

Defining Relevant Product Markets for Pharmaceuticals

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ABSTRACT. To identify the relevant product markets for Swedish pharmaceuticals, a spatial econometrics approach is employed. First, we calculate Moran's Is for different market definitions and then we use a spatial Durbin model to determine the effect of price changes on quantity sold of own and competing products. As expected, the results show that competition is strongest between close substitutes; however, the relevant product markets for Swedish pharmaceuticals extend beyond close substitutes down to products included in the same class on the four-digit level of the Anatomic Therapeutic Chemical system as defined by the World Health Organization. The spatial regression model further indicates that increases in the price of a product significantly lower the quantity sold of that product and in the same time increase the quantity sold of competing products. For close substitutes (products belonging to the same class on the seven-digit level of the Anatomic Therapeutic Chemical system), as well as for products that, without being close substitutes, belong to the same therapeutic/pharmacological/chemical subgroup (the same class on the five-digit level of the Anatomic Therapeutic Chemical system), a significant change towards increased competition is also visible after 1 July 2009 when the latest policy changes with regards to pharmaceuticals have been implemented in Sweden.

Keywords market delineation · competition · horizontal merger guidelines · spatial Durbin model
· market reform

JEL Classification L11 · L25 · L26 · L81

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1 Introduction

Several previous papers have studied competition between brand name and generic pharmaceutical products, with focus on the relevance of consumer information (Frank and Salkever 1992; Grabowski and Vernon 1992; Sorensen 2000; Granlund and Rudholm 2011), the importance of the physician in the choice of pharmaceuticals (Hellerstein 1998; Coscelli 2000; Richard and Van Horn 2004; Granlund and Rudholm 2012), or the relationship between brand name prices and generic market shares (Aronsson et al. 2001; Rizzo and Zeckhauser 2005). Yet other papers have focused on competition between different brand name pharmaceuticals within one or a few specific fields of treatment (Berndt et al. 1995; Ellison et al. 1997; Rudholm 2003; Richard and Van Horn 2004).

Frank and Salkever (1992) showed that an increase in the number of consumers informed about the availability of cheaper generic alternatives would lead to lower brand name pharmaceutical prices. Also, based on a conjecture by Grabowski and Vernon (1992) that an increase in the number of informed customers (i.e., cross-price sensitive consumers) would increase the negative impact of generic entry on brand name pharmaceutical prices, Frank and Salkever showed that, theoretically, this was not necessarily the case. In a more recent paper, Sorensen (2000) studied the relationship between imperfect consumer information and prices among prescription pharmaceuticals. The data were collected from pharmacies in upstate New York, and the price differences among medically equivalent prescriptions (i.e., brands and generics) were found to be large. In fact, the highest listed price exceeded on average the cheapest available alternative by as much as 50 percent. In addition, the results gave support to a consumer search cost model, since frequently purchased pharmaceuticals had both lower markups and lower price differences when compared to one-time prescription pharmaceuticals. Finally, Granlund and Rudholm (2011) studied the impact of increased consumer information on the price of brand name and generic products. In a theoretical model, they showed that an increase in information would, under reasonable assumptions, lead to a price reduction for brand name products, while the results for generic pharmaceuticals were more ambiguous. The results from the empirical part of their paper showed an average reduction in prices due to the an information increasing reform in the Swedish pharmaceuticals market of about four percent during the study period, both for brand name and generic pharmaceuticals. In addition, their results gave some support for the reform-effect being amplified for pharmaceuticals in markets which had previously been characterized by low levels of consumer information, as well as for pharmaceuticals which prior to the reform had high markups over marginal cost.

Another topic under study has been the importance of the physician in the brand name or generic prescription decision (Hellerstein 1998; Coscelli 2000; Richard and Van Horn 2004; Granlund and Rudholm 2012). Using data from a survey of physicians and their patients, Hellerstein (1998) found significant differences between physicians' likelihood to prescribe generics and also found that it was difficult to determine why some physicians were more likely to prescribe generic drugs. Coscelli (2000) used information about doctor and patient characteristics, as well as information about when and how patients switched physicians, to estimate the probability of a switch of pharmaceutical brands. Her results showed that there was persistence in the use of pharmaceuticals for both patients and physicians. Richard and Van Horn (2004) also found that there was persistence in physician prescription choices, especially for incumbent products. They suggested that this was caused by incumbent products having a larger installed base of patients rather than advertising generating goodwill for such products. Finally, Granlund and Rudholm (2012) studied the prescribing physician's influence on consumer choice between medically equivalent pharmaceuticals. In their paper, if consumers cared about the advice of their prescribing physician, they were expected to allow substitution to cheaper products most often for generics since the names of these products were so similar that consumers might have considered them to be the same pharmaceutical. However, when consumers were offered a cheaper substitute instead of a brand or secondary brand with a distinct product name, consumers might have believed that the substitute was different from the pharmaceutical that their physician had prescribed because of the difference in names. As expected from the above discussion, the results from the empirical part of Granlund and Rudholm (2012) also showed that the predicted probability of opposing substitution was considerably higher for brands and secondary brands than for generics. For the whole population, the predicted probability of opposing substitution was 10 percent for a generic and 24-25 percent for a brand or a secondary brand.

A third topic of study has been the relationship between brand name prices and generic market shares. Aronsson et al. (2001) set up a model where the relative change of market share of the original drug depended on the price of the original relative to the price of the generic substitutes. Their empirical results showed that a higher price of the original product, relative to the average price of the generic substitutes, significantly decreased the market share for the original product for five out of twelve studied substances. Also, the results indicated that the introduction of a so called reference price system in 1993 lowered pharmaceutical prices in Sweden. Rizzo and Zeckhauser (2005) showed that the higher the share of prescriptions that was filled by generics, the lower the average brand-name price to consumers. They suggested that this was due to consumers' becoming more likely

to substitute brand-name drugs for generics when the price gap was great. They found that this effect was large, with a 10 percent increase in generic script share associated with a 15.6 percent decline in the average price paid for brand-name drugs.

All papers mentioned above explicitly or implicitly assume that the relevant market to study is where a brand name product is in competition with one or more generic products. Only a few previous studies of the pharmaceuticals market analyze competition between different pharmaceutical substances (e.g., Berndt et al. 1995; Ellison et al. 1997; Rudholm 2003; Richard and Van Horn 2004). The general conclusion from these papers is that there is competition also between substances, but that the degree of competition is considerably lower than between brands and generics for the same active substance.

It should, however, be noted that all papers discussed above, including the studies of competition between substances, set out by assuming a relevant product market to be studied, instead of first trying to empirically decide the relevant scope of the product market. The purpose of our paper is thus to use spatial econometric methods as a way to decide the scope of relevant product markets for pharmaceuticals in Sweden. This is, to our knowledge, the first attempt at defining the relevant product market for pharmaceuticals in Sweden.

We set out by considering the basic definition of the area of a market: a market for a good is the area within which the price of a good tends to uniformity, allowance being made for transportation and transaction costs.¹ Under such circumstances, price movements will be highly correlated. If one seller changes the price of the product, other sellers will have to follow suit, and the cross-price elasticities of demand will be positive and statistically significant. This should also be true in product space; if two imperfect substitutes are similar enough that a price change of one product forces the sellers of the substitute product to change their prices as well, we will consider the products to be competitors in the same product market.

Our results show that price movements are highly positively correlated when the market is defined as brands and generics for a certain pharmaceutical substance (seven-digit level in World Health Organization's Anatomic Therapeutic Chemical (ATC) classification system), indicating that such products are competing in the same product market. However, the results also show clearly correlated price movements in broader market definitions

¹ This definition dates back to Cournot, and is discussed more in detail in Stigler and Sherwin (1985).

(five- and four-digit ATC levels), indicating that the relevant product market for pharmaceuticals in Sweden extends beyond the seven-digit ATC level containing brands and generics of the same pharmaceutical substance.

In this paper, we also investigate the effects of the policy changes from 2009 and 2010 in terms of possible changes in the price elasticity of demand for pharmaceutical products. The results show a pronounced increase in competition (measured as the cross-price elasticity of demand) between brands and generics for a certain pharmaceutical substance (seven-digit ATC level) after 1 July 2009, a slight increase in competition at the five-digit ATC level, and no significant change at the four-digit ATC level.

The Swedish pharmaceuticals market is presented in the next section. Section 3 describes the statistical method, while the data employed and descriptive statistics are presented in section 4. The results from our study are presented in section 5. Finally, section 6 summarizes the findings and draws conclusions.

2 The Swedish pharmaceuticals market 1993-2013

Before 2002, a reference price system introduced in January 1993 was in effect for pharmaceuticals in Sweden. Under that system, the Swedish National Social Insurance Board set a reference price equal to 110 percent of the price of the cheapest available generic product, and all costs exceeding this reference price were to be borne by the consumer (RFFS 1992:20, 1996:31). The effects of the reference price system on pharmaceutical prices have been previously analyzed (see e.g., Aronsson et al. 2001 and Bergman and Rudholm 2003). The results from Aronsson et al. showed that the introduction of the reference price system reduced brand name pharmaceutical prices where generic substitutes were available at the introduction of the system. However, Bergman and Rudholm found that the Swedish reference price system had been effective only for those products which already faced generic competition at the introduction of the system. Before the reference price system was introduced, generic entrants typically set prices far below the brand name product, without capturing more than a relatively small fraction of the market (Aronsson et al. 2001). When the system was introduced, the brand name manufacturers were forced to lower their prices to a level close to that of the generics, in order for consumers to be fully reimbursed.

The Swedish pharmaceuticals market was reformed on October 1, 2002. The reforms require that from that date pharmacists inform the consumers if there are substitute products available, as well as that the cheapest available generic substitute or parallel imported product (which is considered to be perfect substitute for the brand name

drug by the Swedish Medical Products Agency) will be provided within the Swedish pharmaceuticals insurance system. During the period 2002 and until 2009, “available” was interpreted as that the cheapest available product at the local pharmacy should be dispensed to the consumers. The pharmacist also had to inform the consumers that they could buy the prescribed pharmaceutical product instead of the suggested generic if they paid the difference in price between the products themselves. Finally, the rules that have been in effect since 2002 require that pharmacists substitute the prescribed pharmaceutical product to the cheapest available generic or parallel imported product in all cases when neither the prescribing physician prohibits the switch for medical reasons, nor the consumer chooses to pay the price difference between the prescribed and the generic alternative. In cases where the physician prohibits the switch due to medical reasons the consumer is still reimbursed by the insurance system.

It should be noted that even before the 2002 reform a prescribed pharmaceutical product could be substituted for a cheaper generic version if the prescribing physician had given his/her consent to this on the prescription, or if the patient requested substitution. In the latter case there was, however, a recommendation that the physician be contacted before substituting products if possible, and a requirement that the prescribing physician be informed about the substitution after the fact. Since these measures were abolished in 2002, this means that the transaction cost of generic substitution was lowered somewhat, which could also affect the pricing behavior of pharmaceutical firms.

Both before and after the substitution reform of 2002, pharmaceutical firms in Sweden have had the formal right to decide the price of their products, but for a pharmaceutical to be included in the Swedish pharmaceuticals insurance system, its price had to be authorized. The prices of new pharmaceutical products are authorized using a cost-benefit analysis that has to be provided with the application for the right to sell the pharmaceutical product within the Swedish insurance system. During the period 1969 until 2010, pharmaceuticals were sold through a nationwide government owned monopoly, the National Corporation of Swedish Pharmacies (NCSP). The NCSP had a margin on the pharmaceutical products that they sold that was determined by the Pharmaceutical Benefits Board. The regulations also implied that the NCSP was required to charge a nationwide uniform price for each pharmaceutical product in Sweden. Thus, the relevant geographic market for pharmaceutical products is, by regulation, Sweden as a whole.

The 2002 reform also affected the out-of-pocket cost for patients as the rules regulating this were changed when the reference price was abolished. Under the substitution reform costs up to 100 percent of the cheapest generic alternative are included in the pharmaceutical insurance system, compared to 110 percent during the reference price system. This increased patients' out-of-pocket costs for choosing to buy the prescribed pharmaceutical with 0-10 percent of the price of the cheapest generic version, depending on the patient's co-payment rate in the insurance system. On average this means an extra out-of-pocket cost of approximately 19 SEK (\approx 2 EURO, exchange rate 2013-06-28) per pharmaceutical (Granlund and Rudholm 2011).

In 2009 and 2010, the Swedish pharmaceuticals market was reformed again, and this time more substantially than in 2002. From July 1, 2009, the maximum price of pharmaceutical products that had previously been sold under patent protection was set at 35 percent of the price 12 months before patent expiration. According to the Swedish Dental and Pharmaceutical Benefits Agency (DPBA), this resulted in a decrease in pharmaceutical costs of approximately 350 million SEK (\approx 50 million USD, exchange rate 2013-06-28). On November 1, 2009, the trade margin on pharmaceutical products was increased by a fixed amount of 10 SEK per prescription of a generic product or a brand name product that was exposed to generic competition. This change increased the costs of the trade margin with approximately 460 million SEK (\approx 64 million USD, exchange rate 2013-06-28). The purpose of this change was twofold. The decision makers wanted to promote generic substitution and also increase the compensation for the pharmacies in order to increase the number of pharmacies in Sweden. From October 2009, the interpretation of cheapest available generic was changed from the cheapest product at the local pharmacy to the cheapest product in the market as a whole. The cheapest product, called "product of the month" was determined by the DPBA in an auction where the lowest bid wins. Then, May 3, 2010, the number of products labeled "product of the month" has been increased to three, but the pharmacies are obliged to follow the DPBA ranking of the products and should only switch to one of the other two products in exceptional cases. Finally, in February 2010, the nationwide government owned monopoly that had been in effect since 1969 was abolished, and the NCSP was exposed to competition from other pharmacy chains. However, it should be noted that since prices on prescription pharmaceuticals were still regulated, competition between pharmacies was mainly in the pricing of OTC-drugs, but also in opening hours, quality of service, etc.

3 Statistical method

3.1 Spatial dependence

In this paper, we use spatial econometrics to determine the extent of the market for pharmaceutical products in Sweden and to identify the impact of the new regulations introduced during 2009 and 2010. Spatial econometrics has traditionally been used in real estate-related research to model property prices and to identify the impact of amenities and/or disamenities on own and neighboring property values (Cohen and Coughlin 2008; Conway et al. 2010; Izón et al. 2010, among others). The fundamental concept of spatial econometrics is that of spatial dependence. In real estate-related research, spatial dependence implies that the value of each property is influenced not only by its own structural, neighborhood, and locational characteristics (e.g., the square footage of the land, the median household income in the neighborhood, or the distance to the city center), but also by the value of its neighboring properties. If observations $i = 1$ and $j = 2$ represent two neighboring properties, spatial dependence can be expressed as:

$$y_i = \rho_i y_j + \beta_{ik} X_{ik} + \varepsilon_i, \quad \varepsilon_i \sim N(0, \sigma^2) \text{ and} \quad (3.1)$$

$$y_j = \rho_j y_i + \beta_{jk} X_{jk} + \varepsilon_j, \quad \varepsilon_j \sim N(0, \sigma^2), \text{ where} \quad (3.2)$$

$i = 1, \dots, n$ and $j = 1, \dots, n$, where n is the number of properties in the sample; $k = 1, \dots, l$, where l is the number of explanatory variables in the model; y_i and y_j are the values of the two properties; X_i and X_j are vectors of explanatory variables; ρ_i , ρ_j , β_i , and β_j are regression coefficients; and ε_i and ε_j are regression error terms, normally distributed with zero mean and a constant variance of σ^2 . Equations (3.1) and (3.2) show that the data is simultaneously generated, with the value of y_i depending of the value of y_j and the other way around, or, in other words, that the analyzed phenomenon is impacted by spatial dependence, or spatial externalities.

Disregarding this phenomenon, researchers may use Ordinary Least Squares (OLS) to estimate regression parameters in their studies. One of the assumptions of traditional OLS modeling is that of independence of observations, or:

$$E(\varepsilon_i \varepsilon_j) = E(\varepsilon_i) E(\varepsilon_j) = 0. \quad (3.3)$$

This assumption does not hold in the presence of spatial externalities; consequently, the use of OLS produces biased and/or inconsistent coefficients estimates (Anselin 1988; LeSage 2008; Brown et al. 2009). To address this issue, OLS is replaced by a spatial regression model.

Although traditionally used for researching spatially-defined units such as like real estate properties, spatial econometrics has also been employed as a method for analyzing relationships between non-spatial units. Katz (1953) and Bonacich (1987) measure the degree to which an individual's status in a network is a function of those to whom he or she is connected. They use a weight matrix to describe network connections and construct a status index based on the status of the first- and higher-order "neighbors" in the network. The influence of higher-order "neighbors" is weighted down to allow for the lower effectiveness of longer chains. Black (1992) also investigates network autocorrelation: the dependence of variable values on given links to variable values on other links in the same network. He differentiates this from spatial autocorrelation: variable values at given locations being influenced by variable values at neighboring locations in a spatial context. He discusses the level of dependence in the residuals of an OLS model and corrects it by integrating an autoregressive term and, in a second model, by specifying the error term so as to involve a dependency structure. He then applies this method to study migration flows in the United States using a nonspatial network context. Sonis et al. (2001) analyze feedback loops in inter-regional trade in an attempt to identify within-nation trading blocks. They determine the economic interdependencies in inter-regional trade at different levels of aggregation and create functional maps of the hierarchy of trade feedback loops to illustrate regions of intense trade. Ballester et al. (2006) study Nash equilibriums in social networks using the spatial autocorrelation concept. They relate individual outcome to the position in the network of local interactions and discuss the aggregate equilibrium of the network and what happens when this equilibrium is disrupted. Blankmeyer et al. (2007) use nearest-neighbors-based spatial regression modeling to study salary benchmarking in the United States. Salary benchmarking is a practice that violates the assumption of independence in that it adjusts top-level management compensation to reflect salaries offered by peer institutions (those against which firms compete when hiring top-level management). Instead of using the spatial location of firms, Blankmeyer et al. define neighbors on the basis of groups of peer institutions (based on the size of the firms, production processes, and resource or product markets).²

² A description of studies focused on non-spatial structured dependence can be found in LeSage 2008.

To our knowledge, no study has previously used spatial modeling to determine the relevant product market for pharmaceuticals or to investigate changes in competition between pharmaceutical products due to regulatory changes. Our study fills in this gap and the first step in this process is to define the neighbors or, in our case, the competing products, and based on this definition to create a spatial weights matrix to be used in the spatial model. Our data are defined bi-weekly over 132 cross-sections from January 1, 2006 until June 30, 2011. The frequent occurrence of product entry and exit in each cross-section makes the use of a spatial model for the whole panel difficult; instead, we investigate results for each cross-section in part and graph the results against time to emphasize trends in price competition and the impact of price on quantity sold of pharmaceutical products on the Swedish market.

3.2 The spatial weight matrix

The spatial weight matrix is used to define neighbors or, in our study, products that are competing and that are consequently likely to have an impact on each other's prices and/or quantities sold. Pharmaceuticals commercialized on the Swedish market are classified according to the Anatomical Therapeutic Chemical classification system, and this will be used to create different spatial weight matrices.

The ATC system divides pharmaceuticals into categories according to their targeted organ/system and their therapeutic, pharmacological, and chemical properties. At the first level, the least detailed, drugs are divided into 14 main groups solely on the basis of their targeted organ/system. At the second, third, and fourth level, drugs are divided according to their therapeutic/pharmacological/chemical properties. At the fifth level, the most detailed, drugs are categorized by their active chemical substance (WHOCC 2012). For example, the code N02BA01 corresponds to acetylsalicylic acid, commonly known as aspirin. According to the ATC system, this code shows that acetylsalicylic acid impacts the nervous system (**N**), is an analgesic (**02**), belongs to "other analgesics and antipyretics" subgroup (**B**) and to its subdivision "salicylic acid and derivatives" (**A**), and that its active chemical component is acetylsalicylic acid (**01**):

N Nervous system - 1st level: anatomical main group

02 Analgesics - 2nd level: therapeutic subgroup

B Other analgesics and antipyretics - 3rd level: pharmacological subgroup

A Salicylic acid and derivatives - 4th level: chemical subgroup

01 Acetylsalicylic acid - 5th level: chemical substance

We have created weight matrices for each bi-weekly cross-section and ATC level using MATrix LABoratory (MATLAB) so that the relationship between two products is defined as 1 if they are competing products and 0 if they are not. Two products are defined as competing when belonging to the same ATC group. Assuming that we have five products competing to each other as it follows: P1 with P2 and with P3, and P4 with P5, the first-order contiguity weight matrix would be created as:

$$M = \begin{pmatrix} & P1 & P2 & P3 & P4 & P5 \\ P1 & 0 & 1 & 1 & 0 & 0 \\ P2 & 1 & 0 & 1 & 0 & 0 \\ P3 & 1 & 1 & 0 & 0 & 0 \\ P4 & 0 & 0 & 0 & 0 & 1 \\ P5 & 0 & 0 & 0 & 1 & 0 \end{pmatrix} \quad (3.4)$$

The spatial matrix M is symmetrical (if $P1$ competes with $P2$, then $P2$ competes with $P1$) and has zero values on its diagonal, since a product cannot compete with itself. The matrix M can be standardized to have row sums of unity, generating the row-standardized spatial weights matrix W :

$$W = \begin{pmatrix} & P1 & P2 & P3 & P4 & P5 \\ P1 & 0 & 1/2 & 1/2 & 0 & 0 \\ P2 & 1/2 & 0 & 1/2 & 0 & 0 \\ P3 & 1/2 & 1/2 & 0 & 0 & 0 \\ P4 & 0 & 0 & 0 & 0 & 1 \\ P5 & 0 & 0 & 0 & 1 & 0 \end{pmatrix} \quad (3.5)$$

The row-stochastic spatial weights matrix W is then multiplied by a 5×1 vector Y representing the dependent variable to produce a spatial lag of the dependent variable taking the vector form WY , which is a linear combination of the values of the dependent variable Y from the neighboring observations. The spatial lag is then used in the spatial regression model. In our study, Y represents a vector of price or quantity sold of each pharmaceutical product:

$$WY = \begin{pmatrix} & P1 & P2 & P3 & P4 & P5 \\ P1 & 0 & 1/2 & 1/2 & 0 & 0 \\ P2 & 1/2 & 0 & 1/2 & 0 & 0 \\ P3 & 1/2 & 1/2 & 0 & 0 & 0 \\ P4 & 0 & 0 & 0 & 0 & 1 \\ P5 & 0 & 0 & 0 & 1 & 0 \end{pmatrix} \begin{pmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \\ y_5 \end{pmatrix} = \begin{pmatrix} (y_2 + y_3)/2 \\ (y_1 + y_3)/2 \\ (y_1 + y_2)/2 \\ y_5 \\ y_4 \end{pmatrix} \quad (3.6)$$

By standardizing the spatial weight matrix we compare the value of the spatial lag coefficient ρ to 1 when reading the regression results, which is easy to interpret. The spatial lag coefficient shows the strength of spatial dependence and is estimated in the spatial regression model with the aid of the spatial weights matrix.

As explained above, we define neighbors (competing products) according to the level of analysis. At the most detailed level of analysis we define drugs with the same seven-digit ATC code (e.g., all drugs coded as N02BA01) as neighbors, or, in other words, as competing. Consequently, the corresponding element in the matrix M (at the intersection of any row and column corresponding to two competing products) is 1. When moving up one step we define drugs with the same five-digit ATC code (e.g., all drugs coded as N02BA) as competing, and so on.

3.3 The Moran's I statistic

To determine the level and significance of competition between pharmaceutical products we first use the Moran's I statistic. This is the most common descriptive measure of spatial dependence and thus an indicator of the relationship between each item and its neighbors. In our case, the Moran's I statistic is firstly used to determine whether changes in prices of pharmaceutical products are interrelated within the various pharmaceutical groups; secondly, the Moran's I is used as an indicator of the magnitude and significance of the price relationship between competing products (and later of the relationship between quantities sold of pharmaceutical products). The Moran's I is given by the expression:

$$I = \frac{N}{\sum_i \sum_j w_{ij}} \times \frac{\sum_i \sum_j w_{ij} \times (X_i - \bar{X})(X_j - \bar{X})}{\sum_i (X_i - \bar{X})^2}, \text{ where} \quad (3.7)$$

N is the number of analyzed units; X is the variable of interest (e.g., unit price); \bar{X} is the mean of the variable X ; w_{ij} are elements of the spatial weight matrix W ; and $i = 1, \dots, n$ and $j = 1, \dots, n$, where n is the number of observations.

The value of the Moran's I statistic falls in between -1 and 1. A positive value indicates positive spatial autocorrelation. If price is the variable of interest and we consider the fact that we calculated Moran's I values on price differences between two successive time periods, a high positive value of the Moran's I statistic indicates that if the price of a product increases between two successive time periods, it is likely that the price of

competing products also increases. The opposite is also true: if the price of a product decreases, it is likely that the price of competing products also decreases. A negative value of the Moran's I statistic indicates negative spatial autocorrelation. In other words, if a price of a product increases, the price of competing products decreases and the other way around. If Moran's I value is equal to -1, a map of the value of interest (e.g., price changes) for the analyzed units (e.g., pharmaceutical products) would look like a check board, with black representing increase in value and white representing decrease in value. A statistically significant Moran's I indicates significant autocorrelation between the analyzed units. If the value of Moran's I is not statistically significant we can conclude that there is no autocorrelation between the analyzed items at the significance level chosen for analysis.

In our study the Moran's I is used as a first indicator for the extent of the market. We investigate whether there is price competition between pharmaceutical products at each ATC level by calculating the corresponding Moran's I. If we find that the Moran's I for price changes has a high positive and significant value this means that products with that same ATC code are competing in the sense that if one product lowers its price the other products follow suit, and thus belong to the same market. We start by investigating whether there is significant price competition between products with the same seven-digit ATC code, as for example, products coded N02BA01 "acetylsalicylic acid": Albyl minor, Aspirin, Bamyl, and Magnecyl brus (WHOCC 2012). We expect strong competition at this level, since many of these medicines are close substitutes, and since previous literature have in most cases found strong competition on this level. We then move one level up to investigate competition between drugs which have the same first five digits of their ATC code. In other words, at this level we analyze price competition between drugs that belong to the same chemical subgroup, as for example drugs in the category N02BA "salicylic acid and derivatives". The third step is to investigate price competition between drugs with the same first four digits of their ATC code, as for example drugs in the group N02B "other analgesics and antipyretics". The second last step is to consider products with the same first three digits of their ATC code, for example N02 "analgesics". The last step is to investigate competition between drugs pertaining to the main therapeutic groups (same first digit of their ATC code). We expect that at one point between the first and the last level in the analysis, competition between pharmaceuticals weakens sufficiently so that we can define the boundaries of the market for pharmaceuticals in Sweden.

The extent of the market is thus defined by that level where the Moran's I statistic becomes either so small that it does not have any economic significance or when it becomes insignificant at the 95 percent confidence level. There are no studies that define high/low Moran's I values and thus strong/weak autocorrelation. However, since the Moran's I is a type of correlation coefficient measuring the strength of the relationship between each observation and its neighbors, we argue, in accordance to Connolly (2007), that a Moran's I value lower than 0.3 denotes weak product space dependence, a value between 0.3 and 0.6 denotes moderate product space dependence, and a value higher than 0.6 denotes strong product space dependence. Consequently, we imply that a value of Moran's I that is insignificant or lower than 0.3 indicates very weak or no price competition. Thus, the market extent is defined by values of Moran's I that are both statistically significant and higher than 0.3.

3.4 The spatial Durbin model

To analyze the impacts of the new regulations introduced in 2009 and 2010 regarding the sale of pharmaceuticals on the Swedish market we have chosen to use a spatial Durbin model (SDM). The need for the use of a SDM arises from the likely presence of omitted variables that may be correlated with the included variables. LeSage and Pace (2009) show that the presence of an omitted variable that exhibits spatial dependence and is correlated with one of the included explanatory variables requires the use of a spatial model that includes both a spatial lag of the dependent variable and of the explanatory variables (see also Kirby and LeSage 2009). LeSage and Pace (2009), as well as Escobar (2011), also show that the SDM subsumes not only the Spatial Error Model (SEM) and the Spatial Autoregressive (SAR) model, but also the spatial lag of X model (SLX) and OLS. Economic theory also shows that, while the impact of a change in price on quantity sold of a product is usually negative, the impact of the same change in price on quantity sold of other products can be either positive or negative depending on if the products are substitutes or complements. These potentially complex relationships could not be modeled with the use of, e.g., a spatial autoregressive model (SAR), because in a SAR model the direct (the impact of a change in price on quantity sold of a product - or the own-price elasticity of demand) and the indirect effects (the impact of the same change in price on quantity sold of the competing products - or the cross-price elasticity of demand) have the same sign; furthermore, the ratio between the indirect and direct effects is the same in a SAR model for every explanatory variable (LeSage and Pace 2009; Elhorst 2012; Pace and Zhu 2012).

The general form of the SDM is:

$$Y = \rho WY + X\beta + WX\theta + \iota_n\alpha + \varepsilon, \text{ where} \quad (3.8)$$

Y is the dependent variable (quantity sold, in our study); WY is the spatial lag of the dependent variable; ρ is the spatial lag coefficient for the dependent variable; X represents a vector of the explanatory variables of the model; β represents a vector of coefficient estimates, indicating the strength and direction of the impact of the explanatory variables on Y ; WX is the spatial lag of the explanatory variables; θ is the spatial lag coefficient for the explanatory variables; $\iota_n\alpha$ is a vector of constant terms; ε is the error term, $\varepsilon \sim N(0, \sigma^2 I_n)$; and n is the number of observations.

Based on (3.8), the spatial Durbin model can be rewritten as:

$$(I_n - \rho W)Y = X\beta + WX\theta + \iota_n\alpha + \varepsilon. \quad (3.9)$$

Solving for Y we obtain the data generating process for the SDM:

$$Y = \sum_{k=1}^l S_k(W)x_k + V(W)\iota_n\alpha + V(W)\varepsilon, \text{ where} \quad (3.10)$$

$$S_k(W) = V(W)(I_n\beta_k + W\theta_k) \text{ and} \quad (3.11)$$

$$V(W) = (I_n - \rho W)^{-1} = I_n + \rho W + \rho^2 W^2 + \rho^3 W^3 + \dots \quad (3.12)$$

As LeSage and Pace (2009) explain, the matrix product WX reflects a linear combination of the explanatory variables from neighboring regions. The power of the matrix W^2X creates a linear combination of second-order neighbors (neighbors of neighbors). The powers of the matrix W in $V(W)$ will form linear combinations based on neighbors of neighbors for each observation. Since the diagonal elements of the matrix W^k , $k > 1$, are not zero (units can be neighbors to their neighbors), a change in observation i will determine an impact on second-order and higher-order neighboring observations and back to i , or, in other words, feedback effects (LeSage and Pace 2009, 2012). Expanding the relationship in (3.10) we obtain:

$$\begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix} = \sum_{k=1}^l \begin{pmatrix} S_k(W)_{11} & S_k(W)_{12} & \cdots & S_k(W)_{1n} \\ S_k(W)_{21} & S_k(W)_{22} & \cdots & S_k(W)_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ S_k(W)_{n1} & S_k(W)_{n2} & \cdots & S_k(W)_{nn} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{pmatrix} + V(W)l_n\alpha + V(W)\varepsilon. \quad (3.13)$$

In linear regression, the parameters have a straightforward interpretation as the partial derivative of the dependent variable y_i with respect to the explanatory variable x_{ik} , is $\beta_k = \delta y_i / \delta x_{ik}$, for all i and k , while the partial derivative of y_i with respect to any x_{jk} so that $j \neq i$ is zero, $\delta y_i / \delta x_{jk} = 0$. In the case of the SDM the

derivative of y_i with respect to x_{ik} does not equal β_k because of the presence of feedback effects and the derivative of y_i with respect to x_{jk} , $\delta y_i / \delta x_{jk} = S_k(W)_{ij}$, takes a value determined by the i,j th element of the

matrix $S_k(W)$ and it is potentially non-zero. This implies that a change in the explanatory variable (for example the price of a product) for a single observation can potentially affect the dependent variable (quantity sold) in neighboring regions (competing ATC-codes), which represents the fundamental idea of spatial econometrics. Thus, the partial derivative cannot be interpreted the same as in linear regression. The own derivative for the i th region includes the feedback effects where observation i affects observation j and observation j also affects observation i . The feedback effects may be determined along longer paths as well, i.e., from observation i to observation j to observation k and back to observation i (LeSage and Pace 2009).

As LeSage and Pace (2009) explain, a change in a single observation associated with any given explanatory variable will affect the dependent variable associated to the respective observation (a direct impact) and potentially affect all other observations indirectly (indirect impact). Thus, the direct impact represents the changes in the i th observation of x_k (x_{ik}) on y_i and it includes the feedback effects (general equilibrium effects in economic terms) discussed above. The indirect impact represents the impact on the j th observation's dependent variable y_j from a change in the k th explanatory variable of observation x_k (x_{ik}). The total impact to an observation represents the impact on the individual observation y_i from changes in the k th explanatory variable by the same amount across all observations (if averaging on columns). The total impact can also be read as the impact over all y_i from changing the k th explanatory variable by an amount in the j th observation (if averaging on rows). Either way of calculating the total impact yields the same result. The total impact less the direct impact yields the indirect impact. All the impacts are defined as averages in the sense that they represent

means of the main diagonal (the direct effect) or of the off-diagonal (indirect effect) elements of the matrix $S_k(W)$ (LeSage and Pace 2009). From the economic theory viewpoint, the direct effect is expected to be positive in our study as this is closely related to the own-price elasticity of demand, while the indirect effect is expected to be negative since this is similar to the cross-price elasticity of demand. Following Kirby and LeSage (2009), we can explain that the difference in interpretation of SDM coefficients as compared to an ordinary regression model such as OLS is that the latter would make the prediction that a change in the price of a product x_i will affect only the quantity sold of product i , not allowing for spatial spillover impacts, while our model does.

4 Data and descriptive statistics

4.1 Data and explanatory variables

The data used in this study has been provided by IMS Sweden and it contains an unbalanced panel of all pharmaceutical products sold in Sweden. The panel is defined bi-weekly over 132 periods from 1 January 2006 to 30 June 2011 and it includes 269,406 observations, one for each product and analyzed period.

The dependent and explanatory variables used in the analysis are defined in Table 1, while Table 2 presents some of their descriptive statistics. Apart from these variables, the seven-digit to one-digit ATC codes for each pharmaceutical product are also available. Our model uses the natural logarithm of the quantity sold as dependent variable since our estimation and inference methods require a normally distributed dependent variable. Furthermore, we also use a natural logarithm of price per unit so that we can interpret the regression results as elasticities that indicate the impact of price changes on quantity sold of own and competing products.

Table 1 Variable definition

Name	Definition
Dependent variable units	Natural logarithm of quantity sold (in units).
Explanatory variables price	Natural logarithm of price paid to the producer (per unit).
import	Dummy variable equal to 1 if the product is parallel-imported from another European Union country, 0 otherwise.
prodtype	Dummy variable defining product type:
bgn	1 if product type is branded generic, 0 otherwise;
org	1 if product type is original (branded), 0 otherwise;
oth	1 if product type is different than the above, 0 otherwise.

Each pharmaceutical product is included in one of four groups: generic, branded generic, original, or other. The first category is the baseline and thus has been excluded from the regression model to avoid perfect multicollinearity.

Overall standard deviation (Std.Dev.) refers to the whole dataset. Between standard deviation refers to the variation of the means across time periods. Within refers to the variation of the means across individuals. These also apply to the minimum and maximum values (Min and Max). The negative amounts corresponding to Min are not to say that we have, for example, negative prices. Instead, the within number refers to the deviation from each individual's average. Consequently, some of these deviations are negative (StataCorp 2007). There are 269,406 total observations in our sample and 4,493 pharmaceuticals products analyzed.

Table 2 Descriptive statistics of the dependent and explanatory variables

Name		Mean	Std.Dev.	Min	Max
units	overall	2.4636	2.0210	0	10.9540
	between		1.1841	0	6.9897
	within		1.7324	-4.5262	10.7526
price	overall	4.4048	1.3856	-1.6094	10.0715
	between		1.3786	0.9439	10.0715
	within		0.4658	-1.4429	8.2698
import	overall	0.0820	0.2744	0	1
	between		0.3273	0	1
	within		0.0064	-0.0031	0.9987
bgn	overall	0.1003	0.3004	0	1
	between		0.3145	0	1
	within		0.0394	-0.8694	1.0675
org	overall	0.3273	0.4692	0	1
	between		0.4540	0	1
	within		0.0193	-0.6363	1.1145
oth	overall	0.0209	0.1430	0	1
	between		0.1239	0	1
	within		0	0.0209	0.0209

4.2 Moran's I as indicator of simultaneous price change

A first question that we are investigating is whether there is a relationship between the changes in prices of pharmaceutical products from one period to the next. Given the highly unbalanced panel we are dealing with, we consider both the magnitude and the significance of the cross-sectional Moran's I values a good indication of change when calculated for price differences: $diff = p(t) - p(t - 1)$, where p is the price per unit and $t, t - 1$ are two successive time periods (not necessarily consecutive, since some products are not sold in all time periods).

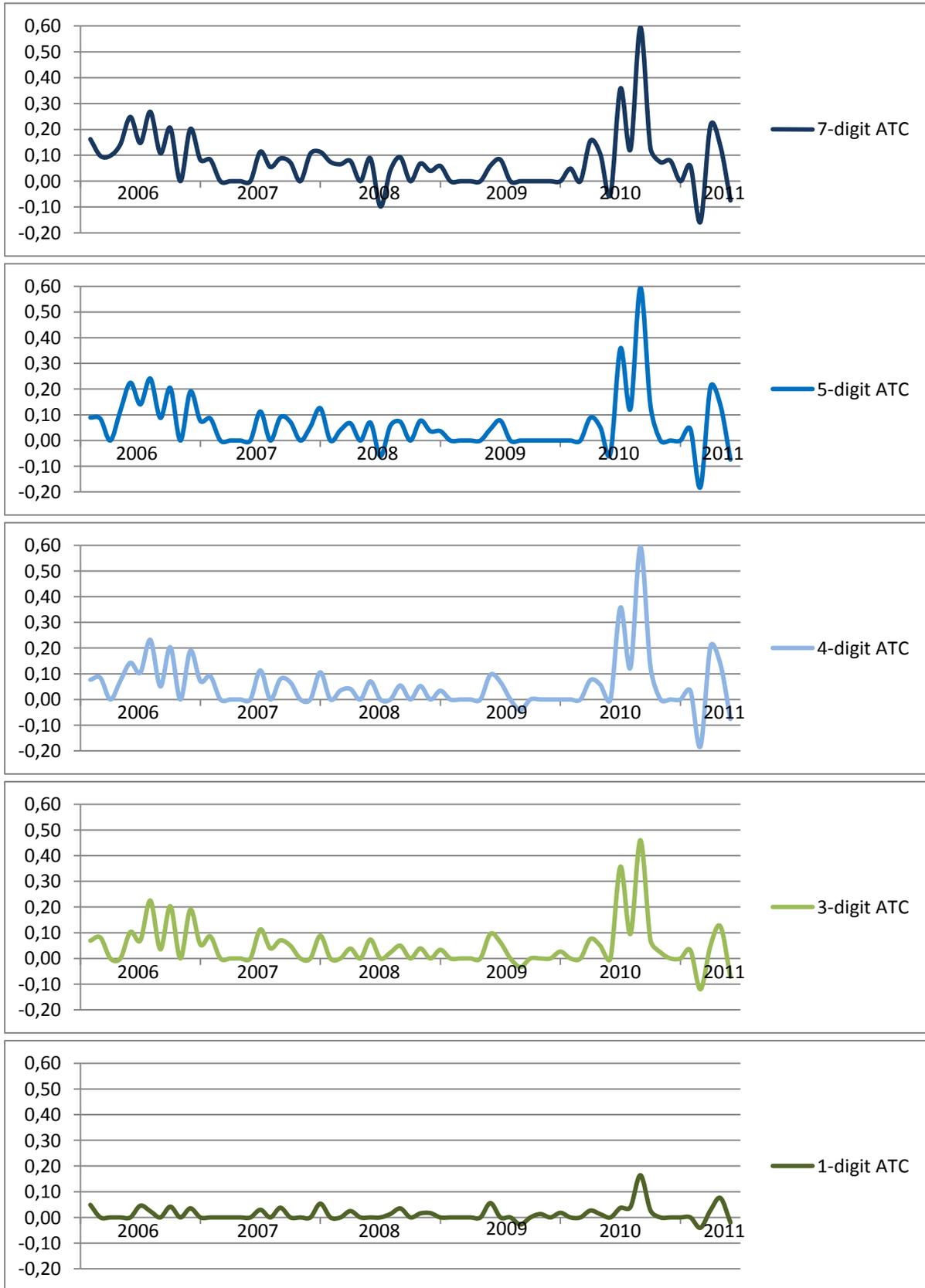


Fig. 1 Moran's Is for price differences, calculated for all ATC codes

Figure 1 illustrates the statistically significant values of the Moran's Is for price differences; those values that were not statistically significant show as zero in the graphs. According to the results, price changes for pharmaceuticals show a certain degree of positive autocorrelation. This autocorrelation is stronger at the seven-digit ATC level than at the other levels, meaning that the interdependence of changes in prices between close substitutes is, as expected, stronger. There is almost no correlation between prices of pharmaceuticals at the one-digit ATC level.

The values of the Moran's Is are generally quite low³, but mostly positive, except for a few isolate instances. There is a clear jump in these values in 2010, which could indicate a simultaneous decrease in prices as a response to the regulation changes implemented in 2009 and 2010. More insight into this matter is given by the analysis of the mutual interrelations between individual prices, which follows in the next section.

4.3 Moran's I associated with price per unit

As discussed, the Moran's I statistics associated with price per unit help us determine the extent of the market for pharmaceuticals in Sweden. In a perfectly competitive market with perfect substitutes all products should have the same price in all time periods, i.e., the Moran's I would then be one in all time periods.

We calculate the Moran's I values for each product and time period. Figure 2 illustrates the results, which show significant dependence between prices of pharmaceutical products at all ATC levels. However, for the three-digit and one-digit ATC levels the Moran's I are lower than 0.3 and thus indicate that the law of one price clearly does not hold, and we interpret this as weak price competition. We can thus conclude that price competition on the pharmaceuticals market in Sweden extends to the four-digit ATC level inclusive. Figure 2 also indicates a reaction of the market to the policy changes that were implemented in 2009 and 2010 in the form of a turbulence that occurs in the beginning of 2010, when there is a sudden drop in the correlation of prices in the Swedish pharmaceuticals market at the seven-, five-, and four-digit ATC levels, which lasts for almost half year before the market recovers and the correlation suddenly increases to return to levels similar to the period before the implementations of the new regulations.

³ The low Moran's I values may be due to the fact that changes in prices as a result of price competition may occur in different time periods for different products (e.g., in subsequent time periods). By using the cross-sectional Moran's Is we only investigate simultaneous price changes.

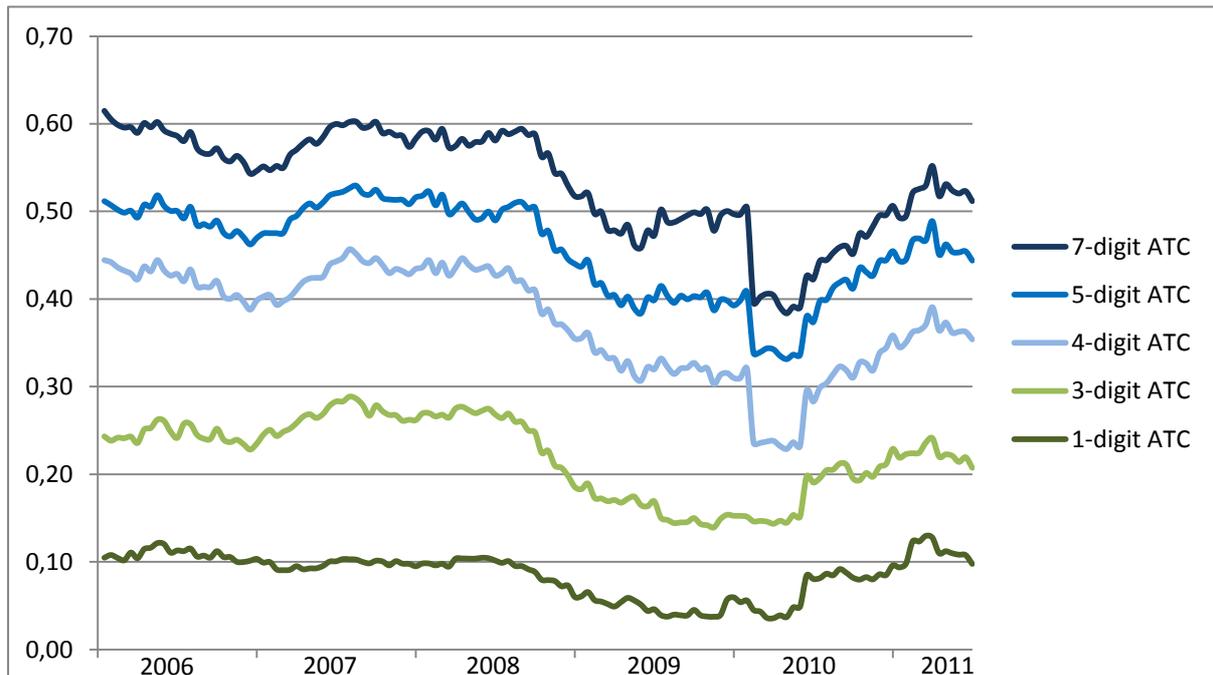


Fig 2 Moran's I values associated with price per unit, calculated for all ATC codes

4.4 Moran's I and spatial lag coefficients associated with quantity sold

For the three ATC-code levels for which we have determined that the products belong to the same market, we further calculate the Moran's I values associated with quantity sold. As the quantity sold at a specific period in time is mostly related to a product being the "product of the month" and thus catering to approximately 80 percent of a given seven-digit ATC-code exchange group (Tillväxtanalys 2012), we expect that the Moran's I for quantity sold will be low, and this is also what we find. However, although low (Figure 3), these Moran's I values are still statistically significant and consequently they justify the use of a spatial model to determine the impact of prices on quantity sold.

This result is supported by the values of the scalar parameter ρ (the spatial lag coefficient for the dependent variable), which is another measure of the overall strength of spatial dependence between the observations in the dataset (Kirby and LeSage 2009) and which can be estimated with the aid of any spatial autoregressive model (Figure 4). The bounds of the spatial lag coefficient are $-1/w_{min}$ and 1, where w_{min} is the smallest characteristic root of the spatial weights matrix (Elhorst 2010). It's interpretation is similar with that of the Moran's I statistic: a positive spatial lag coefficient illustrates positive product space spillovers between the units of analysis as regards the variable of interest (quantity sold), while a negative ρ parameter illustrates negative spatial spillovers between the units of analysis as regards the variable of interest. In our case, a positive and significant

rho parameter associated with the dependent variable indicates that, to a certain extent, products registering high quantities sold are competing with other products registering high quantities sold, while products with low quantities sold are competing with other products with low quantities sold. However, the values of rho are quite low (generally lower than 0.40). They are also significant for most of the cross-sections, indicating the presence of spatial spillovers and supporting the use of a spatial regression model. A break occurs mid-2009, when the new regulations have been implemented, which determined the spatial lag coefficient for all three ATC levels analyzed here to change from constant to slightly upward trending.

Following Brown et al. (2009), when rho is very small or close to zero the spatial Durbin model collapses to the spatial cross-regressive model (also known as SLX, the spatial lag of X model), which can be estimated using OLS. However, if rho is statistically significant, results from the cross-regressive model will be biased and inconsistent (Anselin 1988). In this case, it is still the SDM that provides more reliable estimates.

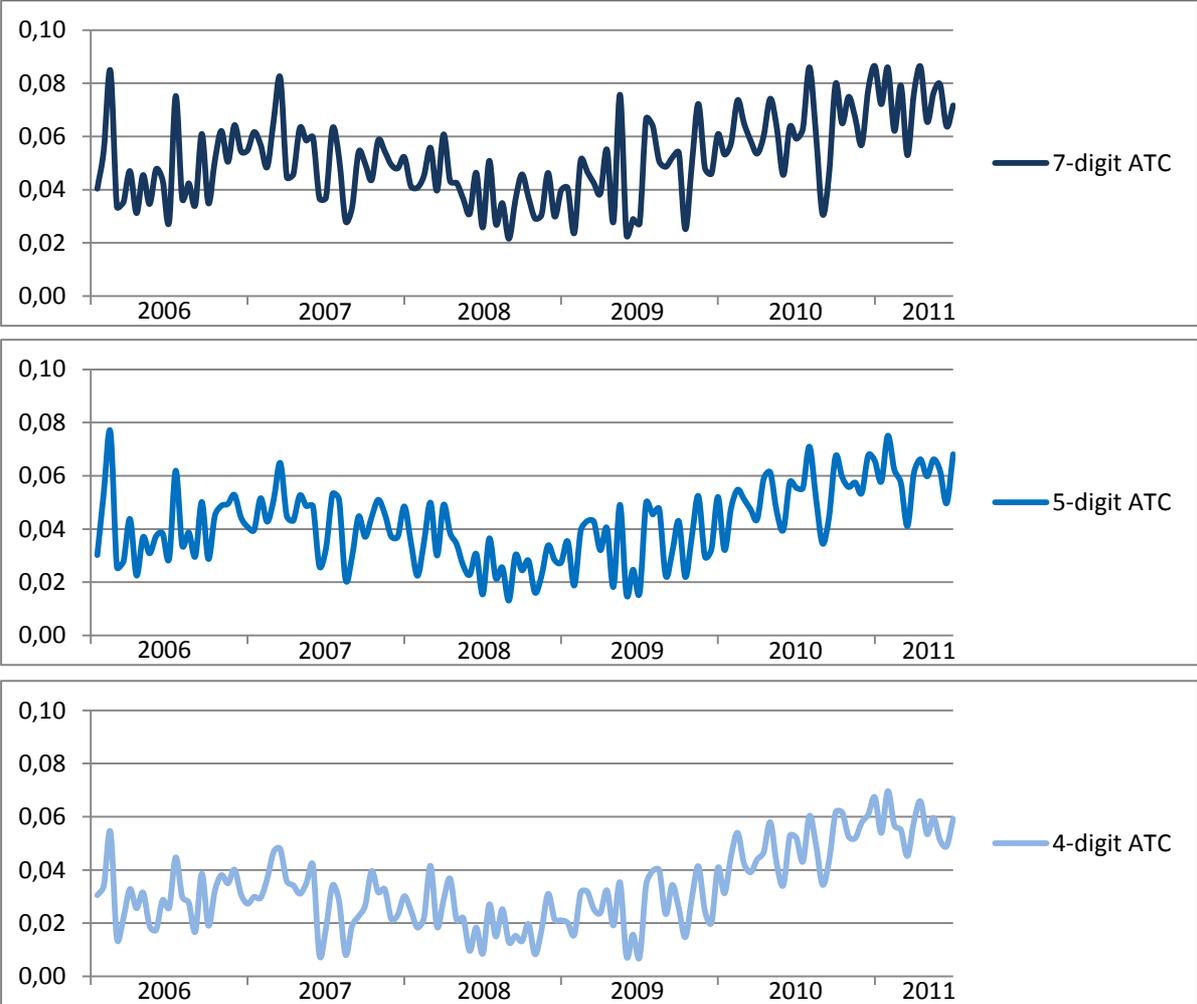


Fig 3 Moran’s I values associated with quantity sold, calculated for seven-, five-, and four-digit ATC codes

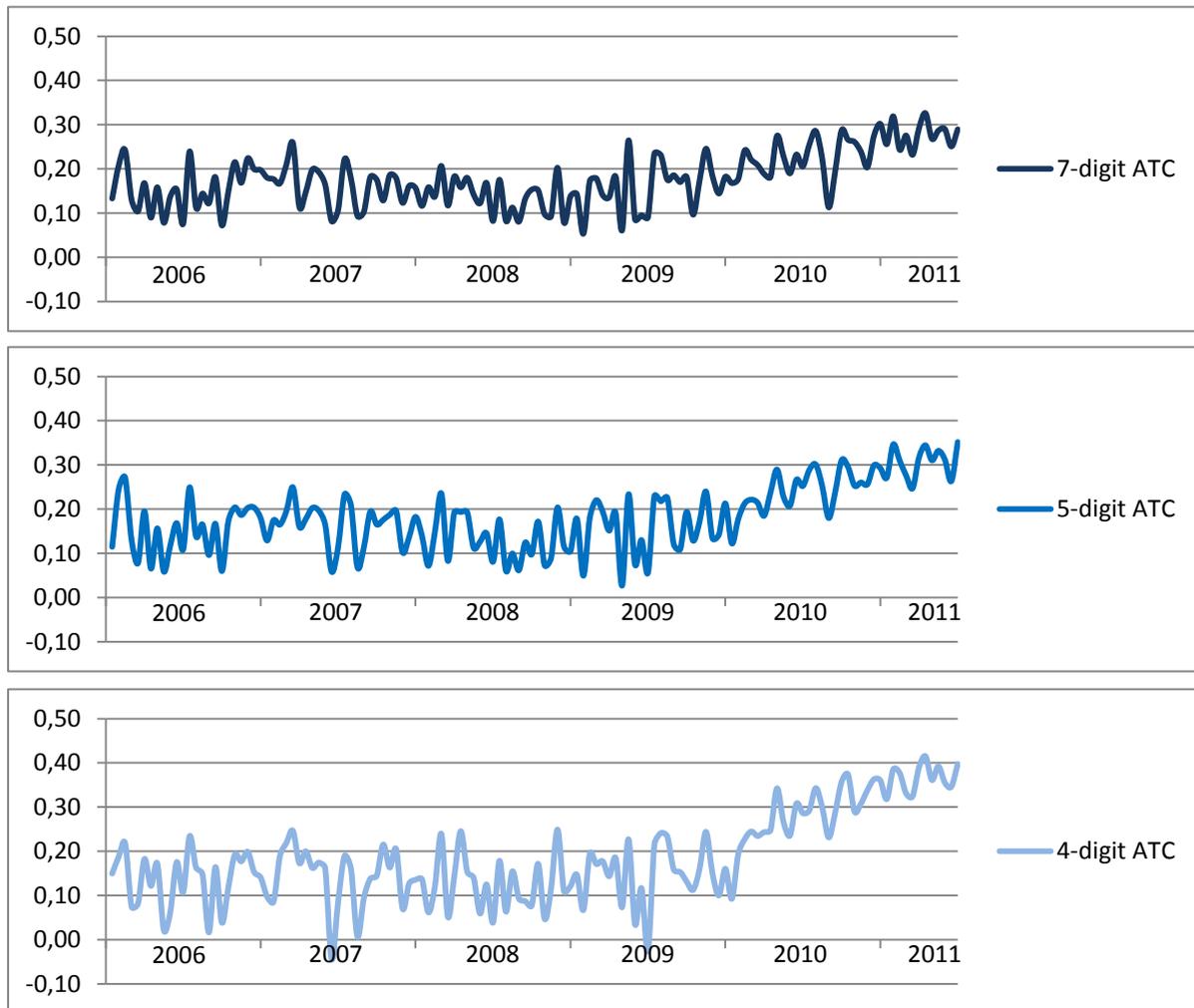


Fig 4 Values of the spatial lag coefficients associated with quantity sold, calculated for seven-, five-, and four-digit ATC codes

It must be mentioned here that the spatial lag coefficient, as well as the Moran's I, are static measures, in the sense that they reflect steady state equilibriums. This means that if we have a high and significant Moran's I value (or rho parameter, for that matter), we can argue that, at a certain point in time and to a certain extent (determined by the magnitude of this value), competing products have similar prices and sell in similar quantities. As expected, the relationship between prices of competing products is much stronger than the relationship between quantities sold of competing products due to the "product of the month" system. However, based on these values we cannot tell how a change in the price/quantity sold of a product will impact the price/quantity sold of competing products or how the relationship between prices/quantities sold of competing products changes over time. An idea of the simultaneous variation in price changes is given in section 5 below where some causal interpretations are provided by the regression model in the form of the direct, indirect, and total effects.

5 Results and discussion

To determine the impact of price on quantity sold of pharmaceutical products in the presence of product space dependence, before and after the policy changes that took place in 2009 and 2010, we calculate the direct, indirect, and total price effects for the four-, five-, and seven-digit ATC levels (which according to our analysis define the extent of the market for pharmaceuticals in Sweden) and all available time periods (January 2006 to June 2011) on a bi-weekly basis. We use a Bayesian Markov Chain Monte Carlo method (MCMC) that provided 5,000 draws to calculate standard deviations from the posterior distribution of the effect estimates. The standard deviations are further used to calculate t-statistics and marginal probabilities on which inferences about the significance of the direct, indirect, and total effects are based. It has been previously shown that these draws can provide valid inferences in non-linear functions of these parameters (Gelfand and Smith 1990; Gelfand et al. 1990; Kirby and LeSage 2009).

The variables have been used in their demeaned form in the MCMC model to account for any time-invariant heterogeneity affecting both prices and demand for different pharmaceuticals. Given the highly-unbalanced panel we are dealing with, repeated cross-sectional analysis has proved a more appropriate form of analysis. However, by demeaning, the average values for each variable (both dependent and explanatory) are subtracted from the observed values of the respective variable. Consequently, within each time period, the mean of each demeaned variable is zero. This operation eliminates all between-periods variability and leaves in only the within-period variability to analyze (Studenmund 2005, Chapter 16, p. 528-530). This is an innovation and a step forward from pure cross-sectional analysis towards panel data analysis. Results of the spatial Durbin model for one of the cross-sections (the second half of May 2011) are presented for exemplification in Table 3.

Reading through the direct impacts, we note that only those for price, import, and original product type are significant at the 95 percent confidence level at the seven-digit ATC code. At this level, a 10 percent increase in the price of a product determines a 3.11 percent decrease in the quantity sold of the respective product; parallel imported substitutes are sold at a 73.66 percent discount, while branded products imply a 36.91 percent higher price on average. On the other hand, increasing the price of the product by 10 percent determines a 1.62 percent increase in the quantity sold of competing products (close substitutes, in this case). The results for the five- and four-digit ATC levels are similar. We note that the direct impact of a change in price at these levels is lower than at the seven-digit ATC level (a 10 percent increase in price causes a 2.75 and 2.61 percent decrease in demand,

respectively). The indirect effects of price are not significant any longer, which indicates that price competition is only present amongst close substitutes.

Table 3 Results of the spatial Durbin model for the second half of May 2011 at the seven-, five-, and four-digit ATC levels

Direct impact	ATC 7			ATC 5			ATC 4		
	Coefficient	Lower 05	Upper 05	Coefficient	Lower 05	Upper 05	Coefficient	Lower 05	Upper 05
price	-0.3106**	-0.3865	-0.2356	-0.2751**	-0.3507	-0.2012	-0.2610**	-0.3332	-0.1920
import	-0.7366**	-1.1969	-0.2716	-0.4968**	-0.9396	-0.0537	-0.5744**	-0.9688	-0.1746
bgn	-0.0712	-0.3305	0.1818	-0.0686	-0.3247	0.1781	-0.0053	-0.2382	0.2332
org	0.3691**	0.1624	0.5742	0.4202**	0.2164	0.6214	0.4188**	0.2175	0.6147
oth	-1.5530	-5.5953	2.5910	-0.8223	-1.8314	0.2340	-0.8621	-1.7799	0.0650
Indirect impact									
price	0.1617**	0.0281	0.2912	0.1073	-0.0359	0.2506	0.0828	-0.0844	0.2459
import	-0.6944	-1.7632	0.3396	-1.4587**	-2.6711	-0.2718	-1.6038	-3.3270	0.0360
bgn	0.4829	-0.0246	0.9973	0.5598	-0.0208	1.1294	0.2115	-0.4673	0.8663
org	0.9405**	0.3867	1.5156	1.1249**	0.4354	1.8413	1.4531**	0.5395	2.4483
oth	2.1429	-2.1111	6.2141	1.8112**	0.3790	3.2207	2.0137**	0.6676	3.3550
Total impact									
price	-0.1489**	-0.2703	-0.0351	-0.1679**	-0.3047	-0.0424	-0.1782**	-0.3359	-0.0248
import	-1.4310**	-2.4872	-0.4617	-1.9555**	-3.1951	-0.7688	-2.1782**	-3.9102	-0.5285
bgn	0.4116	-0.0703	0.9015	0.4912	-0.0604	1.0481	0.2062	-0.4547	0.8568
org	1.3096**	0.7443	1.8970	1.5451**	0.8564	2.2617	1.8719**	0.9495	2.8683
oth	0.5904	-0.1876	1.4279	0.9889**	0.0434	1.9828	1.1516**	0.0920	2.2517

** Significant at the 95 percent confidence level.

Figure 5 illustrates these direct, indirect, and total price effects on quantity sold for pharmaceutical products defined as competing on the basis of the seven-, five-, and four-digit ATC codes for all analyzed cross-sections. The direct effect represents the marginal effect (the effect of a change in price on quantity sold of the same product) plus the feedback effect (the effect of a change in the price of a product on the quantity sold of the competing products, which in turn affects the quantity sold of the respective product). As expected, the direct effect, which is closely related to the own-price elasticity of demand, is negative and significant for almost all the cross-sections included in analysis.⁴

For the seven-digit ATC code, the average of the direct effect over all time periods is -0.22 for those periods when the direct effect is significant. Figure 5 shows a slight drop in the direct effect after 1 July 2009, when the

⁴ The difference is that usually the calculated own-price elasticities of demand do not contain feedback effects while the direct effects in our calculations do.

first new regulations were enforced, which indicates that an increase in price leads to a more considerable decrease in quantity sold after the reference point (1 July 2009) than before it. On average over all analyzed time periods, the direct effect before 1 July 2009 is -0.20, while the average direct effect after 1 July 2009 is -0.26, which represents a 30 percent decrease, significant at the 99 percent confidence level. The feedback effect for the time period used for exemplification (the second half of May 2011) is -0.0038, which represents 1.73 percent of the direct effect. The feedback effects are calculated as the difference between the SDM coefficient estimate and the direct effect. Sometimes they are very small and not likely of economic significance (LeSage and Pace 2009). In our study, feedback effects are quite low over the entire study period. The absolute value of the feedback effects over all analyzed time periods is 0.0012 for those periods when the direct effect is significant (or 0.55 percent of the average direct effect).

The direct effect measures localized effects. The indirect effect measures the spatial spillovers. If both direct and indirect effects are significant we can argue that a change in price not only will impact the quantity sold of the own product, but will also spillover to the competitors. Following Escobar's line of thought (2011) we can show that the induced changes in the competitor will further spillover to the competitors of the competitors, including the product in which the change originated, i.e., there are so called general equilibrium effects. This process of adjustments continues until a new steady-state equilibrium is reached (Molho 1995; LeSage and Pace 2009).

The indirect effect, or the product space spillovers, represents the effect of a change in own price on the quantity sold of the competing products - or the cross-price elasticity of demand. For the same time period considered above, the indirect effect is 0.16 measured at the seven-digit ATC code. This means that a 10 percent increase in the price of a product determines a 1.6 percent increase in the quantity sold of the competing products, on average for all products in this cross-section. It is interesting to note a slight upward trend of the indirect effect, especially after 1 July 2009, which shows a strengthening of competition at this ATC level: a 10 percent increase in the price of a product determines a higher increase in the quantity sold of competing products after 1 July 2009 than before this reference point. The average for the significant effects over all analyzed time periods before 1 July 2009 is 0.04, while the average after 1 July 2009 is 0.16, which represents a 300 percent increase, significant at the 99 percent confidence level. As we will see in the following section, the indirect effect also becomes significant in many more of the analyzed cross-sections after this date than before the new regulations have been introduced. Although the results for the seven-, five-, and four-digit ATC codes look similar in Figure

5, Figure 6 shows that there is an important difference between them in the significance levels of the indirect effect.

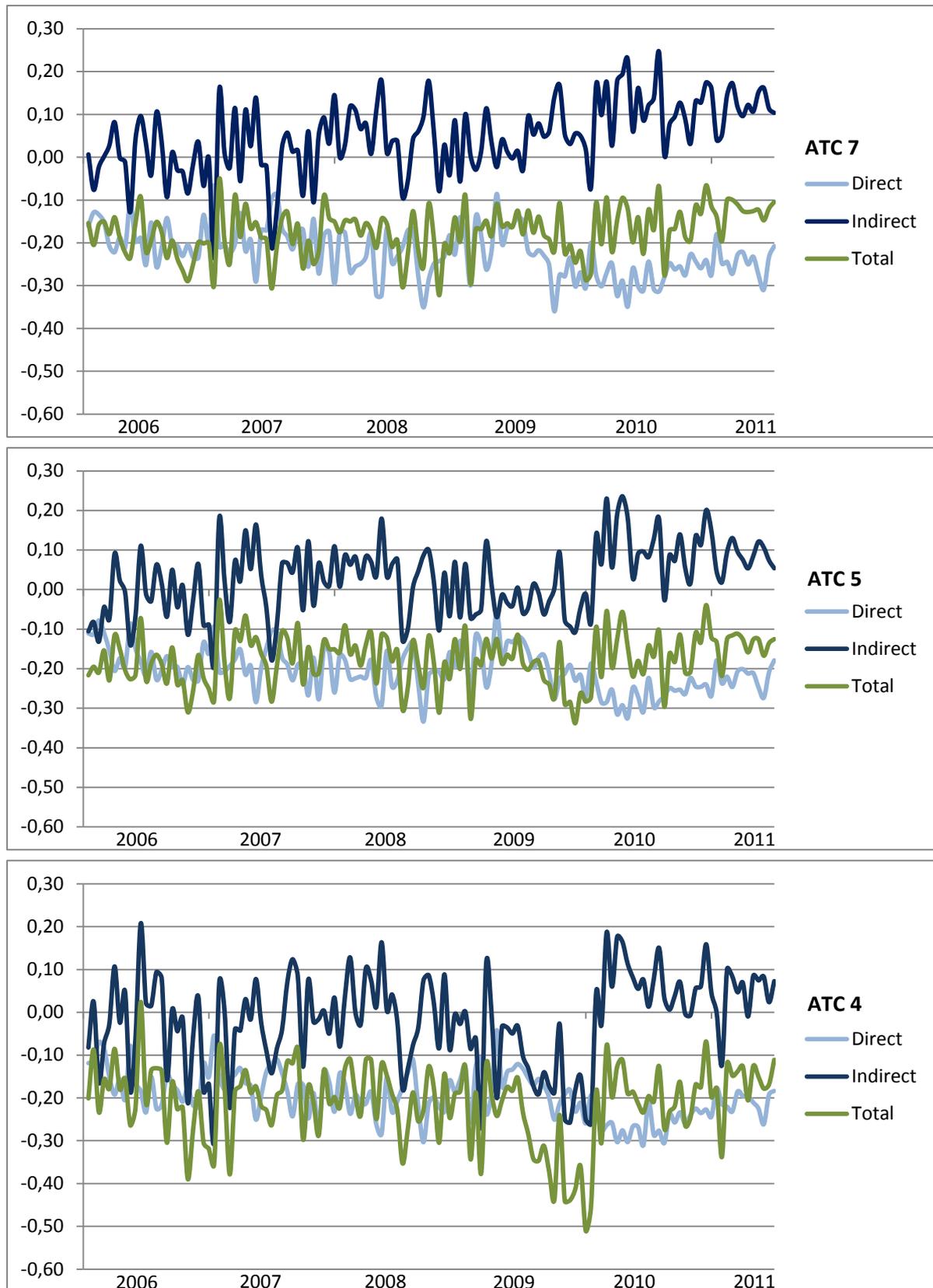


Fig 5 Direct, indirect, and total price effects on quantity sold, seven-, five-, and four-digit ATC codes

A look at the significance of the indirect effect offers a better idea of the changes the market for pharmaceuticals has gone through after the new regulations have been implemented. T-statistics have been calculated from a set of 5,000 simulated parameter values. Although not so visible at the 95 percent confidence level, when investigating the significance of the indirect effect at the 90 percent confidence level a clear shift is revealed from indirect effects being mostly insignificant before 2009 to indirect effects being mostly significant after 2009. The shift is observable at the five-digit ATC level and particularly at the seven-digit ATC level. This result shows that the latest regulations have impacted these two levels in particular, in the sense that the market for close substitutes has started to work better and thus price competition has been strengthened. For the seven-digit ATC level, the indirect effect is significant at the 90 percent level for six cross-sections before 1 July 2009 and for 21 cross-sections after 1 July 2009 (a 250 percent increase). For the five-digit ATC level, the proportion is 6/9 (a 50 percent increase), while for the four-digit ATC level, the proportion is 8/6 (a 25 percent decrease). This is an indication that the policy changes from 1 July 2009 increased market effectiveness especially for those products that are close substitutes (the seven-digit ATC level).

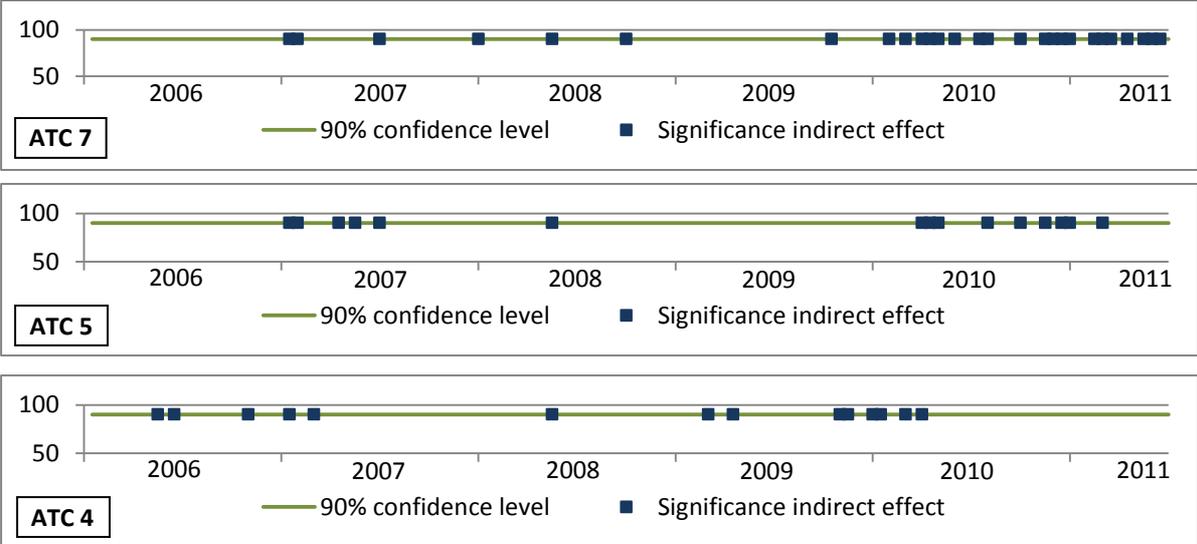


Fig 6 Statistical significance of the indirect effect at the 90 percent confidence level

The total effect represents the sum of the direct and the indirect effects and indicates the impact on an individual observation from changes in a particular explanatory variable by the same amount in all observations. The total effect is -0.15 for the time period used for exemplification, indicating that a 10 percent increase in the price of all pharmaceutical products would cause a 1.5 percent drop in quantity sold on average for all pharmaceutical products sold during this time period. The total effect, averaged over all time periods before 1 July 2009 for which the effect was significant, is -0.19, compared to the total effect, averaged over all time periods after 1 July

2009 for which the effect was significant, which is -0.16. This indicates a 16 percent increase, significant at the 99 percent confidence level.

6 Concluding remarks

The contribution of this study to the literature on markets and competition is that it employs spatial regression methodology to determine, on the one hand, the extent of the product market for pharmaceuticals in Sweden based on price competition between pharmaceutical products, and on the other hand, how the policy changes implemented in 2009 and 2010 have affected the Swedish market for pharmaceuticals in terms of the impact of price changes on quantities sold of own and competitor products. To our knowledge, no previous study has addressed the issue of what is the relevant market for pharmaceuticals in Sweden. Given the particularities of the units of analysis (pharmaceutical products), our study also applies spatial econometric methodology on non-spatial items, which have been seldom performed previously.

Our results show that the relevant product market for pharmaceuticals clearly extends to the seven-digit ATC-code level where brand name products and generic copies with the same chemical substances compete with each other. There is also competition between different chemical substances belonging to the same chemical subgroup (five-digit ATC level), and we even find some weak evidence of competition on the pharmacological level (four-digit ATC level). As such, previous studies focusing on competition between brand name products and generics only might have had too narrow a focus, and thus underestimated the level of competition in the pharmaceuticals market.

Our results also indicate that the Swedish pharmaceuticals market is better functioning after the 2009-2010 reforms. An increase in the price of a product determines a higher increase in the quantity sold of competing products after 1 July 2009 than before the reform. The average of the indirect effects, representing the cross-price elasticity of demand, was 0.04 before 1 July 2009, while the average after 1 July 2009 is 0.16. This represents a 300 percent increase, significant at the 99 percent confidence level. Also, investigating the significance of the indirect effect before and after the reforms, a clear shift is revealed from indirect effects being mostly insignificant before the reforms to indirect effects being mostly significant after the reforms. The reform effect is observable at the five-digit ATC level and particularly at the seven-digit ATC level. This shows that the market reforms in 2009 and 2010 have impacted these two levels of the pharmaceutical market in the sense that the market for close substitutes has started to work better and price competition has been strengthened.

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References

- Anselin L (1988) Spatial econometrics: methods and models. Kluwer Academic Publishers, Dordrecht
- Aronsson T, Bergman MA, Rudholm N (2001) The impact of generic competition on brand name market shares - evidence from micro data. *Rev Ind Organ* 19:423-433. doi: 10.1023/A:1012504310953
- Ballester C, Calvo-Armengol A, Zenou Y (2006) Who's who in networks. Wanted: the key player. *Econom* 74(5):1403-1417
- Bergman MA, Rudholm N (2003) The relative importance of actual and potential competition: empirical evidence from the pharmaceuticals market. *J Ind Econ* 51:455-467. doi: 10.1111/j.0022-1821.2003.00210.x
- Berndt ER, Bui L, Reiley DR, Urban GL (1995) Information, marketing, and pricing in the US antiulcer drug market. *Am Econ Rev* 85:100-105
- Black WR (1992) Network autocorrelation in transport network and flow systems. *Geogr Anal* 24(3):207-222
- Blankmeyer F, LeSage JP, Stutzman J, Knox KJ, Pace RK (2007) Statistical modeling of structured peer group dependence arising from salary benchmarking practices. *Social Science Research Network*. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1020458. Accessed 3 September 2012
- Bonacich P (1987) Power and centrality: a family of measures. *Am J Sociol* 92(5):1170-1182
- Brown JP, Florax JGM, McNamara KT (2011) Determinants of investment flows in US manufacturing. *Rev Reg Stud* 39(3):269-286
- Cohen JP, Coughlin CC (2008) Airport-related noise, proximity, and housing prices in Atlanta. Federal Reserve Bank of St. Louis. <http://research.stlouisfed.org/wp/2005/2005-060.pdf>. Accessed 10 October 2010
- Connolly P (2007) Quantitative data analysis in education: a critical overview using SPSS. Routledge, London
- Conway D, Li CQ, Wolch J, Kahle C, Jerrett M (2010) A spatial autocorrelation approach for examining the effects of urban greenspace on residential property values. *J R Estate Finance Econ* 41:150-169. doi: 10.1007/s11146-008-9159-6
- Coscelli A (2000) The importance of doctors' and patients' preferences in the prescription decision. *J Ind Econ* 48(3):349-369

- Elhorst P (2010) Spatial panel data models. In: Fischer, MM, Getis A (eds) Handbook of applied spatial analysis, Springer, Berlin, pp 377-407
- Elhorst P (2012) MATLAB software for spatial panels. *Int Reg Sci Rev*. doi: 10.1177/0160017612452429
- Ellison SF, Cockburn I, Griliches Z, Hausman JA (1997) Characteristics of demand for pharmaceutical products: an examination of four cephalosporins. *RAND J Econ* 28(3):426-446
- Escobar AMD (2011) Spatial unemployment differentials in Colombia. *EconPapers*.
<http://sites.uclouvain.be/econ/DP/IRES/2011014.pdf>. Accessed 1 October 2012
- Frank RG, Salkever DS (1992) Pricing, patent loss, and the market for pharmaceuticals. *South Econ J* 59:165-179
- Gelfand A, Smith A (1990) Sampling-based approaches to calculating marginal densities. *J Am Stat Assoc* 85(410):398-409
- Gelfand A, Hills S, Racine-Poon A, Smith A (1990) Illustration of Bayesian inference in normal data models using Gibbs sampling. *J Am Stat Assoc* 85(412):972-985
- Grabowski HG, Vernon JM (1992) Brand loyalty, entry and price competition in pharmaceuticals after the 1984 Drug Act. *J Law Econ* 35:331-350
- Granlund D, Rudholm N (2011) Consumer information and pharmaceutical prices: theory and evidence. *Oxf Bull Econ Stat* 73:230-254. doi: 10.1111/j.1468-0084.2010.00614.x
- Granlund D, Rudholm N (2012) The prescribing physician's influence on consumer choice between medically equivalent pharmaceuticals. *Rev Ind Organ* 41:207-222. doi: 10.1007/s11151-012-9347-7
- Hellerstein JK (1998) The importance of the pharmacist in the generic versus brand-name prescription decision. *RAND J Econ* 29:108-136. doi: 10.1016/S0149-2918(03)80157-1
- Izón GM, Hand MS, Fontenla M, Berrens RP (2010) The economic value of protecting inventoried roadless areas: a spatial hedonic price study in New Mexico. *Contemp Econ Policy* 28(4):537-553. doi: 10.1111/j.1465-7287.2009.00190.x
- Katz L (1953) A new status index derived from sociometric analysis. *Psychom* 18(1):39-43. doi: 10.1007/BF02289026
- Kirby DK, LeSage JP (2009) Changes in commuting to work times over the 1990 to 2000 period. *Reg Sci Urban Econ* 39(4):460-471
- LeSage JP, Pace RK (2009) Introduction to spatial econometrics. CRC Press, Boca Raton
- LeSage J (2008) An introduction to spatial econometrics. *Rev Econ Ind* 123:19-44

- Molho I (1995) Spatial autocorrelation in British unemployment. *J Reg Sci* 35(4):641-658
- Pace R, Zhu S (2012) Separable spatial modeling spillovers and disturbances. *J Geogr Syst* 14(1): 79-90. doi: 10.1007/s10109-011-0155-7
- RFFS 1992:20 Riksförsäkringsverkets föreskrifter om fastställande av pris på läkemedel [The National Social Insurance Board's regulations for establishing prices for pharmaceuticals] (in Swedish). Försäkringskassan. http://lagrummet.forsakringskassan.se/ForeskrifterUpphavda/pdf_S1996_31.pdf. Accessed 1 March 2012
- RFFS 1996:31 Riksförsäkringsverkets föreskrifter om fastställande av pris på läkemedel m.m. [The National Social Insurance Board's regulations for establishing prices for pharmaceuticals etc.] (in Swedish). Försäkringskassan. http://lagrummet.forsakringskassan.se/ForeskrifterUpphavda/pdf_G1992_20.pdf. Accessed 1 March 2012
- Richard O, Van Horn L (2004) Persistence in prescriptions of branded drugs. *Int J Ind Organ* 22(4):523-540. doi: 10.1016/j.ijindorg.2003.10.001
- Rizzo JA, Zeckhauser R (2005) Generic scrip share and the price of brand-name drugs: the role of consumer choice. National Bureau of Economic Research. http://www.nber.org/papers/w11431.pdf?new_window=1. Accessed 1 September 2012
- Rudholm N (2003) Competition and Substitutability in the Swedish Pharmaceuticals Market. *Appl Econ* 35:1609-1617. doi: 10.1080/0003684032000125042
- Sonis M, Hewings GJD, Okuyama Y (2001) Feedback loops analysis of Japanese interregional trade, 1980-85-90. *J Econ Geogr* 1:341-362. doi: 10.1093/jeg/1.3.341
- Sorensen AT (2000) Equilibrium price dispersion in retail markets for prescription drugs. *J Polit Econ* 108:833-850. doi: 10.1086/316103
- StataCorp (2007) Stata statistical software: release 10. StataCorp LP, College Station
- Stigler GJ, Sherwin RA (1985) The extent of the market. *J Law Econ* 18:555-585
- Studenmund AH (2011) Using econometrics: a practical guide. Pearson, Boston
- Tillväxtnalys (2012) Apoteksmarknadens omreglering - Effekter på följsamhet, priser och kostnader per dagsdos [Deregulating the Swedish pharmaceuticals market – consequences for regulation compliance, prices and costs per DDD] (in Swedish). Tillväxtverket. http://www.tillvaxtnalys.se/download/18.1ebc24b613b93da1e98407/1357130771502/WP_PM_2012_19.pdf. Accessed 1 February 2013

World Health Organization Collaborating Centre for Drug Statistics (WHOCC) (2012) ATC. WHICC.

http://www.whooc.no/atc/structure_and_principles/. Accessed 4 April 2012