The Impact of a NordDRG-based System on the Behaviour of Swedish Hospitals

An empirical analysis of a prospective payment system based on diagnosis-related groups

by

Nathalie Sönne

June 2019

Master's Programme in Economics

Supervisor Lina Maria Ellegård

Abstract

The aim of this study is to contribute to previous research on the use of Prospective Payment Systems (PPS) based on Diagnosis Related Groups (DRG) in Sweden with an extended evaluation of variation in the utilisation of the system on recent data. This study looks specifically at within county financing and the role the system has played on the performance and behaviour of Swedish hospitals in regards to the number of DRG-weights registered in inpatient and outpatient healthcare. The method used for the analysis is based on a higher dimension fixed effects model, taking into account time-, county-, and diagnosis fixed effects. The data covers the 21 Swedish counties for the time period 2005 - 2017. The dependent variable of interest is *DRG-weights*, which is analysed for inpatient care, outpatient care and the total effect of the two combined. Several robustness tests are also run. The empirical analysis lacks most statistical significance, but a trend suggests that there is a positive impact on outpatient care regarding the amount of DRG-weights registered. The results also indicate a negative impact on inpatient care and a weak negative combined effect on the full sample. This implies that the use of the NordDRG-system may have ambiguous impacts on hospital behaviour. This study suggests an indication of how the financing system influences hospital behaviours and potential changes in quality seen through unplanned readmission rates.

Keywords: Diagnosis Related Groups, Swedish healthcare, Healthcare financing, Inpatient Care, Outpatient Care, Hospital behaviour

Acknowledgements

I want to thank my supervisor for this thesis Lina-Maria Ellegård for guidance, constructive criticism and access to the data used for the empirical analysis. I also wish to dedicate a big thank you to Thea, Linda, Mia and Anna for continuous support and feedback throughout this thesis period. Finally, I would like to thank my fellow master students for support and laughs during the last two years of hard work and memorable moments.

Table of contents

List of Tables

List of Figures

1. Introduction

The funding of healthcare systems have for long been an interesting and controversial topic. Different methods and approaches are frequently tested and evaluated in the search for an optimal infrastructure which supports high-quality care, innovation, research, high levels of productivity, and whilst remaining cost-efficient. One of these designs is a financing model based on Prospective Payment Systems (PPS) which are calculated from Diagnosis Related Group (DRG) weights. The model weights each diagnosis with the expected need for resources per treatment, which results in a reimbursement sum based on actual activity and output. The method was first introduced in 1983 in the Medicare system in the US and has since spread rapidly across the developed economies. The interpretation and use of PPS based on DRG- weights range widely across countries, mainly due to the different time frames in which the policy implementation process took place, as well as the needs of the healthcare system concerned (Geissler et al., 2011).

The Swedish PPS policy using DRG-weights was introduced in 1992 when Stockholm County implemented the model for financing inpatient care. It has since expanded to other counties. The implementation of the DRG-based system held high ambitions as it allowed for descriptions, follow-ups and resource allocation to a greater extent than previous systems. Since the system is flexible and performance-driven, these ambitions were seen in the inherent need for a high level of documentation. The Nordic countries also joined forces and developed a common patient classification system which defined a Nordic set of diagnosis groups called NordDRG, and was adopted in the mid-1990s (Linna and Virtanen, 2011). The Swedish PPS based on DRG-weights will be considered for this analysis, and will hereafter be referred to simply as the NordDRG-system for the remainder of the study.

Since the 1990s, DRG-weights are used in some capacity in almost every Swedish county. One of the uses of DRG-weights is as a basis for within-county financing. Medical diagnoses generate different amounts of DRG-weights, which are used to calculate the amount of financing given to the hospital. Financing is set by a predetermined reimbursement per DRG-weight. This model allows for incentives to increase productivity, and therefore the production of healthcare in hospitals where the price is lower than the marginal cost. As a result, the system encourages hospitals to cut costs and increase efficiency in order to maximise net revenues. The system also increased competition in the market, as the DRG-weights are connected to patients through their diagnosis, which incentivises hospitals to attract individuals to their institutions through improved services.

In addition to the positive influences on the healthcare sector from a DRG-based PPS, there may also be negative impacts. The number of DRG-weights recorded is part of the financing equation which is vulnerable to manipulation through behavioural changes at the hospital level. Incentives to maximize profits through the number of DRG-weights may result in negative effects on hospital services. These may include a restricted patient selection and limitations to equal access to healthcare since a focus on high-profit diagnoses are incentivised. Concerns about the impact on the quality of care have also been expressed, as cost minimisation may have negative spillover effects on patients. Besides the impacts on patients, there is also an increased risk of coding manipulation in this type of system compared to those based on a fixed grant. By increasing the number of secondary diagnoses for patients, and favouring diagnoses which give more DRG-weights, the hospital physicians can actively contribute to the institutions receiving increased funding (Lindgren, 2014). Concerns of financial incentives impacting hospital services and increased manipulation have become more prominent with time, and may in some cases overshadow the positive aspects which motivated the implementation of the system.

An evaluation of the NordDRG-system in the Swedish healthcare sector is motivated by the mix of positive and negative potential effects associated with the use of a PPS based on DRG-weights. This study will specifically look at within-county financing and the role the policy has on the performance and behaviour of Swedish hospitals. The focus will be on how the number of DRG-weights is affected by the use of the reimbursement system in both inpatient and outpatient healthcare. The research question for the analysis is as follows:

Does the use of a prospective payment system based on DRG-weights for within-county financing on county-level alter the behaviour of Swedish hospitals?

The method used for the analysis is based on a higher dimension fixed effects model, taking into account time-, county-, and diagnosis fixed effects into account. The data cover the 21 Swedish counties for the time period 2005 - 2017. The dependent variable of interest is *DRG-weights*, which is analysed for inpatient care, outpatient care and the total effect of the two sectors combined. Several robustness tests are run by creating subsamples based on county-level variation in the time period the system was used. Specifically, the variation is based on if the system was used continuously from implementation to the end of the sample period or if it was replaced during the sample period. A test is also performed by excluding the observations for the largest county, Stockholm, in the data set. An extension of the analysis is enabled by considering the impact of the NordDRG-system on secondary diagnoses, the number of hospitalizations, the number of unplanned readmissions and Length of Stay (LoS). These variables indicate potential changes in behaviour in specific areas of Swedish healthcare provision.

The study is outlined as follows. In section 2, the institutional background of Swedish healthcare is explained. Section 3 provides further details on the policy of implementing the NordDRG-system, theoretical aspects and potential behavioural impacts. Section 4 outlines previous research on the use of DRG globally and in Sweden. Section 5 details the empirical approach and the data used for the empirical analysis. The results are presented in Section 6, followed by a discussion in Section 7 and concluding remarks.

2. Institutional Background

In order to evaluate the impact of the policy on the Swedish healthcare system, it is vital to have an understanding of how Swedish healthcare is organised. The system is based on three political and administrative levels which are involved in financing, evaluating and providing healthcare activities. These are the central government, the county councils and the local municipalities. The central government holds the legislative supervisory role and set the agenda for the healthcare system through laws and through agreements with the Swedish Association of Local Authorities and Regions (SALAR). In addition, the government partially finance health services through state budgets and several agencies, supporting the set political agenda for Swedish healthcare.

Sweden has 21 county councils which are responsible for providing the majority of healthcare services, and to organise care services to enable health-related support all their constituents. The members of the county council are elected officials. They are therefore held accountable by their constituents to provide the best healthcare given the agenda set by the government and the regional requisites. The municipalities are 290 in total and are in charge of the long-term care of the elderly and disabled individuals, including the mentally disabled. An official at this level are also elected by their constituents and can be held accountable (Street et al., 2007; Serdén and Heurgren, 2011; Kliniskastudier.se, 2019).

As the county council is the main provider of healthcare and is responsible for its organisation, it is also a main deciding body in the implementation of healthcare policies. The decision of which system to use for payments and financing allocation falls on the county level which allows for variation in the systems used among the 21 Swedish counties. Historically, several financing systems have been used, and the variation continues with varying degrees of the systems used in the different counties today. The numerous approaches include PPS, such as those based on predetermined grants, on the population size of the county, or on compensation based on product groups (where DRG is one option). There is also a retroactive system based on the medical intervention used in some parts of the Swedish healthcare sector (Lindgren, 2014). The costs for healthcare are mainly covered by public funds from communal taxes, and all counties receive government grants.

3. Policy

This section aims to provide a comprehensive overview of the policy evaluated in this analysis, the use of the NordDRG-system. The theoretical predictions associated with this type of policy are discussed, followed by the initial motivation for using the NordDRG-system and how it was implemented. This section also outlines the technical details of the NordDRG-system and unintended side-effects identified from this type of reimbursement system. Finally, the variation in the use of the NordDRG-system across the Swedish counties is presented.

3.1 Theoretical predictions of PPS based on DRG-weights

The theoretical predictions accompanying the use of a PPS based on DRG-weights, rather than fixed funding, are based on profit maximisation theory and a form of yardstick competition theory. Despite many Swedish hospitals being public healthcare providers, the use of funding based on DRG-weights allow for competition and financial incentives in the market, and therefore for profit maximisation behaviour. The assumption of profit maximisation was a key factor in the case for the introduction of competition into the healthcare sector, whilst keeping consideration for the patients integral to the sector (Brekke et al. 2014; Gaynor et al. 2011).

The yardstick theoretical framework is designed to encourage economic agents to reduce their costs for cases where they face limited competitive pressure. The agents who outperform the competitors benefit directly by obtaining financial surplus, whereas those who underperform generate deficits. Thus all economic agents, in this case hospitals, are incentivized to continue to reduce their costs, even the most efficient ones. The framework is effective when prices reflect the supply cost of efficient providers, but the asymmetric information present in the healthcare sector makes this problematic. (Shleifer 1985; Street et al. 2011). The problems associated with establishing the correct price to enable an efficient market, and the profit-maximizing nature of hospitals, may contribute to increased incentives to manipulate the system by upcoding or changed hospital behaviour.

3.2 Initial motivation for the NordDRG-system and its implementation

Up until the 1990s, Swedish healthcare funding had been based on fixed grants which limited the economic incentives for high or increasing productivity. As a consequence, there was growing discontent with the low level of production and low productivity rates in the Swedish healthcare system. This situation, combined with a need to save money and aims of a more patient-oriented system, paved the way for a new policy. A PPS utilising DRG-weights allows for descriptions, follow-ups, and resource allocation to a greater extent as the system is based on a high level of documentation and registrations. This is necessary to enable flexible and performance-driven financing to the counties and their hospitals. Hospital performance can, as a result, be evaluated trough the number of DRG-weights registered over time. These are calculated by using the sum of hospital contact, weighted by the expected need for resources for a given diagnosis (Serdén and Heurgren, 2011; Ellegård and Häger Glenngård, 2019a).

Another effect that accompanied the introduction of the NordDRG-system was an increase in patient freedom in the choice of hospital. Through more choices for patients in different hospitals, the policy allowed for increased competition since the money effectively follow DRG-weights connected to the patient through his or her diagnosis. The increased competition was, in addition, hoped to contribute to higher quality information and a larger degree of transparency in the healthcare sector. A cost ceiling was introduced with the new system in order to maintain a stable level of production and prevent oversupply and overuse (Serdén and Heurgren, 2011).

The implementation of the NordDRG-system in Sweden began in the 1990s, with Stockholm County introducing it in 1992. The system was developed as a process of increased cooperation between the National Board of Health and Welfare and the County Councils, and as a result, the implementation decisions have mostly involved the county councils. Sweden has a high degree of local autonomy, which contributed to relatively weak central coordination of any DRG-related issues during the 1990s. This changed in 1999 when the National Board of Health and Welfare took over the central coordination of DRG issues. Due to the many different areas of application of the NordDRG-weights, all county councils are now using the NordDRG-system to some extent (Linna and Virtanen, 2011).

The system is continuously updated and Stockholm County implemented a newer version of how patients and diagnoses are grouped in the so-called ‘NordDRG grouper’ in 1997, which was replaced by NordDRG CC in 2013 (Vardgivarguiden.se, 2018). The NordDRG grouper is the common grouper for DRG-weights used by the Nordic countries since the mid-1990s. The NordDRG grouper follows the Healthcare Financing Administration (HCFA) - DRG version 12, using definitions which are based on the World Health Organisation (WHO) International Classification of Diseases 10th revision (ICD - 10) as well as the Nordic Medico-Statistical Committee (NOMESCO) classification of surgical procedures. The first grouper was introduced in 1996 and is since then updated yearly (Linna and Virtanen, 2011).

3.3 Detailed outline of the NordDRG-system

NordDRG-weights are grouped based on diagnosis and cases which are expected to undergo a comparable clinical evolution. They are therefore likely to face similar costs for diagnostics and treatment, and can be placed within a set scale. A fixed price per DRG can be determined using this scale, which is subsequently used as a base for financing. Before the global expansion of the system, the predictability needed to enable a base for DRG-weights was tested and proven in several cost-of-illness studies on some of the major prosperity diseases, and clinical trials on efficiency. When the model succeeded in meeting the challenge facing the diversity of diagnostic groups, DRG spread from the US to Europe and then to other developed economies (Mihailovic, Kocic and Jakovljevic, 2016).

A DRG-based system has two main design characteristics. Firstly, it can be used as an exhaustive patient case classification system through the diagnosis-related groupings. Secondly, it can be used as a payment formula which is calculated from a base rate multiplied by a relative cost weight set specifically for each DRG. The price and cost per DRG are related in every country using the DRG system, however each country, and occasionally hospital, use different methods for calculating prices. The main differences between countries are found in the source of cost data, how outliers are defined and whether costs are converted into prices or cost-weights (Quentin et al., 2011; Mihailovic, Kocic and Jakovljevic, 2016). Quentin et al (2011) have also identified three primary incentives for hospitals to use a DRG-based hospital payment system. First, to reduce the costs per treated patient in the hospital, second, to increase understanding and transparency, and third, to increase the number of patients. These aspects vary in importance with each type of DRG-based system, with how dependent revenues are on DRG-weights, and how well DRG-weights and the monetary conversion rates are adjusted to accommodate the cost-structures for each individual hospital.

The NordDRG-system can be used in several ways. The Swedish counties can overtime be divided into three groups in terms of their usage of the system. The first group includes the counties that use the NordDRG-system for reimbursement to hospitals for a wide range of care and may include both in- and outpatient care. The second group of counties is those who only use the system as a tool for detailed analysis of their healthcare service. These counties use the NordDRG-system to calculate the casemix, for budgeting or for between-county reimbursement for patients. The third and last group includes those counties that use the NordDRG-system a part of the reimbursement system, but only for a small section of the healthcare providers such as a single hospital or institution. The share of counties belonging to each group differs over time as counties alter their healthcare structure. A large share of counties used to belong to the first group, but the numbers have fallen in recent years, as seen in Figures 1 and 2 below. The use of the NordDRG-system for within-county financing is currently limited, with only four counties using the NordDRG-system extensively. (Serdén, L. and Heurgren, M. 2011, Lindgren 2019).

3.4 Unintended side-effects of PPS with DRG-weights

There are some behavioural impacts associated with the use of PPS based on DRG-weights. Mainly in terms of how the policy changes the incentives of physicians and hospitals towards a financial goal. One of the main limitations of this type of system is the possibility to manipulate the coding for different DRGs to increase the financing for the hospital. This is referred to as upcoding. Patients are then coded into a group with higher reimbursements by altering the severity of the diagnosis, or by including redundant secondary diagnoses (Lindgren, 2014). It is, however, worth noting that the occurrence of increased diagnosis registrations in competitive areas may not solely be due to upcoding. Changes in the volume of patients and in the casemix facing the hospital will also result in alterations in the number of DRG-weights registered. The casemix for a hospital can also result in different impacts from the policy on inpatient and outpatient care, as the casemix refers to the composition of the types of patients treated by a hospital (Nccc.uow.edu.au, 2016). Inpatient care is often associated with more complicated diagnosis compared to outpatient care, as inpatient care requires overnight stays.

Interestingly, there have also been indications of administrators under-reporting diagnoses for healthcare units found in primary care in the Swedish county of Skåne (Dackehag and Ellegård, 2019). Such tendencies among administrators would suppress upcoding behaviour and obscure the magnitude of the impact on the number of DRG-weights due to manipulation.

There are also changes in hospital behaviour which may result in a moral hazard effect associated with the use of a DRG-based system. This occurs if hospitals choose to supply more or fewer services to a given type of patient. Such changes in the availability of services would be driven by lower financial compensation for some cases of treatment and diagnosis. As reimbursements are based on DRG-weights, the DRG with a small profit margin may be neglected in favour of those with a large profit margin. There may also be a change in the severity of patients treated, a selection effect, as more severe cases result in higher compensation (Ellis and McGuire, 1996).

In addition to the behavioural influences which aim to manipulate the system, there are also issues that may impact the quality of care given at a hospital. Reducing costs can be achieved through several desirable ways such as improved management and organisation, and improving efficiency in medical procedures. However, there may also be unintended and negative impacts. A clear example is attempting to reduce the length of stay (LoS) of patients and thus decrease costs. This may, however, lead to a premature discharge and as a result also in unplanned readmissions of patients. Another example can be found in attempts at improving cost-efficiency through decreasing supply and resources, which may lead to a reduced quality of medical care provided (Miraldo, Goddard and Smith, 2006).

With a change in the financing model used, an impact on behaviour and incentives of hospitals may be anticipated. However, the extent of the impact on patients and healthcare services in practice largely depends on the structure of the system and the controls put in place.

3.5 The NordDRG-system for within county financing in Sweden

In Sweden, the NordDRG-system for within-county financing can be used in outpatient care, inpatient care or in both sectors. As there is no national reform covering all counties, there is variation in counties who utilise the NordDRG-system, and for which sectors of their healthcare services. The variation over time is displayed for inpatient and outpatient care in Figure 1 and Figure 2 below.

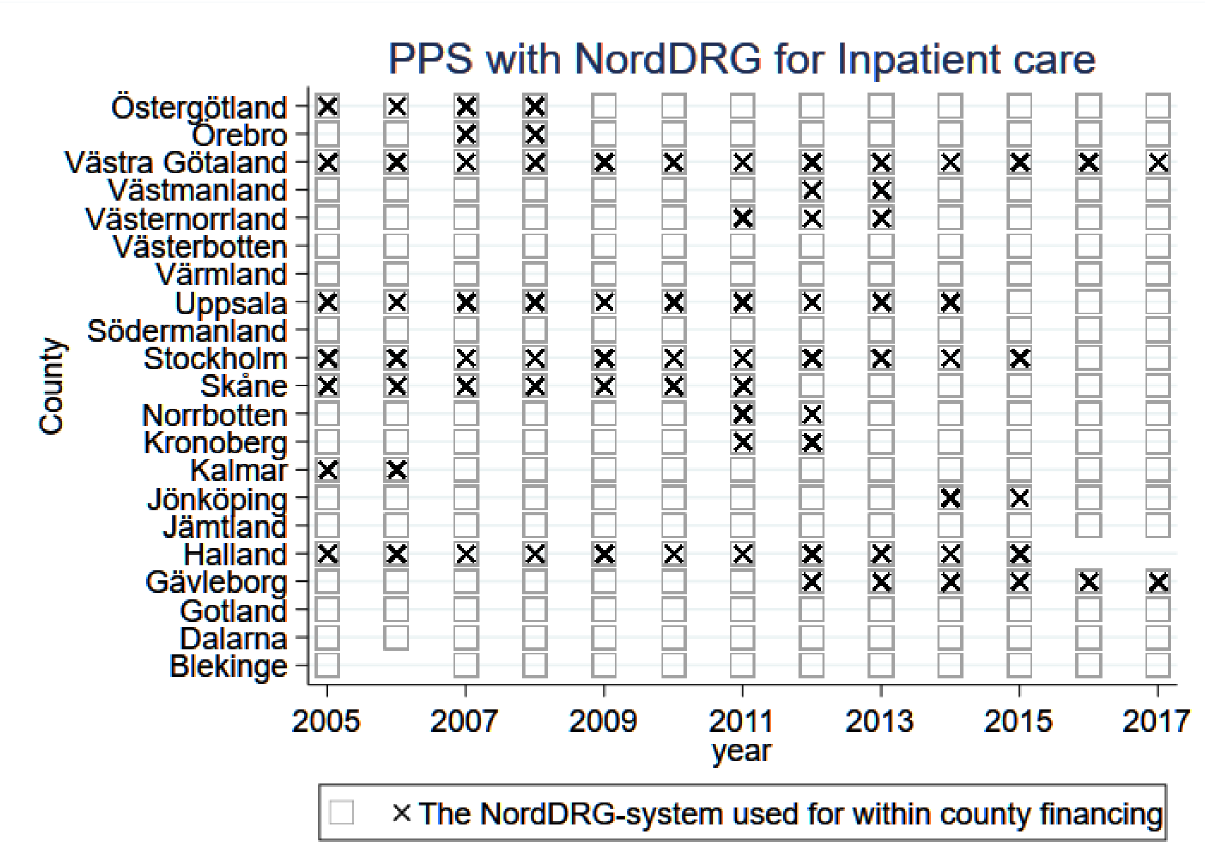

Figure 1 - counties who use the NordDRG-system for within county financing in inpatient care

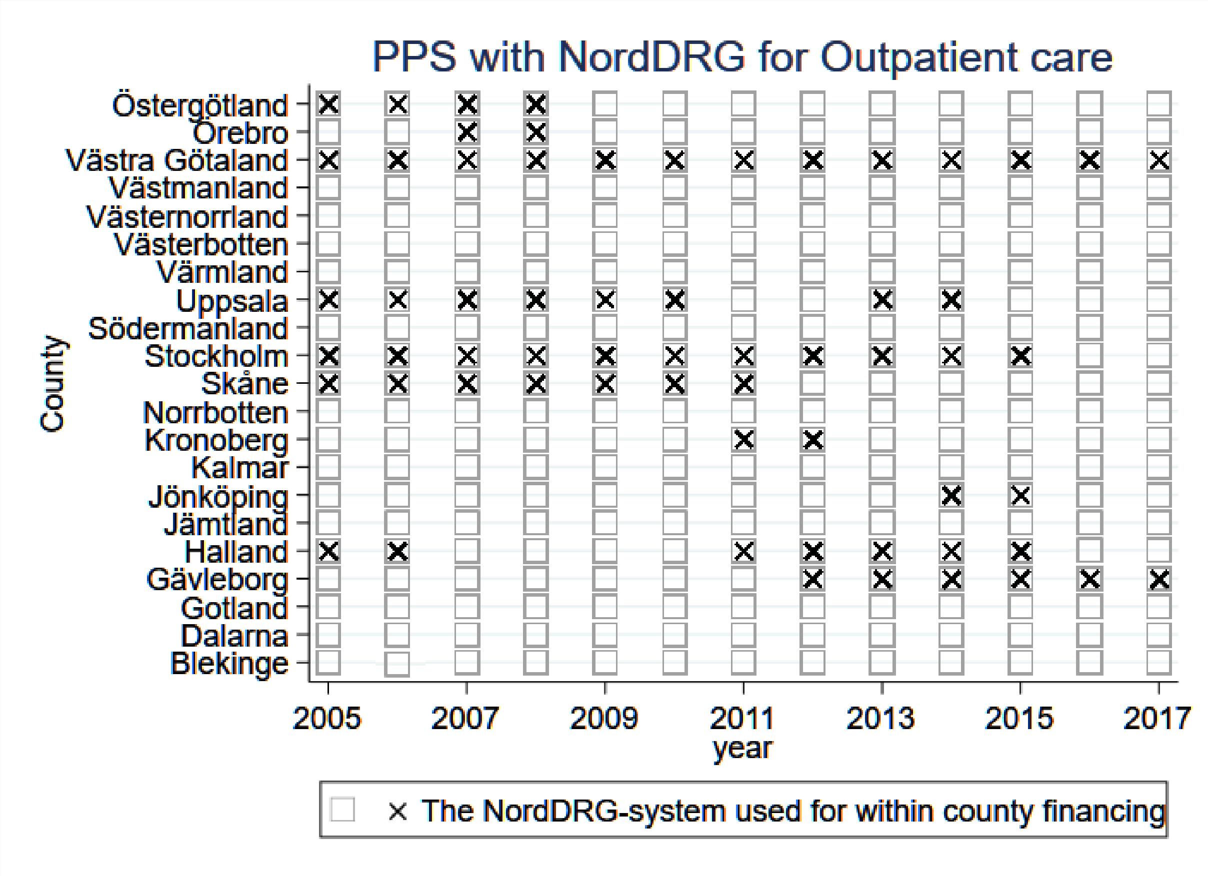

Figure 2 - counties who use the NordDRG-system for within county financing in outpatient care

4. Previous Literature

In this section, relevant previous research on the impact of implementing a PPS based on DRG-weights will be presented. The aim of this section is to provide an overview of the research that has been previously published, and the inconclusive results found from the use of a DRG-based PPS in an international context.

One of the main reasons for introducing a PPS based on DRG-weights was in many countries to increase transparency and reduce costs. By introducing financial incentives into hospital practice, this would increase cost awareness amongst physicians, in line with the yardstick competition theory outlined in 3.1 (Shleifer 1985; Street et al. 2011). Results supporting increased cost awareness and subsequently lower costs were found early in a study by Davis and Rhodes (1988) on the implementation of the system in the USA. They find that the introduction of the system greatly aided in keeping the Hospital Insurance Trust Fund from running out, which was previously forecasted to occur in 1986. Thus, costs were lowered significantly more than anticipated.

Similar results were found by Gerdtham, Rehnberg, and Tambour (1999) on the early impacts in the Swedish medical sector between 1991 and 1993. Here, the potential cost savings for counties without the system, if they were to implement it, was estimated at around 13%. The potential for cost savings has further been identified in several countries who implemented the policy in the 2000s. Hu et al. (2015) find reduced costs in several areas of hospital care associated with the policy implementation in Taiwan. Similarly, Hamada, Sekimoto, and Imanaka (2012) find reductions in resource use through a reduction in total medical charges by 5%, and a reduction in the examination and medication charges of 15% as a result of the policy implementation in Japan. The authors also identify three factors that may influence the impact on Japanese healthcare. First that unnecessary but traditional examinations or medications were reduced after implementation, second a shift of cases from inpatient care to the outpatient sector, and lastly the introduction of generic drugs that were previously not used.

Another incentive for introducing PPS and DRGs was increased market competition for hospitals which was predicted to result in increased efficiency. Empirical indications of the importance of market competition have been found by Kim et al. (2015) who examine the association between the effects of market competition and quality of care following the introduction of a DRG-based system in Korea. The results indicate that the impact of introducing PPS based on DRGs differs depending on the degree of market competition experienced by the hospital. Hospitals in high competition areas following the policy introduction are found to provide a higher quality of care, compared to those in a low competition area. Interestingly, a study on the policy in Germany by Jürges and Köberlein (2015) find that a high level of competition may also be a contributing factor to manipulation of the system as low levels of funding from high competition areas may be compensated by upcoding practices.

Upcoding, the manipulation of the recorded DRG-weights per hospital, is one of the main limitations of the policy. Several studies have been performed to evaluate the presence of this type of manipulation and identify problems with upcoding in different countries. Or (2014) analysed the impact of the implementation of the French version of a DRG-based system. The major objectives for the implementation were similar to the Swedish in improving hospital efficiency and improving transparency in hospital management. The results show that the implementation and use of DRG gave opportunities for increased efficiency and transparency, but also introduced risks. The risks associated with the DRG-base program were realised in 2006, and up-coding became a real problem in French healthcare. Similarly, signs of upcoding were found by Buczak-Stec et al., (2017) in Poland and by Jürges and Köberlein (2015) in neonatology in German hospitals.

Potential outcomes from the implementation of PPS and DRG-weights which will be considered in this study are the correlation between the use of the NordDRG-system and coding practices, secondary diagnosis, hospitalisation, unplanned readmission rates, and LoS. Previous research on these relationships will be considered next.

The correlation between the use of PPS based on DRG-weights and hospital behaviour is the foundation for the hypothesis of this analysis and has been previously discussed in a study by Melberg, Beck Olsen, and Pedersen (2016). The study tests the hypothesis that the Norwegian the NordDRG-system is neutral with respect to the behaviour of the physicians and hospital. The study evaluates the potential impact on the amount of treatment provided for different DRG by changes in the reimbursement between 2002 and 2013. The authors find a correlation between reimbursement rates and treatment activity, indicating that financial incentives influence treatment decisions in Norwegian hospitals that use the NordDRG-system. Over all years, for inpatient and outpatient care, the treatment activity was found to increase by 3.16% for DRGs with increased reimbursement. The associated change for DRGs with a reduction in reimbursement was smaller at a 0.74% increase in average treatment activity. This pattern was also found in different time periods and sub-samples of the data. The combined results from all regressions run in the study indicate that a 10% increase in the reimbursement is associated with an increase in the level of hospital activity of between 0.76 and 1.10%. There are as result strong indications that reimbursement levels for different DRGs have a significant impact on the behaviour of Norwegian hospitals. Given the similarities between the Nordic countries, how the welfare system is operated, and the common use of the NordDRG grouper, these results are interesting to acknowledge for this study.

The impact on secondary diagnoses has also been evaluated in previous literature, with Serdén, Lindqvist, and Rosén (2003) conducting an analysis on Swedish data, using hospital records from 1988 to 2000. The Swedish hospitals were divided into three groups, the early adopters, the late adopters and the hospitals that did not use the NordDRG-system. The early adopters consider the hospitals who introduced the NordDRG-system in 1992, and the late adopters those who introduced it in 1999. The study found indications of an increase in secondary diagnoses coinciding with the introduction of the NordDRG-system through influences on coding practices and higher registered secondary diagnoses with DRGs. Finally, they also find differences in how secondary diagnoses are recorded between the different hospital groups.

The analysis by Serdén, Lindqvist, and Rosén (2003) estimates that between 1991 and 1992, the increase in recorded secondary diagnoses was 40% for the early adopters, 11% for the late adopters and 9% for the other regional hospitals. In 2000, the authors find that hospitals using the NordDRG-system presented about 50% more secondary diagnoses than other regional hospitals. And between the years 1988 and 2000, the early and late adopters saw an increase in secondary diagnoses by between 120-160%, compared to 56% for the other regional hospitals. The analysis also found that in 2000, the early adopters used secondary diagnoses for 54% of all their cases, the late adopters for 53% and all the other regional hospitals for only 41%. These results present strong indications for a behavioural change in hospitals using the NordDRG-system, with financial incentives being integrated into hospital practices through secondary diagnoses.

The number of hospitalisations may also be affected by the implementation of a PPS with DRG-weights. Previous literature analysing this variable find contradicting results. Buczak-Stec et al., (2017) evaluate the policy in Poland through the frequency of hospitalisations due to atherosclerosis in internal medicine units between 2004 and 2012. The authors find a sharp increase in the rate of hospitalizations as the DRG-based system was implemented in 2008. A change in the trend was also found as it fell steadily in the years prior to the implementation, and saw an increase of 2.5 times in the years after. The authors see this as a sign of upcoding or upcapture of this diagnosis and the effect cannot be explained by other structural changes in the sector. Contradicting these results are the estimations of a decrease in hospitalisations in DRG areas found in Switzerland between 2003-2007 by Busato and von Below (2010).

The quality of care may also be influenced by the implementation of a different financing system, and several studies have analysed this relationship internationally. Davis and Rhodes (1988) found a significant fall in admission rates, implying a positive impact on the quality of care with the introduction of PPS and DRG-weights in the USA. In contrast to these findings, Hamada, Sekimoto, and Imanaka (2012) and Busato and von Below (2010) find indications of increased readmission rates with the implementation of the system, indicating a reduction in quality of care. In addition, Hu et al (2015) find increased rates of complications or comorbidities of 11.7% in the Taiwanese hospitals which had a positive profit under the DRG based system, compared to 4.8% in hospitals without the system. These results indicate a clear difference in the quality of care between hospitals with the policy and those without. The combined results provide a reason to suspect that a negative impact on the quality of care may arise from the implementation of the system.

Lastly, there may also be an impact on LoS from the introduction of PPS and DRG-weights. Again, the results differ internationally with some analysis finding a reduction in LoS whilst some find no impact. Busate and von Below (2010) find no correlation between the implementation of PPS and DRG and LoS in Swiss data, nor do Hu et al. (2015) in Taiwan. The Swiss hospitals were found to reach the LoS levels of other comparable OECD countries irrespective on which type of reimbursement system which was used, and Taiwanese hospitals saw no impact. However, Davis and Rhodes (1988), Hamada, Sekimoto, and Imanaka (2012), Or (2014) and Forsberg, Axelsson and Arnetz (2000) all find clear reductions as a result of implementing a PPS based on DRG-weights. A reduction in LoS indicates better resource use, as long as it is not connected to an increase in unplanned readmission rates. If so, the shorter patient stay may result in a negative impact, as patients are prematurely discharged. This correlation is found in Hamada, Sekimoto, and Imanaka (2012), but not in Hu et al (2015) nor in Forsberg et al (2000).

This thesis aims to contribute to previous literature by presenting an empirical analysis of more current Swedish data and evaluating if the NodDRG system continues to impact hospital behaviour after the initial implementation. The analysis also wishes to contribute with a new angle of whether DRGs continue to influence hospital behaviour after it has been replaced with another financing system. A study by Ellegård and Glenngård (2019b) has similarly evaluated the impact of moving from a NordDRG-system to a global budget in Skåne County. The authors find indications that the effect from implementing a NordDRG-system may be larger than the impact of replacing it by reverting back to global budgeting. Their results imply that a move from the NordDRG-system to a global budget system may not result in big change in hospital behaviour. Consequently, there is motivation for an extended analysis on all Swedish counties for this variation in use.

This thesis will evaluate the impact primarily on the NordDRG-system in Sweden to interpret the inconclusive results from previous global research on behavioural influences, secondary diagnoses, quality of care, hospitalisations, unplanned readmission rates, and LoS.

5. Empirical Approach

This section will outline the data sample and variables used in the empirical analysis. In addition, the methodology and empirical specifications will be further detailed.

5.1 Data

The data used in this thesis is commissioned from Socialstyrelsen, the patient register (Socialstyrelsen.se, 2019a). The data detailing the use of DRG for each hospital is obtained from a questionnaire, also commissioned by Socialstyrelsen (Socialstyrelsen.se, nd). The data is observed on the hospital level and divided by major diagnostic category (mdc). As parts of the data are on given on a quarterly basis, the data set is collapsed on year, county, mdc and hospital to allow for a better analysis. The data has also been modified by dropping all observations where DRG-weights are below a threshold value of 52, i.e 1 DRG point per week. Observations that are below this threshold for a whole year stand out as they are too small to be accepted as part of regular hospital services. The reimbursement for 1 DRG-weight was in 2017 equal to 51,420 SEK, which indicates that hospitals with less than 52 DRG-weights per year operate below 51,420 SEK per week for the considered mdc in 2017 (Socialstyrelsen 2019b). This implies the costs for the institution would be below 7,345.71 SEK per day for hospitals with yearly DRG-weights below the threshold. These values are considered at the end of the sample timeframe, which gives indications that the mean value for the whole sample period would be even lower due to inflation and the rapid increase seen in healthcare costs. Thus, with the aim to eliminate observations that distort the data, this threshold appears motivated. The dependent variables have been logged to enable comparison in per cent and allow for a smoother analysis.

The dependent variable for the analysis is *log DRGweight* which is the logged total number of DRG-weights collected over a year. This variable is used to evaluate if there is any impact on the number of DRG-weights, and thus hospital behaviour with the implementation of the NordDRG-system. The analysis also takes into account other dependent variables to evaluate what drives potential changes in DRG-weights, and if there is an impact on the quality of care. *Log SecondaryDiagnoses* takes into account the logged number of secondary diagnosis recorded by each hospital over a year. This variable is interesting as it is one of the ways in which the hospital can affect the number of DRG-weights and therefore financing. If there is upcoding present, it could be seen in this variable. *Log Hospitalizations* considers the logged sum of the number of hospitalisations for each hospital over a year. This is the second variable that may influence the DRG-weight and which can be affected on a hospital level. *UnplannedReadmissionRate* takes into account the rate of unplanned readmissions and is of interest as it indicates how the quality of care may be affected by the within-county financing system. If there is an effect on this rate, there may be changes in how healthcare is provided, leading to more frequent or fewer readmissions. Finally, *log LoS* is evaluated to see if there is any cost-reducing impact on patient stays arising from financial incentives under the NordDRG-system.

In addition to the dependent variables, several dummies are used in the analysis. *SV_DRG_IL* is a dummy for having implemented the NordDRG-system on inpatient care for each respective year. Similarly, *OV_DRG_IL* is a dummy for having implemented the NordDRG-system on outpatient care. *DRGpolicy1* is a dummy variable indicating how extensive the use of the NordDRG-system is at the hospital level. This dummy will equal 1 if the NordDRG-system is used in either inpatient or outpatient care and 0 if the NordDRG-system is not used. Similarly, *DRGpolicy2* is indicative of how extensive the use of the NordDRG-system is, taking the value 1 if NordDRG-system is used in both inpatient and outpatient care and 0 otherwise. *DRGpolicy2* represents full use of the NordDRG-system, whilst *DRGpolicy1* represents partial use of the NordDRG-system.

5.2 Descriptive statistics

In Table 1, the summary statistics for all variables included in the model are shown. The main dependent variable, *log DRGweight* has a total of 26,744 observations in the collapsed data set and a mean of 5.93. It is also worth noting that the standard deviation (sd) is at 20.01 per cent which indicates that there is variation in the variable. This is reasonable as the different hospitals involved vary greatly in size and thus in output. The same pattern is found for the alternative dependent variables. *UnplannedReadmissionRate* has 26,720 observations with a mean of 7.73 and the sd for this value is 131.70 per cent. The sd indicates a very large variation in the variable and will be interesting for regression analysis. *Log Hospitalizations* have 26,744 observations, and a mean of 6.40 and an sd of 52.6 per cent. Log Secondary diagnosis has 43,386 observations with a mean of 5.627 and sd of 33.75 per cent. Lastly, *logLoS* has 15,092 observations, which is close to half compared to the other variables, a mean of 1.56 and an sd of 32.69 per cent. The varying number for observations for the different variables is due to not all hospitals observing a value for some of the variables for every year.

The statistics for *MDC*, *year* and *County* are interesting mainly in the high number of observations included in the analysis. As seen in Table 1, there are a total of 30 different major diagnostic categories in the data sample, and 21 counties. The years present in the data range from 2005 to 2017. See Appendix 1 for a complete table of the counties included in the analysis.

Table 1 - Descriptive statistics after logging and collapsing observations

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
MDC	26,744			1	30
year	26,744			2005	2017
(mean) UnplannedReadmRate	26,720	7.73	10.18	0.00	100
log DRGweight	26,744	5.93	1.19	3.95	10.12
log Hospitalizations	26,744	6.40	2.16	0.00	11.71
log Secondary diagnoses	26,434	6.33	2.01	0.00	11.27
logLoS	15,092	1.56	0.51	-2.30	5.34
County	26,744			1	21

5.3 Empirical specification

The method used for the empirical analysis is based on a fixed-effects model. Fixed effects are used in this analysis since the data set is panel data, and thus repeats observations on the same hospitals over several years. The fixed effects method enables the model to control for unobserved factors that are fixed over year and county etc. present in the data. One of the key assumptions for this model is that unobserved factors that are fixed over time are not independent of the value of the x-variable for all time periods considered. Thus it is assumed that the factors which may bias the estimates are correlated with the hospitals that use the NordDRG-system.

In order to get a flexible regression analysis, a higher dimension fixed effects model with three fixed effects is used. These are fixed effects on the county level, year fixed effects and diagnosis fixed effects. By using the fixed-effects model, the regression implicitly controls for these factors, observable and unobservable, which are constant over time, county and diagnosis. By using this method, the regression removes potential omitted variables bias in the estimation and gives consistent estimates of the data (Angrist and Pischke, 2009). Clustered standard errors on hospital-level are also used in order to correct for serial correlation between hospitals. Using clustered standard errors allow for arbitrary within-hospital correlation in error terms, but assumes independence across the hospitals (Bertrand, Duflo, and Mullainathan, 2004).

The main regression is conducted based on the following formula for regressions on both inpatient and outpatient care.

$$DRGweight_{istm} = \alpha + \beta * DRG_{istm} + countyFE_{s} + yearFE_{t} + mdcFE_{s} + \varepsilon$$

Where *DRGweight* is the dependent variable as it is hypothesised that having a DRG-based system will have an effect on hospital behaviour and thus the number of DRG-weights recorded. *DRG* is a dummy variable indicating if the NordDRG-system was used for within-county financing in the county or not for each year. *CountyFE* accounts for county-level fixed effects, *yearFE* absorbs time fixed effects and *mdcFE* consider fixed effects associated with different diagnosis categories. The subscript $_m$ denotes mdc, the subscript $_i$ denotes hospital, the subscript $_s$ denotes county and subscript $_t$ denotes year. The sample is also restricted in the regression by only using observations on the sector of care considered, inpatient or outpatient care.

The main regression also analyses the combined effect from using the NordDRG-system on both inpatient care and outpatient care using the following formula:

$$DRGweight_{istm} = \alpha + DRGpolicy1_{istm} + DRGpolicy2_{istm} + countyFE_{s} + yearFE_{t} + mdcFE_{s} + \varepsilon$$

DRGpolicy1 is a dummy variable which equals 1 if the NordDRG-system is implemented in one of inpatient and outpatient care for each observation and 0 otherwise. *DRGpolicy2* is a dummy variable which equals 1 if the NordDRG-system is implemented in both inpatient and outpatient care for each observation and 0 otherwise.

The higher dimension fixed effects model here is preferred over other quasi-experimental methods such as a difference-in-differences (DiD) which are often used for the analysis of aggregated data on the county level. Although there is variation in policy implementation across the 21 counties there are, as seen in Figures 1 and 2, also instances of counties reverting back or changing to another financing system. As the use of a DRG based system is hypothesized to alter the behaviour and practice of hospitals, it is not defensible to assume that hospitals who have never had the DRG system and those who used in previous years are similar. Thus one of the fundamental assumptions of a DiD, the distinction between the intervention group and control group cannot be fulfilled.

5.4 Robustness test/ sensitivity analysis

To evaluate which effect is the driving force, and if there are behavioural differences between those who use the NordDRG-system without interruption and those who use the NordDRG-system for a limited period of time, further regressions will be used. By dividing the sample into three rather than two groups the aim is to analyse if there are any differences in effect between regressions on the sub-groups.

The sample groups are as follows; (1) counties who did not use the NordDRG-system during the sample period, (2) counties who continuously used the NordDRG-system without interruption and (3) counties who used the NordDRG-system for a period of time, but who changed to another system during the sample period. In order to alter the regression analysis to enable this comparison, the data was adjusted by removing the counties not included in the subsample considered. The subgroups were created based on variation in inpatient care and outpatient care separately. For details on the selection into each group, see Appendix 2. The formulas for the main regression will be used for the analysis of the different variations in the reduced data samples. First, the counties included in the subgroup (1) and (2) are used whilst subgroup 3 is removed, then subgroup (1) and (3) are used whilst (2) is removed. This extended analysis will be used as a robustness test and to evaluate if there are different effects found depending on which subgroup is considered.

In addition, a robustness test will be performed by removing the observations from Stockholm County. This is motivated by the fact that Stockholm is the largest county in terms of healthcare providers with the university hospital Karolinska and the highest absolute values in most variables considered in this analysis. It is therefore plausible that Stockholm County may be driving the effects of the use of the NordDRG-system. In addition to these factors, Stockholm was the first county to introduce the policy in 1992 which may continue to influence their behaviour. The formulas from the main regression are applied to the analysis, with observations for Stockholm removed from the data set.

5.5 Alternative dependent variable

Additional tests will be run using the log of secondary diagnosis and the log number of hospitalizations as the dependent variable. These two variables are the ways in which the hospital can impact the number of DRG-weights and it is therefore of interest to see which, if any, is driving the results. Further, by using the rate of unplanned readmissions for the different hospitals, the impact on the quality of healthcare provided will be evaluated. Readmission rates are widely regarded as an accepted proxy for measuring the quality of healthcare as the risk of unplanned readmission increases with lower quality healthcare (Ashton, et al., 1997; Weissman et al., 1999; Balla, Malnick and Schattner, 2008). Lastly, LoS will be used as a dependent variable motivated by the extensive use of this variable in combination of unplanned readmission rate in previous research (Hamada, Sekimoto and Imanaka, 2012; Hu et al., 2015; Busato and von Below, 2010; Or., 2014; Forsberg, Axelsson and Arnetz, 2000). The aim is to evaluate if there are cost-reducing impacts on LoS and if this can be correlated to changes in readmission rates.

6. Results

In this section, the results from the main regression, the robustness tests, and the different dependent variables are presented.

6.1 Main regression results

The regression results from the main regression are presented in Table 2 below. Column (1) presents the impact of using the NordDRG-system for inpatient care, excluding all observations which are not on inpatient care. Column (2) presents the results from the NordDRG-system in outpatient care on a reduced sample set only considering the outpatient observations. Column (3) in turn presents the combined effect of the NordDRG-system in inpatient care and outpatient care depending on the degree of use of the NordDRG-system in the hospital.

Table 2 - Regression results main regression

VARIABLES	(1) Inpatient care	(2) Outpatient care	(3) Combined effect
DRGpolicy1			-0.0702
			(0.0505)
DRGpolicy2			-0.00580
			(0.0396)
Outpatient care			-0.547***
			(0.0374)
Inpatient care DRG	-0.0454		
	(0.0466)		
Outpatient care DRG		0.0366	
		(0.0315)	
Constant	6.151***	5.646***	6.171***
	(0.0954)	(0.0762)	(0.0940)
Observations	15,106	11,638	26,744
R-squared	0.319	0.310	0.288

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The estimation of inpatient care presented in Table 2 column (1) above indicates that there is a negative effect on the amount of DRG-weights with the implementation of the DRG-based system on inpatient care. The results indicate a decrease of 4.54 per cent. However, the point estimation is not statistically significant at conventional levels. The estimation on outpatient care is presented in column (2) and indicates a positive effect of 3.66 per cent. However, the result is similar to the estimation for inpatient care not significant.

Column (3) in Table 2 presents the combined effects, thus taking into account the use of the NordDRG-system in both inpatient and/or outpatient care for the whole sample. The results lack any significance, however, there is an indication of a difference in effect based on how extensive the use of DRG is. This is seen by the difference between *DRGpolicy1* and *DRGpolicy2*. The regression estimation for *DRGpolicy1* is at -7.02 per cent. The estimation for *DRGpolicy2* is lower at -0.58 per cent. Thus, the main regression analysis indicates that counties using the NordDRG-system in one or both sectors experience a negative impact on the amount of DRG-weights recorded, albeit with reduced magnitude for full use of the system. The value for the dummy variable *Outpatient care* is not of importance as it solely indicates the level difference between inpatient and outpatient care.

6.2 Robustness tests

The first robustness test looks at the variation in the NordDRG-system used for inpatient care. The data sample has been reduced to only include counties who implement the policy and use the NordDRG-system continuously until the last year of available data and those counties who did not use the policy during the sample period. These results are presented in columns (1) to (3). Column (4) to (6) presents the results from when the sample has been trimmed down to only include those counties who used the NordDRG-system during a limited time period before changing to another system and those counties who did not use it during the whole sample period.

Table 3 - Robustness test 1, variation in inpatient care

VARIABLES	(1) Inpatient care	(2) Outpatient care	(3) Combined effect	(4) Inpatient care	(5) Outpatient care	(6) Combined effect
DRGpolicy1			-0.0600			-0.0193
			(0.191)			(0.0221)
DRGpolicy2			0.137			-0.0428
			(0.130)			(0.0450)
Outpatient care			-0.631***			-0.506***
			(0.0475)			(0.0412)
Inpatient care DRG	0.140			-0.0664		
	(0.187)			(0.0486)		
Outpatient care DRG		0.187***			0.00514	
		(0.0684)			(0.0382)	
Constant	6.118***	5.538***	6.157***	6.089***	5.634***	6.113***
	(0.151)	(0.111)	(0.141)	(0.103)	(0.0828)	(0.103)
Observations	5,762	4,496	10,258	12,621	9,512	22,133
R-squared	0.409	0.382	0.365	0.298	0.299	0.269

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results shown in Table 3 for robustness test 1 indicate that there are few significant effects on inpatient or outpatient care with the use of DRG for within county financing in inpatient care, independent of the grouping of counties. However, the sign of the effect on the inpatient care observations shifts depending on the group of counties used in the regression. This occurs both in the single regressions and in the combined effect on both inpatient and outpatient care. The sign for the outpatient care estimations maintain a positive character over the different subgroups. The impact on inpatient and outpatient care for subsample (1) and (2) is similar, with a positive effect of 14.00- 18.70 percent as shown in column (1) and (2), whilst the combined effect is -6 per cent for partial use of DRG and 13.70 per cent for full use, as seen in column (3). Interestingly, there is only significance for outpatient care observations at a 1 per cent level as seen in column (2).

For subsample (1) and (3), the impact is different with a negative impact of -6.64 per cent for inpatient care and a positive 0.51 per cent for outpatient care as seen in column (4) and (5). The combined effect is negative and at -1.93 per cent for partial use and -4.28 per cent for the full use of the system, as shown in column (6).

The second robustness test base the subsample on variation in outpatient care. Similarly, as for inpatient care above, the data sample is limited to counties who have implemented and continuously use the NordDRG-system during the sample period and those who did not use the NordDRG-system for outpatient care in column (1) to (3). In column (4)-(6) the results are shown for those counties who used the NordDRG-system for a limited time period and those counties who did not use the system during the sample period.

Table 4 - Robustness test 2, variation in outpatient care

VARIABLES	(1) Inpatient care	(2) Outpatient care	(3) Combined effect	(4) Inpatient care	(5) Outpatient care	(6) Combined effect
DRGpolicy1			-0.00531			-0.0193
			(0.0440)			(0.0221)
DRGpolicy2			0.166			-0.0428
			(0.113)			(0.0450)
Outpatient care			-0.595***			-0.506***
			(0.0421)			(0.0412)
Inpatient care DRG	0.0334			-0.0664		
	(0.0556)			(0.0486)		
Outpatient care DRG		0.180***			0.00514	
		(0.0645)			(0.0382)	
Constant	6.053***	5.503***	6.060***	6.089***	5.634***	6.113***
	(0.111)	(0.0909)	(0.108)	(0.103)	(0.0828)	(0.103)
Observations	8,330	6,220	14,550	12,621	9,512	22,133
R-squared	0.406	0.387	0.361	0.298	0.299	0.269

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The estimates in robustness test 2 also have few results with significance, with outpatient care in column (2) being the only estimation significant at a conventional level. Similarly to the results found in robustness test 1, selection based on inpatient care, the sign of the estimates for inpatient care vary depending on which counties are considered. The estimations for subsample (1) and (2) indicate a positive 3.34 per cent impact for inpatient care, column (1), and outpatient care was estimated at 18.0 per cent significant at 1 per cent level, column (2). The combined effect is negative at -0.531 per cent for partial use, and positive at 16.6 per cent for full use, column (3). For subsample (1) and (3), the estimations are similar to those found in robustness test 1 given in Table 3 column (4)-(6), with a negative impact of -6.64% for inpatient care, positive of 0.51% for outpatient care and negative -1.93% and -4.28% for the combined effect. These results appear to be similar to robustness test 1 as the subsample excluded from the analysis (2) is the same in both tests, even though there is variation in members of group (1) and (3).

The third robustness test runs the main regression again but excluding all observations for Stockholm County. The estimation results are presented in Table 5 below.

Table 5 - Robustness test 3, without observations for Stockholm County

VARIABLES	(1) Inpatient care	(2) Outpatient care	(3) Combined effect
DRGpolicy1			-0.0771
			(0.0510)
DRGpolicy2			-0.0176
			(0.0468)
Outpatient care			-0.564***
			(0.0348)
Inpatient care DRG	-0.0488		
	(0.0524)		
Outpatient care DRG		0.00328	
		(0.0354)	
Constant	6.122***	5.622***	6.150***
	(0.0983)	(0.0804)	(0.0979)
Observations	12,994	9,684	22,678
R-squared	0.364	0.359	0.325

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results presented in Table 5 for robustness test 3 show insignificant estimations in all regression variations, similar to the results in the main regression and in the previous robustness test. However, here the estimation for outpatient care is also insignificant at a conventional level. The estimation for inpatient care is negative at -4.88 per cent as seen in column (1), and for outpatient care positive at 0.328 per cent, column (2). The combined effect is negative at -7.71 per cent for use of the NordDRG-system in one of the sectors, as well as for full use of the NordDRG-system in both inpatient and outpatient care of -1.76 per cent, column (3).

6.3 Analysing alternative dependent variables.

The results from additional tests on alternative dependent variables are presented in Table 6 below, utilising log secondary diagnosis and log number of hospitalizations as the dependent variables. These tests are motivated by the fact they are the main drivers of the impact on DRG-weights which can be manipulated by the hospitals.

Table 6 - Regression results alternative dependent variables, secondary diagnosis, hospitalizations

VARIABLES	(1) Inpatient care Secondary Diagnoses	(2) Outpatient care Secondary Diagnoses	(3) Combined effect Secondary Diagnoses	(4) Inpatient care Hospitalizations	(5) Outpatient care Hospitalizations	(6) Combined effect Hospitalizations
DRGpolicy1			-0.0702			-0.0575
			(0.0505)			(0.0618)
DRGpolicy2			-0.00580			0.0146
			(0.0396)			(0.0538)
Outpatient care			-0.547***			1.576***
			(0.0374)			(0.0392)
Inpatient care DRG	0.0519			-0.0421		
	(0.0555)			(0.0574)		
Outpatient care DRG		0.0313			0.0626	
		(0.0535)			(0.0436)	
Constant	6.256***	6.388***	6.171***	5.709***	7.283***	5.707***
	(0.105)	(0.111)	(0.0940)	(0.111)	(0.107)	(0.111)
Observations	15,025	11,409	26,744	15,106	11,638	26,744
R-squared	0.607	0.609	0.288	0.582	0.663	0.592

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

When looking into the components of *DRGweight* which the hospitals can affect through their behaviour, there are no significant results at a conventional level. The results in column (1) above indicate that using DRG results in a 5.19 per cent increase in the number of secondary diagnoses. The estimations for outpatient care are also positive at 3.13 per cent, as seen in column (2). In addition, the combined effect indicates a negative correlation for use in both sectors, and for use in only one of the inpatient and outpatient sectors. The estimations for both levels of use are insignificant at -7.02 per cent and -0.580 per cent as seen in column (3). Column (4) to (6) shows the regression results for the number of hospitalizations. For these estimations, there is no significant effect found. The sign for inpatient care is negative in column (4), at -4.21 per cent, and positive for outpatient care column (5), at 6.26 per cent. The combined effect is negative for the first level of use of the NordDRG-system at -5.75 per cent and positive for full use at 1.46 per cent.

The next set of regressions presented in Table 7 use unplanned readmission rates and LoS as the dependent variable in order to evaluate if there is any impact on the quality of healthcare provided by hospitals. The estimation for only inpatient care, column (1), shows indications of a positive relationship, with an increase in 13.7 per cent. The estimation for only outpatient care, column (2) also show indications of a positive relationship with unplanned readmission rated of 6.54 per cent. However, both estimations are statistically insignificant. The combined effect in column (3) indicates a positive relationship between unplanned readmission rates for both levels of use of DRG, 31.9 per cent, and 12.2 per cent, but these estimates are also insignificant.

Table 7 - Regression results alternative dependent variable, unplanned readmission rate, LoS

VARIABLES	(1) Inpatient care UnplannedReadmissionRate	(2) Outpatient care UnplannedReadmissionRate	(3) Combined effect UnplannedReadmissionRate	(4) Inpatient care LoS	(5) Combined effect LoS
DRGpolicy1			0.319		-0.0133
			(0.422)		(0.0201)
DRGpolicy2			0.122		0.00906
			(0.377)		(0.0169)
Outpatient care			-10.14***		
			(0.384)		
Inpatient care DRG	0.137			0.00379	
	(0.568)			(0.0143)	
Outpatient care DRG		0.0654			
		(0.154)			
Constant	11.79***	2.373***	12.09***	1.554***	1.553***
	(0.305)	(0.0923)	(0.276)	(0.0171)	(0.0173)
Observations	15,092	11,628	26,720	15,092	15,092
R-squared	0.353	0.186	0.372	0.396	0.397

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The last regression series estimate the impact on log LoS and is presented in column (4) and (5) in Table 7 above. Due to the nature of outpatient care with no overnight stays, the number of observations was insufficient to provide estimates for outpatient care. The impact on LoS for inpatient care is positive at 0.379 per cent and the combined effect is estimated at -1.33 per cent for partial use and 0.906 per cent for full use of the NordDRG-system. These results are not statistically significant at a conventional level.

7. Discussion

The different regressions in Section 6 present ambiguous and inconclusive results as the magnitude and signs of the point estimations differ widely across the regressions. The main regression presented in Table 2 gives no significant results but indicates a negative impact in the separate analysis of *Inpatient care DRG* and a positive impact on *Outpatient care DRG*. The combined effect shows a negative impact on both levels of use of the NordDRG-system.

However, when also considering the different variations in regressions used for the robustness tests, some trends in the results can be found. The estimations for outpatient care observations see a positive effect in all regressions, with a range between 0.51 per cent and 18.7 per cent. Two variations in the sample, the manipulation based on subsample (1) and (2) for inpatient and outpatient care data, are statistically significant at a 1% level. The significant estimations show an impact of 18.7 per cent and 18.0 per cent which is relatively large compared to the positive impact estimated from the other regressions. This indicates that the results found in the main regression may be driven by the counties who extensively and continuously use of the NordDRG-system during the sample period. Similar regressions on subsamples (1) and (3) yield relatively small point estimates, further supporting these indications. The trend supported by these significant results implies that the use of the NordDRG-system in outpatient care may have a positive impact on the number of registered DRG-weights. These results could weakly concur with previous literature on upcoding taking place as a result of increased financial incentives (Or, 2014; Jürges and Köberlein, 2015; Buczak-Stec et al., 2017).

However, it is important to note that these positive results are not clearly supported by any trends in hospitalisation or secondary diagnosis, which are regressed on the total sample. There is a lack of supporting results found in the variables impacting the main regression. This incites the possibility that the effect may originate from improved efficiency, an increase in the volume of patients or a change in the casemix. Suggestions for future research to clearly establish what causes the trend for outpatient care would be to conduct further tests on the different subsamples used in robustness test 1 on hospitalisations and secondary diagnosis.

In contrast to outpatient care, there are predominately negative results found for inpatient care, with the main regression, robustness test 1 on subsample (1) and (3) and robustness test 3 giving similar estimations between -4.54 and -6.64. Interestingly, the estimations from subsample (1) and (2) in both Robustness test 1 and 2 give positive results and thus move in the opposite direction. Only a weak trend can be inferred from these results, in favour of a negative impact on inpatient DRG-weights.

The combined effect with the use of PPS and NordDRG in one of the two sectors implies a clear negative trend as all regression variations are negative, ranging from values of -0.531 per cent to -7.71 per cent. This indicates a negative trend on combined effects when considering the use of the NordDRG-system in one of the two sectors. A weak trend for negative impact can also be found in the full use of the NordDRG-system as, similarly to the results for inpatient care, there are negative estimations for the main regression, robustness test 1 on subsample (1) and (3) and robustness test 3. Although several negative trends can be found in the different regressions, the results should not be over-interpreted as the point estimates are not significant at conventional levels.

The estimations for alternative dependent variable secondary diagnosis, LoS and hospitalisations indicate no clear trend in the analysis. This conclusion is drawn as the signs of the point estimations vary across the regressions conducted. However, the estimations for unplanned readmissions are all positive, which implies a weak positive trend despite the lack of significance. The findings for unplanned readmission rates range between 3.19 per cent and 13.7 per cent and can be interpreted as a trend of a potential decrease in quality of care. This variable is indicative of quality as it reflects mistakes or lack of treatment occurring in the initial hospitalisation which results in a need for further unplanned action after discharge. The results for different dependent variables are interesting when compared to previous literature on Swedish data which have presented indications of a significant impact from the policy on these different aspects of hospital behaviour (Gerdtham, Rehnberg and Tambour, 1999; Forsberg, Axelsson and Arnetz, 2000; Serdén, Lindqvist and Rosén, 2003). In this analysis, no strong affirming results to these studies are found since all point estimates lack statistical significance at a conventional level.

Considering all results from the analysis there appear to be behavioural changes, albeit weak, associated with the NordDRG-system. However, the estimations are ambiguous as the results indicate both positive and negative effects on DRG-weights with the use of the policy. The negative impacts found on DRG-weights with the use of the NordDRG-system are difficult to interpret but may be explained by hospitals experiencing a difference in the casemix with the use of the NordDRG-system. If the mix of patients treated at the hospital changes due to external factors, or due to hospital selection, this can also result in a decrease in the amount of DRG-weights registered. In addition, as previously discussed, there are indications in Swedish data of under-registering from administrators with the implementation of this type of policy in Skåne county (Dackehag and Ellegård, 2019). If such an effect is present in the data in Skåne and other counties, this could also contribute to the negative results found.

Surrounded by the extensive support in previous international literature for financial incentives affecting hospital behaviour, these conclusions stand out. In contrast to previous literature conducted on Swedish data from the 1990s, when the policy was only implemented in Stockholm, this analysis considers data beginning 13 years after DRGs were first introduced. The lack of significant results indicates that the use of output-based reimbursement for hospitals through the NordDRG-system does not appear to have a strong impact on the behaviour of Swedish hospitals since 2005. However, there are indications of an underlying or indirect relationship as the trends from several of the tests coincides. In addition, the signs of the estimations differ between the different subsamples, indicating that hospital behaviour is affected differently depending on the extent of use of the system.

Arguments for why this empirical analysis is still valid and of significance can be found in the different time periods used. This analysis takes into account observations several years after the implementation of the NordDRG system, and use variations in how the policy was used to further evaluate the system. Based on the lack of significant results, it appears as the behavioural effects found in previous research (Gerdtham, Rehnberg and Tambour, 1999; Forsberg, Axelsson and Arnetz, 2000; Serdén, Lindqvist and Rosén, 2003) were centred on the years when the policy was first introduced. It can therefore be argued that with times, the financial incentives appear to have become common practice in hospitals and the effect has been reduced.

8. Conclusion

The aim of this study was to contribute to previous research on the use of PPS based on DRGs in developed economies and in Sweden. An extended evaluation based on variation in the use of the system was also conducted. By using panel data on Swedish healthcare provision, a higher dimension fixed-effects model was applied to evaluate the impact of the NordDRG system for within-county financing on the 21 Swedish counties.

Although most of the results found in the empirical analysis lack statistical significance, some trends were found indicating a positive impact in outpatient care on the amount of DRG-weights registered. These findings are further supported by the estimation of an 18.0 per cent - 18.7 per cent positive estimation in robustness test 1 and 2, significant at a 1 per cent level. Trends were also found which indicate a negative impact on inpatient care and the combined effect on the full sample. This implies that the use of the NordDRG system may contribute to alter hospital behaviour as to both increase and decrease the number of DRG-weights, and thus financing.

This study could further be extended by a more in-depth analysis of the different components of DRG-weights, using the variation in inpatient care and outpatient care to create subsamples. By analysing the effect of the policy on the alternative dependent variables, further conclusions could be drawn regarding which factors drive the impact on hospital behaviour. In addition, the variation in the casemix for hospitals could be used to evaluate the role patient characteristics play in the NordDRG system. The components of DRG-weights and the casemix could be of interest to account for unobserved factors that impact financing, beyond the factors considered in this thesis. Finally, by using data on the real monetary reimbursements during the years in the sample period, the analysis could be extended to evaluate how potential behavioural changes affect the real level of financing for hospitals.

The potential policy implications that can be derived from these results are limited. The results indicate trends of altered behaviour and an increase in unplanned readmission rates. However, given the lack of statistical significance in the estimations, no policy conclusions should be drawn. Rather, this study mainly provides indications of that the financing system utilised in hospitals affects hospital behaviour and potentially quality of care.

References

Angrist, J. and Pischke, J. (2009). *Mostly harmless econometrics*. Princeton: Princeton University Press.

Ashton, C., Del Junco, D., Souchek, J., Wray, N. and Mansyur, C. (1997). The Association Between the Quality of Inpatient Care and Early Readmission. *Medical Care*, [online] 35(10), pp.1044-1059. Available at: http://www.jstor.org/stable/3766953. [Accessed 15 Apr. 2019].

Balla, U., Malnick, S. and Schattner, A. (2008). Early Readmissions to the Department of Medicine as a Screening Tool for Monitoring Quality of Care Problems. *Medicine*, 87(5), pp.294-300.

Bertrand, M., Duflo, E. and Mullainathan, S. (2004). How Much Should We Trust Differences-In-Differences Estimates?. *The Quarterly Journal of Economics*, [online] 119(1), pp.249-275. Available at: https://www.nber.org/papers/w8841 [Accessed 13 May 2019].

Brekke, K. R., H. Gravelle, L. Siciliani, and O. R. Straume. (2014), "Patient Choice, Mobility and Competition among Healthcare Providers", *Development in Health Economics and Public Policy* 12, pp. 1–26.

Buczak-Stec, E., Goryński, P., Nitsch-Osuch, A., Kanecki, K. and Tyszko, P. (2017). The impact of introducing a new hospital financing system (DRGs) in Poland on hospitalisations for atherosclerosis: An interrupted time series analysis (2004–2012). *Health Policy*, [online] 121(11), pp.1186-1193. Available at: https://doi.org/10.1016/j.healthpol.2017.09.009 [Accessed 6 May 2019].

Busato, A. and von Below, G. (2010). The implementation of DRG-based hospital reimbursement in Switzerland: A population-based perspective. *Health Research Policy and Systems*, [online] 8(1). Available at: https://health-policy-systems.biomedcentral.com/track/pdf/10.1186/1478-4505-8-31 [Accessed 6 May 2019].

Dackehag, M. and Ellegård, L. (2019). Competition, Capitation, and Coding: Do Public Primary Care Providers Respond to Increased Competition?. *CESifo Economic Studies*.

Davis, C. and Rhodes, D. (1988). The impact of DRGs on the cost and quality of healthcare in the United States. *Health Policy*, [Online] 9(2), pp.117-131. Available at: https://doi.org/10.1016/0168-8510(88)90029-2

Ellegård, L. and Häger Glenngård, A. (2019a). Erfarenheter av förändrad ersättningsmodell i skånsk sjukhusvård - från prestation till anslag. [online] *Kefu.se*. Available at: https://www.kefu.se/media/kefu/rapporter/Rapportpercent202018-2.pdf [Accessed 5 Apr. 2019].

Ellegård, L. and Glenngård, A. (2019b). Limited Consequences of a Transition From Activity-Based Financing to Budgeting: Four Reasons Why According to Swedish Hospital Managers. *INQUIRY: The Journal of Healthcare Organization, Provision, and Financing*, [online] 56. Available at: https://doi-org.ludwig.lub.lu.se/10.1177 percent2F0046958019838367 [Accessed 15 May 2019].

Ellis, R. and McGuire, T. (1996). Hospital response to prospective payment: Moral hazard, selection, and practice-style effects. *Journal of Health Economics*, [online] 15(3), pp.257-277. Available at: https://www.sciencedirect.com/science/article/pii/0167629696000021 [Accessed 6 May 2019].

Forsberg, E., Axelsson, R. and Arnetz, B. (2000). Effects of performance-based reimbursement in healthcare. *Scandinavian Journal of Public Health*, 28(2), pp.102-110.

Gaynor, M. and R. J. Town. (2011), "Competition in Healthcare Markets", in M.V. Pauly, T.G. Mcguire, and P.P. Barros, eds, *Handbook of Health Economics*, *Volume 2*, Elsevier, Amsterdam, pp. 499–637.

Geissler, A., Quentin, W., Scheller-Kreinsen, D. and Busse, R. (2011). Introduction to DRGs in Europe: Common objectives across different hospital systems. In: R. Busse, A. Geissler, W. Quentin and M. Wiley, ed., *Diagnosis-Related Groups in Europe, 1st ed*. Maidenhead: Open University Press.

Gerdtham, U., Rehnberg, C. and Tambour, M. (1999). The impact of internal markets on healthcare efficiency: evidence from healthcare reforms in Sweden. *Applied Economics*, [online] 31(8), pp.935-945. Available at: https://doi.org/10.1080/000368499323652 [Accessed 6 May 2019].

Hamada, H., Sekimoto, M. and Imanaka, Y. (2012). Effects of the per diem prospective payment system with DRG-like grouping system (DPC/PDPS) on resource usage and healthcare quality in Japan. *Health Policy*, [online] 107(2-3), pp.194-201. Available at: http://10.1016/j.healthpol.2012.01.002 [Accessed 3 May 2019].

Hu, W., Yeh, C., Shiao, A. and Tu, T. (2015). Effects of diagnosis-related group payment on health-care provider behaviors: A consecutive three-period study. *Journal of the Chinese Medical Association*, [online] 78(11), pp.678-685. Available at: https://doi.org/10.1016/j.jcma.2015.06.012 [Accessed 3 May 2019].

Jürges, H. and Köberlein, J. (2015). What explains DRG upcoding in neonatology? The roles of financial incentives and infant health. *Journal of Health Economics*, 43, pp.13-26.

Kim, S., Park, E., Kim, S., Han, K., Han, E., Jang, S. and Kim, T. (2015). The effect of competition on the relationship between the introduction of the DRG system and quality of care in Korea. *The European Journal of Public Health*, [online] 26(1), pp.42-47. Available at: https://academic.oup.com/eurpub/article/26/1/42/2467449 [Accessed 6 May 2019].

Kliniskastudier.se. (2019). Det svenska sjukvårdssystemet - Kliniska Studier Sverige. [online] Available at: https://www.kliniskastudier.se/forskningslandet-sverige/det-svenska-sjukvardssystemet.html# [Accessed 9 Apr. 2019].

Lindgren, P. (2014). Ersättning i sjukvården. Stockholm: SNS Förlag.

Lindgren, P. (2019). Ersättningen och e-hälsan. Stockholm: SNS Förlag.

Linna, M. and Virtanen, M. (2011). NordDRG: The benefits of coordination. In: R. Busse, A. Geissler, W. Quentin and M. Wiley, ed., *Diagnosis-Related Groups in Europe*, *1st ed*. [online] Maidenhead: Open University Press. Available at: http://www.euro.who.int/__data/assets/pdf_file/0004/162265/e96538.pdf [Accessed 9 Apr. 2019].

Melberg, H., Beck Olsen, C. and Pedersen, K. (2016). Did hospitals respond to changes in weights of Diagnosis Related Groups in Norway between 2006 and 2013?. *Health Policy*, [online] 120(9), pp.992-1000. Available at: https://doi.org/10.1016/j.healthpol.2016.07.013 [Accessed 3 May 2019].

Miraldo, M., Goddard, M. and Smith, P.C. (2006) The incentive effects of payment by results, *Working paper series* [online] Centre for Health Economics, University of York. Available at: https://www.york.ac.uk/media/che/documents/papers/researchpapers/rp19_the_incentive_effects_of_payment_by_results.pdf [Accessed 6 May 2019]

Nccc.uow.edu.au. (2016). About CaseMix. [online] Available at: https://nccc.uow.edu.au/casemix/aboutcasemix/index.html [Accessed 20 May 2019].

Or., Z. (2014). Implementation of DRG Payment in France: Issues and recent developments. *Health Policy*, 117(2), pp.146-150.

Serdén, L. and Heurgren, M. (2011). Sweden: The history, development and current use of DRGs. In: R. Busse, A. Geissler, W. Quentin and M. Wiley, ed., *Diagnosis-related groups in Europe*, *1st ed*. [online] Maidenhead: Open University Press. Available at: http://www.euro.who.int/__data/assets/pdf_file/0004/162265/e96538.pdf [Accessed 9 Apr. 2019].

Serdén, L., Lindqvist, R. and Rosén, M. (2003). Have DRG-based prospective payment systems influenced the number of secondary diagnoses in health care administrative data?. *Health Policy*, [online] 65(2), pp.101-107. Available at: https://doi.org/10.1016/S0168-8510(02)00208-7 [Accessed 27 May 2019].

Shleifer, A. (1985). A Theory of Yardstick Competition. *The RAND Journal of Economics*, [online] 16(3), p.319. Available at: https://www.jstor.org/stable/2555560 [Accessed 6 May 2019].

Socialstyrelsen. nd. *DRG-användning I landstingen* (various years), Survey by Lisneth Serdén made available to the author's supervisor.

Socialstyrelsen.se. (2019a). Patientregistret. [online] Available at: https://www.socialstyrelsen.se/register/halsodataregister/patientregistret [Accessed 9 May 2019].

Socialstyrelsen.se. (2019b). Viktlistor för NordDRG. [online] Available at: https://www.socialstyrelsen.se/klassificeringochkoder/norddrg/vikter [Accessed 15 May 2019].

Street, A., O'Reilly, J., Ward, P., and Mason, A. (2011). DRG-Based hospital payment and efficiency: Theory, evidence, and challenges. In: R. Busse, A. Geissler, W. Quentin and M. Wiley, ed., *Diagnosis-Related Groups in Europe, 1st ed.* [online] Maidenhead: Open University Press. Available at: http://www.euro.who.int/__data/assets/pdf_file/0004/162265/e96538.pdf [Accessed 6 May. 2019].

Street, A., Vitikainen, K., Bjorvatn, A. and Hvenegaard, A. (2007). Introducing activity-basfinancing: a review of experience in Australia, Denmark, Norway and Sweden. *White Rose Research Online*. [online] Eprints whiterose.ac.uk.. Available at: http://eprints.whiterose.ac.uk/140285/ [Accessed 17 Apr. 2019].

Vardgivarguiden.se. (2018). *DRG | Vårdgivarguiden*. [online] Available at: https://www.vardgivarguiden.se/drg [Accessed 9 Apr. 2019].

Weissman, J., Ayanian, J., Chasan-Taber, S., Sherwood, M., Roth, C. and Epstein, A. (1999). Hospital Readmissions and Quality of Care. *Medical Care*, 37(5), pp.490-501.

Appendix 1

Swedish counties included in the data set:

Blekinge
Dalarna
Gotland
Gävleborg
Halland
Jämtland
Jönköping
Kalmar
Kronoberg
Norrbotten
Skåne
Stockholm
Södermanland
Uppsala
Värmland
Västerbotten
Västernorrland
Västmanland
Västra Götaland
Örebro län
Östergötland

Appendix 2

Groupings of subsamples in inpatient care

(1) Counties who did not use the NordDRG-system:

Blekinge
Dalarna
Gotland
Jämtland
Södermanland
Värmland
Västerbotten

(2) Counties who used the NordDRG-system continuously after implementation in the sample period:

Halland
Gävleborg
Västra götaland

(3) Counties who used the NordDRG-system for a limited period of time:

Jönköping
Kalmar
Kronoberg
Norrbotten
Skåne
Stockholm
Uppsala
Västernorrland
Västmanland
Örebro
Östergötland

Groupings of subsamples in outpatient care

(1) Counties who did not use the NordDRG-system:

Blekinge
Dalarna
Gotland
Jämtland
Kalmar
Norrbotten
Södermanland
Värmland
Västerbotten
Västernorrland
Västmanland

(2) Counties who used the NordDRG-system continuously after implementation in the sample period:

Halland
Gävleborg
Västra götaland

(3) Counties who used the NordDRG-system for a limited period of time:

Jönköping
Kronoberg
Skåne
Stockholm
Uppsala
Örebro
Östergötland