



**LUND UNIVERSITY**

School of Economics and Management

**ON VARIATIONS IN CESAREAN SECTION RATES  
BETWEEN COUNTIES IN SWEDEN**

-A cross sectional study of data from 2011

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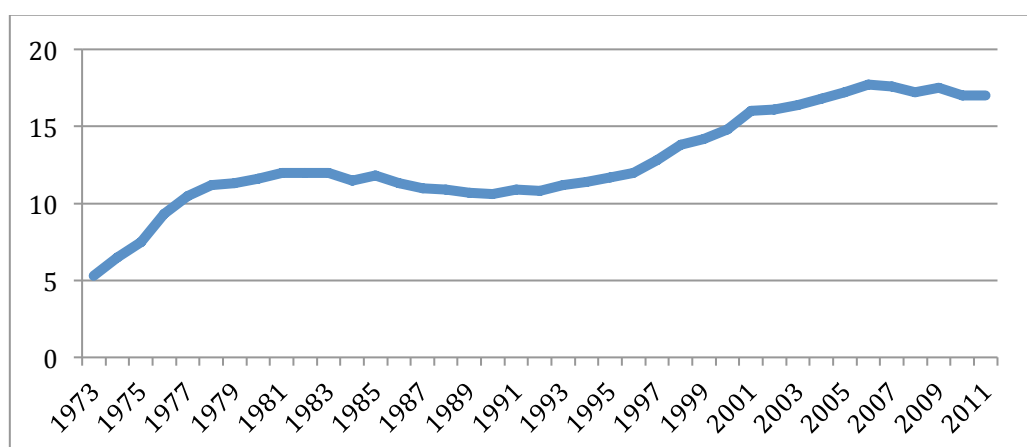
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## 2 INTRODUCTION

Deliveries can be performed either vaginally, or abdominally by cesarean section. In Sweden, vaginal delivery is recommended, as it is believed to be the safest method of delivery for both the mother and the child.<sup>1</sup> Despite of this around 17 % of deliveries in Sweden are performed with cesarean section.<sup>2</sup>

Cesarean section rates have increased substantially during the last four decades. As Graph 1 shows, in 1973 the rate was 5,3 %, more than doubled during the 1970s, and reached a maximum of 17,7 % in 2006.<sup>3</sup>

Graph 1: Cesarean section rates in Sweden, %



Source: The National Board of Health and Welfare, Sweden

The National Board of Health and Welfare emit guidelines with medical indications to ensure that health care is purposive, safe and equal throughout the country, with an ambition of a more knowledge-based health care. Caregivers should rely on these guidelines to decide whether an intervention should, or should not, be carried out.<sup>4</sup>

<sup>1</sup> The National Board of Health and Welfare. *Rapport 2011:09 från samarbetsprojektet Nationella medicinska indikationer*, p 21

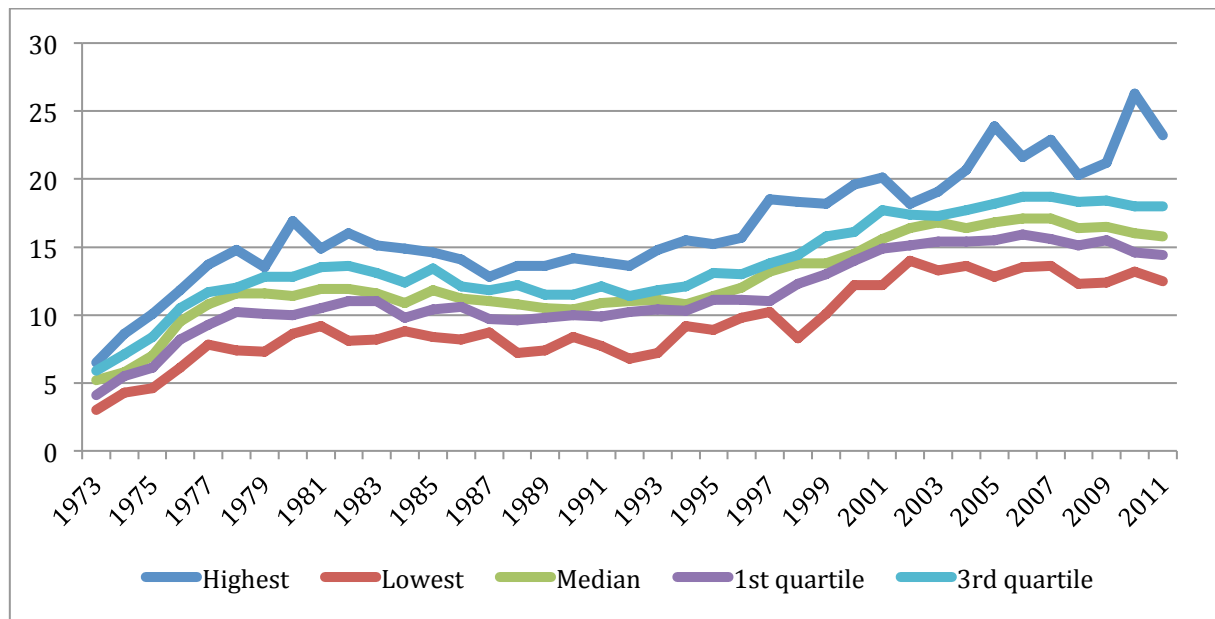
<sup>2</sup> The National Board of Health and Welfare. *Medicinska födelseregistret 1973-2011*, Bilaga 1, p 46

<sup>3</sup> The National Board of Health and Welfare. *Medicinska födelseregistret 1973-2011*, Bilaga 1, p 46-47

<sup>4</sup> The National Board of Health and Welfare. *Rapport 2011:09 från samarbetsprojektet Nationella medicinska indikationer*

Despite of these guidelines substantial variation in cesarean section rates exist, both between counties and between hospitals, see Graph 2. For example, rates for Östergötland's county and Stockholm's county are 12,5 % and 23,2 % respectively, and rates for Linköping University Hospital and Danderyd Hospital are 8,7 % and 22,5 % respectively.<sup>5</sup>

Graph 2: Variation in cesarean section rates between counties in Sweden, %



Source: The National Board of Health and Welfare, Sweden

Variations in the utilization of health services have empirically been explained by factors related to demography, medical need, lifestyle and abilities related to resources and capacity. Theoretically the variations have been explained through contract theory - on the physician's role as a double agent, and economic theories on medical practice variation associated with practice style, and opportunities and constraints of the caregivers.

Through a cross-sectional study of data from 2011 I will estimate the variation in cesarean section rates between counties in Sweden. On one hand I will look at demand-related variables associated with demography like average age of mothers, nulliparity, birthweight and education, medical indications like multiple births, and variables

<sup>5</sup> The National Board of Health and Welfare. *Medicinska födelseregistret 1973-2011 Bilaga 1*, p 46-47

related to lifestyle like BMI and smoking habits of the mother. On the other hand I will look at variables related to resources, capacity and opportunities, for example number of deliveries per available hospital bed and type of reimbursement system. I will evaluate these possible determinants of cesarean section, to see how well they explain the variation between different counties in Sweden. If the variations cannot be explained by these factors, it is plausible to believe that the differences are affected by local influences and differences in practice style.<sup>6</sup> Variations between hospitals or counties should not necessarily be seen as a negative as they can be reflections of innovation and development. However, it is important to be attentive and evaluate the variations, as they can be indications of inefficiencies, especially since obstetric care is among the most resource consuming of in-patient care in Sweden.<sup>7</sup>

## 2.1 Objective

The objective of this paper is to examine if the variation in cesarean section rates can be derived from factors related to demography, medical need and lifestyle, as well as factors related to resources and capacity. If the variations cannot be derived from these factors, theories on medical practice variation indicate that practice style can be a possible cause of the variations. Ultimately, this means that inefficiencies either in the form of overutilization or underutilization may exist.

## 2.2 Delimitations

I will do this analysis based on data on county-level even though some of the data is clearly better suited for hospital level examination. The reason is a wish to include variables, for example age, education and reimbursement-system, which can only be found on county level.

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<sup>6</sup> Eckerlund, Ingemar and Gerdtham, Ulf. *Variations in Cesarean Section Rates in Sweden – Causes and Economic Consequences*, p 18

<sup>7</sup> The National Board of Health and Welfare and The Swedish Association of Local Authorities and Regions. *Vårdkostnader 2011 för NordDRG*, p 16

Variables on medical indications are only included in the form of multiple births. This is due to lack of data on other medical indications, like for example malpresentation, placenta praevia and previous cesarean section.

### **2.3 Disposition**

Section 3 handles indications, costs and effectiveness of cesarean section, as well as possible economic incentives due to reimbursement and organizational system in health care in Sweden. Section 4 gives an overview on the theoretical framework on medical decision-making, medical practice variation and reimbursement systems in health care, and a selection of the empirical research on the area. Method and data material is described in section 5, followed by a presentation of the results in section 6. In section 7 a sensitivity analysis is presented, and section 8 concludes this paper with a discussion of the results.

### 3 CESAREAN SECTION

Cesarean section is when the child is delivered through an incision in the lower end of the mother's uterus. There are three types of cesarean sections, planned, acute and immediate cesarean section. Around half of performed cesarean sections are planned and are made either on medical or psychosocial indication. Medical indication for planned cesarean exist for example if the child has abnormal presentation, or if the mother has a narrow pelvis, suffers from preeclampsia or already has been delivered by cesarean section. Psychosocial indication to cesarean section is fear of labour. If cesarean delivery is decided upon once the labour is in progress, the procedure is either acute, if executed within one to several hours, or immediate, if carried out within 10-15 minutes. Medical indications for acute or immediate cesarean section are fetal distress and stagnant labour.<sup>8</sup>

#### 3.1 Costs of deliveries in Sweden

Obstetric care is among the most resource-consuming diagnostic care groups. Vaginal delivery is the most resource-consuming group and cesarean delivery is the tenth most consuming group, with 3,52 % and 1,52 % of total in-patient costs respectively.<sup>9</sup>

Different delivery means requirements for different resources. For example, a midwife and an assistant nurse usually assists a vaginal delivery, while an obstetrician, nurses, anaesthesiologist and possibly also a paediatrician perform cesarean section. Post-natal care also differs, when delivered by cesarean section average time for care is 3,2 days, and when delivered vaginally average time for care is 1,9 days. Different resource requirements imply different costs; in 2012 costs for cesarean section were SEK 55769 with complications and SEK 43913 without complications, costs for vaginal delivery the same year was SEK 31390 with complications and SEK 21062 without complications.<sup>10</sup>

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<sup>8</sup> The National Board of Health and Welfare. *Rapport 2011:09 från samarbetsprojektet Nationella medicinska indikationer*, p 21

<sup>9</sup> The National Board of Health and Welfare and The Swedish Association of Local Authorities and Regions. *Vårdkostnader 2011 för NordDRG*, p 16

<sup>10</sup> The National Board of Health and Welfare. *Nationella vikter för slutenvårdsgrupper, NordDRG CC-versionen 2013*

## 3.2 Effectiveness

Most cesarean sections are made on medical indication; this is when the risks of not doing the procedure are considered higher than the risks of doing the procedure, around 8 % of cesarean sections are made on request of the mother.<sup>11</sup>

Cesarean section on psychosocial indication lacks medical motivation, therefore, long- and short-term risks for both the mother and the child needs to be considered and compared against the risks of not performing the cesarean section. For the mother, risks associated with cesarean section are infections, deep venous thrombosis, blood transfusion and hysterectomy, and long-term effects, especially during future pregnancies, are uterus rupture and placenta complications.<sup>12</sup> For the child, short-term risks associated with cesarean section are respiratory disorder, hypoglycaemia and hypothermia. Regarding long-term effects for the child studies have shown a possible correlation between cesarean delivery and asthma, gastroenteritis, gluten intolerance and type 1 diabetes. In comparison, the risk of severe asphyxia during delivery reduces with cesarean section.<sup>13</sup>

When assessing the effectiveness in health economic evaluations one should consider not only medical outcomes, but also outcomes in quality of life. It is plausible to believe that accepting a mother's wishes to cesarean delivery would increase her quality of life, and thus, increase the effectiveness of cesarean section.

According to the national medical guidelines for cesarean section on request of the mother, no studies have been made on the cost-effectiveness of cesarean section on request of the mother compared to vaginal delivery. According to the guidelines, the scientific evidence on the effects of different deliveries is deficient; therefore it has not been possible to present a comprehensive cost-effectiveness-analysis in the guidelines.<sup>14</sup> As uncertainty is considerable regarding the cost-effectiveness of different deliveries, this could be another reason to the variation in cesarean section rates between counties.

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<sup>11</sup> The National Board of Health and Welfare. *Rapport 2011:09 från samarbetsprojektet Nationella medicinska indikationer*, p 1

<sup>12</sup> Ibid, p 5-6

<sup>13</sup> Ibid, p 6-8

<sup>14</sup> The National Board of Health and Welfare. *Rapport 2011:09 från samarbetsprojektet Nationella medicinska indikationer*, p 11



### 3.3 Organisation and reimbursement in Swedish health care

In Sweden, decision-making in health care is decentralized to 20 county councils and one city council. The county councils are responsible for a majority of the organisation and financing of health services. Financing is made through proportional income tax in the counties, contributions from the state, and national social insurance.<sup>15</sup>

In the 1990s, county councils in Sweden underwent three substantial reforms regarding health care. First, all county councils introduced free choice of primary health centre and a majority of the county councils introduced free choice of hospital. Extended freedom to choose care providers in other counties was introduced, as well as a possibility to turn to private care providers if a health care guarantee of three months was not kept. In most counties, the system was designed so that the reimbursements went with the choice of the patients; therefore there was a clear incentive to attract patients through improvements of quality.<sup>16</sup> Second, most county councils worked towards a separation of the responsibilities for purchasing and providing health services. The aim was to create some form of an internal market by transforming the purchaser from a passive payer to an active negotiator, however, criticism was made that the impact of this reform was rather weak since many important decisions, for example on structural changes in the supply of health services and the reimbursement conditions, was made politically.<sup>17</sup> Third was the reform of reimbursement system. County councils in Sweden adopted, to various extents, DRG-based payment schemes for reimbursements in health care. Since prospectively set cost per case gives incentives for increases in production, this was mainly an attempt to overcome the existing discontent towards the county councils due to long waiting times, inaccessibility and low productivity in health care, which were thought to be consequences of the global budgeting systems used before.<sup>18</sup>

Today, there are basically two directions influencing the reimbursement systems in the different counties; allocation-based systems, for example global budgeting, where budgets are mostly focused on covering expenses, and performance-based systems like

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<sup>15</sup> Anell, Anders. *The Monopolistic Integrated Model and Health Care Reform: The Swedish Experience*, p 22

<sup>16</sup> Ibid, p 23-24

<sup>17</sup> Ibid, p 24-25

<sup>18</sup> Anell, Anders. *The Monopolistic Integrated Model and Health Care Reform: The Swedish Experience*, p 25

for example DRG.<sup>19</sup> DRG is used in most hospitals and county councils for management, control and follow ups, around 50 % of the county councils use DRG for budgeting and reimbursements in in-patient care, and almost all county councils use it for cross-county payments.<sup>20</sup> See appendix 9.1 for county-specific details.

These reforms had implications for the usage of cesarean section as mode of delivery. First of all, increased competition between hospitals, as well as a reinforced role for the patient, makes it plausible to believe that physicians to a larger extent would grant the wishes of the patients. This would increase cesarean section rates, as there is an increasing demand for cesarean section on request of the mother.<sup>21</sup> Secondly, as DRG payments bring incentives to increase production, relative to global budgeting systems, it is also likely that the reimbursement-reform would increase the usage of cesarean section during deliveries.

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<sup>19</sup> Högberg, Michael and Lindvall, Staffan. *Ersättningssystem inom Hälso- och Sjukvård. Erfarenheter, utvecklingslinjer och vägval för den mer specialiserade vården (Sjukhus slutenvård och öppenvård)* p 5-6

<sup>20</sup> The National Board of Health and Welfare. *DRG användning 2012*

<sup>21</sup> Ryding, Elsa Lena. *Vägledning angående kejsarsnitt på kvinnors begäran*, p 1

## 4 PREVIOUS RESEARCH

### 4.1 Theoretical framework

The primary theory used to explain differences in the utilization of health services is *medical practice variation*. To understand the physician's role better, I will begin this section with an explanation of the physician's double agent problem in *medical decision-making*. Further follows an explanation of the two main approaches in medical practice variation, a preference-oriented approach and an opportunity/constraint-driven approach. Related to medical practice variation are the different economic incentives that come of different reimbursement systems in health care, this is discussed in the final section of the theoretical framework.

#### 4.1.1 Medical decision-making

Theories on *medical decision making* usually designates the physician as the decision-maker. The physician is however exposed to a *double agent problem* as he or she, on one hand acts as agent to the patient, and on the other hand act as agent to the hospital or the county council. In the role as the patient's agent, the physician should act on behalf of the patient's needs and preferences with an aim to maximize his or her individual health; this implies a risk of overutilization.<sup>22</sup> In the role as the hospital's or the county council's agent the physician will have to place emphasis on other factors. Depending on the goals of the hospital or the county, this could be anything from maximizing profits to maximizing social health. This contract theory dilemma also implies that one must consider the physician's self-fulfilling motives related to economic self-interest and personal beliefs and preferences, and it is important to understand these sometimes-conflicting interests to better understand medical practice variations.<sup>23 24</sup>

#### 4.1.2 Medical practice variation

Variations in the utilization of health care services between areas can be studied through theories of *medical practice variation*. Many of the existing studies on medical

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<sup>22</sup> Eckerlund, Ingemar and Gerdtham, Ulf. *Variations in Cesarean Section Rates in Sweden – Causes and Economic Consequences*, p 10

<sup>23</sup> Ibid p 9, 11

<sup>24</sup> Gonzales, Paula. *Should Physicians Dual Practice Be Limited? An Incentive Approach*, p 506

practice variation explain the phenomenon through, either a preference-oriented approach where differences in attitudes and personal attributes of the physicians play a big role, or through an opportunity/constraint approach where incentives and other intervening forces, often organizational, are of importance.<sup>25</sup> According to *the practice style hypothesis*, a preference-oriented approach to medical practice variation, professional uncertainty regarding diagnosis and treatment enhances variations in utilization of health services, since there is greater room for interpretation.<sup>26</sup> Improvements in technology, as well as research and development, gives physicians better guidelines to deal with uncertainty. The adoption of different practice styles also has to do with attributes of the physician, for example age, gender, medical education or training, as well as aversion for uncertainty.<sup>27</sup> An alternative approach to study medical practice variation is the opportunity/constraint driven approach, according to which differences in the social context provide incentives for certain decisions, or restrict the physician's behavioural choices.<sup>28</sup> This could for example be affected by organizational constraints related to capacity and resources, technological level and attitudes against research and development, as well as reimbursement systems leading to different opportunities of resource allocation and different economic incentives.<sup>29</sup>

### 4.1.3 Reimbursement systems in health care

*Reimbursements systems* relate to the way hospital and other care providers are paid for the services they provide. It is important to distinguish between reimbursement systems as they affect the incentives for quantity and quality in health care. First I make a distinction between *retrospective* and *prospective* reimbursement systems.

#### 4.1.3.1 Retrospective reimbursement

Retrospective reimbursement means that hospitals are paid after they have provided the service. The reimbursement ( $\rho$ ) is set after the treatment, depending on the

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<sup>25</sup> Westert, Gert P and Groenewegen, Peter P. *Medical Practice Variations: Changing the Theoretical Approach*, p 174-178

<sup>26</sup> Ibid p 174-176

<sup>27</sup> Eckerlund, Ingemar and Gerdtham, Ulf. *Variations in Cesarean Section Rates in Sweden – Causes and Economic Consequences*, p 9-11

<sup>28</sup> Westert, Gert P and Groenewegen, Peter P. *Medical Practice Variations: Changing the Theoretical Approach*, p 177-178

<sup>29</sup> Long, Michael J. *An Explanatory Model of Medical Practice Variation: A Physician Resource Demand Perspective*, p 169-172

workload (W) and, either by average actual cost (AC), or on fee for service-basis where number of services per case (S) is multiplied by the fee per item of service (I). This model gives few incentives to minimise costs as the hospitals are paid for actual expenditures incurred, or the volume of services provided.<sup>30</sup>

$$\rho = W \times (AC) \text{ or}$$

$$\rho = W \times (S \times I)$$

If financial incentives are strong they could result in *supplier-induced demand*, when a negative income shock for the physician leads to an excessive production of care.<sup>31</sup> Supplier induced demand is an important aspect in the choice of reimbursement system, however not so relevant in Swedish health care as economic incentives for the physician are low, therefore further attention in this paper is unnecessary.

#### 4.1.3.2 *Prospective reimbursement*

Prospective reimbursement systems mean that the size of costs are decided on in advance, however, the payment is not received in advance. There are two main versions of prospective reimbursement, *global budgeting* and *prospectively set cost per case*. Global budgeting means that a budget is set in advance across all services provided by the hospital. This provides incentives for the hospital to constrain total expenditure. Prospectively set cost per case means that the cost for a specific case is set in advance. In this way, actual expenditure and services provided are separated from the cost; however, it can still increase by workload, which gives an incentive for increase in production. An example of this method is DRG –based pricing schemes to determine costs.<sup>32</sup>

In DRG-based systems reimbursements are based on, average costs per case in each diagnostic group (DRG) derived from a specific group of hospitals, and the workload.

$$\rho = W \times DRG$$

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<sup>30</sup> Morris et al. *Economic Analysis in Health Care*, p 167-168

<sup>31</sup> Gruber, Jonathan and Owings, Maria. *Physician Financial Incentives and Cesarean Section Delivery*, p 99

<sup>32</sup> Morris et al. *Economic Analysis in Health Care*, p 169

If  $AC > DRG$ , hospitals will have an incentive to lower the expenditure, and if  $AC < DRG$  hospitals will have an opportunity to increase quality. This method generates an incentive for containment of expenditures but avoids cost-minimising effects.<sup>33</sup>

## 4.2 Empirical research

Cesarean section is a frequently studied topic; both regarding correlated factors and variations in the utilization of cesarean section. Next follows a selection of the empirical research in the area.

Adashek et al.<sup>34</sup> found that cesarean section rates was more than twice as high for women aged 35 years or older, when compared with women aged between 20 and 29 years, 21,6 % and 10,2 % respectively. If birth weight was above 3600g, women in the older group were three times as likely to be delivered by cesarean section.<sup>35</sup>

A cohort study on 837,312 births from the medical birth registry in Norway during 1967-2004 was made to assess the correlation between cesarean section rates and maternal education level.<sup>36</sup> Tollånes et al. found that the lowest educated group had the highest risk of being delivered by cesarean section, followed by the medium educated group. From 1988 and onwards this study examined the effect of education level on planned and emergency cesarean sections; the result was persistent in both groups. According to the authors, strong social migration, as well as an increased demand of cesarean section on request of the mother, could be reasons for this trend. This implies, as social migration is considerable also in some areas in Sweden, that education level of the mother is a possible explanation for variations in cesarean section rates.

BMI, birthweight, smoking during pregnancy, nulliparity and multiple births are other demand-related factors that have been positively correlated with cesarean delivery in previous studies.<sup>37 38 39</sup>

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<sup>33</sup> Morris et al. *Economic Analysis in Health Care*, p 170

<sup>34</sup> Adashek, Joseph A. et al. *Factors Contributing to the Increased Cesarean Birth Rate in Older Parturient Women*, p 936

<sup>35</sup> Ibid, p 936

<sup>36</sup> Tollånes, Mette et al. *Cesarean Section and Maternal Education; Secular Trends in Norway*, p 840

<sup>37</sup> Wanjiku, Kabiru and Raynor, Denise. *Obstetric Outcomes Associated with Increase in BMI Category During Pregnancy*, p 929-931

Grytten et al. tested the practice style hypothesis by comparing variations in cesarean section rates with time of adoption of advanced diagnostic technology. They used panel data from Norway between 1967 and 2005 on variations in cesarean section rates and time of adoption of advanced diagnostic technology; two-dimensional ultrasound, cardiotocography, ST waveform analysis and fetal blood analyses.<sup>40</sup> Grytten et al. assumed that the adoption of advanced diagnostic technology reduced clinical uncertainty regarding risk for mother and child during delivery. Thus, the reduced variations in cesarean section rates upon adoption of advanced diagnostic technology supported the practice style hypothesis.

Ellis and McGuire did a study on provider behavior under prospective payment, where they compared cost-based and prospective reimbursement systems. They stated that prospective payment systems would lead to efficient supply of health services only if the physician acts as a perfect agent, which would mean prioritize between patient's benefit and provider's interests equally, the physician's self-interest was not included.<sup>41</sup> Imperfect agency was their main argument to instead present a mixed model, which consisted of a lump sum component proportional to the resource consumption, combined with a prospective component. According to Ellis and McGuire this system moderated the incentives to reduce supply of care, when moving from full cost-based to prospective reimbursement.<sup>42</sup> The supply-side cost sharing features of a prospective system was desirable according to the authors, however a complete shift from full cost-based to prospective system was too radical of a change.<sup>43</sup>

Eckerlund and Gerdtham<sup>44</sup> did a study on the causes and economic consequences of variations in cesarean section rates in Sweden. Through a cross-sectional study of birth data from the Swedish medical birth registry (1991), one third of the variation could be

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<sup>38</sup>Graves, Barbara W. et al. *Maternal Body Mass Index, Delivery Route, and Induction of Labor in a Midwifery Caseload*, p 254

<sup>39</sup> The National Board of Health and Welfare. *Graviditeter, förlossningar och nyfödda barn*, p 23

<sup>40</sup> Grytten, Jostein; Monkerud, Lars and Sörensen, Rune. *Adoption of Diagnostic Technology and Variation in Cesarean Section Rates: A Test of the Practice Style Hypothesis in Norway*, p 2174-81

<sup>41</sup> Ellis, Randall P. and McGuire, Thomas G. *Provider Behavior Under Prospective Reimbursement*, p 148

<sup>42</sup> Ibid, p 148

<sup>43</sup> Ibid, p 149

<sup>44</sup> Eckerlund, Ingemar and Gerdtham, Ulf. *Variations in Cesarean Section Rates in Sweden – Causes and Economic Consequences*, p 3

explained by factors; mother's age above 35, placenta praevia and systematic follow-ups on all cesarean sections performed within the unit, the first two having a positive correlation, and the last a negative correlation, with cesarean section rates.<sup>45</sup> According to the authors, there is reason to believe that a large part of the unexplained variations has to do with differences in practice patterns, however these patterns were difficult to identify and estimate. Eckerlund and Gerdtham concluded that the variation implied inefficiencies, and resulted in an excess societal cost.

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<sup>45</sup> Eckerlund, Ingemar and Gerdtham, Ulf. *Variations in Cesarean Section Rates in Sweden – Causes and Economic Consequences*, p 18



## 5 DATA MATERIAL AND METHOD

### 5.1 Data material

I used cross-sectional data from three different sources; The Medical Birth Registry published by The National Board of Health and Welfare, The Central Bureau of Statistics and The Swedish Association of Local Authorities and Regions. The data was collected on county level, or aggregated to county level from hospital level. All data is from 2011, exceptions noted.

Data was collected from The National Board of Health and Welfare on:

- Number of cesarean sections
- Number of deliveries
- Average age of women giving birth
- BMI of women at registration of maternal care
- Birth weight
- Number of multiple pregnancies
- Nulliparity
- Number of women smoking during pregnancy
- Number of midwives employed (data is from November 2010)
- Number of obstetricians/gynaecologists employed (data is from November 2010)
- Type of hospitals in the county (university/other)
- Usage of DRG for remunerations of in-patient care within counties (data is from 2012)

Data was collected from The Central Bureau of Statistics on:

- Population
- Women aged 16-45 years with higher education (at least 3 years of after graduate level)

Finally, data was collected from The Swedish Association of Local Authorities and Regions on:

- Available beds in obstetric care
- Number of admissions on inpatient care due to pregnancy, delivery and puerperium.

## 5.2 Method

The aim of this paper was to estimate variations in cesarean section rates between different county councils in Sweden to see if these variations could be explained through, on one hand demand-related variables associated with demography, medical need and lifestyle choices of the mother, and on the other hand variables related to resources, capacity and opportunities of the supplier.

### 5.2.1 Linear regression

In order to analyse the variation in cesarean section rates between counties I performed a multiple regression with OLS<sup>46</sup> in STATA, a data analysis and statistical software programme.

I defined the dependent variable, CS, as number of cesarean sections divided by number of deliveries in the county. Each specification also consists of a random part, which is the error-term,  $\epsilon$ . The systematic part in the different specifications varied, it is presented in each specification.

#### 5.2.1.1 Specification 1

Previous research states that demand-related variables like birth weight, age and BMI of the mother, nulliparity, multiple births and smoking during pregnancy are all positively correlated with cesarean section rates. Education is according to the same negatively correlated with cesarean section rates.

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<sup>46</sup> See appendix 10.3

To test this hypothesis the systematic part of the specification consists of variables:

- WEIGHT- average birth weight of children in the county
- AGE - average age of mothers in the county
- BMI - average body mass index of mothers in the county
- NULL - number of first-time mothers giving birth divided by total number of deliveries in the county
- MULT – number of deliveries with multiple children born divided by total number of deliveries in the county
- SMOK - number of women smoking during pregnancy divided by total number of women pregnant in the county
- EDU – number of women aged 16-45 years with higher education divided by total number of women aged 16-45 years in the county

An ocular examination of the variables revealed skewness in some of the variables. The variables that improved to a more normal distribution in logarithmic transformation were transformed, and the first specification was as follows:

$$CS = \alpha + \beta_1 \text{WEIGHT} + \beta_2 \text{AGE} + \beta_3 \text{BMI} + \beta_4 \ln \text{NULL} + \beta_5 \text{MULT} + \beta_6 \text{SMOK} + \beta_7 \ln \text{EDU} + \varepsilon$$

### ***5.2.1.2 Specification 2***

Supply-related factors, for example organizational, technological and economic factors, affect resources and capacity, and thus, affect opportunities to perform cesarean section. In the following specification I wanted to add variables that reflected varying pressure on the delivery units in each county. To achieve this I defined the following independent variables:

- DELIV- number of deliveries divided by the population in the county
- MIDW- number of deliveries per midwife employed in the county
- OBS\_GYN - number of deliveries per obstetrician and gynaecologist employed in the county
- BED - number of deliveries per available bed in obstetric care in the county
- ADM - number of admissions of inpatient care in obstetric divided by number of midwives, obstetricians and gynaecologist employed in the county

It was more difficult regarding these variables to predict the correlation with cesarean section rates. Variables DELIV, MIDW, OBS\_GYN and ADM are measures of the capacity and workload delivery-units in the different counties are exposed to. Since cesarean delivery is more resource consuming, these variables should have a negative correlation with cesarean section rates. However, a temporary high pressure on a delivery-unit could probably in some cases be positively correlated with cesarean section, since cesarean delivery itself (not postnatal care) is less time-consuming than vaginal delivery. I therefore expected a positive correlation with the variable BED. In reality this is probably the case only after a certain threshold where maximum capacity is met, but more specific data on utilization of available beds in delivery units would be required to evaluate this.

As university hospitals are teaching facilities, it is plausible that they use advanced technology and take part in new research and development to a greater extent than other hospitals. Professional uncertainty enhances variations in utilization of health services; therefore, the level of technology could affect cesarean section rates. The variation between areas is expected to decrease with improvements in technology since it decreases uncertainty,<sup>47</sup> however less uncertainty could both increase and decrease actual cesarean rates. According to Gerdtham and Eckerlund, cesarean section rates in university hospitals are slightly higher than in other hospitals.<sup>48</sup> As an indication of the level of technology I have included a dummy-variable,  $D_{uni}$ , for the presence of a university hospital in the county.

Different reimbursement systems bring different incentives in the production of health care. As mentioned before, there are basically two directions influencing the reimbursement systems in the different counties, allocation-based systems and performance-based systems. As an indication for the variation in reimbursement systems I have included a dummy-variable,  $D_{drg}$ , indicating which counties use DRG-schemes for within-county inpatient reimbursements. As DRG based systems give

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<sup>47</sup> Grytten, Jostein; Monkerud, Lars and Sørensen, Rune. *Adoption of Diagnostic Technology and Variation in Cesarean Section Rates: A Test of the Practice Style Hypothesis in Norway*, p 2174

<sup>48</sup> Eckerlund, Ingemar and Gerdtham, Ulf. *Variations in Cesarean Section Rates in Sweden – Causes and Economic Consequences*, p 13

greater incentives for increased production and lower incentives for cost-control, relative to allocation-based systems, DRG-should be positively correlated with cesarean sections rates.

An ocular examination of these variables also revealed skewness in some of the variables. The variables that improved to a more normal distribution in logarithmic transformation were transformed logarithmically, as well as variable OBS\_GYN, which had widely spread observations. The second specification was as follows:

$$CS = \alpha + \beta_8 \ln DELIV + \beta_9 MIDW + \beta_{10} \ln OBS\_GYN + \beta_{11} \ln BED + \beta_{12} ADM + \beta_{13} D_{uni} + \beta_{14} D_{drg} + \varepsilon$$

### 5.2.1.3 Specification 3

Specification 1 and 2 both showed signs of omitted variables,<sup>49</sup> to avoid this problem, and to see if significance in the variables was persistent when considering both demand- and supply-factors; I tried to merge the two specifications. The third specification was as follows:

$$CS = \alpha + \beta_1 WEIGHT + \beta_2 AGE + \beta_3 BMI + \beta_4 \ln NULL + \beta_5 MULT + \beta_6 SMOK + \beta_7 \ln EDU + \beta_8 \ln DELIV + \beta_9 MIDW + \beta_{10} \ln OBS\_GYN + \beta_{11} \ln BED + \beta_{12} ADM + \beta_{13} D_{uni} + \beta_{14} D_{drg} + \varepsilon$$

### 5.2.1.4 Specification 4

Specification 3 showed signs of multicollinearity,<sup>50</sup> for example high level of determination and large differences in parameter-values and significance levels when adding or removing variables. I suspected that this problem was related to my small sample size in combination with a relatively large number of independent variables.

When removing variables AGE, lnEDU and lnDELIV from the specification, the model no longer suffered from multicollinearity, however, since it is empirically argued, and in line with my previous results, that AGE has a statistically and economically significant correlation with cesarean section, I chose to remove only variables lnEDU and lnDELIV.

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<sup>49</sup> See appendix 10.3

<sup>50</sup> See appendix 10.3

This reduced the multicollinearity in the model so that variance inflation factor was at an acceptable level.<sup>51</sup>

I checked the correlation between variables MIDW, lnOBS\_GYN, ADM and lnBED, as these variables are quite similar and all measures of workload, to see if it was appropriate to reduce number of independent variables. Since the correlation between these variables was less than 0,8 in all cases, I didn't think it was necessary to take action.<sup>52</sup>

I removed variables MULT and SMOK as they gave disproportionate results that were difficult to interpret in specification 3.

The final specification was as follows:

$$CS = \alpha + \beta_1 \text{WEIGHT} + \beta_2 \text{AGE} + \beta_3 \text{BMI} + \beta_4 \text{lnNULL} + \beta_5 \text{MIDW} + \beta_6 \text{lnOBS\_GYN} + \beta_7 \text{lnBED} + \beta_8 \text{ADM} + \beta_9 D_{\text{uni}} + \beta_{10} D_{\text{drg}} + \varepsilon$$

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<sup>51</sup> See appendix 10.3

<sup>52</sup> Westerlund, Joakim. *Introduktion till Ekonometri*, p 160

### 5.3 Descriptive statistics

In the datamaterial 21 counties were observed regarding 15 different variables, and 41 hospitals were observed regarding 3 variables. Table 1 shows descriptive statistics of this datamaterial.

**Table 1: Descriptive statistics**

VARIABLES	Counties (21 observations)				Hospitals (41 observations)			
	Average	Std. Dev	Min value	Max value	Average.	Std.dev.	Min value.	Max value.
<i>CS</i>	0,164	0,026	0,125	0,232	0,164	0,031	0,087	0,225
<i>BIRTHWEIGHT</i>	3518,4	19,348	3479,1	3550,3				
<i>AGE</i>	29,8	0,534	29,2	31,5				
<i>BMI</i>	25,1	0,420	24,0	25,7				
<i>NULL</i>	0,433	0,018	0,402	0,478				
<i>MULT</i>	0,014	0,002	0,010	0,019				
<i>SMOK</i>	0,067	1,513	0,033	0,088				
<i>EDU</i>	0,228	0,033	0,186	0,306				
<i>DELIV</i>	0,011	0,001	0,009	0,013				
<i>MIDW</i>	14,9	1,634	12,2	18,8				
<i>OBS_GYN</i>	81,9	14,782	36,9	107,7				
<i>BED</i>	117,7	43,606	64,6	276,7	138,3	184,0	64,5	272,9
<i>ADM</i>	14,5	3,090	2,6	18,5				
<i>Duni</i>	0,286	0,452	0	1	0,146	0,353	0	1
<i>Ddrg</i>	0,476	0,499	0	1				

## 6 RESULTS

### 6.1 Specification 1

I initiated the analysis with a specification that tested how well cesarean section rates were explained by some demand-related variables.

**Table 2: Results specification 1**

VARIABLES	CS	VARIABLES	CS
<i>WEIGHT</i>	5.54e-05	<i>MULT</i>	2.487
	(0.000375)		(3.421)
<i>AGE</i>	<b>0.0444***</b>	<i>SMOK</i>	0.108
	(0.0121)		(0.489)
<i>BMI</i>	0.0190	<i>lnEDU</i>	<b>-0.118*</b>
	(0.0185)		(0.0633)
<i>lnNULL</i>	0.136	<i>Constant</i>	-1.936
	(0.157)		(1.425)
<i>Observations</i>			21
<i>R-squared</i>			0.496
<i>adj R-squared</i>			0,225

*Robust standard errors in parentheses*

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

As expected, most variables had a positive correlation with cesarean section rates except for EDU, which had a negative relationship, however, the only variables that were statistically significant was AGE and lnEDU. Age was significant on 1 % level and indicated that one year's increase in average age of mothers gives 4,44 percentage points increase in cesarean section rates. LnEDU was significant on 10 % level and indicated that one percentage point increase in the share of women with higher education decreases cesarean section rates with 0,118 percentage points.



## 6.2 Specification 2

Furthermore, in specification 2 I examined variables, which would reflect organizational, technological and economic factors.

**Table 3: Results specification 2**

VARIABLES	CS	VARIABLES	CS
<i>lnDELIV</i>	0.0538 (0.0673)	ADM	-0.00195 (0.00121)
<i>MIDW</i>	0.00271 (0.00306)	Duni	<b>-0.0272*</b> (0.0135)
<i>lnOBS_GYN</i>	<b>-0.0792*</b> (0.0382)	Ddrg	0.0111 (0.0105)
<i>lnBED</i>	<b>0.0329*</b> (0.0185)	Constant	0.593 (0.395)
<i>Observations</i>		21	
<i>R-squared</i>		0.427	
<i>adj R-squared</i>		0,118	

*Robust standard errors in parentheses*

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Three of the variables in this specification were statistically significant. Variable *lnOBS\_GYN* showed a negative correlation on 10 % level, indicating that an increase of one unit deliveries per obstetrician and gynaecologist decreases cesarean section rates with 0,0792 percentage points. *lnBED* showed positive correlation on 10 % level, indicating that an increase of one unit deliveries per available hospital bed in obstetric care increases the cesarean section rate with 0,0329 percentage points. Regarding mentioned variables, the results went in the direction of my expectations. Variable *D<sub>uni</sub>* was also significant on 10% level, indicating a negative effect of 2,72 percentage points on cesarean section rates, with the presence of a university hospital in the county. This result was somewhat surprising; although I was indifferent in my expectations, this result contradicted the results of Eckerlund and Gertham.<sup>53</sup>

Variables *lnDELIV*, *MIDW* and *ADM* were statistically insignificant in this specification and the first two showed a surprising positive correlation with cesarean section rates.

<sup>53</sup> Eckerlund, Ingemar and Gertham, Ulf. *Variations in Cesarean Section Rates in Sweden – Causes and Economic Consequences*, p 13

Dummyvariable  $D_{drg}$ , showed a positive correlation with cesarean section rates, as expected, but was statistically insignificant.

### 6.3 Specification 3

In specification 3 I merged the previous specifications.

Table 4: Results specification 3

VARIABLES	CS	VARIABLES	CS
<i>WEIGHT</i>	<b>0.000758***</b>	<i>MIDW</i>	<b>0.00971***</b>
	(0.000183)		(0.00248)
<i>AGE</i>	<b>0.0228*</b>	<i>lnOBS_GYN</i>	<b>-0.0447*</b>
	(0.00961)		(0.0194)
<i>BMI</i>	-0.0128	<i>lnBED</i>	<b>0.0954***</b>
	(0.0116)		(0.0139)
<i>lnNULL</i>	0.107	<i>ADM</i>	<b>-0.00420***</b>
	(0.141)		(0.000853)
<i>MULT</i>	<b>10.84***</b>	<i>Duni</i>	-0.00210
	(2.255)		(0.0114)
<i>SMOK</i>	<b>-0.765*</b>	<i>Ddrg</i>	<b>0.0283**</b>
	(0.326)		(0.00862)
<i>lnEDU</i>	<b>-0.250***</b>	<i>Constant</i>	-3.535***
	(0.0574)		(0.611)
<i>lnDELIV</i>	0.0126		
	(0.0459)		
<i>Observations</i>			21
<i>R-squared</i>			0.945
<i>adj R-squared</i>			0,815

Robust standard errors in parentheses

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Ten out of the fourteen variables were found statistically significant. AGE was still significant but now on 10 % level indicating that; an increase of one year in average age of mothers increases cesarean section rates with 2,28 percentage points. LnEDU was statistically significant, now on 1 % level, indicating that; an increase of one percentage point in the share of women with higher education decreases cesarean section rates with 0,25 percentage points. WEIGHT was significant on 1 % level indicating that; an increase of one gram in average birth-weight increases cesarean section rates with 0,0758 percentage points. MIDW, lnBED and ADM were all significant on 1 % significance level, and the interpretations of the results are; an increase of one unit

deliveries per midwife increases cesarean section rates with 0,971 percentage points, an increase of one unit deliveries per available bed for obstetric care increases cesarean section rates with 0,0954 percentage points, and increase of one unit of admissions per employed midwife, obstetrician and gynaecologist decreases the dependent variable with 0,42 percentage points. LnOBS\_GYN had a negative correlation on 10 % level indicating that; an increase of one unit of deliveries per obstetrician and gynaecologist decreases cesarean section rates with 0,0447 percentage points. D<sub>drg</sub> showed a statistically significant positive correlation on 5 % level indicating that; usage of DRG-schemes for within-county reimbursements for in-patient care increases cesarean section rates with 2,83 percentage points.

Variables MULT and SMOK were both statistically significant, on 1 % and 10 % respectively. The interpretation of the results indicated that, one percentage point increase in multiple pregnancies rate would increase cesarean section rates with over one thousand percentage points, and an increase of one percentage point in the rate of nulliparity would increase cesarean section rates with 76,5 percentage points. These values were unrealistic and unlikely to be correct, however I was not able to find the specific cause of this problem. This, in combination with high values on the coefficients of determination (R-squared and adj R-squared in the table), indicated that something was wrong in the model.

## 6.4 Specification 4

The final specification was reduced due to multicollinearity.

Table 5: Results specification 4

VARIABLES	CS	VARIABLES	CS
<i>WEIGHT</i>	0.000106 (0.000370)	<i>lnBED</i>	0.0297 (0.0210)
<i>AGE</i>	<b>0.0440**</b> (0.0161)	<i>ADM</i>	-0.00252 (0.00160)
<i>BMI</i>	0.0199 (0.0205)	<i>Duni</i>	<b>-0.0383***</b> (0.00998)
<i>lnNULL</i>	0.0130 (0.151)	<i>Ddrg</i>	-0.000532 (0.0150)
<i>MIDW</i>	0.00554 (0.00499)	<i>Constant</i>	-1.984 (1.554)
<i>lnOBS_GYN</i>	-0.0454 (0.0406)		
<i>Observations</i>			21
<i>R-squared</i>			0.666
<i>adj R-squared</i>			0,333

Robust standard errors in parentheses

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Only two variables were statistically significant in the final specification, AGE and  $D_{uni}$ . AGE had a positive correlation on 5 % significance level indicating that; an increase of one year in average age of mothers increases cesarean section rates with 4,4 percentage points, and  $D_{uni}$  had a negative correlation on 1 % level indicating that; the presence of a university hospital in the county decreases cesarean section rates with 3,83 percentage points.

Many variables were statistically insignificant in this specification, however most of them were correlated to cesarean section rates according to expectations. Variables WEIGHT, BMI, lnNULL, lnBED and MIDW showed positive correlation. lnOBS\_GYN and ADM showed negative correlation, as well as  $D_{drg}$ , which was quite surprising as it in previous specifications showed positive correlation.

The coefficient of determination was lower in this specification, 0,666, and adjusted for number of independent variables it was 0,333. However, considering the few significant independent variables, it was still somewhat unrealistic.

## 7 SENSITIVITY ANALYSIS

A common procedure in a sensitivity analysis is to remove outlier from the data to make sure they are not driving the results. I checked all my variables for outliers through an iqr-test in STATA and only one variable showed signs of severe outliers, lnADM. When excluding the outlying observation from the dataset, lnADM was no longer statistically significant in any of the specifications.

Some of the variables are clearly better suited for evaluation on hospital level. To see if my results were stable, I tested two of the variables on hospital level, lnBED and  $D_{uni}$ . The dependent variable in this specification,  $CS_{hos}$ , was cesarean section rates on hospital level. I used the following independent variables in my sensitivity analysis:

- $BED_{hos}$  - deliveries on hospital level divided by available beds in obstetric care on hospital level
- $D_{uni\_hos}$  –a dummy variable for being university hospital

Specification 5 was:

$$CS_{hos} = \alpha + \beta_1 BED_{hos} + \beta_2 D_{uni\_hos} + \varepsilon$$

**Table 6: Results specification 5**

VARIABLES	CShos	VARIABLES	CShos
<i>Duni_hos</i>	<b>-0.0301**</b>	<i>Constant</i>	0.0871**
	(0.0121)		(0.0371)
<i>lnBEDhos</i>	<b>0.0172**</b>		
	(0.00742)		
<i>Observations</i>			41
<i>R-squared</i>			0,173
<i>adj R-squared</i>			0,129

*Robust standard errors in parentheses*

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

When analyzed on hospital level the variables  $D_{uni}$  and  $\ln BED$  were both significant on 5 % level.  $\ln BED$  indicated that; one unit's increase in deliveries per available bed in obstetric care increased cesarean section rates with 0,017 percentage points. Thus, the positive correlation found in the county-level analysis was stable, but with weaker economic significance. The results of the dummy indicated that being a university hospital had a negative effect on cesarean section rates with 3 percentage points, this result was consistent with the analysis on county-level.

## 8 DISCUSSION/CONCLUSION

The aim of this paper was to estimate the variation in cesarean section rates between counties in Sweden to see how well the variation could be explained by factors related to demography, lifestyle and medical need, as well as organizational factors related to resources and capacity.

Empirically it has been shown that variations in cesarean section rates can be derived from varying demographic factors, as well as varying medical need. It has also been argued in previous research that variations in utilization of health services to a large degree depends on preference-based approaches in medical practice variation, as well as problems related to the physician as a double agent. But even though for example the practice style hypothesis is widely discussed, it is not as commonly analysed in research. According to many researchers, this problem occurs because values reflecting practice style are not directly observable or measurable. Some have made attempts, for example Grytten et al., whom used access to technology as a proxy for uncertainty to test the practice style hypothesis. However good attempt, in their study they excluded the possibility of reversed causality of practice style on level of technology. To me this seemed unlikely as I think it is highly plausible that the level of technology a hospital holds, at some level is decided by the preferences and enthusiasm of the hospital's employees.

Theoretically it has been shown that variations in the utilization of health services depend on varying opportunities and constraints of different caregivers, for example can workload and capacity affect the ability to perform time- and resource-consuming procedures. Differently educated personnel, varying access to technology, and attitudes in the management can also be causes of the variation. According to theories on reimbursement systems in health care, different economic incentives can be reasons for variations in the utilization of health services. For example, a prospectively set cost per case system like DRG give incentives to increase production, while a more allocation based system like global budgeting have cost-minimising effect that inhibits production. Since decision-making and responsibilities for providing health care is decentralised to the counties, there is a strong possibility that varying conditions rule, regarding

workload and capacity, which would cause variations in the utilization of cesarean section.

Initially in this analysis, I evaluated the effect of birth weight, age, body mass index, nulliparity, multiple pregnancies and education on cesarean section rates and found that age and education had a statistically significant effect. Subsequent specifications included birth weight, multiple pregnancies and smoking as statistically significant independent variables, however the last two with disproportionate results. Regarding age, education and birth weight, the results resembled my expectations, however it is noteworthy that the two variables, nulliparity and multiple births, which both have strong empirical indication of positive correlation, were insignificant.

Furthermore I evaluated the effect of several workload and capacity measures; number of deliveries per population, number of deliveries per employed midwife, number of deliveries per employed obstetrician and gynaecologist, number of deliveries per available hospital bed in obstetric care, and number of admissions of inpatient care in obstetrics per employed midwife, obstetrician and gynaecologist. The capacity measures showed strong significance in some of the specifications and most effects resembled my expectations, however when excluding variables  $\ln\text{EDU}$  and  $\ln\text{DELIV}$ , none of the capacity measures were statistically significant. Theoretically it should be possible to say that high pressure in a specific county would result in a more frequent use of the least resource-demanding procedure, however I think it is just as important to take into consideration for example how often maximum capacity is met, as it is to measure the demand in comparison to the capacity. The capacity measures were a bit difficult to interpret since the results were moving in different directions. Variable  $\ln\text{BED}$  was analysed both on county level and hospital level and in specification 2 and 3 variable  $\ln\text{BED}$  showed a statistically significant positive correlation with cesarean section rates, however when reducing the model in specification 4 it lost its significance, thus were the results in specification 2 and 3 probably a result of multicollinearity. When examined on hospital level, variable  $\ln\text{BED}$  showed a statistically significant but weaker positive correlation with cesarean section. With this, I draw the conclusion that capacity variables probably should be evaluated individually and on hospital level to overcome problems with multicollinearity and small sample size.



I also added two dummy variables,  $D_{uni}$  and  $D_{drg}$ , for the presence of a university hospital in the county and the usage of DRG schemes for within-county inpatient reimbursements. Since the dummy variable for presence of a university hospital intuitively is better suited for examination on hospital level, I analyzed this variable both on county and hospital level. A statistically significant negative correlation was stable in both tests indicating that the presence or being a university hospital decreased cesarean section rates with 3 %. This result was interesting since Eckerlund and Gerdtham found a positive correlation between university hospitals and cesarean section rates in Sweden.<sup>54</sup> Eckerlund and Gertham studied data from 1991 so perhaps there has been a change of practice at university hospitals due to new research. Regarding variable  $D_{drg}$ , the theoretically expected result was found only in specification 3, a positive correlation with cesarean section rates. This may have to do with the weak explanatory characteristics of the variable. The variable indicates if within-county reimbursements of inpatient care are estimated with DRG-schemes, it does however not say anything about how other county councils estimate their reimbursements, it could therefore be incorrect to expect only a positive effect.

To sum up the interpretation of my results I conclude that some of the examined variables have shown correlation with cesarean section rates. Differences in the population regarding these variables can be possible causes of the variation in cesarean section rates between counties. However, my aim was also to see how well these variables explain the variation and this is where I fall short of a reliable and estimable measure. All of my specifications showed, to some degree, disproportionate levels of determination. With this, I draw the conclusion that my model does not explain the variation in cesarean section rates very well. Previous empirical research and economic theories emphasize preference-based approaches like for example the practice style hypothesis, as contributing factors to variations in the utilization of health services. Therefore, I draw the conclusion that some of the variation is a result of practice style, on county, hospital or individual level.

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<sup>54</sup> Eckerlund, Ingemar and Gerdtham, Ulf. *Variations in Cesarean Section Rates in Sweden – Causes and Economic Consequences*, p 13

What does this say about the objective of my paper? If practice style is a contributor to the variations in cesarean section rates between counties in Sweden, does it imply that inefficiencies exist? Well, differences could imply inefficiencies if overutilization or underutilization exist, however since no cost-effectiveness analysis has been able to determine the cost-effectiveness regarding vaginal delivery and cesarean section on request of the mother, it is also difficult to determine the efficient level of cesarean section rates. In Eckerlund and Gerdhams study, a rough estimation of 12-14 million SEK was made of the societal cost for unnecessary cesarean sections.<sup>55</sup> The cost was based on number of cesarean sections succeeding the average cesarean section rate in Sweden, multiplied with the cost difference between vaginal and cesarean delivery. This way of estimating the societal excess cost is however far too trivial for two reasons; it does not take into account costs and effectiveness, which is important in economic evaluations, and it uses the average rate as the desirable rate even though this might not be the efficient rate. Looking at the descriptive statistics it seems unlikely that the large variations in cesarean section rates between counties and hospitals do not suffer from under- or overutilization, some level of inefficiency is therefore plausible, however a detailed estimation is beyond my ability with the available data.

With this experience, I would suggest a less generalized model for future studies of variations in cesarean section rates. The interesting part turned out to be factors related to practice style etc., however these values were both difficult to find and estimate. During this study I have come across data, which indicates that large differences exist in other areas of obstetric care, for example regarding incidence of pharmacological and non-pharmacological analgesia and duration of postnatal care. To detect practice style perhaps it would be interesting to examine if hospitals that deviate regarding cesarean sections, also differs regarding these factors.

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<sup>55</sup> Eckerlund, Ingemar and Gerdtham, Ulf. *Variations in Cesarean Section Rates in Sweden – Causes and Economic Consequences*, p 20

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## 10 APPENDIX

### 10.1 DRG-usage in Swedish county councils 2012, inpatient care <sup>56</sup>

	<b>U</b>	<b>B</b>	<b>IL</b>	<b>UL</b>
Stockholms läns landsting	X	X	X	X
Landstinget i Uppsala län	X	X	X	
Landstinget Sörmland	X			X
Landstinget i Östergötland	X			X
Landstinget i Jönköpings län	X			X
Landstinget Kronoberg	X		X	X
Landstinget i Kalmar län	X			X
Landstinget Blekinge	X			X
Region Skåne	X	X	X	X
Landstinget Halland	X	X	X	X
Västra Götalandsregionen	X	X	X	X
Landstinget i Värmland				X
Örebro läns landsting	X			X
Landstinget Västmanland	X		X	X
Landstinget Dalarna				X
Landstinget Gävleborg	X	X	X	X
Landstinget Västernorrland	X		X	X
Jämtlands läns landsting				X
Västerbottens läns landsting	X			X
Norrbottnens läns landsting	X	X	X	X
Gotlands kommun		X		X

U = Follow ups, B = Budgeting, IL = Within-county remunerations, UL = Between-county remunerations

### 10.2 Linear regression analysis

I have performed a multiple regression analysis with ordinary least squares (OLS).

A linear regression is a way of modelling a relationship where the variation in a dependent variable is explained by, on one hand a systematic part consisting of one or several independent variables, and on the other hand a random part consisting of an

<sup>56</sup> The National Board of Health and Welfare. *DRG användning 2012*

error-term. OLS provides estimations where the sum of the squared error-terms is minimized.

To make sure that my model is based on significant data, i.e. that my model is unbiased, consistent and effective, I need to make sure that my model meets six basic assumptions, the so called Gauss-Markov-assumptions;<sup>57</sup>

1. Linearity -the dependent variable can be described as a linear function of an intercept, one or more independent variables and an error-term
2. Errors in variables-the independent variables are measured without error
3. Homoscedasticity-homogeneity of variance, i.e. the variance of the residual should be constant
4. Independence-the residuals should not be correlated with each other- do not suffer from autocorrelation.
5. The independent variable is not random and assumes at least two values -does not suffer from multicollinearity.
6. Normality-the residuals should be normally distributed.

### 10.3 Testing the Gauss-Markov-assumptions

The tests have been conducted for all of the specifications presented in section 5.

To test assumption 1 and 2 I have conducted RESET-tests (*ovtest*) on my specifications in STATA. This test is designed to detect specification errors such as omitted variables, by including a term for *the estimated value of  $Y_i$ ,  $\hat{Y}_i^2$* , which will include effects of omitted variables and non-linear effects.<sup>58</sup> The RESET-test will evaluate whether *the parameter of  $\hat{Y}_i^2$ ,  $\gamma$* , is significant or not. Specifications 1 and 2 seem to suffer from omitted variables, however specification 3 and 4 seem to be correctly specified, all on 5 % significance level.

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<sup>57</sup> Westerlund, Joakim. *Introduktion till Ekonometri*, p 72-73

<sup>58</sup> Westerlund, Joakim. *Introduktion till Ekonometri*, p 158-159

An alternative test to detect specification errors was also used, the *linktest*, which can detect other errors than omitted variables, for example incorrect functional form. This test is similar to the RESET-test; it also forms a new variable that detects mispecifications when significant.<sup>59</sup> All specifications appeared to be correctly specified according to the *linktest*.

If assumption 3 on homoscedasticity is not fulfilled the variance in the residuals are not constant. Testing for heteroscedasticity can be done in different ways; plotting the residuals for visual examination (*rvfplot, yline(0)*), or through other tests, for example White's test (*estat imtest*). Command tests like White's can be very sensitive to model assumptions, therefore it is good to combine these kinds of tests with diagnostic tests to determine the severity of the heteroscedasticity.<sup>60</sup> White's test state the specifications as homoscedastic, however when plotting the residuals, patterns in specification 1,3 and 4 showed signs of heteroscedasticity, i.e. they are not spread randomly. In STATA, I used the command *robust* in the regressions to correct in case of heteroscedasticity.

If assumption 4 -on the independence of residuals is not fulfilled the model could suffer from autocorrelation. This is however not a problem in cross-sectional data, therefore I do not suspect my specifications to suffer from autocorrelation.

Multicollinearity might exist if there is a linear relationship between the independent variables. To test my specifications for multicollinearity I estimated the correlation between my variables and conducted VIF-tests. A VIF-test calculates the variance inflation factor for the independent variables in the model.<sup>61</sup> There is no formal value for determining the presence of multicollinearity, but VIF-values exceeding 10 are regarded as strong indication for multicollinearity,<sup>62</sup> however commonly accepted are VIF-values between  $\approx 1-4$ .

In specification 1 and 2 all VIF-values are between  $\approx 1-4$ . In specification 3, only four variables are between  $\approx 1-4$ . By dropping variables with highest VIF-values one by one the

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<sup>59</sup> Institute for Digital Research and Education, UCLA. *Stata Web Book*, Chapter 2.6

<sup>60</sup> Institute for Digital Research and Education, UCLA. *Stata Web Book*, Chapter 2.3

<sup>61</sup> Westerlund, Joakim. *Introduktion till Ekonometri*, p 159-161

<sup>62</sup> Institute for Digital Research and Education, UCLA. *Stata Web Book*, Chapter 2.4

model is finally specified according to specification 4 with VIF-values between  $\approx 1-4$ . The correlation between my variables were below 0,8 in all cases.

To test assumption 6, normality in the residual, I have performed *kdensity*-kernel density plots, *pnorm* -standardized normality plot and *qnorm*-plotting the quantiles of the variables against the quantiles of a normal distribution. Some deviation was found in all specifications however most severe in specification 3. To complement the graphic tests on normality I performed a numerical test, *iqr*, which assumes symmetry in the distribution and measures mild and severe outliers by an inter-quartile range. None of the specifications had mild or severe outliers in the residuals so I assumed that the residuals had an approximately normal distribution.