless there is no tax distortion. The first-best is characterised by a P4P scheme in which an optimal adherence bonus of zero and an improvement bonus equal to the benefit that the patient gets if his health status improves.

5.5 Further Research

In our model we consider that adherence, when not attractive, can be induced through a payment mechanism provided to the physician. However, the patient also bears an adherence cost (k) which will determine the threshold level $\underline{x}$. Therefore, we can extend our model to allow a scheme which includes payments to both the patient and physician.[13] This extension would allow us to compare the impact of each type of payment and find out if just one of them or a combination of both should be put in practice.

Moreover, and follow the work performed by Fichera et al. (2018), we can extend our model to consider the probability of improving depends not only on the physician's effort

[13] One possible way is to reduce the value of co-payments.

but also on the patient's effort.

5.6 Conclusion

In this paper we design a model to answer to the question: "Is it possible to improve a mental health patient status when treatment non-adherence is a possibility through payment mechanisms?". Our model considers a mental health patient, a semi-altruistic physician and an utilitarian Government. The patient may not adhere to the treatment and the physician's payment depends not only on the patient's adherence but also on the patient's health status. That is, we introduce two types of payments: an adherence bonus, w_1, if the patient adheres to the treatment; and an improvement bonus, w_2, if the patient's health status improves. The adherence bonus can be seen as a proxy of FFS while the improvement bonus can be assumed as P4P mechanism.

We conclude that, if adherence is not guarantee since the patient may not adhere and the physician may prefer non-adherence, the optimal bonuses depend on how costly it is to collect money from taxpayers. Specifically, for a high level of tax distortion, the Government has no saying on the final outcome and should refrain from collecting taxes. If the level of tax distortion is moderate, then what matters is not the payment mechanism *per se* as long as the expected payment to the physician does not change. That is, it is possible to achieve the same result combining both bonuses or only using one of them. When tax distortion is low, the optimal adherence bonus is zero and the improvement bonus depends negatively on the level of altruism and with the benefit that patient gets from improving.

In our model the first-best is characterised by an optimal adherence bonus of zero and an improvement bonus equal to the benefit that the patient gets if his health status improves. However, the first-best is never attained unless there is no tax distortion.

Part III

Socio-economic determinants of mental health

Chapter 6

Young, well-educated and unemployed: A risky combination for perceived mental health?[1]

6.1 Introduction

The mental health status of an individual is a result of a sequence of events that occur in various domains throughout his live. Risk factors are characteristics which not only increase the likelihood of developing a mental health problem, but can also worsen the burden of existing conditions. These may comprise individual characteristics, family characteristics and functioning, school context, community and cultural factors and stressful life events, such as unemployment (OECD, 2012*b*). Indeed, unemployment is associated with lower income, earnings instability, lower life-satisfaction, social stigma, loss of self-esteem and social contacts, lower physical and mental activity and under-use of one's skills (Artazcoz et al., 2004; OECD, 2012*b*). All these factors have a negative impact on mental health

[1]The co-authors of this paper are Ana Moura, Adriana Loureiro, Paula Santana and Pedro Pita Barros.

status since they contribute to depression and anxiety. In addition, the young unemployed people have a higher risk in developing a mental health disorder when compared to the young people who remain employed (WHO, 2011*a*). Therefore the unemployed, namely the young unemployed, are a specially vulnerable group and have lower levels of mental health than the general population (Artazcoz et al., 2004).

Due to the recent global economic and financial crisis, unemployment rates, namely the youth unemployment ones, have increased significantly.[2] These economic developments raised additional interest on the impact of youth unemployment on mental health status.

The recent report on youth unemployment issued by the ILO (ILO, 2015), states that the global youth unemployment rate increased from 11.7% in 2007 to 13% in 2010. Despite this fast increase the rate settled at 13% between 2012 and 2014 but it is expected to slightly raise to 13.1% in 2015 (ILO, 2015). In the euro area, the unemployment rate among individuals under 25 amounted to 23% in 2014 (Banerji et al., 2014).

Despite the improvements at the aggregate level between 2012 and 2014, youth unemployment rate still exceeded 30% in several European countries such as in Greece (52,4%), Italy (42,7%), Portugal (34,8%), and Spain (53,2%) (ILO, 2015). Due to the crisis, some of these countries are still undergoing austerity adjustments. According to ILO, these adjustments prove to have harmful consequences for youth (ILO, 2015).

It is worth highlighting that the European Commission considers youth unemployment a priority and has taken action by adopting a set of measures aimed at fighting its trend (Banerji et al., 2014; EC, 2019).

Portugal provides the ideal framework to assess the link between youth unemployment and mental health status as it has been continuously among the worst performers in the European Union in terms of youth unemployment.

[2]The youth unemployment rate is defined as the number of unemployed youth (typically between 15 and 24 years old) divided by the youth labour force.

Using data from a survey carried out in 2014 and 2015 among individuals living in the Lisbon area, we unveil a strong negative relationship between unemployment and mental health for individuals under 35. The magnitude of this relationship increases with the level of education of the individual. This may reflect the unmet expectations of young individuals who completed more years of schooling, as far as labour market outcomes are concerned, a conjecture deserving future exploration.

This study is integrated in the research project SMAILE (Study on Mental health - Assessment of the Impact of Local and Economic conditioners) which aims to assess the effect of environmental and territorial health determinants on the mental health and on the use of mental health services in times of social and economic crises.

The remainder of this chapter is as follows. The next section briefly reviews the literature. Section 6.3 presents the dataset used throughout our analysis, while the methodological approach is described in Section 6.4. Section 6.5 presents the main results of our analysis, which are then discussed in Section 6.6. Section 6.7 provides the limitations of our study. Finally, Section 6.8 concludes.

6.2 Literature Review

The body of literature on the impact of unemployment on mental health is vast and a special interest on the topic has recently been growing. A negative relationship between mental health status and unemployment has long been established (Paul and Moser, 2009; Berchick et al., 2012; OECD, 2012*b*; Farré, Fasani and Mueller, 2018). Specifically, Huegaerts, Puig-Barrachina and Vanroelen (2017) find that unemployed youth face a worse mental health situation when compared to employed youth. More recent literature has focused on the evolution of this relationship in light on the current economic and financial crisis, as well as on the identification of protective socio-economic factors that can ease the impact of unemployment on mental health (Berchick et al., 2012; Huegaerts, Puig-Barrachina and Vanroelen, 2017).

As far as the relationship between unemployment and mental health is concerned, evidence has shown that it was exacerbated by the economic crisis.

Two main theories have been put forward in the literature aimed at assessing for which population groups is the impact produced by unemployment on mental health more negative. On the one hand, we have the theory of role loss posing that those most affected from job loss are the ones who are more privileged as far as job content and salary are concerned (Ashforth, 2001). On the other hand, there are theories of general/differential susceptibility, which state that people with few social and economic resources are those who suffer the most from job loss (Syme, 1996). The rationale behind this theory relates to the idea that being in a disadvantaged socio-economic position will exacerbate the negative effect produced by unemployment on mental health (Backhans and Hemmingsson, 2011).

Other determinants of mental health include age, gender and socio-economic variables such as education and income (Esteban et al., 2012; OECD, 2012*b*). In contrast with other conditions, mental health diseases have an early onset at a median age of 14. By the age of 24, 75% of all mental illnesses have already been developed (OECD, 2012*b*). According to the last Portuguese epidemiological study, the 18-34 age group is more likely to develop a mental health disease than the other age groups. The younger have a higher prevalence (50.1%) of having at least one psychiatric disease (Almeida et al., 2013).

Men and women have different roles in society so that gender determines the susceptibility and the exposure to certain mental health risk factors (WHO, 2002). According to the gender roles hypothesis, gender differences should narrow as the roles of women and men converge (Seedat et al., 2009). Epidemiological studies state that women are more likely to have anxiety and humour diseases than men. However men are more prone to have both alcohol and substance abuse diseases (Almeida et al., 2013).

Finally, there is evidence that individuals with poorer mental health status have both lower education and financial resources (OECD, 2012*b*). However, a recent study found that population with higher education, along with unemployment, is a high context risk factor for hospitalisation due to mental illness (Loureiro et al., 2015*a*).

Despite the fact that age, education, and unemployment *per se* have been associated with mental health, to our best knowledge, no study as yet focused on the effect of the interaction between these three variables. We propose to fill in this gap, by allowing the impact of unemployment on perceived mental health to differ by age group and, within each age group, to vary according to the education level of the individual. This allows to differentiate the impact of unemployment on mental health according to certain characteristics of the individuals, thus increasing the understanding of the dynamics of this relationship.

6.3 Data

A survey was carried out between August 2014 and February 2015, targeting the population ageing 18 and older living in the municipalities of Amadora, Lisbon, Mafra and Oeiras. These four municipalities were selected from the Great Lisbon Area and represent consolidated urban areas areas (Lisbon), recent urban growth areas (Amadora and Oeiras) and rural areas (Mafra), according to their distinct geographical and socioeconomic characteristics present in Table F.1 in appendix F.1. This allows having a diversity of territorial backgrounds while having a sufficient number of observations from each these territorial backgrounds. The statistical population consists of 808,110 inhabitants (INE, 2012) among which was collected data from 1,609 residents through simple random sample (estimated with a margin of error of 3.21% and a confidence level of 99%).

This survey collected individual information on demographic characteristics (age and gender); socioeconomic characteristics (education, professional status, marital status, household financial situation and expenditure concerns); health information (diabetes, hypertension, BMI); behavioural characteristics (smoking, physical activity), and self-assessed mental health status.

For the specific case of self-assessed mental health, it was measured by the mental health and vitality scale (MHVS) on the version validated to Portuguese population of the Short Form 36-item Health (SF-36v2) (Ferreira, Ferreira and Pereira, 2012). The SF-36 is a generic health survey, which measures functional health and well-being from the individual's viewpoint. It consists of 36 questions and is widely used to assess health-related quality of life (Ware and Sherbourne, 1992). More precisely, the MHVS ranges from 0 to 100, corresponding to the situations in which the individual experiences total and no disability, respectively. The MHVS was computed following the methodology proposed by Ware et al. (1993).

Additional information was gathered by the survey but it was not relevant for the purpose of our analysis. A more detail analysis on the data of this survey can be found on the study carried by Loureiro et al. (2015*b*) who used a multilevel approach.

A description of all the variables included in the model, their respective designations and summary statistics is presented in Table F.2 in appendix F.1. Note that, though 1,609 individuals were surveyed, there were some missing values in the data and we ended up with 1,464 complete observations.

6.4 Methodology

Our dependent variable is the MHVS described in the previous section. Given that it can be considered a continuous variable, we opted to use a multiple OLS regression model as a means to assess the impact of being unemployed on the mental health of the individuals. The OLS technique produces coefficients which are not only easy to interpret but also relatively robust when compared to those of other techniques (Cameron and Trivedi, 2005).

As far as the independent variables are concerned, our variable of interest is a binary one, which takes value 1 in case the individual was unemployed when the survey was carried out and value 0 otherwise (*UNEMP*).

We control for several other factors, which are likely to play a role in explaining individual mental health. These include age, gender, education, household financial situation, variables capturing physical health, among others. In addition, a variable indicating whether the individual is retired or not (*NRET*) was also included. While retired individuals are not unemployed by definition, their mental health score is still affected by their individual characteristics. Hence, by introducing *NRET* in the model we are able to use all the available data, instead of excluding this group from the analysis.

Our approach consists in estimating the impact of unemployment on MHVS by introducing interaction terms between some of the key regressors, as a means to differentiate the impact of unemployment on mental health according to certain individual characteristics, namely gender, age and the level of education.

In our first model specification, we allow the effect produced by unemployment on mental health to differ by education level. Hence, interaction terms between *UNEMP*, the variables capturing the education level of individuals and *NRET* are introduced in the model as regressors. Furthermore, we allow for unemployment to exert a distinct effect on the mental health of men and women. In order to do this, an interaction between *UNEMP*, *NRET* and the binary variable capturing the individuals' gender is introduced in the model. The corresponding equation is presented below.

$$MHVS_i = \alpha_0 + \alpha_1 * UNEMP_i + \alpha_2 * NRET_i + \alpha_3 * \Omega_i + \alpha_4 * \Upsilon_i + \epsilon_i \tag{6.1}$$

, where Ω is a vector of the interaction terms and Υ is a vector of individual characteristics. Table F.3 in appendix F.2 presents the variables comprised within this vector.

As previously mentioned, literature suggests the association between unemployment and mental health differs across age groups. In order to capture this effect, we divide our observations into age groups instead of considering only the two broad groups of retired and non-retired individuals. We introduce interaction terms between *UNEMP*, the variables capturing the education level of individuals and the age groups. Such approach allows us to assess whether the impact of unemployment on mental health differs by age group and, within each age group, whether it varies depending on the education level of the individual. Similarly to what was done in model specification (6.1), we allow for the impact of unemployment on mental health to vary according to gender and hence introduce an interaction term between *UNEMP*, gender and the age groups. The corresponding model specification is as follows.

$$MHVS_i = \alpha_0 + \alpha_1 * UNEMP_i + \alpha_2 * YOUNG_i + \alpha_3 * ADULT1_i + \alpha_4 * ADULT2_i + \alpha_5 * \Gamma_i + \alpha_6 * \Upsilon_i + \epsilon_i \tag{6.2}$$

, where $YOUNG$, $ADULT1$ and $ADULT2$ are the variables corresponding to the age groups, as defined in Table F.2. Individuals above 65 are set as reference group. Γ is a vector containing the above-mentioned interaction terms. Table F.3 in appendix F.2 presents the variables comprised within this vector.

It should be highlighted that we also regress both model specifications without considering the interaction terms, which we call the restricted versions of equations (6.1) and (6.2). In section 6.5 we present those results.

6.5 Results

The results from the estimation of equations (6.1) and (6.2) are presented in Table F.4 in appendix F.3. The results of the restricted versions of both equations (6.1) and (6.2) are presented as models 1 and 3, respectively. The first column presents the results for the full model, whereas the second column presents the results of a restricted model, in which the variables that were found not to be statistically significant were recursively eliminated.

Before presenting the results from the model specifications, it is worth recalling that our dependent variable, $MHVS$, ranges from 0 to 100. A higher score on the $MHVS$ is associated with a lower level of disability, meaning that a positive coefficient sign of a given regressor is associated with a better mental health status. Conversely, a negative coefficient is associated with a poorer mental health status.

According to model 1, the restricted version of equation (6.1), being unemployed does not produce statistically significant impact on perceived mental health. Similarly result is found for age and *NRET*. The level of education, in turn, was found to be positively associated with mental health. The remaining control variables bear the expected signs.

In model specification (6.1) we allowed the impact of unemployment on mental health to differ according to gender and the level of education, for non-retired individuals. None of the newly introduced interaction terms is statistically significant. As for the remaining variables, the results are similar to the ones obtained in the previous model specification, in terms of both statistical significance and magnitude.

Regarding model 3, where we did not introduce the interaction terms of the model specification (6.2), the coefficients associated with each age group are not statistically significant, similarly to what happened with the variable AGE in previous model specification. Therefore, we can state that this model converges to the first restricted model.

The output of the last model specification is presented in Table F.4 in the last two columns. For the newly introduced interaction terms between the level of education, age group and *UNEMP*, we have that the only statistically significant ones are those referring to individuals under 35 years old. In terms of marginal effects, the impact of being unemployed on perceived mental health is estimated at 2.1, -3.1 and -10.1 points, for young individuals with basic, secondary and college education, respectively.[3] The interactions corresponding to the remaining age groups are dropped in the restricted model, similarly to what occurs with the interactions including the variable gender.

Table F.5 summarises the results of the restricted versions of the four model specifications. Overall, being unemployed *per se* does not have an impact on perceived mental health as the associated coefficient is statistically undistinguishable from 0, regardless of model specification. Regarding the control variables, the associated effects operate in the expected direction and their sign and magnitude are very similar across all estimated models. We have that women score about 7 points less than men on the MHVS. Additionally, being concerned about daily expenses and facing difficulties in paying current household expenditures are associated with poorer mental health status (the effects amount to -5.4 and -6.4 points, respectively). In contrast, being able to accumulate savings after paying all expenses is positively associated with mental health (5.5 points). Suffering from hypertension is associated with a poorer mental health (around -5.4), whereas being physically active produces a positive impact on MHVS amounting to 4.7 points. None of the remaining control variables is statistically significant.

6.6 Discussion

Our results show that the mental health impact of being unemployed under the age of 35 varies according to education level of the individual. Though this impact is slightly positive for individuals who only completed basic education, it becomes increasingly negative for individuals with secondary and college education.

The magnitude of this effect is sizeable and amounts to -10.1 for individuals holding a college degree. We conjecture that people with more years of schooling may have higher

[3] These figures correspond to the derivative of the estimated equation in order to *UNEMP*.

expectations regarding job market opportunities, which are not met by the labour market. The extent to which the magnitude of these unmet expectations is being affected by the current economic and financial situation in Portugal one cannot know. As a matter of fact, since we only have information referring to 2014/2015, we are not able to understand whether the unmet expectations were caused by the crisis or if they were already present and the crisis only contributed to their exacerbation.

As for the slightly positive effect of being unemployed on the MHVS that was found for young individuals with basic schooling, we put forward the hypothesis that the utility originating from the increase in leisure time more than compensates for the income decrease faced by these individuals when moving to unemployment.

Both these results provide evidence in favour of the role loss theory in the sense that more privileged individuals (in terms of educational level) are the ones being more affected by unemployment, as far as mental health is concerned (Ashforth, 2001).

Regarding the control variables introduced in our model specifications, their associated coefficients are in line with previous literature. We find evidence of gender differences in the sense that women have poorer mental health than men (WHO, 2002).

As for the variables capturing the financial situation and expenditure concerns of the household, evidence from WHO also shows that financial difficulties are positively associated with mental health problems (WHO, 2011*a*; WHO and CGF, 2014).

In addition, we found the relationship between unemployment and perceived mental health to be similar for men and women as the coefficient associated with the interaction term between *UNEMP* and gender is statistically insignificant in the two model specifications where it is introduced. Previous evidence points to the fact that, when facing an unemployment situation, men tend to react more negatively than women (Paul and Moser, 2009; Backhans and Hemmingsson, 2011; Breslin and Breslin, 2013; Clemens, Popham and Boyle, 2014). This result may be related to the traditional breadwinning role of men within the household, so that men experience feelings of personal failure when they find themselves unable to maintain that role (Backhans and Hemmingsson, 2011). Alternatively, the fact that women can more easily replace the rewards formerly provided by their job with the nurturant family role, as put forward by the role enhancement hypothesis, may also be contributing to this result (Artazcoz et al., 2004). The reason why we do not find any statistically significant gender difference may be related to the increase in female labour market participation rates in the last decade (OECD, 2012*b*).

Overall, our results may be reflecting the consequences of the recent economic crisis, which is still present. Indeed, variables such as unemployment and income, two of the main determinants of poor mental health, were largely affected by the economic downturn (OECD, 2012*b*).

Finally, our results allow us to draw some policy implications. Policies aiming at enhancing mental health and promoting employment should be coordinated rather than dissociated. These policies should account for the fact that there is a particularly group within the population which is more vulnerable. This group consists in individuals under 35 years old, unemployed and holding a college degree. Evidence shows that individuals living in countries with generous unemployment benefits experience higher well-being during unemployment than those living in less generous countries (McKee et al., 2005). Despite the fact that national social security systems have been facing additional pressure due to the economic crisis (ISSA, 2012),[4] policies focusing on unemployment benefits should not be discarded. Hence, effective policies should combine the three key-areas: health, labour market and social security. This approach was already put forward by WHO (2005*b*), which suggested several combined strategies, such as the protection of mental health of the unemployed through social and re-employment programs. Additionally, policies aimed at strengthening the strong

[4]Such pressure is originated both by increased expenditures with unemployment benefits and lower revenue from contributions.

social ties and networks are also of relevance as they help avoiding social isolation (Kawachi and Berkman, 2001; Berchick et al., 2012).

In practice, Portugal has been implementing several measures targeting youth unemployment. Most of these were recommended by the EU to all member-states. To the best of our knowledge, no assessment of the effects of these measures on the youth unemployment rate was done so far.

All in all, our results point to the need for a coordinated and system-wide approach towards mental health and unemployment. Though the policies implemented in Portugal are not coordinated across these areas, the fact that they tackle unemployment may exert a positive impact on the mental health of young individuals.

6.7 Limitations

It is worth highlighting some limitations of our analysis. The first one relates to the difficulty in establishing a causal relationship between unemployment and poor mental health. Such difficulty has been widely documented in the literature and termed as *reverse causality* (Diette et al., 2012). More specifically, this effect relates to the fact that causality may run in both directions: on the one hand, it may be that unemployment acts as a stressor thus affecting the mental health of the individuals; on the other hand, those individuals might be unemployed precisely due to their poorer mental health status. More recent studies using a longitudinal, individual or panel approaches have manage to overcome this issue either by controlling for the mental health status of individuals before their unemployment experience or by focusing on changes in employment status (OECD, 2012*b*). Such studies were therefore able to find a causal impact of unemployment on mental health (Paul and Moser, 2009; Farré, Fasani and Mueller, 2018). Since our data refers to a survey which was only carried out once, we are not able to control for previous mental health status. Moreover, we lack information on the previous employment status of individuals, meaning that we cannot know whether individuals faced a change from employment to unemployment. Hence, reverse causality may be present in our results. As a guideline for further research, and in order to eliminate this possible bias, one would need to conduct this survey at a different point in time and use propensity score matching techniques to match the individuals in the two samples (note that the individuals surveyed will not be the same in the two samples since it is not possible to track their identities).

Additionally, we have only been concerned about whether an individual is employed or unemployed. However, as previously put forward in the literature, the type of job and the characteristics of the working environment also play an important role as far as mental health status is concerned. In fact, it has been shown moving from unemployment to low quality job can be detrimental to mental health (OECD, 2012*b*). Job insecurity, exposure to stress, no career prospects and lack of work task control are some of the characteristics of low quality jobs (OECD, 2012*b*).

There is also evidence in the literature that people experiencing mental health issues remain unemployed for a longer period, which may further exacerbate their mental health status and deplete their skills (OECD, 2012*b*). Previous literature has also highlighted the importance of distinguish unemployed individuals in two groups, depending in whether they are receiving unemployment benefits or not (Artazcoz et al., 2004). Due to the design of the survey, we did not account for unemployment duration nor unemployment benefits in our analysis.

6.8 Conclusion

This study provides additional evidence on the unemployment-mental health relationship, using a sample of Portuguese population living in 4 different municipalities in the Lisbon area, covering distinct territorial backgrounds. We allow the impact of unemployment on mental health to differ by age group and, within each age group, to vary according to the individual educational level.

Our results provide evidence of a negative relationship between unemployment and mental health for individuals under 35, while no such effect is found for other age groups. The magnitude of this relationship increases with the level of education of the individual, corresponding to -10.1 points on the MHVS for those with a college degree. We conjecture that our results may be reflecting the unmet expectations of young individuals who completed more years of schooling, as far as labour market outcomes are concerned. That is, well-educated young unemployed appear as a particular vulnerable group of mental health exposed to unemployment in times of economic crises. These results point to the need of coordinating policies targeting both mental health and unemployment at this age group.

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Appendix A

Chapter1

A.1 Literature Review

A.1.1 Why a new mental health financing plan for Portugal?

Portugal was one of the first European countries to adopt a national law ("Lei de Saúde Mental", 1963) in accordance to the principles of sectorisation,[1] which enabled the creation of mental health centers in every district and the appearance of various important actions, such as integration of mental health in primary care and social psychiatry — moving medical teams from psychiatric hospitals to community. These changes had a positive impact on the improvement of accessibility and quality of care, enabling responses closer to the population and a greater interaction with health centers and other community agencies (Almeida, 2009).

According to Kovess et al. (2005), Portugal does not have a consistent support to improve mental health services, namely in terms of accessibility, equity and quality of care, which explains why it is lagging behind in relation to other European countries. In fact, and based on a study carried by the Portuguese Mental Health Plan,[2] it was found psychiatric

[1]Establishment of small geographical catchment areas with dedicated mental health staff providing services to all patients living in the area.

[2]Questionnaire performed in 5 psychiatric emergency services in the first quarter of 2007. The aim was

patients have been struggling in schedule consultations and consequently their first option is to use the emergency services. This finding can be related to problems with accessibility to specialised care. Regarding quality of care, particularly continuity care, this study also revealed patients who have been discharged can wait more than one month for a subsequent consultation (Almeida, 2009).

Another important issue raised by this plan concerns the low level of resources, namely human and financial, available for mental health in Portugal when compared to the real contribution of mental illness to the global burden of disease. Both financial and human resources are distributed in an unbalanced way between the various regions of the country, where we have a clearly dichotomy between inland and rural areas (ACSS, 2015). Also, and since most patients are being treated in general hospitals, it was found a discrepancy in the distribution of psychiatrists between psychiatric hospitals and psychiatric departments in general hospitals.[3] This plan claims all these factors have been constrained the development and improvement of services in the mental health sector.

Management and financing models of services have also been mentioned as another fundamental restraint on the development of mental health services.[4] The argument is that placing management and financing of local services in general hospitals and limiting the financial autonomy of mental health departments, avoids any effort to develop comprehensive services in the community (Almeida, 2009). Availability of community services is essential since these services along with outpatient care can avoid relapses and, therefore, reduce rehospitalisations (CIHI, 2008).

to evaluate the obstacles in the access to specialised psychiatric care in the past 12 months. Limitations of the study: non-randomised study and selection bias.

[3]Data from 2005 revealed that we had 2.6 and 1.1 psychiatrists per 25,000 inhabitants in psychiatric hospitals and general hospitals, respectively.

[4]Financing is the "mechanism by which mental health plans and policies are translated into action through the allocation of resources"(WHO, 2003*b*, p.2).

A.1.2 Empirical works on mental health financing

Reference	Objective	Methodology	Results	Conclusion
Dwyer et al. (1995)	Evaluate a capitation-financed system of mental health services delivery for SMI developed in Rochester, NY.	A cost-benefit analysis was conducted using data (n=227) from baseline and two-years of follow-up. Patient outcomes were compared across randomly assigned study groups and across enrolment status. Difference in difference analysis was implemented to control for potentially non-random attrition and selective	Capitated community-based mental health program reduced costs considerably without worsening patients' health status, even after controlling for attrition and sample selection.	Placing SMI patients in community may have important implications for welfare, employment policies and health policy. Productivity of patients treated in the community can increase through more preventive and less intrusive treatment which can result in less welfare transfers and more productive population.

Reference	Objective	Methodology	Results	Conclusion
		non-compliance.		Limitations: treatment program requires extensive inter-agency cooperation and some patients may not participate and will require hospitalisation.

Reference	Objective	Methodology	Results	Conclusion
Bloom et al. (1998)[5]	Examine utilisation, cost and outcomes of inpatient and outpatient (including community) services before and after (first nine months) the implementation of a capitated payment system for Colorado's Medicaid mental health services compared to services that remained under FFS.	A stratified random sample of 513 SMI patients (Model I: 188; Model II: 179; FFS: 146). Patient outcomes were collected by trained interviewers and include 17 measures of symptoms, health status, functioning, quality of life and patient satisfaction. A two-step regression was performed: first step adjusted	Findings indicate reductions in inpatient user costs and probability of outpatient use under capitation. Estimated total cost per person for model I suggests virtually no change from the pre- to post-capitation period. Model II had the highest pre-capitation and the lowest post-capitation estimated	In the short-run, capitation can reduce service cost per person without considerably change in patients' health condition. Limitations: short follow-up period, lack of detail and possible under-reporting of outpatient services provided by the shadow billing data system.

[5] To improve the financing of Colorado's public mental health system, the state designed, implemented, and evaluated an experimental program that consisted in three reimbursement models for the provision of outpatient services. CHMCs (primary providers of comprehensive mental health services to Medicaid recipients in Colorado) had to search for ways to provide cost-effective services.

Reference	Objective	Methodology	Results	Conclusion
	Two models of capitation were compared with FFS. Model I: state's mental health authority contracts with community mental health centers (CMHCs) who both manage the care and deliver the services. Model II: state contracted with a joint venture between a for-profit managed care firm who manage the care with either a single or alliance of	for the presence of individuals with use or no service use during the specified time; second step applied an ordinary least-squares regression to the utilised services sample.	cost per person.	

Reference	Objective	Methodology	Results	Conclusion
	CMHCs who deliver the services.			
Catalano et al. (2000)	Test two hypotheses regarding the effect of capitated financing on mental health services for Medicaid-eligible children and youth in Colorado: (i) Capitation reduces costs; (ii) Increase efforts to prevent illness when shifting providers from FFS to capitation.	Data collected from Medicaid FFS claims and from "shadow billing" system for the postcapitation period (eight time series-143 weeks). Interrupted time-series applied to a quasi experiment created by the state of Colorado's reorganisation of mental health services financing.	The cost of services was notably lower in counties with capitated services compared to counties with FFS financing. Economic incentives may conduct to greater efforts at secondary and tertiary prevention.	Capitation can reduce costs of children's mental health services compared to FFS financing. Capitation *per se* does not incentivise prevention.

Reference	Objective	Methodology	Results	Conclusion
Chou et al. (2005)	Assess specific outpatient mental health services delivery to Medicaid-eligible patients under this program.	Claims from Colorado's Medicaid and Mental Health Services Agency (1994-1997). Models I and II considered in Bloom et al. (1998) were compared with FFS for specific outpatient services namely day-treatment visits, group therapy and medication monitoring.	Differences were found in service delivery between reimbursement models over time. Providers under capitation had higher initial utilisation in most outpatient service categories than their FFS counterparts. Outpatient services provided under capitation decreased to converge to the FFS pattern. In the postcapitation period less com-	Mental health service delivery is affected by financing models and organisational arrangements. The impact of capitation is reflected in changes in utilisation and costs in some outpatient service categories. These changes have implications for improving the financing of public mental health systems, co-ordination of mental health services

Reference	Objective	Methodology	Results	Conclusion
			plex service packages were provided and more service integration was observed.	with other healthcare services, and provision of services through a more efficient financing system.
Bloom et al. (2011)	Five-year follow-up of the capitation program in Colorado. Impact on service utilisation and costs.	Data was collected from the Medicaid billing system (precapitation year, 1994) and from the shadow billing system (postcapitation period, 1995-1999). Random-effect approach was used to estimate	In both models there were significant decreases in each postcapitation year regarding high-cost treatments (inpatient services), except in 1999 for the not-for-profit CHMCs (model I). The for-profit programs	Different strategies were used in both models to restrain expenditures and utilisation. The for-profit programs were more successful in reducing cost per user.

Reference	Objective	Methodology	Results	Conclusion
		the effects of the two models considered in Bloom et al. (1998) controlling for all the covariates such as age, gender, and specific diagnosis.	(model II) had notably decreased the cost per user in both outpatient services and total services. Regarding model I, there was a significant reduction in the cost per user for outpatient services in 1995 and 1996 but no significant changes in the cost per user for total services.	

Reference	Objective	Methodology	Results	Conclusion
Douven, Remmerswaal and Mosca (2015)	Evaluate the introduction of a discontinuous discrete step function in Dutch mental healthcare: when the provider passes a treatment duration threshold the fee does not increase until the next threshold is reached.	Data was collected from an administrative dataset (2008-2010) and comprises 1.4 million observations from 15 mental health disorders. 10% of all self-employed mental healthcare providers are paid according to the new payment scheme, while the remaining providers are paid according to a fixed salary (control group). It was	It was estimated a reduction in treatment duration by 2-7% and lower costs by 3-6% compared to the control group. However, unintended effects were found. Providers extended the treatment duration in order to reach the next threshold and get a higher fee. These effects offset efficiency effects which results in an increase in	Mental health providers react to financial incentives so it is important to monitor providers' behavior. Authors suggest that quality should be added to tariffs and providers should get paid based on patients' well-being.

Reference	Objective	Methodology	Results	Conclusion
		used non-linear regressions for each mental health disorders and providers.	total costs of about 3-4%.	

A.1.3 Studies on managed care, AOTs, and CRTs

Reference	Objective	Methodology	Results	Conclusion
(Bernstein and Fox, 2000)	Analyse the accountability and effective management of public mental health systems. Policy issues in adapting Medicaid managed care to people with SMI are reviewed.	Experience of senior officials of state and local government. Each of the officials had first-hand experience with managed behavioural healthcare.	Managed care have been adopted in several states. Positive effects were found such as increased access, decreased use of inappropriate inpatient care, and expanded array of services. Negative effects were observed namely incentive in a risk-based contract to under-treat people with serious disorders, an undue	Managed care was considered a useful tool to achieve cost efficiency and to respond to the demands in a way that protects consumers and balances risks. Using managed care appropriately, States can claim greater accountability from mental health providers.

Reference	Objective	Methodology	Results	Conclusion
			focus on acute care and neglect of rehabilitation and other services with significant long-term pay-off in improved functioning, and difficulties in ensuring quality and outcomes consistently across regions. Management of public mental health is suffering from the existence of multiple funding options and service-delivery systems.	

Reference	Objective	Methodology	Results	Conclusion
Chisholm and Ford (2004)	Describe the development of AOTs and CRTs for people with SMI based on the experiences of new and existing teams across England.	Two-year study that looked at 10 sites across England. Some of them were pioneered in the use of AOTs and CRTs and others had introduced them more recently. Interviews to the staff and users were performed.	Several learning points are stated such as consultation with service users and carers should take place at an early stage, CRTs should focus on individuals who, otherwise, would need hospital admission, and CRTs that are not well integrated with other services, specifically inpatient care, may not reduce inpatient	The benefits of these service models arise when they generate change in the whole mental health system. To achieve real change, policymakers should focus their attention to key aspects — structures, processes, and people (culture/attitudes). A structured project management with key stakeholders is essential for the im-

Reference	Objective	Methodology	Results	Conclusion
			admissions. Teams had some difficulties to hired particular professions. There is evidence of engagement improvement between families and teams.	plementation of new teams. The skill mix of these teams may need to be revised.
Wane et al. (2007)	Assess if AOTs are effective in reducing hospital bed use and in improving engagement with services and social functioning in a urban-rural area in the UK.	Cohort of AO patients (n=42). Data was collected between 24 and 12 months prior to the initiation of AO and for the first 12 months receiving AO. Friedman test	Significant reduction in hospital admissions, and occupied bed days after AO was initiated. Improvements in engagement with services and in social functioning.	Significant benefits for people with SMI who are higher users of inpatient beds.

Reference	Objective	Methodology	Results	Conclusion
		was used to check differences between the three time periods.		
McCrone et al. (2009)	Assess the economic impact of CRTs in South London.	Two cohort of patients — pre-CRT (n=65) and post-CRT (n=116). Regression analysis was carried and sensitivity analysis was performed.	The post-CRT cohort presented a lower cost than the pre-CRT cohort but it was not statistically significant. A significant difference (£2189) was found between patients that had any contact with CRT and those with none.	CRTs resulted in lower costs which can help release funds for other forms of care.

Reference	Objective	Methodology	Results	Conclusion
Barker et al. (2011)	Evaluate the impact of CRTs on the admission rates and length of stay after the introduction of these teams in Edinburgh in 2008.	Data on inpatient was collected 5-years before and 1-year after the introduction of CRTs. Unpaired t-tests were performed on admissions, readmissions, and LOS.	Reduced number of admissions to inpatient psychiatric facilities. For those who were admitted, the LOS significantly reduced. Readmission rate remained stable.	CRTs can bring a more efficient use of inpatient care.

Reference	Objective	Methodology	Results	Conclusion
Jacobs and Barrenho (2011)	Determine the impact of CRTs on the number of admissions across England.	Data from primary care trusts (PCTs) 2-years before the implementation of CRTs and 4-years post policy implementation. Cross-sectional (PCTs with and without CRTs) and temporal changes (pre-CRT and post-CRT). Difference-in-difference method. To correct for selection effects it was used the propensity score matching.	No significant differences in admissions between PCTs with and without CRTs.	More research is needed regarding the policy as a whole.

Reference	Objective	Methodology	Results	Conclusion
Hamilton et al. (2015)	Estimate the impact of AOTs on hospital admissions for people with psychosis in England.	Monthly admissions with primary diagnosis of psychosis and schizophrenia in NHS Hospitals in England between April 1999 and December 2010. Interrupted time series analysis was used to evaluate the implementation o AOTs in 2003.	Significant reduction in the daily rate of admissions after the implementations of AOTs.	Evidence of the effectiveness of AOTs in reducing hospital admissions for people with SMI.

A.2 Data

A.2.1 DRG description codes

Table A.1: DRG description codes

DRG	Description
424	Operating room procedure with principal diagnosis of mental illness
425	Acute adjustment reaction & psychosocial dysfunction
426	Depressive neuroses
427	Neuroses except depressive
428	Disorders of personality & impulse control
429	Organic disturbances and mental retardation
430	Psychosis
431	Childhood mental disorders
432	Other mental disorder diagnosis

A.2.2 Sources of Information — Hospital characteristics

The following hospital reports were used to gather information on hospital characteristics:

- EPE hospitals: Relatórios e Contas from 2003 to 2012 — variables: cmi, beds, dp, lstay, cost.
- from Unidade Operacional de Financiamento e Contratualização: Relatórios Nacionais de Retorno 2007, 2008, and 2009 (EPE and SPA hospitals) — variables: cmi, dp, lstay.
- from Unidade Operacional de Gestão Financeira: Relatório e Contas 2006 and 2007 (SPA hospitals), 2008 (EPE and SPA hospitals) — variables: cmi, beds, dp, lstay, cost.
- from Instituto de Gestão Informática e Financeira da Saúde:
  - Departamento de Consolidação e Controlo da Gestão do SNS: Contas Globais 2001, 2002, and 2003 (SPA hospitals) — variables: cmi, beds, dp, lstay, cost (except for 2003).

  - Relatório e Contas 2004 and 2005 (SPA hospitals) — variables: cmi, beds, dp, lstay, cost.

- from ACSS: Tabela Hospitalar 2010, 2011, 2012 — variables: cmi, dp, lstay.

- from the report "Avaliação da experiência de gestão privada do Hospital Fernando Fonseca (1995-2008)" issued by Universidade Nova de Lisboa we collect information about Fernando Fonseca Hospital (Hospital Amadora-Sintra) from 2001 to 2007.

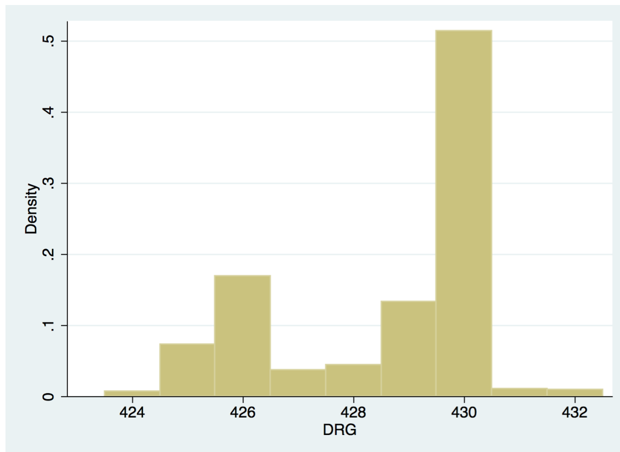
A.2.3 Hospital Mergers

Table A.2: Hospital Mergers

ID before merge	ID after merge	Merge_year
COND VARZ	PVVC	2001
FUND COVI	CHCB	2001
REAL PESO	CHVR	2002
ABRA NOVA TOMA	CHMT	2003
VIAN LIMA	CHAM	2003
PMAO LAGO	CHBV	2004
SERP BEJA	CHBA	2005
EGAS XAVI CRUZ	CHLO	2006
SETU OUTA	CHSE	2006
BRAC MACE MIRA	CHNT	2006
JOSE ESTE MART CAPU	CHLC	2007
CHVR CHAV LAME	CHTA	2007
GAIA ESPI	CHGE	2007
FAMA TIRS	CHMA	2007
PLEG ELVA	ULNA	2007
GUIM FAFE	CHAA	2007
AMAR VALE	CHVS	2008
MARI PULI	CHLN	2008
ANTO MPIA DINI	CHPO	2008
ALCB PENI CALD	CHON	2009
FEIR MADE OLIV	CHDV	2009
GUAR SEIA	ULSG	2009
CHAM	ULAM	2009
CHBA	ULBA	2009
MONT BARR	CHBM	2010
CAST	ULCB	2010
JOAQ	CHPO	2011
HUCO CHCO	CHUC	2011
AVEI AGUE ESTA	CBVG	2011
POMB LEIR ALCB	CHLP	2011
JOAO VALO	CHSJ	2011
VISE TOND	CHTV	2011
CURR MACO	CHLC	2012
CHON VEDR	CHO	2012
CHBV FARO	CHAL	2012

A.2.4 Histogram – DRG

Figure A.1: Histogram – DRG



A.2.5 "Costs" and Hospital Capacity

Figure A.2: Average "Cost" per case by Small and Medium Capacity Hospitals

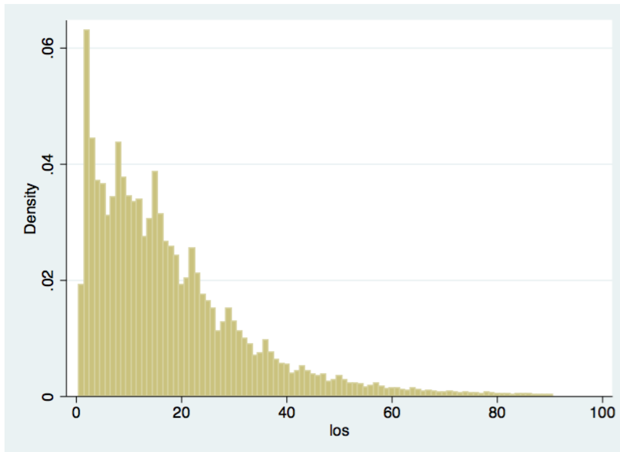
A.2.6 Summary statistics

Table A.3: DRG 430

Variable	Description	Mean	Std. Dev.	Min	Max	N
los	period of time a patient remains in the hospital in days	25.39	136.09	1	16,675	82,612
volume	number of inpatient discharges per year per DRG	287.22	139.57	1	822	82,612
age	age in years	45.98	15.18	16	104	82,612
gender	binary variable (=1 if male)	0.47	0.50	0	1	82,612
cmi	average DRG relative weight for a hospital	1.05	0.21	0.61	2.71	82,612
beds	number of beds	641.61	415.29	20	2,279	82,612
dp	average number of patients discharged (in thousands)	24.065	13.894	0.518	71.159	82,612
lstay	average period of time a patient remains in the hospital in days	7.61	0.99	4	21	82,612
totalcost	operating, financial and extraordinary costs (in million €)	140.34	111.81	4.03	462.76	82,612
dum_cmi	binary variable (=1 if information used for *cmi* regards from previous/next year)	0.23	0.42	0	1	82,612
dum_totcost	binary variable (=1 if information used for *totcost* regards from previous/next year)	0.25	0.43	0	1	82,612
dum_lstay	binary variable (=1 if information used for *lstay* regards from previous/next year)	0.13	0.33	0	1	82,612
dum_dp	binary variable (=1 if information used for *dp* regards from previous/next year)	0.12	0.33	0	1	82,612
dum_beds	binary variable (=1 if information used for *beds* regards from previous/next year)	0.18	0.38	0	1	82,612

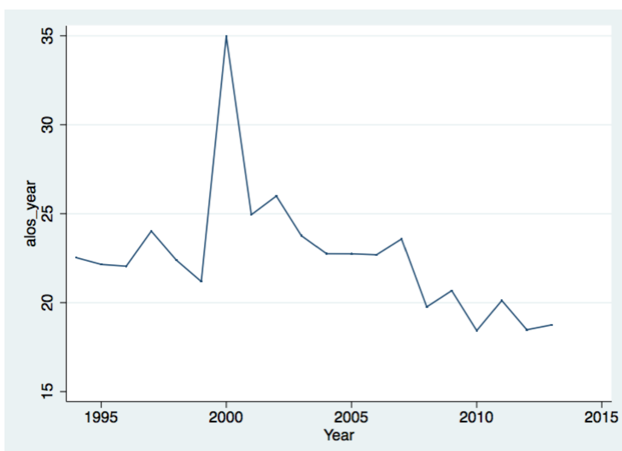
A.2.7 Histogram – LOS

Figure A.3: Histogram – LOS less than 90 days



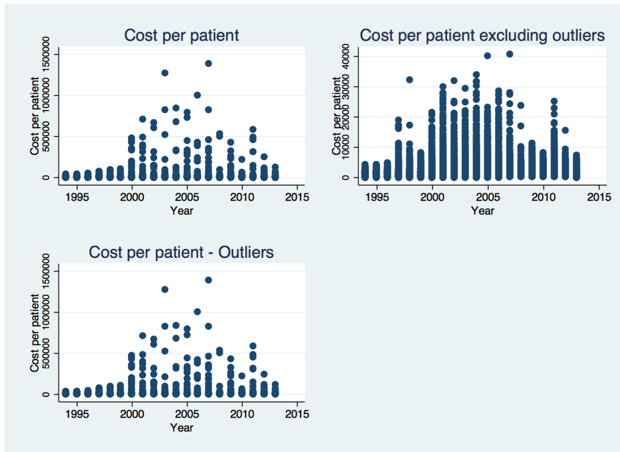
A.2.8 Average Length of Stay

Figure A.4: ALOS per year



A.2.9 "Cost" per patient

Figure A.5: "Cost" per patient per year



A.3 Results

A.3.1 Treatment Outcomes

Table A.4: Fractional Response Generalized Linear Model — Average Marginal Effects on Readmission Rate

	DRG425	DRG426	DRG427	DRG428	DRG429	DRG430	DRG431	DRG432
volume	0.000160*	0.000171***	0.000291***	0.000592***	0.000265***	0.000185***	0.00137***	0.0000430
	(2.14)	(5.92)	(6.71)	(4.18)	(4.55)	(8.31)	(4.74)	(1.44)
cmi	-0.000146	-0.0286*	0.000237	-0.0127	-0.0244***	-0.0206	0.0424*	-0.0276
	(-0.02)	(-2.39)	(0.03)	(-0.56)	(-3.36)	(-1.74)	(2.38)	(-1.62)
beds	0.0000127	-0.0000413*	0.00000602	0.0000672	-0.0000257	0.0000193	0.0000407	-0.0000159
	(0.53)	(-2.10)	(0.34)	(1.19)	(-1.36)	(0.84)	(1.55)	(-0.82)
dp	-0.000356	0.000277	-0.000208	-0.00193	-0.0000118	-0.00292**	0.000347	0.000202
	(-0.58)	(0.60)	(-0.34)	(-1.27)	(-0.02)	(-2.97)	(0.60)	(0.69)
lstay	0.00106	0.00102	0.00113	0.000548	0.00203	-0.00348	-0.00235	0.000170
	(0.83)	(0.77)	(1.04)	(0.14)	(1.79)	(-1.71)	(-1.44)	(0.23)
totalcost	-0.0000340	0.000121**	-0.0000890*	-0.000125	0.0000724	0.000169	-0.000425**	0.0000534
	(-0.63)	(2.71)	(-1.97)	(-1.24)	(1.84)	(1.35)	(-2.84)	(1.05)
dum_cmi	-0.00551	-0.00869	-0.00977	-0.00353	-0.0805	-0.00932	0.0284**	-0.0468
	(-0.91)	(-1.59)	(-1.24)	(-0.22)	(-0.31)	(-1.74)	(3.25)	(-1.92)
dum_totcost	-0.00774	-0.00449	-0.00703	-0.00530	-0.00501	-0.00498	0.0221***	0.00410
	(-1.37)	(-1.04)	(-1.33)	(-0.34)	(-0.90)	(-0.49)	(3.31)	(1.29)
dum_lstay	-0.000178	-0.0308***	0.00835	-0.0332	-0.0259*	-0.0308	-0.0254	-0.00986
	(-0.01)	(-4.00)	(1.33)	(-0.77)	(-2.56)	(-1.62)	(-1.41)	(-1.04)
dum_dp	-0.0154	0.0290**	-0.000794	0.0111	-0.0485	0.0351	-0.0267	0.0286
	(-1.15)	(3.05)	(-0.10)	(0.37)	(-0.11)	(1.72)	(-1.42)	(1.89)
dum_beds	0.00975	0.0149**	-0.00742	-0.00214	0.00514	-0.00637	-0.0104	-0.0179*
	(1.50)	(2.99)	(-1.16)	(-0.20)	(0.92)	(-0.47)	(-1.53)	(-2.04)
N	687	666	443	421	771	645	354	386

t statistics in parentheses

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

A.3.2 Rehospitalisations – Financing determinants

Table A.5: Probit Model — Marginal effects

	(1) dum_rehosp	(2) dum_rehosp
volume	0.0000664***	0.0000639***
	(14.72)	(14.80)
age	-0.00094***	-0.00094***
	(-27.17)	(-27.26)
gender	0.00428***	0.00421***
	(3.43)	(3.37)
cmi	-0.0365***	-0.0361***
	(-6.17)	(-6.12)
beds	-0.000057***	-0.000064***
	(-6.52)	(-12.84)
dp	-0.00034	
	(-1.37)	
lstay	0.00475***	0.00548***
	(5.96)	(8.09)
totalcost	0.00000897***	0.00000768***
	(4.76)	(4.30)
dum_cmi	-0.00135	
	(-0.63)	
dum_totcost	-0.00316	
	(-1.27)	
dum_lstay	0.01029	
	(1.36)	
dum_dp	-0.0164*	-0.00898***
	(-2.06)	(-3.30)
dum_beds	-0.00341	-0.00494*
	(-1.21)	(-2.15)
weight	0.0569***	0.0569***
	(30.67)	(30.66)
N	135,367	135,367
$Pseudo R^2$	0.0390	0.0388

t statistics in parentheses

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

Table A.6: Probit Model — Marginal effects

	(1) dum_rehosp	(2) dum_rehosp
volume	0.0000669***	0.0000659***
	(14.90)	(15.29)
age	-0.000976***	-0.00098***
	(-29.09)	(-29.18)
gender	0.00800***	0.00793***
	(6.42)	(6.37)
cmi	-0.03848***	-0.0385***
	(-6.64)	(-6.63)
beds	-0.0000657***	-0.0000655***
	(-7.17)	(-13.17)
dp	-0.00012	
	(-0.47)	
lstay	0.00528***	0.005592***
	(6.64)	(8.27)
totalcost	0.00001***	0.00000877***
	(4.99)	(4.86)
dum_cmi	-0.0023	
	(-1.07)	
dum_totcost	-0.0038	-0.00449*
	(-1.54)	(-2.23)
dum_lstay	0.01003	
	(1.35)	
dum_dp	-0.01545	-0.00895***
	(-1.94)	(-3.52)
dum_beds	-0.0023	
	(-0.83)	
price_rehosp	-0.000045	
	(-0.88)	
N	135,361	135,361
$Pseudo R^2$	0.0252	0.0251

t statistics in parentheses

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

A.3.3 Cost of emergency readmissions

Table A.7: Negative Binomial Regression

	(1) readmission	(2) readmission
age	0.00300***	0.00301***
	(5.58)	(5.63)
gender	-0.0554***	-0.0577***
	(-3.37)	(-3.51)
cmi	-0.344***	-0.213**
	(-3.62)	(-2.81)
beds	-0.000248*	-0.000230*
	(-2.46)	(-2.38)
dp	0.00440	0.00683**
	(1.71)	(2.87)
lstay	0.0714***	0.0725***
	(6.44)	(6.56)
totalcost	0.0006*	
	(2.43)	
dumread3	-1.343***	-1.342***
	(-30.66)	(-30.68)
dumread6	-0.726***	-0.738***
	(-22.55)	(-23.34)
dumread13	0.0310	
	(1.03)	
dumread21	0.508***	0.505***
	(10.65)	(10.61)
_cons	2.183***	2.059***
	(21.07)	(22.99)
lnalpha		
_cons	-0.928***	-0.927***
	(-44.60)	(-44.54)
N	7538	7538

t statistics in parentheses

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

We omit the results for the dummy variables due to space restrictions.

Figure A.6: Observed versus Predicted Probabilities

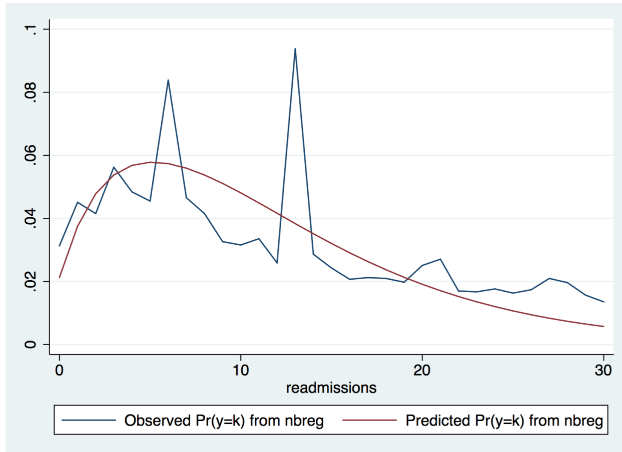
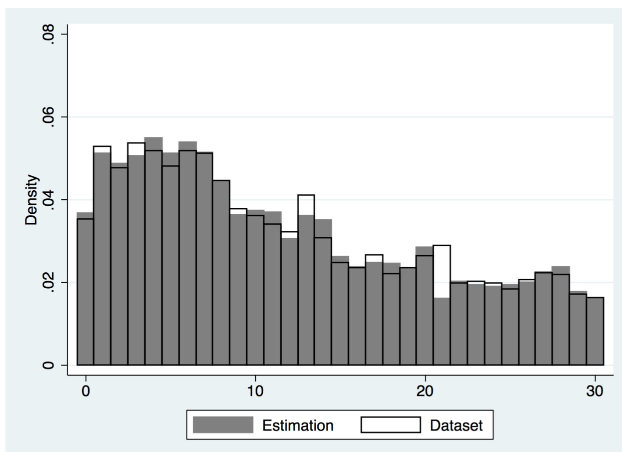


Figure A.7: Estimation results *vs* Real emergency readmissions



A.3.4 Services Organisation

A.3.4.1 *Volume*: Median and Percentile 75

Table A.8: *Volume*: Median and Percentile 75

	Median	Pctl 75
DRG 425	30	45
DRG 426	81	117
DRG 427	26	70
DRG 428	32	49
DRG 429	42	65
DRG 430	278	350
DRG 431	10	21
DRG 432	9	53

A.3.4.2 Duration Model

Table A.9: Duration Model

	(1) DRG425	(2) DRG425	(1) DRG426	(2) DRG426	(1) DRG427	(2) DRG427	(1) DRG428	(2) DRG428
volume	-0.00468*	-0.00471**	-0.00666***	-0.00655***	0.00522**	0.00472***	0.00238	0.00207**
	(-2.55)	(-2.74)	(-13.05)	(-13.64)	(3.16)	(7.94)	(1.44)	(2.85)
volume^2	0.0000399*	0.0000362*	0.0000222***	0.0000216***	-0.00000412		-0.00000184	
	(2.05)	(2.07)	(10.65)	(11.55)	(-0.31)		(-0.11)	
age	-0.0000181		-0.00738***	-0.00738***	-0.00520***	-0.00531***	0.000851	
	(-0.04)		(-16.17)	(-16.14)	(-6.10)	(-6.24)	(0.91)	
gender	-0.0274		0.0287		-0.0780**	-0.0783**	0.0245	
	(-1.38)		(1.88)		(-2.71)	(-2.73)	(0.98)	
cmi	0.460***	0.426***	0.392***	0.392***	0.103		-0.277	-0.319**
	(7.33)	(7.36)	(5.60)	(5.79)	(0.76)		(-1.92)	(-2.61)
beds	-0.00117***	-0.00129***	-0.00104***	-0.00102***	-0.00104***	-0.00107***	-0.00163***	-0.00162***
	(-9.27)	(-12.09)	(-9.88)	(-10.05)	(-5.20)	(-11.80)	(-10.26)	(-11.08)
dp	0.0215***	0.0251***	0.0219***	0.0211***	-0.00127		0.0323***	0.0325***
	(5.30)	(7.60)	(5.85)	(5.81)	(-0.19)		(6.31)	(6.56)
lstay	-0.0222		0.0235**	0.0239**	0.0354	0.0433**	0.0790***	0.0826***
	(-1.70)		(2.77)	(2.82)	(1.76)	(2.89)	(4.58)	(4.85)
totalcost	0.000694**	0.000635*	0.000553*	0.000556*	0.00245***	0.00252***	0.00155***	0.00156***
	(2.65)	(2.45)	(2.29)	(2.32)	(6.17)	(8.65)	(4.17)	(4.42)
N	11,029	11,029	24,626	24,626	6,102	6,102	7,305	7,305

t statistics in parentheses

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

We omit the results for the dummy variables due to space restrictions.

Table A.10: Duration Model

	(1) DRG429	(2) DRG429	(1) DRG430	(2) DRG430	(1) DRG431	(2) DRG431	(1) DRG432	(2) DRG432
volume	-0.00342***	-0.00340***	-0.000894***	-0.000891***	-0.0222***	-0.0218***	0.0325***	0.0340***
	(-5.47)	(-5.46)	(-9.05)	(-9.73)	(-4.66)	(-4.69)	(12.48)	(13.60)
volume^2	0.0000256***	0.0000254***	0.00000172***	0.00000170***	0.000250***	0.000236***	-0.000130***	-0.000139***
	(6.99)	(6.99)	(12.70)	(13.32)	(3.52)	(3.39)	(-10.82)	(-12.09)
age	0.00877***	0.00877***	-0.00416***	-0.00416***	0.00168		0.00279*	0.00284*
	(21.68)	(21.69)	(-16.42)	(-16.45)	(1.23)		(2.08)	(2.19)
gender	-0.0424**	-0.0423**	-0.0740***	-0.0740***	0.0355		0.429***	0.424***
	(-2.73)	(-2.73)	(-9.81)	(-9.81)	(0.73)		(7.77)	(7.41)
cmi	0.361***	0.361***	0.527***	0.528***	0.0575		0.00487	
	(6.46)	(6.46)	(11.77)	(11.95)	(0.25)		(0.02)	
beds	-0.000279*	-0.000280*	-0.000378***	-0.000382***	-0.000293	-0.000393**	0.0000425	
	(-2.34)	(-2.34)	(-7.70)	(-15.31)	(-0.94)	(-2.78)	(0.13)	
dp	0.00737*	0.00741*	-0.000221		-0.00165		-0.0106	-0.0108***
	(2.14)	(2.15)	(-0.14)		(-0.15)		(-1.05)	(-5.68)
lstay	-0.0730***	-0.0733***	-0.0209***	-0.0204***	-0.0470		-0.0102	
	(-7.35)	(-7.41)	(-3.74)	(-4.36)	(-1.56)		(-0.27)	
totalcost	-0.000599*	-0.000599*	-0.000306**	-0.000316**	0.00165*	0.00165**	-0.0000576	
	(-2.56)	(-2.56)	(-2.74)	(-3.14)	(2.15)	(3.20)	(-0.08)	
N	18,227	18,227	82,612	82,612	1,837	1,837	1,758	1,758

t statistics in parentheses

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

We omit the results for the dummy variables due to space restrictions.

A.4 Robustness checks

Table A.11: OLS estimation

	(1) DRG425	(2) DRG425	(3) DRG426	(4) DRG426	(5) DRG427	(6) DRG427	(7) DRG428	(8) DRG428
volume	0.0755*	0.0869**	0.0734**	0.0762**	-0.0210		0.0197	
	(2.46)	(2.99)	(2.60)	(2.86)	(-0.97)		(0.29)	
volume^2	-0.000624	-0.000695*	-0.000274*	-0.000268*	-0.000171	-0.000357***	-0.000536	
	(-1.86)	(-2.22)	(-2.21)	(-2.34)	(-0.90)	(-5.62)	(-0.74)	
gender	0.993**	0.994**	0.986		1.515***	1.496***	-0.143	
	(2.86)	(2.87)	(1.03)		(3.83)	(3.79)	(-0.14)	
age	-0.00247		0.145***	0.146***	0.0488***	0.0474***	-0.0333	
	(-0.30)		(5.38)	(5.44)	(4.19)	(4.08)	(-0.85)	
cmi	-5.289***	-5.691***	-7.640	-6.495*	1.387		2.800	
	(-5.03)	(-6.64)	(-1.87)	(-2.01)	(0.74)		(0.49)	
beds	0.0135***	0.0136***	0.0144*	0.0151**	0.0167***	0.0180***	0.0323***	0.0306***
	(6.10)	(7.52)	(2.40)	(2.93)	(6.52)	(7.44)	(5.01)	(5.19)
dp	-0.257***	-0.332***	-0.320	-0.388**	-0.180*	-0.000219**	-0.785***	-0.815***
	(-3.84)	(-6.53)	(-1.64)	(-2.63)	(-2.18)	(-2.77)	(-4.08)	(-4.69)
lstay	0.278		0.209		-0.992***	-0.890***	-1.929**	-1.620**
	(1.31)		(0.39)		(-4.15)	(-4.10)	(-2.65)	(-2.61)
totalcost	-0.0101*		-0.0045		-0.0264***	-0.0244***	-0.009	
	(-2.09)		(-0.30)		(-4.78)	(-5.03)	(-0.58)	
_cons	11.53***	13.99***	11.15*	11.63***	16.74***	16.94***	30.99***	30.45***
	(6.85)	(14.27)	(2.30)	(3.41)	(8.69)	(10.46)	(5.15)	(6.47)
N	11,029	11,029	24,626	24,626	6,102	6,102	7,305	7,305

t statistics in parentheses

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

We omit the results for the dummy variables due to space restrictions.

Table A.12: OLS estimation

	(1) DRG429	(2) DRG429	(3) DRG430	(4) DRG430	(5) DRG431	(6) DRG431	(7) DRG432	(8) DRG432
volume	-0.0690		0.0154		0.348***	0.190***	-0.209***	-0.218***
	(-0.46)		(1.29)		(3.34)	(6.23)	(-8.77)	(-10.60)
volume^2	-0.000909	-0.00101*	-0.0000266		-0.00211		0.000894***	0.000922***
	(-1.04)	(-2.45)	(-1.55)		(-1.35)		(7.50)	(8.69)
gender	7.105		5.316***	5.319***	0.0000752		-3.651***	-3.758***
	(1.94)		(5.36)	(5.37)	(0.00)		(-5.97)	(-6.17)
age	-0.262**	-0.290**	0.304***	0.305***	-0.0285		-0.0998***	-0.104***
	(-2.88)	(-3.24)	(9.32)	(9.34)	(-1.01)		(-6.91)	(-7.33)
cmi	-45.80***	-48.41***	-12.61*	-8.781**	5.620		-3.963	-3.583*
	(-3.69)	(-4.26)	(-2.45)	(-3.17)	(1.05)		(-1.65)	(-2.21)
beds	0.0577*	0.0571*	-0.00684		0.00590		0.0177***	0.0151***
	(2.11)	(2.12)	(-1.10)		(0.83)		(4.16)	(4.07)
dp	-1.07	-1.39*	0.387*		0.00544		-0.328*	-0.298**
	(-1.42)	(-1.99)	(2.02)		(0.02)		(-2.48)	(-2.84)
lstay	8.708***	8.305***	2.874***	2.036***	-0.168		-0.221	
	(3.87)	(3.82)	(4.00)	(3.48)	(-0.25)		(-0.49)	
totalcost	-0.0416		-0.0112		-0.0378*		-0.0041	
	(-0.78)		(-0.78)		(-2.06)		(-0.46)	
_cons	26.09	35.47*	0.995	8.211*	8.424	11.90***	23.17***	21.40***
	(1.38)	(2.07)	(0.16)	(2.00)	(1.55)	(15.44)	(7.61)	(12.24)
N	18,227	18,227	82,612	82,612	1,837	1,837	1,758	1,758

t statistics in parentheses

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

We omit the results for the dummy variables due to space restrictions.

Table A.13: OLS estimation — ALOS

	(1) DRG425	(2) DRG425	(3) DRG426	(4) DRG426	(5) DRG427	(6) DRG427	(7) DRG428	(8) DRG428
volume	0.0746***	0.0728***	0.0541***	0.0540***	-0.0441***	-0.0536***	-0.0770***	-0.0604***
	(9.72)	(9.68)	(13.06)	(13.04)	(-5.85)	(-20.70)	(-3.87)	(-7.39)
volume^2	-0.000639***	-0.000610***	-0.000210***	-0.000209***	-0.0000907		0.000197	
	(-7.63)	(-7.61)	(-11.56)	(-11.52)	(-1.37)		(0.94)	
gender	-0.0188		0.142		-0.0440		-0.510	
	(-0.22)		(1.00)		(-0.32)		(-1.67)	
age	-0.0133***	-0.0131***	-0.00945*	-0.00944*	-0.0112**	-0.0109**	-0.0471***	-0.0477***
	(-6.53)	(-6.45)	(-2.39)	(-2.39)	(-2.78)	(-2.76)	(-4.15)	(-4.22)
cmi	-4.731***	-4.756***	-6.552***	-6.496***	-1.146		3.138	
	(-17.97)	(-18.09)	(-10.94)	(-10.98)	(-1.76)		(1.91)	
beds	0.0128***	0.0127***	0.0130***	0.0130***	0.0117***	0.0111***	0.0256***	0.0264***
	(23.02)	(22.95)	(14.71)	(15.08)	(13.20)	(15.50)	(13.69)	(15.05)
dp	-0.234***	-0.231***	-0.225***	-0.227***	0.0545	0.0703**	-0.532***	-0.552***
	(-13.95)	(-13.81)	(-7.86)	(-8.01)	(1.91)	(2.83)	(-9.55)	(-10.13)
lstay	0.297***	0.291***	0.584***	0.590***	0.0549		-1.501***	-1.412***
	(5.57)	(5.47)	(7.51)	(7.59)	(0.66)		(-7.12)	(-7.26)
totalcost	-0.0106***	-0.0106***	-0.0113***	-0.0113***	-0.0339***	-0.0354***	-0.0176***	-0.0126***
_cons	11.48***	11.57***	14.33***	14.27***	12.99***	12.53***	27.09***	28.59***
	(27.23)	(27.70)	(20.08)	(20.20)	(19.46)	(57.35)	(15.51)	(18.56)
N	11,029	11,029	24,626	24,626	6,102	6,102	7,305	7,305

t statistics in parentheses

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

We omit the results for the dummy variables due to space restrictions.

Table A.14: OLS estimation — ALOS

	(1) DRG429	(2) DRG429	(3) DRG430	(4) DRG430	(5) DRG431	(6) DRG431	(7) DRG432	(8) DRG432
volume	-0.0541	-0.0746*	0.00115		0.270***	0.275***	-0.218***	-0.225***
	(-1.60)	(-2.37)	(0.95)		(8.20)	(8.58)	(-15.04)	(-17.75)
volume^2	-0.000932***	-0.000776***	-0.0000288***	-0.0000277***	-0.00311***	-0.00309***	0.000919***	0.000948***
	(-4.70)	(-4.49)	(-16.58)	(-33.51)	(-6.30)	(-6.34)	(12.74)	(14.39)
gender	1.525		0.0332		-0.178		-1.871***	-1.904***
	(1.83)		(0.33)		(-0.51)		(-5.05)	(-5.16)
age	-0.175***	-0.182***	-0.00866**	-0.00884**	-0.0131		-0.0558***	-0.0552***
	(-8.46)	(-8.92)	(-2.61)	(-2.71)	(-1.47)		(-6.37)	(-6.43)
cmi	-44.37***	-44.43***	-17.08***	-17.01***	-2.214		-5.099***	-4.152***
	(-15.69)	(-15.71)	(-32.64)	(-32.62)	(-1.31)		(-3.49)	(-4.22)
beds	0.0553***	0.0552***	0.0126***	0.0123***	0.00570*	0.00556***	0.0118***	0.0116***
	(8.88)	(8.86)	(19.93)	(20.67)	(2.53)	(4.94)	(4.61)	(5.20)
dp	-0.929***	-0.925***	-0.0920***	-0.0799***	-0.0223		-0.154	-0.179**
	(-5.40)	(-5.37)	(-4.73)	(-4.45)	(-0.30)		(-1.92)	(-2.84)
lstay	8.522***	8.496***	3.308***	3.329***	0.557*	0.404*	0.265	
	(16.66)	(16.62)	(45.41)	(46.48)	(2.57)	(2.35)	(0.97)	
totalcost	-0.0509***	-0.0509***	-0.00514***	-0.00532***	-0.0230***	-0.0277***	-0.00368	
	(-4.21)	(-4.21)	(-3.52)	(-3.68)	(-3.95)	(-6.98)	(-0.68)	
_cons	19.84***	21.75***	16.62***	16.61***	10.22***	8.624***	16.74***	17.88***
	(4.62)	(5.15)	(26.34)	(26.68)	(5.92)	(7.09)	(9.07)	(16.78)
N	18,227	18,227	82,612	82,612	1,837	1,837	1,758	1,758

t statistics in parentheses

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

We omit the results for the dummy variables due to space restrictions.

Appendix B

Chapter 2

B.1 Methodology

Table B.1: Characterisation of experts

Number	Profession	Sex	Experience (years)	Region
1	Biologist, hospital manager	M	11	North
2	Psychiatrist	M	37	South
3	Economist, hospital manager	M	18	South
4	Psychiatrist, hospital manager	M	36	North
5	Psychiatrist	M	39	North
6	Nurse	F	39	South
7	Psychiatrist	F	3	South
8	Psychologist	F	29	South
9	Public health physician	F	4	South
10	Psychiatrist	M	3	South
11	Economist, hospital manager	F	30	South
12	Psychiatrist	M	24	South
13	Psychiatrist	M	40	South
14	Psychiatrist	F	3	South
15	Nurse	M	14	South
16	Psychiatrist	M	35	South
17	Social assistant	F	25	South
18	Economist, hospital manager	F	10	North
19	Psychologist	M	19	South
20	Economist	M	11	South
21	Psychiatrist	F	10	North
22	GP	M	42	South

B.2 Results

Table B.2: Proposed model for mental health providers' financing

Dimension	**Proposal for financing**	**Implementation aspects**
Prevention early in life	Bundled payment to the PC team for the follow-up of children at risk or with special needs during the two first years of life	1. Children registration on a central platform, including information/justification for being considered at risk or with special needs, using a diagnosis evaluation grid; 2. Presence of a psychologist available for consultation in PHC practices

Continues on next page

Table B.2 – *Continued from previous page*

Dimension	**Proposal for financing**	**Implementation aspects**
Early detection of mental health disorders	1. Adding an indicator in the P4P scheme for PHC practices, namely the "percentage of users in the key-ages of the PNSIJ who have effectively attended the vigilance consultations, according to the diagnosis evaluation grid"; 2. Payment of an additional fee to GPs for each follow-up consultation including mental health evaluation, using the diagnosis evaluation grid	The diagnosis evaluation grid must be subject to public discussion, revised, and subject to a large approval by GPs. The current grid, defined by the PNSIJ, includes several mental health recommendations for children and adolescents, related to emotional and behavioural disorders, psycho-affective and social development, and environment safety

Continues on next page

Table B.2 – *Continued from previous page*

Dimension	**Proposal for financing**	**Implementation aspects**
Stepped collaborative model for depression	1. Adding an indicator in the P4P scheme for PHC practices, namely the “Proportion of users with depression whose condition has been diagnosed with PHQ-9 and treatment has been initiated in the adequate phase of the collaborative stepped care model”; 2. Payment of a fixed monthly fee to compensate these reference physicians for the extra work.	1. Nomination of a reference GP in the PHC team and a reference psychiatrist in the specialised mental health team of catchment area, to enhance the collaboration between primary and specialised care; 2. Presence of a psychologist available for consultation in PHC practices.

Continues on next page

Table B.2 – *Continued from previous page*

Dimension	Proposal for financing	Implementation aspects
Integrated community-based care for SMI patients	1. Per period payment, in which the hospital receives an annual payment for each patient registered with SMI, covering all healthcare services; and 2. A P4P component: (i) a bonus/penalty for hospitals in the lowest/highest decile of the distribution regarding inpatient stays; (ii) bonus/penalty for hospitals in the lowest/highest decile of the distribution in terms of post-discharge consultations up to 30 days after discharge;; (iii) a budget penalty in case hospital does not contribute/update a national registry of SMI, specifically created within this new payment model.	1. The payment is attributed to the mental health department, which has full autonomy and responsibility in managing funds, being the residual claimant; 2. The mental department disposes of community-based mental health teams, with protocols with PHC practices, residential units, patients and families associations, rehabilitation units, nursing homes, social services, and local authorities.

Appendix C

Chapter 3

C.1 Data

Table C.1: 3-digit codes from ICD-9-CM considered in the analysis

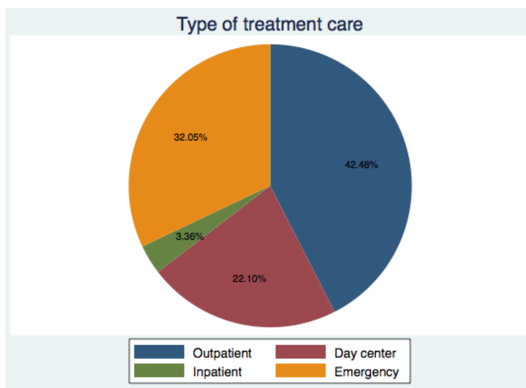
ICD-9-CM	Description
291	Alcohol-induced mental disorders
292	Drug-induced mental disorders
295	Schizophrenic psychosis
296	Affective disorders
297	Delusional disorders
298	Non-organic psychosis

C.1.1 Descriptive Statistics

Table C.2: Absolute and relative frequencies of the number of patients per ICD-9-CM

ICD-9-CM	Number of patients	Percentage
291	12	0.41%
292	65	2.22%
295	1,167	39.83%
296	989	33.75%
297	195	6.66%
298	500	17.06%

Figure C.1: Type of treatment services provided



C.2 Results

C.2.1 Direct treatment costs

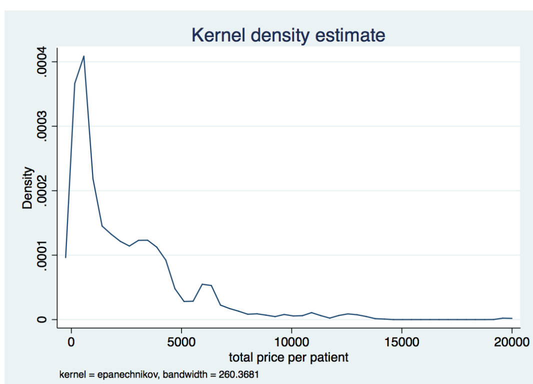
Table C.3: Average cost per ICD-9-CM per year

ICD-9-CM	Average cost (€)	Standard deviation
292	1,138	1,372
295	1,577	2,213
296	1,104	1,466
297	1,493	1,981
298	933	1,313

Table C.4: Average cost per type of care and its % of the total per diagnostic

Type of care	Average cost (€)	ICD 292	ICD 295	ICD 296	ICD 297	ICD 298
Outpatient	1,770	11.5%	13.1%	10.7%	8.7%	11.2%
Day care	3,759	17.9%	22.8%	6.5%	26.3%	9.6%
Inpatient care	3,752	61%	60.9%	75.9%	59.6%	64.6%
Emergency room	2,160	9.6%	3.2%	6.9%	5.4%	14.6%

Figure C.2: Kernel Density Estimate



C.2.2 Cost determinants

Table C.5: GLM – Estimation results

	ICD 292	ICD 295	ICD 296	ICD 297	ICD 298
age	0.022***	-0.016***	-0.002*	-0.007***	-0.017***
	(7.86)	(-26.30)	(-2.22)	(-4.07)	(-22.44)
gender	-0.807***	0.094***	0.399***	-0.206***	-0.120***
	(-11.92)	(4.62)	(15.28)	(-4.12)	(-4.70)
treat_phase	-0.124*	0.034	0.123***	0.087	0.308***
	(-2.21)	(1.55)	(4.57)	(1.77)	(11.56)
_cons	7.575***	8.648***	7.401***	8.379***	8.045***
	(65.28)	(243.91)	(141.03)	(83.05)	(163.11)
N	633	13,447	8,585	1,792	5,861

t statistics in parentheses

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

Appendix D

Chapter 4

D.1 Data

D.1.1 Sources of Information

The socio-economic variables were collected for each municipality belonging to ARS Centro.

- Unemployment rate (*unemp_rate*) – It was computed considering the number of unemployed individuals registered in the Institute for Employment and Vocational Training (IEFP) divided by the total number of residents in each municipality aged between 15 and 64 years. This information was collected from the Pordata database (available at `www.pordata.pt`) and is available from 2009 to 2015.

- Average wage (*avg_wage*) – Average monthly wage of employed workers, expressed in euros. This information was gathered from Pordata database and it is available between 2009 and 2013.

- Percentage of beneficiaries of social benefits (Rendimento Social de Inserção, RSI) (*pct_rsi*) – Quoting verbatim from `www.pordata.pt`, the social benefit is "included in the welfare sub-system and social integration programme, in order to provide support for beneficiaries and their households, which is adapted to their specific context, meets their essential needs and fosters progressive social, community and labour force integration". The information was collected from PORDATA database and we have data from 2009 to 2015.

- Number of physicians per 10,000 inhabitants (*nr_phys*) – This data was collected from Marktest Consulting database. It is available for all years under analysis.

- Pharmacy index (*pharm_index*) – It is a relative measure created by Marktest Consulting in order to compare municipalities with one another. It is expressed in ‰ and its computation uses the following formula:

$$marktest\_index_j = \frac{\sum_{i=1}^{n} P_{ji}}{n}$$

  where, P_{ji} is the relative weight of municipality j in relation to a variable i. In our case, we only have one variable, which is the number of pharmacies. This information is available from 2009 to 2015.

D.1.2 Descriptive Statistics

Figure D.1: Number of patients per year

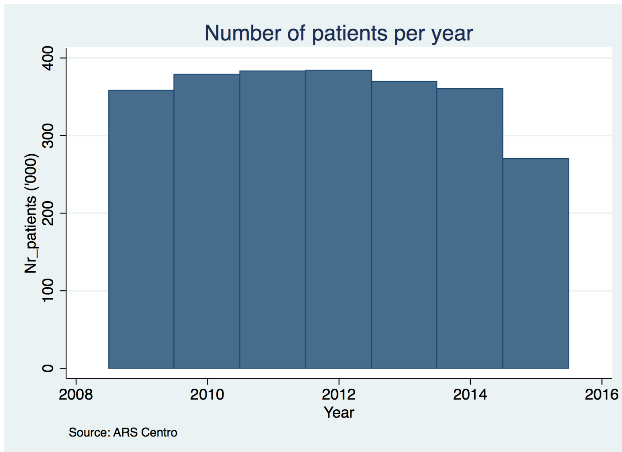


Figure D.2: Prescription volume per year

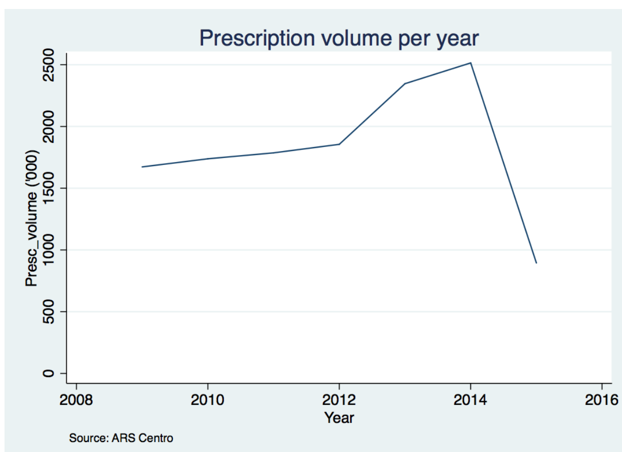


Figure D.3: Prescription rate by ATC codes

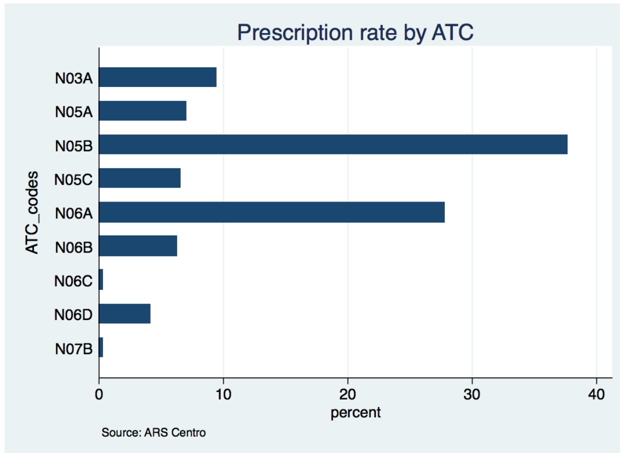


Figure D.4: Yearly evolution of prescription rates by main ATC codes

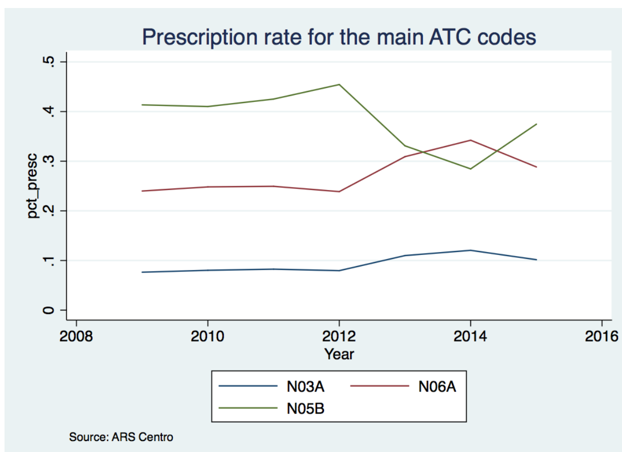


Figure D.5: Non-adherence rate — Kernel density

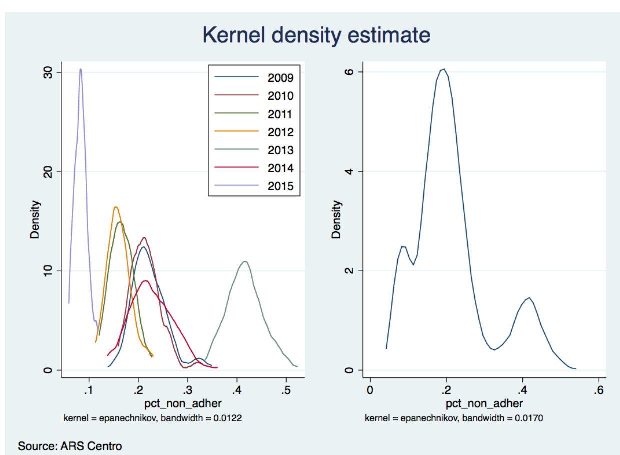


Figure D.6: Average non-adherence rate per year

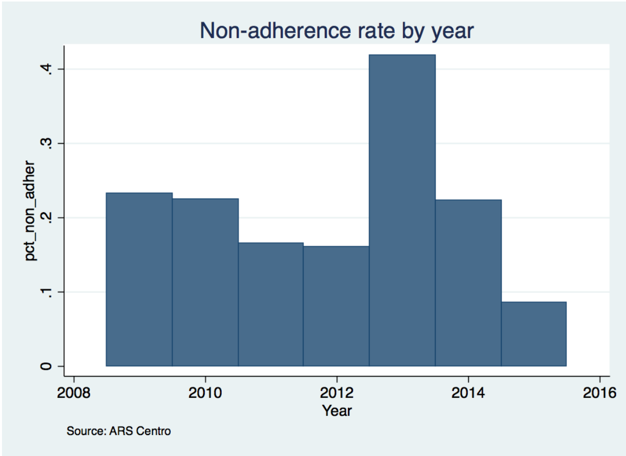


Figure D.7: Non-adherence rate by ATC codes

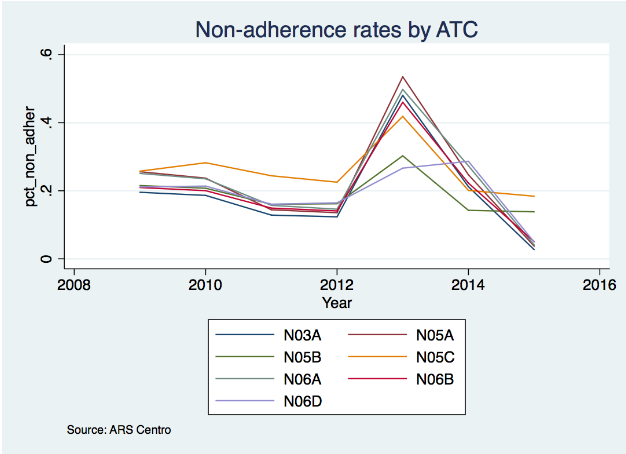


Figure D.8: Non-adherence rate per municipality — Top and bottom 10%

Figure D.9: Prescription rate per municipality — Top and bottom 10%

Table D.1: Summary statistics

Variable	**Description**	**Mean**	**Std. Dev.**	**Min**	**Max**	**N**
pct_non_adher	percentage of patients per municipality and year	21.3	10	5.9	52.3	539
avg_age	average age (in years) of patients per municipality and year	63.94	2.29	58.11	71.27	539
unemp_rate	unemployment rate per municipality and year (in %)	7.26	1.92	2.7	13.1	539
avg_wage	average monthly wage of employed workers per municipality and year (in €)	711.17	84.24	571.9	953.8	539
pct_rsi	percentage of beneficiaries of RSI	3.25	1.57	0.4	9.6	539
nr_phys	number of physicians per 10,000 inhabitants	18.65	30.41	0	295.04	539
pharm_index	relative measure on the number of pharmacies (in ‰)	2.54	2.79	0	17.98	539

D.2 Results

Table D.2: Estimates of equation (4.3) using GEE method — fractional probit

	All psychotropics		AHS		Antidepressants	
	Coefficient	APE	Coefficient	APE	Coefficient	APE
pct_rsi	0.053***	0.015***	0.028***	0.008***	0.042**	0.012***
avg_wage	-0.001**	-0.0003**	-0.0002	-0.0001	-0.002***	-0.001***
unemp_rate	0.038***	0.011***	-0.015*	-0.004*	0.086***	0.024***
pharm_index	0.033*	0.009*	0.002	0.001	0.062**	0.017**
nr_phys	-0.020**	-0.006**	-0.012**	-0.003**	-0.020**	-0.006**
avg_age	-0.031**	-0.009**	-0.040***	-0.011***	-0.057***	-0.016***
_cons	-0.068	-	0.203	-	-0.397	-
Working correlation	0.029		0.412		-0.082	
Number of municipalities	539		539		539	

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

Estimations include time averages of the six explanatory variables.

D.3 Robustness Checks

Table D.3: Estimates of equation (4.3) using GEE method — fractional probit using independent WCM

	All psychotropics		AHS		Antidepressants	
	Coefficient	APE	Coefficient	APE	Coefficient	APE
pct_rsi	0.053***	0.015***	0.028***	0.008***	0.043**	0.012**
avg_wage	-0.001**	-0.0003**	-0.0002	-0.0001	-0.002***	-0.001***
unemp_rate	0.038***	0.011***	-0.015*	-0.004*	0.086***	0.024***
pharm_index	0.034*	0.009*	0.002	0.001	0.062**	0.017**
nr_phys	-0.020**	-0.006**	-0.012**	-0.003**	-0.020**	-0.006**
avg_age	-0.031**	-0.009**	-0.040***	-0.011***	-0.057***	-0.016***
_cons	-0.076	-	0.187	-	-0.377	-
Number of municipalities	539		539		539	

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

Estimations include time averages of the six explanatory variables.

Table D.4: Estimates of equation (4.3) using GEE method — fractional probit with year dummies

	All psychotropics		AHS		Antidepressants	
	Coefficient	APE	Coefficient	APE	Coefficient	APE
pct_rsi	-0.024**	-0.007**	-0.021*	-0.006*	-0.023**	-0.006**
avg_wage	0.0001	0.000	0.0002	0.0001	-0.0001	-0.000
unemp_rate	-0.009	-0.002	-0.004	-0.001	-0.013	-0.003
pharm_index	0.005	0.001	0.008	0.002	0.002	0.001
nr_phys	-0.006***	-0.002***	-0.006***	-0.002***	-0.005**	-0.001**
avg_age	-0.006	-0.002	-0.022**	-0.006**	-0.004	-0.001
_cons	-0.434	-	0.026	-	-1.137*	-
Working correlation	0.449		0.504		0.271	
Number of municipalities	539		539		539	

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

Estimations include time averages of the six explanatory variables and year dummies.

Appendix E

Chapter 5

Proof of Proposition 1

The equation which generates $\hat{x}_a(w_2)$ is $F(w_2, x_a) = 0$, with $F(w_2, x_a) = p'_a(x_a)(w_2 + \alpha b) - c'(x_a)$. As F is C^3, $F'_{x_a}(w_2, \hat{x}_a(w_2)) = p''_a(\hat{x}_a(w_2))(w_2 + \alpha b) - c''(\hat{x}_a(w_2)) < 0$ and $F'_{w_2}(w_2, \hat{x}_a(w_2)) = p'_a(\hat{x}_a(w_2)) > 0$, we get, using the implicit function theorem, that $\hat{x}'_a(w_2) > 0$. As w_2 does not influence $\underline{x}$, according to (5.17), x_a^* is increasing with w_2.

Proof of Proposition 2

Let f be the function defined by $f(x) = (p_a(x) - p_n(x))b - k$. We know that f is differentiable and, in the conditions of this proposition, $f(0) \geq 0$. On the other hand, because of (5.3), $f'(x) = (p'_a(x) - p'_n(x))b \geq 0$, which means $\forall x \geq 0, f(x) \geq 0$ and, $\forall x \geq 0, d^*(x) = a$. Therefore, $\underline{x} = 0$.

As for the patient's and physician's utilities, they become defined by, respectively:

$$u(x) = p_a(x)b - k \tag{E.1}$$

$$v(x) = w_1 + p_a(x)(w_2 + \alpha b) - c(x) \tag{E.2}$$

As w_1 is a constant in (E.2), it does not influence x^*. Hence, the Government's utility is defined by:

$$s(w_1, w_2) = u(x^*(w_2)) + v_u(x^*(w_2)) - \lambda(w_1 + p_a(x^*(w_2))w_2) \tag{E.3}$$

As w_1 only has a negative effect in (E.3), $w_1^* = 0$, which proves 1.

We know that $\forall x \geq 0, v''(x) = p_a''(x)(w_2 + \alpha b) - c''(x) < 0$, because of (5.4) and (5.8). Besides, (5.1), (5.7) and (5.8) imply that $\exists x \geq 0 : v'(x) < 0$. Let g be the function defined by $g(w_2) = p_a'(0)(w_2 + \alpha b) - c'(0)$. This function gives, for each value of w_2, $v'(0)$. As $g'(w_2) = p_a'(0) \geq 0$, it is increasing, and it has a zero at:

$$\frac{c'(0)}{p_a'(0)} - \alpha b \tag{E.4}$$

If (E.4) is non - negative, then, $\forall w_2 \geq 0, g(w_2) \geq 0$, which means that there is exactly one $\hat{x} \geq 0$ such that $v'(\hat{x}) = 0$. As v is C^2 and strictly concave, $\hat{x}$ is the unique global maximizer of v. In this case, $x_a^* = \hat{x}_a(w_2)$ which, according to the Proof of Proposition 1, means that x_a^* is strictly increasing with w_2. Hence, no value of w_2 is ruled out as a possible equilibrium and $\underline{w_2} = 0$. But, if (E.4) is negative, no w_2 lower than (E.4) is ever chosen by the Government. This is because, if w_2 were in that interval, $\forall x \geq 0, v'(x) \leq 0$. As the domain of v is $\mathbb{R}_0^+$, we would have $x^*(w_2) = 0$. Observing (E.3), the Government's utility would be lower in this case than when $w_2 = 0$, which means w_2 is not optimal. Gathering both cases, we get that $\underline{w_2} = \max\{0, (E.4)\}$. As (E.4) is decreasing in b and in α, so is $\underline{w_2}$.

On the other hand, if $w_2 = b$, (5.16) and (5.22) become equivalent, which means the physician chooses x^{FB}. In this case, the expression $u(x^*(w_2)) + v_u(x^*(w_2))$ in (E.3) attains its maximum. A higher w_2 than b does not increase this expression and, as x^* is increasing in w_2, reduces $-\lambda(w_1 + p_a(x^*(w_2))w_2)$, which means any $w_2 > b$ is never chosen by the Government, and $\underline{w_2} \leq b$, thus concluding the proof of 2.

If $\lambda = 0$, (E.3) becomes (5.21) when $d = a$, and the Government's utility is not affected by its choice of w_1 and w_2. Therefore, the Government chooses $w_2 = b$ in order to induce $x^* = x^{FB}$ and maximize (5.21). This proves 3.

If $\lambda \geq \overline{\lambda}$, $w_2^* = 0$ and $x^* = x_a^I$, both constant and, therefore, non - strictly increasing in α and b and non - strictly decreasing in λ. Otherwise, w_2^* is positive and characterized by (5.24). On the other hand, $x^* > 0$, because, otherwise, w_2^* would not be positive. This means that the physician is choosing the effort level according to (5.24). The implicit function theorem, as used in the Proof of Proposition 1, allows us to conclude the following (omitting the arguments, for an easier reading):

$$x^{*\prime}(w_2) = -\frac{p_a'}{(w_2 + \alpha b)\, p_a'' - c''} \tag{E.5}$$

$$x^{*\prime\prime}(w_2) = -x^{*\prime}\frac{p_a''\left((w_2 + \alpha b)\, p_a'' - c''\right) - p_a'\left(p_a'' + (w_2 + \alpha b)\, p_a''' - c'''\right)}{\left((w_2 + \alpha b)\, p_a'' - c''\right)^2} \tag{E.6}$$

Using (5.3), (5.4), (5.5), (5.8) and (5.9), we conclude that (E.5) is positive and (E.6) is negative. Gathering (5.16) and (5.24), we get that $w_2^*(\alpha, b, \lambda)$ is defined by $F(\alpha, b, \lambda, w_2) = 0$, with $F(\alpha, b, \lambda, w_2) = (b - (1 + \lambda)\, w_2)\, p_a'(x^*(w_2))\, x^{*\prime}(w_2) - \lambda p$. As F is C^3, omitting the arguments, we get that $F_{w_2}' = -\lambda p_a' x^{*\prime} + (b - (1 + \lambda)\, w_2)\left(p_a'' x^{*\prime 2} + p_a x^{*\prime\prime}\right)$. According to (5.25), $(b - (1 + \lambda)\, w_2) > 0$, which implies that $F_{w_2}' < 0$, and the implicit function theorem may be applied to get $w_{2\alpha}^{*\prime}$, $w_{2b}^{*\prime}$ and $w_{2\lambda}^{*\prime}$. As (omitting the arguments), $F_\alpha' = 0$, $F_b' = p_a' x^{*\prime} > 0$ and $F_\lambda' = -w_2^* p_a' x^{*\prime} - p < 0$, we conclude that $w_{2\alpha}^{*\prime} = 0$, $w_{2b}^{*\prime} > 0$ and $w_{2\lambda}^{*\prime} < 0$. Because (E.5) is positive, we also get that x^* is increasing with α and b and decreasing with λ. This proves 4.

Proof of Proposition 3

The f function in the Proof of Proposition 2 is still differentiable and such that $\forall x \geq$

$0, f'(x) \geq 0$. However, as $(p_a - p_n)(0)\, b < k$, $f(0) < 0$ and $\underline{x} > 0$. But, as $v_a\left(x_a^I\right) \geq v_n(x_n^*)$, in any possible equilibrium, the patient's, physician's and Government's utilities are still defined by, respectively, (E.1), (E.2) and (E.3), which means 1 is still valid. As for the proof of 2 and 4, the reasoning in the Proof of Proposition 2 may be adjusted, replacing $x = 0$ with $x = \underline{x}$. The proof of 3 suffers no changes.

Proof of Proposition 4

In this situation, we have $\underline{x} > 0$, and, if $(w_1^*, w_2^*) = (0, 0)$, $x^* = x_n^*$. If $x^* > \underline{x}$, x^* must be the unique global maximizer of v_a. This is because, if $x \geq \underline{x}$ is a non - binding constraint in the problem $\max_{x_a} v_a(x_a)$ subject to $x_a \geq \underline{x}$, then it must be true that $v_a'(x^*) = 0$. As v_a is differentiable and $v_a'' < 0$, v is strictly concave and x^* is the unique global maximizer of v_a. Because $v_n \leq v_a$ and $x_n^* \neq x^*$, we get that $v_a(x^*) > v_n(x_n^*)$.

Proof of Proposition 5

There are three types of equilibrium in this setting. In the first, the physician chooses x_n^* and the Government's utility is given by $u_n(x_n^*) + v_n(x_n^*) - l$, which is not affected by λ.

In the second, the physician is indifferent between inducing adherence or not, and, according to Proposition 4, is choosing $\underline{x}$. In this type of equilibrium, it must be true that $v_n(x_n^*) = v_u(\underline{x}) + w_1^* + p_a(\underline{x})\, w_2^*$. Hence, the Government's utility is given by $u_a(\underline{x}) + v_u(\underline{x}) - \lambda\left(w_1^* + p_a(\underline{x})\, w_2^*\right) = u_a(\underline{x}) + v_u(\underline{x}) - \lambda\left(v_n(x_n^*) - v_u(\underline{x})\right)$, which is decreasing in λ.

In the third, the physician strictly prefers to induce adherence, and we have $x^* > \underline{x}$, $w_1^* = 0$ and $w_2^* > 0$. To see why, notice that, if w_1^* were positive, it would be possible to increase s_a by reducing w_1 to 0 which would change nothing in the physician's decision and would decrease the term $w_1^* + p_a(\underline{x})\, w_2^*$ in s_a. If $w_1^* = 0$, and because $v_a\left(x_a^I\right) < v_n(x_n^*)$, w_2^* must be positive so that the decision of the physician is not x_n^*. If we had $x^* = \underline{x}$, the Government could reduce w_2 until the physician was indifferent between inducing adherence or not, which would change nothing but the expected payment of the Government, thus increasing the Government's utility.

In this type of equilibrium, as we know from the Proof of Proposition 2, $w_2^* \leq b$. In general, if $(w_1, w_2) = (0, 0)$, $x^* = \underline{x}$. This is because, if x_a^I were higher than $\underline{x}$, we would get, by the same reason applied in the Proof of Proposition 4, that x_a^I would be the global maximizer of v_a, implying that $v_a\left(x_a^I\right) \geq v_n\left(x_n^*\right)$, a contradiction. Hence, and given that, in this type of equilibrium, $w_1^* = 0$, w_2^* must be high enough such that $x^* > \underline{x}$. The highest value of w_2 which assures that this is not true is the one which makes $x > \underline{x}$ a non - binding constraint. That is, $\underline{w_2}$ is such that $v_a'\left(\underline{x}\right) = 0$, or $\left(\underline{w_2} + \alpha b\right) p_a'\left(\underline{x}\right) - c'\left(\underline{x}\right) = 0$.

Notice that $\underline{x} = \left(p_a - p_n\right)^{-1}\left(\frac{k}{b}\right)$, which is increasing in k and decreasing with b, so we can write $\underline{x}_b'\left(b, k\right) \leq 0$ and $\underline{x}_k'\left(b, k\right) \geq 0$. Defining $F\left(\alpha, b, k, \underline{w_2}\right) = \left(\underline{w_2} + \alpha b\right) p_a'\left(\underline{x}\left(b, k\right)\right) - c'\left(\underline{x}\left(b, k\right)\right)$, a C^3 function, and noticing that $F_{\underline{w_2}}'\left(\alpha, b, k, \underline{w_2}\right) = p_a'\left(\underline{x}\left(b, k\right)\right) > 0$, $F_\alpha'\left(\alpha, b, k, \underline{w_2}\right) = bp_a'\left(\underline{x}\left(b, k\right)\right) > 0$, $F_b'\left(\alpha, b, k, \underline{w_2}\right) = \alpha p_a'\left(\underline{x}\left(b, k\right)\right) + \left(\alpha b p_a''\left(\underline{x}\left(b, k\right)\right) - c''\left(\underline{x}\left(b, k\right)\right)\right) \underline{x}_b'\left(b, k\right) > 0$ and $F_k'\left(\alpha, b, k, \underline{w_2}\right) = \left(\left(\underline{w_2} + \alpha b\right) p_a''\left(\underline{x}\left(b, k\right)\right) - c''\left(\underline{x}\left(b, k\right)\right)\right) \underline{x}_k'\left(b, k\right) \leq 0$, we conclude that $\underline{w_2}_\alpha'\left(\alpha, b, k\right) < 0$, $\underline{w_2}_b'\left(\alpha, b, k\right) < 0$ and $\underline{w_2}_k'\left(\alpha, b, k\right) \geq 0$.

Applying the envelope theorem to $\max_{w_2} s_a\left(0, w_2\right)$, we find that:

$$s_{a\lambda}^{*\prime}\left(\lambda\right) = -p_a\left(x^*\left(0, w_2^*\left(\lambda\right)\right)\right) w_2^*\left(\lambda\right) < 0$$

, which mean the optimal Government's utility in this type of equilibrium is decreasing in λ. When $\lambda = 0$, we know, from the Proof of Proposition 2, that, in this type of equilibrium, $x^* = x^{FB}$ and the Government's utility is as high as it may be, higher than what it is in the other two types of equilibrium. As the Government's utility changes continuously with λ in all three types of equilibrium, this type of equilibrium is the one which occurs when λ is low. In the second and third type of equilibrium, the Government's utility approaches $-\infty$ when λ approaches $+\infty$, whereas, in the first type of equilibrium, it is not affected by λ. Therefore, when λ is high, the first type of equilibrium is occurring. The second type of equilibrium may occur for moderate values of λ if, when λ grows from 0 to $+\infty$, there are some values of λ such that the Government's utility in this type of equilibrium is higher than in the others.

Appendix F

Chapter 6

F.1 Data

Table F.1: Geographical and Socioeconomic characteristics of the municipalities by study area

	Lisbon	**Amadora**	**Oeiras**	**Mafra**
Population density (inhab./km^2)	6,448.2	7,363.4	3,751.3	262.9
Population variation (%) 1991-2011	-17.5	-3.8	13.7	75.4
Unemployment rate (%) 2011	11.8	15.0	10.8	9.1
Unemployment variation (%) 2001-2011	62.2	91.8	53.6	102.4
Population with higher education (%) 2011	33.6	16.3	33.4	17.4
Population living in small areas with high material deprivation (%) 2001 (Santana et al., 2015)	9.6	19.34	0.0	9.4

Table F.2: Summary statistics

Variable	Description	Mean	Std. Dev.	Min	Max	N
MHVS	0 (total disability) to 100 (no disability)	58.225	19.523	0	100	1464
unemp	binary variable (=1 if unemployed)	0.117	0.321	0	1	1464
nretired	binary variable (=1 if not retired)	0.71	0.454	0	1	1464
younger	binary variable (=1 if age≤35)	0.259	0.438	0	1	1,464
adult1	binary variable (=1 if age>35 and age≤49)	0.266	0.442	0	1	1,464
adult2	binary variable (=1 if age>49 and age≤65)	0.231	0.422	0	1	1,464
age	age in years	50.318	18.726	18	97	1464
gender	binary variable (=1 if female)	0.633	0.482	0	1	1,464
single	binary variable (=1 if single)	0.285	0.451	0	1	1,464
divorced	binary variable (=1 if divorced)	0.122	0.328	0	1	1,464
widowed	binary variable (=1 if widowed)	0.115	0.319	0	1	1,464
BMI	body mass index – kg/m^2	25.572	4.536	15.37	45.7	1,464
diabetes	binary variable (=1 if diabetes)	0.114	0.318	0	1	1,464
hypertension	binary variable (=1 if hypertension)	0.288	0.453	0	1	1,464
smoke	binary variable (=1 if smoke)	0.2	0.4	0	1	1464
physical	binary variable (=1 if physically active)	0.497	0.5	0	1	1,464
primary_educ	binary variable (=1 if completed up to 4 years)	0.163	0.37	0	1	1,464
basic_educ	binary variable (=1 if completed 9 years of schooling)	0.21	0.404	0	1	1,464
second_educ	binary variable (=1 if completed 12 years of schooling)	0.204	0.403	0	1	1,464
college_educ	binary variable (=1 if completed over 12 years of schooling)	0.338	0.473	0	1	1,464
higher_income	binary variable (=1 if household income increased in the past 12 months)	0.074	0.261	0	1	1,464
lower_income	binary variable (=1 if household income decreased in the past 12 months)	0.486	0.4	0	1	1,464
saving_capacity	binary variable (=1 if household is able to save)	0.504	0.5	0	1	1,464
financial_restraint	binary variable (=1 if household finds hard to pay current expenditures)	0.135	0.342	0	1	1,464
high_financial_concern	binary variable (=1 if household is considerably concerned about daily expenditures)	0.643	0.479	0	1	1,464
low_financial_concern	binary variable (=1 if household is not worried about daily expenditures)	0.018	0.132	0	1	1,464

Continues on next page

Table F.2 – *Continued from previous page*

Variable	Description	Mean	Std. Dev.	Min	Max	N
prim_unemp_nret	interaction variable between *primary_educ*, *unemp* and *nretired*	0.008	0.09	0	1	1,464
basic_unemp_nret	interaction variable between *basic_educ*, *unemp* and *nretired*	0.046	0.211	0	1	1,464
second_unemp_nret	interaction variable between *second_educ*, *unemp* and *nretired*	0.028	0.165	0	1	1,464
college_unemp_nret	interaction variable between *college_educ*, *unemp* and *nretired*	0.027	0.161	0	1	1,464
gender_unemp_nret	interaction variable between *gender*, *unemp* and *nretired*	0.069	0.254	0	1	1,464
younger_unemp	interaction variable between *younger* and *unemp*	0.04	0.197	0	1	1,464
adult2_unemp	interaction variable between *adult2* and *unemp*	0.04	0.195	0	1	1,464
basic_unemp_younger	interaction variable between *basic_educ*, *unemp* and *younger*	0.017	0.13	0	1	1,464
second_unemp_younger	interaction variable between *second_educ*, *unemp* and *younger*	0.009	0.094	0	1	1,464
college_unemp_younger	interaction variable between *college_educ*, *unemp* and *younger*	0.012	0.11	0	1	1,464
prim_unemp_adult1	interaction variable between *primary_educ*, *unemp* and *adult1*	0.001	0.037	0	1	1,464
basic_unemp_adult1	interaction variable between *basic_educ*, *unemp* and *adult1*	0.019	0.137	0	1	1,464
second_unemp_adult1	interaction variable between *second_educ*, *unemp* and *adult1*	0.01	0.097	0	1	1,464
college_unemp_adult1	interaction variable between *college_educ*, *unemp* and *adult1*	0.005	0.069	0	1	1,464
prim_unemp_adult2	interaction variable between *primary_educ*, *unemp* and *adult2*	0.007	0.082	0	1	1,464
basic_unemp_adult2	interaction variable between *basic_educ*, *unemp* and *adult2*	0.01	0.1	0	1	1,464
second_unemp_adult2	interaction variable between *second_educ*, *unemp* and *adult2*	0.01	0.097	0	1	1,464
college_unemp_adult2	interaction variable between *college_educ*, *unemp* and *adult2*	0.01	0.097	0	1	1,464
gender_unemp_younger	interaction variable between *gender*, *unemp* and *younger*	0.025	0.155	0	1	1,464
gender_unemp_adult1	interaction variable between *gender*, *unemp* and *adult1*	0.024	0.153	0	1	1,464
gender_unemp_adult2	interaction variable between *gender*, *unemp* and *adult2*	0.02	0.142	0	1	1,464

F.2 Methodology

Table F.3: Variables within the vectors

Υ	Ω	Γ
AGE		
		GENDER_UNEMP_YOUNGER
GENDER	GENDER_UNEMP_NRET	GENDER_UNEMP_ADULT1
		GENDER_UNEMP_ADULT2
SINGLE		
DIVORCED		
WIDOWED		
BMI		
DIABETES		
HYPERTENSION		
SMOKE		
PHYSICAL		
PRIMARY_EDUC	PRIM_UNEMP_NRET	PRIM_UNEMP_ADULT1
		PRIM_UNEMP_ADULT2
		BASIC_UNEMP_YOUNGER
BASIC_EDUC	BASIC_UNEMP_NRET	BASIC_UNEMP_ADULT1
		BASIC_UNEMP_ADULT2
		SECOND_UNEMP_YOUNGER
SECOND_EDUC	SECOND_UNEMP_NRET	SECOND_UNEMP_ADULT1
		SECOND_UNEMP_ADULT2
		COLLEGE_UNEMP_YOUNGER
COLLEGE_EDUC	COLLEGE_UNEMP_NRET	COLLEGE_UNEMP_ADULT1
		COLLEGE_UNEMP_ADULT2
HIGHER_INCOME		
LOWER_INCOME		
SAVING_CAPACITY		
FINANCIAL_RESTRAINT		
HIGH_FINANCIAL_CONCERN		
LOW_FINANCIAL_CONCERN		

F.3 Results

Table F.4: Estimation results Model 1 to Model 4

	(Model 1)		(Model 2)		(Model 3)		(Model 4)	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
	MHVS	MHVS	MHVS	MHVS	MHVS	MHVS	MHVS	MHVS
unemployed	0.521		10.85		0.633		7.827	
nretired	-0.067		-0.555					
age	-0.045		-0.039					
gender	-7.099***	-6.766***	-7.286***	-7.143***	-6.992***	-6.766***	-7.152***	-7.254***
single	-2.521*		-2.435		-1.981		-1.982	
divorced	-2.219		-2.264		-2.425		-2.543	
widowed	-3.399	-3.361*	-3.148		-4.084*	-3.361*	-3.781*	
BMI	0.005		-0.018		-0.004		-0.018	
diabetes	-1.435		-1.210		-1.554		-1.365	
hypertension	-5.043***	-5.208***	-5.079***	-5.395***	-5.441***	-5.208***	-5.520***	-5.371***
smoke	-1.760		-1.561		-1.617		-1.302	
physical	4.702***	4.779***	4.719***	4.592***	4.724***	4.779***	4.800***	4.685***
primary_educ	1.202		1.893		1.243		1.943	
basic_educ	5.669**	4.999***	6.975**	5.936***	6.259**	4.999***	7.595***	5.966***
second_educ	6.281**	5.500***	7.772***	6.471***	6.963**	5.500***	8.481***	6.805***
college_educ	4.552*	3.801**	6.370**	4.875***	5.252*	3.801**	7.109**	5.450***
higher_income	-2.021		-2.110		-1.922		-2.242	
lower_income	-1.412		-1.557		-1.543		-1.629	
saving_capacity	5.229***	5.458***	5.166***	5.442***	5.242***	5.458***	5.196***	5.469***
financial_restraint	-6.579***	-6.643***	-6.639***	-6.587***	-6.601***	-6.643***	-6.648***	-6.447***
high_financial_concern	-5.167***	-5.604***	-5.044***	-5.467***	-5.125***	-5.604***	-4.999***	-5.397***
low_financial_concern	5.252		4.873		5.262		4.692	
prim_unemp_nret			-5.803					
basic_unemp_nret			-11.41					
second_unemp_nret			-12.67*					
college_unemp_nret			-16.32*					
gender_unemp_nret			2.614					
younger					-0.114		-0.631	
adult1					-0.112		-1.098	
adult2					0.073		-0.433	
younger_unemp							17.54	25.20*
adult2_unemp							-1.075	
basic_unemp_younger							-24.41*	-23.14*
second_unemp_younger							-27.73*	-28.25*
college_unemp_younger							-35.54**	-35.28**
prim_unemp_adult1							-1.234	
basic_unemp_adult1							-5.672	
second_unemp_adult1							-10.16	
college_unemp_adult1							-8.268	
prim_unemp_adult2							-0.845	
basic_unemp_adult2							-11.70	
second_unemp_adult2							-5.658	
college_unemp_adult2							-6.777	
gender_unemp_younger							1.224	
gender_unemp_adult1							2.128	
gender_unemp_adult2							0.963	
_cons	63.96***	60.33***	63.35***	59.49***	61.42***	60.33***	60.96***	59.22***
N	1464	1464	1464	1464	1464	1464	1464	1464
R^2	0.210	0.203	0.215	0.200	0.209	0.203	0.218	0.207

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

Table F.5: Summary of the results obtained in restricted Models 1 to 4

	(1) (MHVS)	(2) (MHVS)	(3) (MHVS)	(4) (MHVS)
financial_restraint	-6.643***	-6.587***	-6.643***	-6.447***
second_educ	5.500***	6.471***	5.500***	6.805***
basic_educ	4.999***	5.936***	4.999***	5.966***
gender	-6.766***	-7.143***	-6.766***	-7.254***
saving_capacity	5.458***	5.442***	5.458***	5.469***
physical	4.779***	4.592***	4.779***	4.685***
widowed	-3.361*		-3.361*	
high_financial_concern	-5.604***	-5.467***	-5.604***	-5.397***
college_educ	3.801**	4.875***	3.801**	5.450***
hypertension	-5.208***	-5.395***	-5.208***	-5.371***
second_unemp_younger				-28.25*
college_unemp_younger				-35.28**
younger_unemp				25.20*
basic_unemp_younger				-23.14*
_cons	60.33***	59.49***	60.33***	59.22***
N	1464	1464	1464	1464
R^2	0.203	0.200	0.203	0.207

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