Entry and Regulation – the case of Health Care Professions*

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Abstract

Health care professions in Europe have been subject to substantial entry and conduct regulation. We develop and estimate an entry model to study the competitive interaction between two key health care suppliers: pharmacies and physicians. The model accounts for the fact that there may not be free entry; geographic entry restrictions apply to pharmacies.

We find that the entry decisions of the two professions are strategic complements, and that entry does not lead to intensified competition within each profession. Furthermore, the entry restrictions have significantly limited the number of pharmacies, which has indirectly also reduced entry by physicians. We use the results to perform policy simulations on the effects of deregulation. A simple removal of the entry restrictions without any accompanying measures would more than double the number of pharmacies, and indirectly increase the number of physicians by about 7% (due to the strategic complementarities). If the removal of entry restrictions is combined with a reduction of the regulated pharmacies' margins by between 10%-18%, there would be no overall increase in the number of pharmacies, and the availability of supply would not be reduced. These findings show that the current regime is not in the public interest. Our findings are relevant in the light of the renewed attention by competition authorities to liberalize professional regulation.

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1 Introduction

Professional or occupational regulation has been a widespread phenomenon in many countries. It consists of a variety of measures affecting entry conditions (such as minimum standards of competency and territorial entry restrictions) and additional measures stipulating conduct (e.g. price and advertising). According to Kleiner (2000), professional regulation has been one area where the impact on the labor markets has been stronger in the U.S. than in Europe. Its impact on competition in the product markets, however, appears to have been more important in Europe in recent years. While the U.S. courts started to consistently apply their antitrust laws to professional practices after a Supreme Court Decision in 1975, European countries continued to be tolerant towards the anti-competitive effects of professional regulation; see Wise (2000). Only very recently, the European Commission has shown an interest in making the practices more in line with current competition policy rules.[1] The economic debate on the desirability of professional regulation is still ongoing. Proponents have emphasized the presence of various kinds of market failures, but critical assessors have pointed out that many of the regulations essentially serve to protect the professions' private interests. In general, it has become clear that the effects of professional regulation should be examined on a case by case basis.

The health care professions in Europe provide an interesting and economically important case. Physicians and pharmacies supply essential services to patients, and their activities have been heavily regulated. Both professions need to satisfy minimum educational standards and are subject to strict conduct regulation, with regulated fees and bans on most types of advertising. In addition, the number of pharmacies is restricted on a territorial basis in many countries. These regulations have been commonly motivated as being in the public interest because of many obvious market failures in the provision of health care services. Notably, the high fixed markups to pharmacies and their territorial entry restrictions have been argued to be necessary to ensure a minimum availability of supply in the less profitable regions, without inducing excessive entry elsewhere. The private interest view challenges these motivations, arguing that the regulations are anti-competitive and have no beneficial effects to other parties. In a detailed report, the U.K.'s Office of Fair Trading (2003) concluded that free entry by pharmacies in the U.K. would benefit consumers. The O.E.C.D. (2000) obtained similar conclusions based on the experiences in a larger set of countries, but also emphasized that a holistic view be taken. For example, simply introducing free entry to pharmacies

[1] This interest is evident from the extensive report describing the state of professional regulation in Europe, written by Paterson, Fink and Ogus (2003) for the European Commission. This report subsequently lead to an official Communication, COM (2004) 83, showing the Commission's commitment to liberalize the professions.

without any accompanying measures would likely create excessive entry at the currently high regulated margins.

In this paper, we aim to shed new light on the role of professional regulation in health care professions. We develop an econometric model of entry by two types of professions: pharmacies and physicians (defined as general family practitioners). Extending previous free entry models of Bresnahan and Reiss (1991), Mazzeo (2002) and others, we account for two features that are specific to this market in many European countries. First, territorial entry restrictions apply to one of the professions, i.e. pharmacies. Second, both professions are strategically interdependent; their entry decisions may be either strategic complements or substitutes. The entry model allows us to assess to which extent the entry restrictions have limited the number of entrants. In addition, it can be used to draw inferences about the nature and the extent of competitive interaction between professions of the same type, and between professions of different types. Finally, we can perform policy simulations to assess the effects of deregulation. We apply the model to a data set for Belgium in 2001, containing information on the number of pharmacies and physicians per market, and the corresponding demographic market characteristics.

We find that the entry restrictions are often binding and have significantly limited the number of pharmacies. Regarding competitive interaction, we find that entry into one profession has a positive effect on the profitability of entry into the other profession, i.e. the entry decision of the professions are strategic complements. Furthermore, entry does not lead to intensified (non-price) competition between firms of the same profession. We use these results to perform policy simulations on the effects of deregulation. A simple removal of all entry restrictions without any accompanying measures would more than double the number of pharmacies, and also indirectly increase the number of physicians by about 7% (due to the complementarities between both). If a full removal of entry restrictions is combined with an absolute reduction in the pharmacies' regulated gross markup by between 10%-18% (down from the current 28%), the total number of pharmacies in the country would remain constant and geographic coverage (number of markets with at least one pharmacy) would essentially remain the same. We also draw conclusions on a partial removal of the entry restrictions. In sum, we find that a new regime with full free entry and drastically reduced markups would generate substantial cost savings to consumers (tax payers) without the risk of reducing the availability of supply. This strongly indicates that the current regime protects the private interests of pharmacies rather than the public interest.

The existing literature on professional regulation has mainly focused on less extreme entry restrictions in the form of minimum standards of competency, usually referred to as professional or occupational licensing (see e.g. Kleiner's (2000) overview). The evidence on the effects of such entry restrictions has been mixed. Some studies find that professional licensing may raise prices or earnings in specific cases, e.g. Kleiner and Kudrle (2000) for dentists, and Kleiner (2000) and Pagliero (2004) for lawyers, thus supporting the private interest view.[2] Other studies however find evidence in favour of the public interest view. Most notably, Law and Kim (2004) undertook a comprehensive historical study on the introduction of educational licensing during the late nineteenth and early twentieth century in the U.S. They find that professional licensing has not restricted entry into professions in general (and in the one exception where it did, there was no effect on earnings). In comparison with this literature, we focus on the effects of more stringent entry regulations, i.e. territorial entry restrictions, and we show how this can be studied naturally within an empirical model of entry. At least in our case study, we find unambiguous support that territorial entry restrictions are not in the public interest. Hence, our results point out that professional regulation beyond pure licensing, which has especially been common in European countries, should be considered with extreme care.

The paper is organized as follows. Section 2 discusses the entry and conduct regulations applying to pharmacies and physicians, and introduces the data set. Section 3 presents the econometric entry model and section 4 discusses the empirical results. The implications for policy reform are discussed in section 5 concludes.

2 The markets of pharmacies and physicians

Health care markets are subject to extensive regulation in most countries. Governments generally recognize the presence of various market failures associated with the supply of basic health care services, such as problems of asymmetric information and uncertainty; see for example Dranove and Satterwaite (2000) for an overview. Furthermore, especially in Europe, equity considerations are often invoked to justify government intervention. In this section we provide a selective overview of the health care markets in which the pharmacies and physicians operate in Belgium, focusing on those elements that motivate our econometric model. We begin with a discussion of the entry process, including the presence of entry restrictions on pharmacies as imposed by the Belgian government. We next discuss the general economic and regulatory factors influencing the nature of competitive interaction within and between pharmacies and physicians. Finally, we provide descriptive statistics of our collected data set, to document some of our discussion in this section, and to introduce

[2] A variant of the private interest view on regulation is that it serves the regulators' interest (rather than the industry's). Djankov, La Porta, Lopez-de-Silanes, and Shleifer (2002) find evidence from a comparison between 85 countries that entry restrictions mainly benefit politicians and bureaucrats.

our subsequent econometric analysis.

2.1 Entry

Both pharmacies and physicians need to satisfy minimum educational standards. Otherwise, their services are not covered by the health insurance companies, and a different professional title must be used. Physicians, which we define as General Practitioner (as opposed to specialists), need to obtain a university degree in medical sciences. Until recently, every highschool student was eligible to start this degree. Since 1998, there is an introductory examination at the start of the first year in one region of the country (Flanders) to restrict the number of incoming students. However, this potential entry restriction is irrelevant for our empirical analysis, which covers the year 2001. In practice, only a minority of the students (about 25%) with a medical degree choose to become a physician, in the sense of a General Practitioner. Other employment opportunities are to become a specialist, an occupational health officer, an expert for the health insurance funds, etc. For practical purposes it is thus reasonable to think of a fairly large pool of individuals satisfying the minimum educational standards required to become a physician. There are no essential further restrictions to setting up a physician's practice[3]. In particular, a physician can choose to locate an establishment anywhere in Belgium. According to WIV, the majority of physicians (about 78%) currently operate as a single-person establishment. In recent years, there has been a development to form associations of several physicians, but these are considerably less developed than in other countries.

Pharmacies also need to satisfy minimum educational standards[4]. A university degree in pharmaceutical sciences provides the right to independently prepare and sell drugs in an existing establishment. However, in contrast to the physicians' case, this degree is not sufficient to entitle one to set up a new establishment. Since 1974, there exists an establishment act, restricting the number of pharmacies in each municipality. Many other European countries have adopted similar acts; countries with the most comparable population-based establishment acts are Finland, France and Portugal. The idea behind the establishment act was to reduce the extent of competition to protect the quality of services provided by the pharmacies, while ensuring that there would be a sufficient regional coverage. The act essentially stipulates that there should be no more than one pharmacy per 2,000 inhabitants

[3] There are some requirements of secondary importance. First, the Medical Committee needs to certify the medical degree and the applicant has to enroll with the medical association, the so-called "Order of Physicians". Second, it is necessary to register at the National Institute of Health Insurance (RIZIV), so that the medical consultation services to consumers can be covered by the health insurance companies.

[4] For a more detailed discussion on the regulation of pharmacies in Belgium, we refer to Philipsen (2003).

in small municipalities (with fewer than 7,500 inhabitants); no more than one pharmacy per 2,500 inhabitants in intermediate municipalities (with a number of inhabitants between 7,500 and 30,000); and no more than one pharmacy per 3,000 inhabitants in the larger municipalities. For example, in a municipality with 6,000 inhabitants, there can be no more than one pharmacy per 2,000 inhabitants, implying that there can be at most 3 pharmacies. The act stipulates slightly more lenient, i.e. lower, threshold population levels if the physical distance between a new candidate pharmacy and any incumbent is sufficient large. Because of the establishment act, people with a university degree in pharmaceutical studies have only two ways to start an independent pharmacy: either apply for a new establishment at a location where the entry restrictions are not yet binding, or buy an existing pharmacy from an incumbent. The latter is the more common event; it is often a transaction between an incumbent who has reached retirement age and a candidate pharmacist who has obtained several years of experience in the same or in another pharmacy[5].

2.2 Competitive interaction

Both physicians and pharmacies are heavily regulated in Belgium, which affects the nature of competitive interaction. We first discuss the relevant factors determining competition among physicians, among pharmacies, and between the two different professions. We next discuss the extent of competition at the geographic level, motivating the relevant geographic market definition we use in the empirical analysis.

Physicians provide medical consultations on a fee-for-service basis. A fixed price is negotiated between the government and the health insurance funds. Physicians are free to charge a higher price, but the social insurance companies do not reimburse patients for the extra price. In practice, only 15% of the physicians have not signed the fixed price agreement. Self-regulation traditionally prevented physicians from competing through advertising, though in recent years and under pressure of the European Commission there has been an increased tolerance towards informative advertising. While price and advertising competition have traditionally been quite limited, physicians have a broad range of other instruments to compete for patients: availability (consultation hours, waiting times and possibility to make appointment), quality and time spent on medical consultations (which can show a large variation among physicians), and willingness to provide medical prescriptions and sick-days.

Pharmacies have the exclusive right to sell drugs. In contrast to most other countries, this exclusivity applies to both prescribed drugs and over-the-counter (OTC) drugs. The

[5] The average number of pharmacists (with a university degree) working in a pharmacy is 1.5. Hence, as in the physicians' case, most pharmacies operate as single-person establishments.

prices of drugs are fixed by the Ministry of Economic Affairs, after negotiations with the pharmaceutical companies and the pharmacies' association. The pharmacies obtain a fixed margin of 31% of the drug price, up to a ceiling of 7.44€ per package, which implies an effective margin of 28% (de Bruyn (1994)). Consequently, there is essentially no price competition. There is, however, some price competition for the pharmacists' own preparations and for some other general care products (such as cosmetics). But since these constitute a small fraction of overall sales, the overall extent of price competition is limited, just as in the physicians' case. Advertising has until recently also been prevented due to self-regulation by the pharmacies' association, but there are various potential non-price instruments: availability (opening hours), quality of service and advice, and the supply of an assortment of general care products. In sum, competition among physicians and among pharmacies has until recently been limited with respect to price and advertising instruments, but they have a variety of other instruments at their disposal to compete for patients.

We now discuss the nature of competitive interaction between the two different professions. There is an obvious direct link between their services. Physicians have the exclusive right to provide medical consultations and prescribe drugs. For Belgium, a large percentage of the consultations end with a prescription (87%), which benefits the pharmacies since they have the exclusive right to prepare and sell the prescribed drugs. Hence, the two professions' core services may be viewed as strong complements, implying that the nearby presence of one profession would benefit the other profession. A recent study by the OFT (2003) confirms the strong link between both professions: up to 47% of U.K. patients go to the pharmacy immediately after having visited their physician. However, the distinction between the services offered by both professions is in practice not always that clear-cut; they regularly operate on each other domain, which has led to many conflicts between the two professions[6]. In addition to providing medical advice, physicians frequently offer free drugs to their patients, obtained from the pharmaceutical companies as a way to promote their products. The pharmacies do not oppose such drug promotions *per se*, but they claim that the distribution should remain the exclusive right of the pharmacies. Conversely, pharmacies also provide services that are in the physicians' domain. They offer an increasing amount of independent medical advice to patients when selling their drugs. This development has actually been actively promoted by the European Commission: in the near future, pharmacies will be partly rewarded on a fee-for-service basis, rather than as a percentage of their sales, giving them additional incentives to provide medical advice; they will also obtain the right to substitute the prescribed drugs

[6] An interesting discussion of the conflicts arising from competition between physicians and pharmacies is provided in an article of the Belgian newspaper De Standaard (08/06/2004), with the self-explanatory translated title "Why physicians want to sell drugs, and pharmacies want to provide medical consultations."

by equivalent but less expensive generic alternatives. We conclude that the physicians' and the pharmacies' core services are strong complements, but since both also operate on each others' domain they may also be viewed as providing substitute services. It will ultimately be an empirical question whether the two professions should be viewed as complements or substitutes.

We finally discuss the competitive interaction at a geographic level. Consistent with earlier health care studies, it is reasonable to define the relevant geographic markets at the town level. The population within each town is typically concentrated around the center, with the exception of the densely populated urban areas, which we will exclude from our sample. Both physicians and pharmacies cannot engage in advertising or other active promotional selling activities, so that it is reasonable to expect that the patients' choices are largely guided by local information. Survey evidence indicates that the majority of patients do indeed not travel outside their town to visit a physician. In the Netherlands, a country with similar demographic characteristics as Belgium, 85% of the patients travel less than 5 kilometers, which usually falls within the geographic boundaries of the town. Furthermore, 94% of the Belgian patients have a single fixed physician, which is conceivably located close to the patient's home. For the pharmacies, the above study by the OFT (2003) finds that only 6% of the patients visit their pharmacy while commuting to work, confirming the local nature.

The above discussion has focused on the demand-side factors influencing the extent of competitive interaction. In principle, competitive interaction may also stem from supply side factors. For example, pharmacies and physicians may generate knowledge spill-overs and learning effects, which can affect both their variable and fixed costs. The health care literature we have surveyed has however not put emphasis on these sources of competitive interaction, so we will interpret our empirical findings below as largely stemming from demand-side sources.

2.3 Overview of the data

An overview of the data documents part of the above discussion, and also introduces our subsequent econometric analysis. The data set contains information on $1,136$ markets in 2001, defined at the town-level based on our earlier discussion of the relevant geographic markets. To reduce problems with overlapping markets, we do not include urban towns, which are defined by a population density of more than 800 per km^2 or a population of more than 15,000. This reduces our sample of towns to 847. We have information on the number of active pharmacies and physicians per market, and the corresponding demographic characteristics[7][8]. Table 1 presents counts of the observed market configurations, which we will model in our econometric analysis. For example, there are 142 markets with no pharmacies or physicians, and 58 markets with one pharmacy and two physicians. More generally, the table shows that there is a quite strong correlation between the number of pharmacies and physicians; the correlation coefficient is 0.85. This strong correlation may be due to common observed and unobserved factors influencing the profitability of pharmacies and physicians. However, our discussion above suggested that the correlation may also be due to the fact that both professions provide complementary services. Our econometric analysis is able to distinguish between these alternative possibilities. Table 1 also shows that there are several market configurations that never occur, e.g. three physicians and more than three pharmacies. The final row shows the percentage of all markets (broken down by the number of pharmacies), in which the geographic entry restriction imposed on the pharmacies is binding, in the sense that no additional pharmacies are allowed to enter by the establishment act. This will be important in our empirical analysis. The entry restrictions are binding for 82% of all the markets. Binding entry restrictions occur the least frequently in markets with two established pharmacies, but even here the percentage is quite large (74.7%). Note that when entry restrictions are binding, the establishment act may sometimes be violated. This is due to historical factors, since many pharmacies were set up in anticipation of the act, and these pharmacies were not forced to shut down at the moment the act was introduced. However, the excess number of pharmacies is generally small in these cases, and it is not relevant for our econometric framework below.

[7] The data were obtained from various governmental organizations in Belgium. The number of physicians and pharmacies was made available by RIZIV (the National Institute of Health Insurance). The demographic characteristics were provided by the NIS (National Institute of Statistics), Ecodata (Federal Government Agency for Economics), and the RSZ (the National Institute of Social Security)

[8] In accordance with RIZIV, a physician is defined as a General Practitioner who has more than 49 patients and has annually more than 199 consultations, of which more than 0.9% are house visits.

Table 1. Observed market configurations*

		Number of pharmacies						Total
		0	1	2	3	4	5+	
	0	142	11	1	0	0	0	154
	1	62	36	2	0	0	0	100
Number of	2	27	58	3	0	1	0	89
physicians	3	6	38	16	3	0	0	63
	4	8	35	31	4	0	0	78
	5+	1	41	93	95	69	64	363
Total		246	219	146	102	70	64	847
restricted entry		199	179	109	85	61	64	697
% of total		80.9	81.7	74.7	83.3	87.1	100	82.3

Table 2 provides summary statistics on the demographic variables, which may affect the profitability of both professions. We include information on population size, the percentage of young people (under the age of 18), the percentage of elderly (over the age of 65), the percentage of foreigners, the unemployment rate, mean income, and a dummy variable to account for structural differences between the region of Flanders and Wallonia.

Table 2. Summary statistics*

Variable	Description	mean	std. dev.
# pharmacies	Number of pharmacies	1.76	1.81
# physicians	Number of physicians	4.93	4.62
ln(population)	Logarithm of population	7.91	1.13
% young	Fraction of population, 17 years or younger	22.50	2.55
% old	Fraction of population, 65 years or older	16.11	2.79
% foreign	Fraction of population with foreign nationality	4.27	5.67
% unemployed	Unemployment rate	5.61	2.80
Flanders	Dummy variable, 1 for the region of Flanders	0.39	0.49
mean income	Mean income (in 10,000€)	2.47	0.40

3 The entry model

Our entry model fits in the recent empirical entry literature, as initiated by Bresnahan and Reiss (1990, 1991) and Berry (1992). This literature models entry as a strategic game, and aims to draw inferences about the nature of competitive interaction from the relationship between the observed market structure and market characteristics, such as market size.

Our own model is in the spirit of Mazzeo (2001). He distinguishes between two types of substitute firms, and he models the number of firms of each type as the equilibrium outcome of a strategic game. We extend this approach in two main respects. First, we account for the fact that entry is regulated, in the sense of binding entry restrictions for one of the two types of firms. Second, we allow for the possibility that the entry decisions of firms of different types are either strategic complements or strategic substitutes, since both possibilities cannot be ruled out *a priori* in our case[9].

3.1 Payoffs

There are two types of firms, $i = 1, 2$, with a large pool of firms for each type. In our application, firms of type 1 are pharmacies, and firms of type 2 are physicians. Each firm decides whether or not to enter the market. The number of firms of type i entering a market is denoted by the random variable N_i; realizations of this random variable are denoted by n_i. Firms of type 1 are subject to an entry restriction $N_1 \leq \overline{N}_1$: in each market there cannot be more than $\overline{N}_1$ firms, which is determined by population criteria, as discussed in section 2. If $N_1 < \overline{N}_1$, the entry restriction is not binding in equilibrium; if $N_1 = \overline{N}_1$ the entry restriction is binding.

Firms of the same type are identical, i.e. they have the same payoff functions. If a firm of either type i does not enter, its payoffs are zero. If a firm of type i enters, its payoffs depend on the number of entering firms of both types, as given by:

$$\pi_i^*(n_1, n_2) = \pi_i(n_1, n_2) - \varepsilon_i, \tag{1}$$

where $\pi_i(n_1, n_2)$ is the deterministic component of payoffs, and ε_i is a random component, unobserved to the econometrician. The payoffs of a firm of type i thus depend on both the number of entering firms of its own type and on the number of entering firms of the other type. The precise relationship reflects the nature of competitive interaction between firms of the same type and of different types. Our main assumption is that entry decisions by firms of the same type are strategic substitutes, i.e. when one firm decides to enter, the payoffs from entry by another firm of the same type decreases. This amounts to assuming that payoffs are decreasing in the number of firms of the same type.

[9] A third difference between our approach and Mazzeo's lies in the specific modeling of the strategic entry game. Mazzeo assumes that firms can choose their type at or after entering, whereas we assume that the types are determined prior to the entry game. This is a more natural assumption in the case of medical professions. As we will discuss below, this different assumption implies a different way to select among multiple Nash equilibria.

Assumption 1. (Entry decisions by firms of the same type are strategic substitutes)

$$\pi_1(n_1+1, n_2) < \pi_1(n_1, n_2)$$
$$\pi_2(n_1, n_2+1) < \pi_2(n_1, n_2)$$

This assumption is consistent with the previous empirical entry literature, and is central to characterize the Nash equilibrium outcomes below.

Regarding firms of different types, we do not make *a priori* assumptions as to whether their entry decisions are strategic substitutes, strategic complements, or independent. This will ultimately be an empirical question. Mazzeo (2001) and subsequent entry contributions have considered the case in which the entry decisions by firms of different types are strategic substitutes, implying that payoffs are not only decreasing in the number of firms of the own type, but also in the number of firms of the other type (though to a lesser extent). Since the alternative case of strategic complements has not been studied before, and since this is also what we will find empirically, we concentrate the exposition in the text on this case. In the Appendix, we describe the case in which entry decisions by firms of different types are strategic substitutes.

The case in which entry decisions by firms of different types are strategic complements or independent may be summarized as follows.

Assumption 2. (Entry decisions by firms of different types are strategic complements or independent)

(a)
$$\pi_1(n_1, n_2) \leq \pi_1(n_1, n_2+1)$$
$$\pi_2(n_1, n_2) \leq \pi_2(n_1+1, n_2)$$

(b)
$$\pi_1(n_1+1, n_2+1) < \pi_1(n_1, n_2)$$
$$\pi_2(n_1+1, n_2+1) < \pi_2(n_1, n_2)$$

Assumption 2 (a) states that payoffs are either increasing or independent of the number of firms of the other type, so that the entry decisions by firms of different types are (weak) strategic complements. Assumption 2 (b) says that the extent of strategic complementarity between firms of different types is weaker than the extent of strategic substitutability between firms of the same type. Hence, payoffs decrease when there is an additional firm of both the own type and the other type.[10]

Our background discussion in Section 2 emphasized that the competitive interaction within and between pharmacies and physicians mainly stems from demand side factors. On

[10]Strictly speaking, we only require one of the pair of inequalities in Assumption 2 (b) to be strict.

the one hand, the services by firms of the same type tend to be (imperfect) substitutes to consumers. On the other hand, the services by firms of different types may be either complements or substitutes, as indicated by qualitative evidence on the recent rivalry between both professions. In addition, we found that there is little reason to expect that the strategic interaction within and between pharmacies and physicians stems from cost side factors, such as learning from each others' experience. We will therefore interpret our subsequent empirical findings about competitive complements or substitutes as mainly stemming from demand side factors.

Based on these assumptions we can now derive the equilibrium number of firms and the implied likelihood function to be taken to the data. In the empirical analysis, we will verify whether these assumptions are indeed satisfied at the obtained parameter estimates and confront this with the alternative case of strategic substitutes.

3.2 Equilibrium with nonbinding entry restrictions

When entry restrictions are not binding, i.e. $N_1 < \overline{N}_1$, each firm freely decides whether or not to enter, given the entry decisions of the other firms. As is well-known, there is a large number of pure-strategy Nash equilibria in this entry game. Bresnahan and Reiss (1990) resolve this problem in two alternative ways. First, they aggregate the non-unique Nash equilibrium outcomes to obtain an econometric model for the total number of firms entering in a Nash equilibrium. In their application in which all firms are substitutes, this yields a unique prediction for the total number of entering firms. Second, they put additional structure to the entry game and assume that firms move sequentially. This alternative approach yields a unique subgame perfect Nash equilibrium at the disaggregate firm level. Mazzeo (2001) may be viewed as a combination of both approaches: he specifies a model for the total number of firms per type entering in a Nash equilibrium, and then refines the Nash equilibrium to obtain a unique prediction for the total number of firms per type. We take a related approach here.

The market configuration (n_1, n_2) is a Nash equilibrium outcome if and only if the random component of profits $\varepsilon = (\varepsilon_1, \varepsilon_2)$ satisfies the following conditions:

$$\begin{aligned} \pi_1(n_1+1, n_2) &< \varepsilon_1 \leq \pi_1(n_1, n_2) \\ \pi_2(n_1, n_2+1) &< \varepsilon_2 \leq \pi_2(n_1, n_2). \end{aligned} \quad (2)$$

When (2) is satisfied, n_1 firms of type 1, and n_2 of type 2 find it profitable to enter, and no additional firm of either type has an incentive to enter; hence (n_1, n_2) is indeed a Nash equilibrium outcome. Assumption 1 guarantees that there are realizations of ε for which (2) holds, so that the market configuration (n_1, n_2) is observed with positive probability.

However, (n_1, n_2) may show multiplicity with other Nash equilibrium outcomes for some realizations of ε. This is illustrated in Figure 1. The bold lines delineate the areas of ε for which the market configurations $(1, 2)$ and $(2, 3)$ are the Nash equilibrium outcomes. The shaded rectangle is the area of overlap, where both market configurations are Nash equilibrium outcomes. Note that the area of multiplicity would disappear if firms are independent, i.e. if the conditions in Assumption 2(a) hold with equality, so that $\pi_1(2, 2) = \pi_1(2, 3)$ and $\pi_2(1, 3) = \pi_2(2, 3)$. As the extent of complementarity increases, the area of multiplicity increases. Figure 2 shows an extreme case of strong complementarity. In this case, the entire area of ε for which $(1, 2)$ is a Nash equilibrium outcome is a subset of the area of ε for which $(2, 3)$ is a Nash equilibrium. Hence, there would be no ε for which $(1, 2)$ is a Nash equilibrium without $(2, 3)$ also being one. Assumption 2(b) rules out this possibility, since it requires that $\pi_1(2, 3) < \pi_1(1, 2)$ and $\pi_2(1, 3) < \pi_2(2, 4)$.

In general, the multiplicity of Nash equilibrium outcomes may be characterized as follows. If firms of different types are independent, i.e. Assumption 2(a) holds with equality, then the market configuration (n_1, n_2) is the unique Nash equilibrium outcome in the area of ε satisfying (2). In contrast, if the entry decisions of firms of different types are strategic complements, i.e. Assumption 2(a) holds with strict inequality, then (n_1, n_2) may show multiplicity with other Nash equilibrium outcomes for some realizations of ε. In the Appendix, we show the following three results, which together imply that the areas of ε for which (n_1, n_2) shows multiplicity with any other Nash equilibrium outcome are simply given by the areas of overlap with the outcomes $(n_1 + 1, n_2 + 1)$ and $(n_1 - 1, n_2 - 1)$.

- First, (n_1, n_2) may only show multiplicity with Nash equilibrium outcomes of the form $(n_1 + m, n_2 + m)$, where m is a positive or a negative integer. For example, if $(1, 2)$ is a Nash equilibrium outcome, there may be multiplicity with, say, $(0, 1)$ or $(2, 3)$ or $(3, 4)$ but not with $(2, 4)$.

- Second, (n_1, n_2) necessarily shows multiplicity with $(n_1 + 1, n_2 + 1)$ and $(n_1 - 1, n_2 - 1)$. The area of multiplicity with $(n_1 + 1, n_2 + 1)$ is given by:

$$\begin{aligned} \pi_1(n_1 + 1, n_2) &< \varepsilon_1 \leq \pi_1(n_1 + 1, n_2 + 1) \\ \pi_2(n_1, n_2 + 1) &< \varepsilon_2 \leq \pi_2(n_1 + 1, n_2 + 1), \end{aligned} \tag{3}$$

  and similarly for $(n_1 - 1, n_2 - 1)$.

- Third, while (n_1, n_2) may also show multiplicity with $(n_1 + m, n_2 + m)$ for $m > 1$ or $m < 1$, these areas of multiplicity are necessarily a subset of the areas of multiplicity with $(n_1 + 1, n_2 + 1)$ and $(n_1 - 1, n_2 - 1)$.

The multiplicity problem follows from the weak structure implied by the Nash equilibrium concept. To obtain unique predictions, we put additional structure on the entry game. We assume that firms make their entry decisions sequentially, i.e. after observing all previous entry decisions, and impose the subgame perfect Nash equilibrium refinement.[11] With complementary entry decisions, it is not necessary to make specific assumptions regarding the exact ordering of entry moves. This additional structure makes it possible to assign a unique subgame perfect equilibrium outcome to every realization of ε. Suppose ε is such that both (n_1, n_2) and $(n_1 + m, n_2 + m)$ are Nash equilibrium outcomes (with m a positive or negative integer). The outcome with the fewest number of firms cannot be subgame perfect, since there would then always be an additional firm of one type with an incentive to enter, in anticipation of triggering further entry by a firm of the other type as well. Hence, when there are multiple Nash equilibrium outcomes, the one with the largest number of firms is the unique subgame perfect equilibrium. Making use of our earlier characterization of the multiplicity of Nash equilibrium outcomes, it immediately follows that (n_1, n_2) will be a subgame perfect Nash equilibrium outcome if and only if (i) ε satisfies conditions (2) and (ii) ε does not satisfy conditions (3). This can be illustrated on Figure 1. The market configuration $(1, 2)$ is a subgame perfect Nash equilibrium outcome if and only if ε falls in the relevant area bounded by the bold lines, minus the shaded area in the lower left corner.

Assuming that ε has a bivariate density $f(\cdot)$, it is now possible to derive the probability that the market configuration (n_1, n_2) will be observed as the unique subgame perfect equilibrium outcome when entry restrictions are not binding:

$$\begin{aligned}\Pr(N_1 &= n_1, N_2 = n_2 \mid N_1 < \overline{N}_1) = \int_{\pi_1(n_1+1,n_2)}^{\pi_1(n_1,n_2)} \int_{\pi_2(n_1,n_2+1)}^{\pi_2(n_1,n_2)} f(u_1, u_2)\mathrm{d}u_1\mathrm{d}u_2 \\ &- \int_{\pi_1(n_1+1,n_2)}^{\pi_1(n_1+1,n_2+1)} \int_{\pi_2(n_1,n_2+1)}^{\pi_2(n_1+1,n_2+1)} f(u_1, u_2)\mathrm{d}u_1\mathrm{d}u_2. \qquad (4)\end{aligned}$$

3.3 Equilibrium with binding entry restrictions

When the entry restrictions are binding, $N_1 = \overline{N}_1$, the analysis needs to be modified. Essentially, there are some firms of type 1 (pharmacies in our application) that have an incentive to enter but are not able to do so because of the restriction. This has the following immediate

[11] This approach is in the spirit of Mazzeo (2002), but adapted to the circumstances in this application. Mazzeo assumes that firms can choose their type at or after entering. We instead assume that there is a given pool of entrants of each type; firms can only make entry decisions and can no longer choose their type at that point. This yields somewhat different conditions defining the unique subgame perfect equilibrium outcome.

implication. From the market configuration (n_1, n_2) it is no longer possible to infer that entry by $n_1 + 1$ firms would be unprofitable. Hence, with binding entry restrictions the market configuration (n_1, n_2) is a Nash equilibrium outcome if and only if ε satisfies the following conditions:

$$\begin{aligned} &\varepsilon_1 \leq \pi_1(n_1, n_2) \\ \pi_2(n_1, n_2 + 1) < \ &\varepsilon_2 \leq \pi_2(n_1, n_2). \end{aligned} \tag{5}$$

For firms of type 2 these conditions are still the same as in (2). For firms of type 1 they are different, since it is no longer possible to infer a lower bound on profits from observing (n_1, n_2). This actually simplifies the problem of multiple Nash equilibrium outcomes. With nonbinding entry restrictions, we showed that (n_1, n_2) may only show multiplicity with Nash equilibrium outcomes of the form $(n_1 + m, n_2 + m)$, with m either a positive or a negative integer. When the entry restrictions are binding, it is immediately obvious that there can no longer be such multiplicity for positive integers m. Hence, (n_1, n_2) can only have multiplicity with equilibria of the form $(n_1 + m, n_2 + m)$, for negative integers m. However, similar to the case of nonbinding entry restrictions, the equilibrium with the fewer number of firms cannot be selected as the subgame perfect Nash equilibrium. Hence, with binding entry restrictions on firms of type 1, the market configuration (n_1, n_2) is the unique subgame perfect Nash equilibrium if and only if ε satisfies (5).

The probability of observing the market configuration (n_1, n_2) as the subgame perfect Nash equilibrium when entry restrictions are binding, i.e. when $N_1 = \overline{N}_1$, is therefore:

$$\Pr(N_1 = n_1, N_2 = n_2 \mid N_1 = \overline{N}_1) = \int_{-\infty}^{\pi_1(n_1,n_2)} \int_{\pi_2(n_1,n_2+1)}^{\pi_2(n_1,n_2)} f(u_1, u_2) \mathrm{d}u_1 \mathrm{d}u_2. \tag{6}$$

3.4 Econometric specification

We can now specify the likelihood function for our sample of observations on market configurations and the corresponding market characteristics. We suppress a market subscript m indexing the unit of observation. In both the case of nonbinding and binding entry restrictions, there is a unique subgame perfect equilibrium outcome for every possible realization of ε. Hence, the probabilities of observing a market configuration, as derived by (4) and (6), can be sensibly used to construct the likelihood function. Defining a dummy variable $d = 1$ if $N_1 < \overline{N}_1$ and $d = 0$ otherwise, the contribution to the likelihood function of a representative observation on (N_1, N_2) is:

$$l_C = d \Pr(N_1 = n_1, N_2 = n_2 \mid N_1 < \overline{N}_1) + (1 - d) \Pr(N_1 = n_1, N_2 = n_2 \mid N_1 = \overline{N}_1), \tag{7}$$

where the probability terms are defined by (4) and (6). We use the subscript C in l_C to emphasize that the likelihood contributions entering the likelihood function have been derived under the assumption that the entry decisions of firms of different types are strategic complements. In the Appendix, we consider the alternative possibility of strategic substitutes, and derive the corresponding likelihood contributions, l_S. We will estimate both alternative models, and subsequently verify whether the assumptions are met at the obtained parameter estimates.

Specify the density $f(\cdot)$ as the bivariate normal density, with a parameter ρ measuring the correlation between ε_1 and ε_2. There are some interesting special cases of this model. First, if firms of different types are independent, the second term in (4) vanishes, so that the model reduces to a bivariate ordered probit model with censoring, where the censoring refers to observations where the entry restrictions are binding. Second, if in addition the entry restriction is not binding for any observation, the model reduces to a uncensored bivariate ordered probit model. Third, if the correlation parameter $\rho = 0$, we end up with two traditional ordered probit models, one for each type, as estimated by Bresnahan and Reiss (1991) and several subsequent contributions. In the empirical analysis, we will consider the first two special cases and compare it with the general model.

It remains to specify the payoff function entering the likelihood function through the probabilities (4) and (6). There are two economic interpretations of the payoffs $\pi_i^*(n_1, n_2)$, both with the required property that a firm would enter if and only if $\pi_i^*(n_1, n_2) \geq 0$. In a direct interpretation payoffs are simply profits, i.e. variable profits minus fixed costs. We adopt an alternative interpretation here, similar to Genesove (2001). Define a firm's profits as $\Pi_i^*(n_1, n_2) = V_i(n_1, n_2) \exp(-\varepsilon_i) - F_i(n_1 n_2)$, where $V_i(n_1, n_2)$ is variable profits, $F_i(n_1 n_2)$ is fixed costs, and ε_i is a multiplicative error term capturing unobserved variable profits or fixed costs. Firms enter if and only if $\Pi_i^*(n_1, n_2) \geq 0$, or equivalently $\pi_i^*(n_1, n_2) = \ln\left(V_i(n_1, n_2)/F_i(n_1, n_2)\right) - \varepsilon_i \geq 0$. Hence, we can interpret a firm's payoffs $\pi_i^*(n_1, n_2)$ as the log of the variable profits to fixed costs ratio. Consider the following specification:

$$\pi_i^*(n_1, n_2) = \lambda_i \ln(S) + X\beta_i - \alpha_i^j + \gamma_i^k / j - \varepsilon_i, \tag{8}$$

where S is market size, measured by the number of consumers (population), X is a vector of other observed market characteristics, such as average income, percentage of elderly, and λ_i and β_i are the corresponding type-specific parameters. The parameters α_i^j and γ_i^k are fixed effects for type i when there are, respectively, j firms of the own type and k firms of the other type.

The fixed effects α_i^j are similar to the "cut-values" in simple ordered probit models, and measure the effect of j firms of the own type on payoffs. The fixed effects γ_i^k measure the effect of k firms of the other type on payoffs, and reflect the extent of complementarity between the entry decisions of different types. One may reasonably expect the complementarity effect to be stronger when there are few firms of the own type. We incorporate this by dividing γ_i^k by the number of firms of the own type j. A more general approach would be to specify a full set of fixed effects α_i^{jk} for every market configuration, instead of the additive specification $\alpha_i^j + \gamma_i^k/j$. This more general specification would however require a too large number of parameters to be estimated.

As is common in discrete choice models, the scale of the payoffs is not identified. To proceed with estimation, we restrict the standard deviation of ε_i to be equal to one. This restriction is irrelevant for most of our empirical analysis. In our subsequent analysis of policy reform, however, we need to know the scale of the payoffs. We then make the assumption that $\lambda_i = 1$, which says that the variable profits per consumer (i.e., $V_i(n_1, n_2)/S$) are independent of the number of consumers. The estimated parameter for S can then be reinterpreted as the inverse of the standard deviation of ε_i, allowing us to proceed with our policy analysis (see below).

Apart from the scaling issue, the fixed effects α_i^j and γ_i^k are not all identified. Let J be the maximum number of firms observed in any market of the own type, and K the maximum number of firms of the other type. The fixed effect parameters entering the model then are $\alpha_i^0 \dots \alpha_i^{J+1}$ and $\gamma_i^0 \dots \gamma_i^{K+1}$. To identify the model, set $\alpha_i^0 = -\infty$, $\alpha_i^{J+1} = \infty$, $\alpha_i^1 = 0$, $\gamma_i^0 = 0$, and $\gamma_i^{K+1} = \gamma_i^K$for each i.[12] Assumptions 1 and 2 imply that the model is internally consistent if the estimated fixed effects α_i^j and γ_i^k entering (8) satisfy the following conditions for all i, j and k:

$$\begin{aligned} \alpha_i^{j+1} &> \alpha_i^j \\ \gamma_i^{k+1} &\geq \gamma_i^k \\ \alpha_i^{j+1} - \gamma_i^{k+1}/(j+1) &> \alpha_i^j - \gamma_i^k/j. \end{aligned} \tag{9}$$

Since we normalized $\alpha_i^1 = 0$ and $\gamma_i^0 = 0$, it also follows that the fixed effects α_i^j and γ_i^k should all be positive. The first row of inequalities in (9) simply says that an additional firm of the own type decreases the ratio of variable profits over fixed costs.[13] The second row says that an additional firm of the other type increases the ratio of variable profits over fixed costs.

[12] With these normalization assumptions, a constant term in β is identified. Alternatively, one can normalize this constant term to zero, and estimate α_i^1.

[13] This is similar to the requirement of the cut-points in traditional ordered probit models. In our case, the condition $\alpha_i^{j+1} > \alpha_i^j$ is a sufficient but not a necessary condition for Assumption 1 to be satisfied. The necessary and sufficient condition is slightly weaker, i.e. $\alpha_i^{j+1} > \alpha_i^j - \gamma_i^k/((j(j+1))$. We presented the sufficient condition, since it is easier to interpret in the empirical analysis, and since they were always met anyway.

Finally, the third row says that an additional firm of both types reduces the ratio of variable profits over fixed costs. In the empirical analysis, we will verify whether these conditions are satisfied. If they are, the estimates are consistent with the initial assumptions.

Finally, following Bresnahan and Reiss (1991) we define entry thresholds and entry threshold ratios. We elaborate on these in some more detail, since their interpretation needs additional care in our framework. The entry threshold $S_i^{j,k}$ is the market size at which the j-th firm would just be willing to enter, when there are k firms of the other type, i.e. the market size such that the deterministic component of payoffs given by (8) is equal to zero. The per-firm entry threshold ratio is defined as $ETR_i^{j+1,k} = (S_i^{j+1,k}/(j+1))/(S_i^{j,k}/j)$, which can be written as:

$$ETR_i^{j+1,k} = \exp\left(\frac{\alpha_i^{j+1} - \alpha_i^j}{\lambda_i}\right)\left(\frac{j}{j+1}\right)\exp\left(-\frac{\gamma_i^k/(j+1) - \gamma_i^k/j}{\lambda_i}\right). \tag{10}$$

An entry threshold ratio greater than 1 means that the per-firm entry threshold has to increase to support an additional firm. In our framework, this can occur for two reasons. First, as in Bresnahan and Reiss, additional entry may lead to lower margins and hence more intense competition. This "competitive entry" effect is captured by the first two terms in (10). Second, additional entry means that the beneficial effect from complementarity with the other-type firms has to be shared with one more firm. This is captured by the third term in (10). Note that when no other-type firms are present ($k = 0$), then only the third term vanishes (since $\gamma_i^0 = 0$) so that the entry threshold ratios have a clean competitive entry interpretation as in Bresnahan and Reiss. In our empirical analysis, the entry threshold ratios will be useful in two respects. First, they provide a natural starting point for imposing restrictions on the number of fixed effects α_i^j to be estimated. Second, they are of independent interest in interpreting the empirical results, in particular the estimated fixed effects α_i^j and γ_i^k.

4 Empirical analysis

Our empirical analysis proceeds in two steps. First, we compare the model in which the entry decision of the different types are strategic complements to the model in which they are strategic substitutes, and find that only the first gives internally consistent parameter estimates. Second, we discuss the parameter estimates of this model in more detail and compare it to special cases, i.e. the bivariate ordered probit model in which different types are independent, with and without censoring for binding entry restrictions.

4.1 Strategic complements or substitutes

Our first entry model, in which the entry decisions of firms of different types are strategic complements, is given by (7). The second model, in which they are strategic substitutes, is derived in the Appendix. We estimate both models, and verify whether the parameter estimates are internally consistent, i.e. satisfy the implied restrictions (as given by (9) in the case of strategic complements).

We begin with the first model, the case of strategic complements. There may be up to 11 pharmacies and up to 21 physicians in a market, implying a large number of fixed effects α_i^j and γ_i^k. It is necessary to impose restrictions on the pharmacies' own-type fixed effects α_1^j, since the entry restrictions are always binding in markets with more than 4 pharmacies: for $j > 4$, we set α_1^j such that there is no competitive entry effect[14]. To estimate the other-type fixed effects, γ_i^k, we impose restrictions following a "bottom-up" approach[15]. We obtain a specification with one significant other-type fixed effect for pharmacies, and four significant other-type fixed effects for physicians. The model is internally consistent, i.e. the estimated parameters satisfy all the conditions given by (9). We defer a more detailed discussion of the economic interpretation of the fixed effects and the other parameters to the next subsection.

We adopt the same approach to estimate the alternative model, in which the entry decisions of firms of different types are strategic substitutes. We find that this model is not internally consistent, i.e. the estimated parameters violate the restrictions required by the model. In particular, we find that entry by other-type firms raises payoffs, while the assumption of strategic substitutes requires the opposite. We conclude that the entry decision of pharmacies and physicians are strategic complements. In section 2 we discussed that there were good reasons to expect complementarities, since patients usually require both services. Yet, we did not rule out the possibility of substitutability, since the two professions often provide overlapping services. Our empirical results provide more conclusive evidence, showing that on balance there is more strategic complementarity than substitutability. We can now turn to a more detailed discussion of the empirical results.

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[14] Following our discussion in section 3.4, this amounts to setting the first two terms in the entry threshold ratio (10) equal to 1, so that the constrained α_1^j are given by $\alpha_1^j = \alpha_1^{j-1} + \lambda_1 \ln((j-1)/j)$.

[15] We first estimate a limited number of other-type fixed effects, and set the remaining γ_i^k such that $\gamma_i^k = \gamma_i^{k-1}$, implying that there is no additional complementarity after a given number of other-type firms has entered. We subsequently verify whether the estimated fixed effects satisfy the conditions in (9), which results in 3 cases. First, if the conditions are significantly violated, the model is internally inconsistent. Second, if they are insignificantly violated, we impose the relevant condition to hold with equality and re-estimate the model. Finally, if the conditions are satisfied, we relax the initial constraint $\gamma_i^k = \gamma_i^{k-1}$ for an additional γ_i^k, re-estimate the model and verify again the conditions (9).

4.2 Parameter estimates

Table 3 presents the parameter estimates from three different models. The specification in the first column is an uncensored bivariate probit model. This model assumes that different types are independent (no complementarity, so all $\gamma_i^k = 0$), and that there are no binding entry restrictions. This model still allows the unobserved factors influencing the pharmacies' and physicians' payoffs to be correlated (ρ). The specification in the second column is a censored bivariate probit model. It still assumes that different types are independent, but it accounts for the fact that entry restrictions on pharmacies are binding in some of the markets. The specification in the third column is our general entry model, allowing the entry decision of the different types to be strategic complements and accounting for binding entry restrictions.

A comparison between the first and the second specification clearly demonstrates the importance of accounting for the presence of binding entry restrictions on pharmacies. Several of the parameters change to a substantial extent. Furthermore, a comparison between the second and the third specification shows that there are significant strategic complementarities between different types (likelihood ratio test statistic of 41.78). It is interesting to point out that the correlation parameter ρ is lower in the third specification than in the second. Intuitively, the second specification suggests there is a (small) positive correlation between the unobserved market characteristics affecting the pharmacies' and physicians' payoffs, but this correlation drops once one accounts for the presence of strategic complementarity. We now discuss the parameter estimates of the general entry model in more detail.

Table 3. Estimation results*

	Uncensored bivariate ordered probit		Censored bivariate ordered probit		General model with strategic complements	
Pharmacies' payoff equation						
constant	-19.05	(1.18)	-14.09	(3.40)	-13.54	(1.82)
ln(population)	2.49	(0.06)	1.95	(0.12)	1.43	(0.13)
% young	-0.31	(2.48)	0.73	(9.18)	0.22	(4.26)
% old	10.18	(2.43)	19.00	(5.20)	19.32	(3.54)
% foreign	-1.03	(0.94)	-0.94	(0.96)	-1.00	(1.08)
% unemployed	9.20	(2.22)	22.71	(4.85)	23.06	(4.40)
Flanders	-0.03	(0.14)	0.13	(0.34)	0.11	(0.25)
income	-0.43	(0.14)	-0.35	(0.18)	-0.32	(0.19)
α_1^2	2.26	(0.11)	1.50	(0.18)	1.09	(0.23)
α_1^3	3.64	(0.13)	2.56	(0.20)	1.94	(0.30)
α_1^4	4.83	(0.15)	3.14	(0.22)	2.37	(0.35)
γ_1^1	–		–		0.78	(0.29)
Physicians' payoff equation						
constant	-19.41	(0.94)	-19.28	(1.12)	-17.42	(0.98)
ln(population)	2.54	(0.07)	2.53	(0.08)	2.27	(0.07)
% young	3.45	(2.08)	2.22	(2.25)	2.02	(2.15)
% old	6.85	(1.84)	6.81	(1.90)	5.98	(1.89)
% foreign	-3.61	(0.73)	-3.58	(0.69)	-3.43	(0.72)
% unemployed	2.30	(1.83)	2.29	(1.98)	0.67	(1.89)
Flanders	-0.65	(0.12)	-0.56	(0.13)	-0.58	(0.13)
income	0.32	(0.11)	0.32	(0.12)	0.37	(0.11)
α_2^2	1.30	(0.10)	1.32	(0.10)	1.23	(0.10)
α_2^3	2.34	(0.12)	2.36	(0.12)	2.27	(0.13)
α_2^4	2.99	(0.13)	3.09	(0.13)	2.91	(0.14)
γ_2^1	–		–		0.16	(0.19)
γ_2^2	–		–		2.01	(0.29)
γ_2^3	–		–		3.89	(1.01)
γ_2^4	–		–		5.99	(0.83)
ρ	0.32	(0.03)	0.05	(0.07)	-0.15	(0.09)
Log Likelihood	-2,255.6		-1,761.5		-1,740.6	

* The number of observed markets is 847. Standard errors are in parentheses. The other estimated α_2^k are not shown; constraints on the other α_1^k and γ_i^k are discussed in the text.

Market size, as measured by population, is the most important market characteristic affecting the pharmacies' and physicians' payoffs. This is consistent with the results from previous entry models, such as Bresnahan and Reiss (1991). In line with expectations, the population's age distribution has an important impact on payoffs. More specifically, the percentage of elderly in a market has a positive and significant effect on both professions' payoffs; the effect is stronger for the pharmacies. The other market characteristics only have a significant effect on the payoffs of one of the two professions. The percentage of foreigners has a negative effect on payoffs, but the effect is significant only in the case of physicians. Physicians do not obtain significantly different payoffs in markets with higher unemployment, whereas pharmacies tend to obtain significantly higher payoffs in such markets. Income per capita positively and significantly affects the physicians' payoffs. Finally, there are some regional differences: payoffs to physicians are significantly lower in the region of Flanders than in the other two regions (Brussels and Wallonia). This may be due to either different medical consumption habits or to better alternative employment opportunities in the region of Flanders.

As discussed in the previous section, the entry fixed effects α_i^j and γ_i^k all satisfy the conditions given by (9) to have an internally consistent model. More specifically, the own-type effects α_i^j are all positive and show an increasing pattern, as required by the first condition in (9).[16] This implies that additional entry by firms of the same type lowers payoffs. The same pattern occurs for the other-type effects γ_i^k, satisfying the second condition in (9). This means that additional entry by firms of different types raises payoffs (complementarity). Finally, one can verify that the third condition in (9) is satisfied for all observed market configurations. Intuitively, this means that the extent of complementarity between firms of different types is lower than the extent of substitutability between firms of the same type.

To better interpret the magnitude of the other-type effects γ_i^k, and the implied complementarities, consider the change in market size required to support j firms when one moves from k to $k+1$ firms of the other type. This can be measured by the ratio $S_i^{j,k+1}/S_i^{j,k} = \exp(-(\gamma_i^{k+1} - \gamma_i^k)/(j\lambda_i))$. The estimates imply that the market size required to support one pharmacy when a physician is present is only 58% of the required market size when no physician is present (standard error of 14%). Conversely, the market size required to support one physician is not significantly lower in the presence than in the absence of a pharmacy (ratio of 93% with a standard error of 8%). However, the market size required to support one physician in the presence of two pharmacies is only 45% of the required market size in the presence of one pharmacy (standard error of 10%).

Further insights in the magnitude of the own-type fixed effects can be obtained from the

[16] Recall that α_i^1 and γ_i^0 are normalized to zero.

per-firm entry thresholds, as shown in Table 4. They are given by (10) and measure the extent to which the per-firm market size has to increase to support an additional firm of the same type. As discussed above, their interpretation is more complicated in our framework than in Bresnahan and Reiss'. If no other-type is present ($k = 0$), the entry threshold ratios can still be interpreted as measures of the effect of additional entry on competition. But in the presence of other types, they also capture the extent to which the beneficial effect from complementarity has to be shared with an additional firm.

We therefore concentrate our discussion of Table 4 on the entry threshold ratios in the first column ($k = 0$), which have the interpretation of capturing the competitive effects from entry. The numbers show that these entry threshold ratios are generally insignificantly different from 1, for both pharmacies and physicians. To illustrate, the entry threshold ratio for two pharmacies is 1.07 (standard error 0.14), which is insignificantly different from 1: the per-firm market size to support a duopoly of pharmacies is thus insignificantly different from the market size required to support a monopoly pharmacy. The general conclusion from the first column is that additional entry does not appear to imply intensified competition. In section 2, we already discussed that neither pharmacies nor physicians can use price or advertising to compete; our estimates thus imply that both professions do also not appear to use the other non-price instruments (such as quality of service) in response to additional entry. Some caution is however warranted. In general, the entry threshold ratios are only informative about the change in competition in response to entry, but not about the *level* of competition to start with. In principle, it could thus be possible that monopoly pharmacies and physicians already behave competitively, because of the threat of new entry as in contestable markets. However, at least for the pharmacies, this possibility appears to be rather unlikely. As Table 1 showed, the entry restrictions stemming from the establishment act are binding in the majority of the markets, so that most monopoly pharmacies are effectively protected from the threat of new entry.

As a final point, we discuss the entry threshold ratios in the second and third column of Table 4, which refer to markets in which there are one or two firms of the other type. The ratios are all greater than in the first column, and usually greater than 1. This is due to our finding of significant complementarities: additional entry by a firm of the same type means that the beneficial effect from complementarity has to be shared with that additional firm.

Table 4. Own-type entry effects*

	$k=0$		$k=1$		$k=2$	
Pharmacies' entry threshold ratios						
$ETR_1^{2,k}$	1.07	(0.14)	1.40	(0.17)	1.40	(0.17)
$ETR_1^{3,k}$	1.20	(0.11)	1.32	(0.12)	1.32	(0.12)
$ETR_1^{4,k}$	1.02	(0.08)	1.06	(0.08)	1.06	(0.08)
Physicians' entry threshold ratios						
$ETR_2^{2,k}$	0.86	(0.04)	0.89	(0.05)	1.34	(0.10)
$ETR_2^{3,k}$	1.05	(0.04)	1.07	(0.04)	1.22	(0.06)
$ETR_2^{4,k}$	0.99	(0.03)	1.00	(0.03)	1.07	(0.04)

* Entry threshold ratios are defined as $ETR_i^{j+1,k} = (S_i^{j+1,k}/(j+1))/(S_i^{j,k}/j)$, as given by (10) in the text. Standard errors are in parentheses.

5 Policy reform towards pharmacies

We now use the empirical entry model to assess the effects of policy reform towards pharmacies. According to the public interest view, the high regulated markups combined with geographic entry restrictions are needed to ensure a sufficient coverage of pharmacies in the less attractive areas, without triggering excessive entry elsewhere. To assess whether this view has empirical support, we compute the effects of both liberalizing the entry restrictions and reducing the regulated markups.

5.1 Approach

To compute the effects of liberalizing the entry restrictions we proceed as follows. The current regime restricts the number of type 1 firms (pharmacies) to be no more than a maximum number $\overline{N}_1$ per market, based on the population threshold criteria discussed in section 2. Entry liberalization is modelled by multiplying the maximum allowed number of firms $\overline{N}_1$ per market by a common factor $\phi > 1$ (i.e., by dividing the population threshold criteria set out the establishment act by this factor ϕ). The expected number of type 1 firms in a given market is then computed as:

$$E(N_1) = \sum_{n_1=1}^{\phi\overline{N}_1-1} \Pr(N_1 = n_1 \mid N_1 < \phi\overline{N}_1)n_1 + \Pr(N_1 = n_1 \mid N_1 = \phi\overline{N}_1)\phi\overline{N}_1,$$

where $\Pr(N_1 = n_1 \mid N_1 < \overline{N}_1)$ and $\Pr(N_1 = n_1 \mid N_1 = \overline{N}_1)$ are the marginal probabilities, obtained from summing the joint probabilities (4) and (6) over all n_2. A similar expression holds for the expected number of type 2 firms in a given market. If $\phi = 1$, we obtain the status quo predictions of the expected number of firms under the current regime; if ϕ is arbitrarily large, we obtain the predictions when entry becomes completely free.

Computing the entry effects of lowering the pharmacies' regulated gross markups ρ_1, currently set at 28%, generally requires information on the pharmacies' variable retail costs other than wholesale costs. To avoid this, we first predict the related entry effects of lowering the net variable markups μ_1, i.e. the gross markups ρ_1 net of other variable retail costs. To continue, we make two assumptions on the pharmacies' variable profits. First, variable profits move proportionally with the number of consumers S; it seems natural for our professions that variable profits per consumer are independent of the number of consumers. This assumption implies that $\lambda_i = 1$, so that the estimated parameter for S can now be reinterpreted as the inverse of the standard deviation of ε_i. Second, the net markups μ_1 are constant and uniform across markets. This is plausible since we earlier found that entry does not affect competition. With this additional structure, a reduction in the net variable markups μ_1 by a given factor Δ_1 (between -1 and 0) to $\mu_1(1+\Delta_1)$ can be modelled by adjusting the intercept β_1^0 in the payoff specification (8) with the constant amount of $\lambda_1 \ln(1+\Delta_1)$, where λ_1 is the coefficient of $\ln(S)$ in (8)[17]. The expected number of firms can then be predicted as before.

To retrieve the reduction in the regulated gross markup corresponding to a net markup reduction by the factor Δ_1, additional information on the variable retail costs other than wholesale costs is required. A reasonable starting point is to assume that the other variable retail costs are zero, so that $\mu_1 = \rho_1$[18]. The absolute reduction in the gross regulated markups is then simply $\rho_1\Delta_1 = 0.28\Delta_1$ at the current gross markups of 28%. As a robustness check, we will also consider the possibility that there are other variable retail costs, i.e. $\mu_1 < \rho_1$. It can be verified that the implied absolute gross markup reduction is then given by $((1-\rho_1)/(1-\mu_1))\,\mu_1\Delta_1$. As a robustness check, we will use this formula to consider the possibility that other variable retail costs cause the net variable markups to be 10% lower than the regulated gross markups of 28%, i.e. $\mu_1 = \rho_1 - 10\% = 18\%$.

[17]Formally, if the variable profits are $V_1(n_1,n_2) = \mu_1 \cdot R_1(n_1,n_2) \cdot S$, where the revenues per consumer $R_1(n_1,n_2)$ are independent of S, and if $\ln(R_1(n_1,n_2)/F_1(n_1,n_2)) = X\overline{\beta}_1 - \overline{\alpha}_1^j + \overline{\gamma}_1^k/j$, we essentially obtain our earlier specification (8), where the coefficient on $\ln(S)$ is now restricted to 1 so that the standard deviation of ε_1, σ_1, is now identified. This implies that our earlier population coefficient λ_1 can be reinterpreted as $1/\sigma_1$, and our intercept β_1^0 as $\left(\overline{\beta}_1^0 + \ln(\mu_1)\right)/\sigma_1$, i.e. as containing the net markup μ_1. Hence, a change in the net markup μ_1 to $\mu_1(1+\Delta_1)$ amounts to adjusting β_1^0 to $\beta_1^0 + \lambda_1 \ln(1+\Delta_1)$.

[18]The pharmacies' most important other retail costs are labor costs, and it is reasonable to treat these as fixed, since time spent on servicing patients is essentially fixed during opening hours (in contrast to physicians who spend a variable amount of their time on servicing patients).

5.2 Findings

Table 5 summarizes the entry predictions under alternative regulatory policies towards entry and markups. It compares three entry regimes: the status quo entry regulation ($\phi = 1$; panel a), "partial" entry deregulation where the maximum allowed number of pharmacies in each market is doubled ($\phi = 2$; panel b), and a full free entry situation (ϕ large; panel c). We also consider three possible net markups: no change in the markups ($\Delta_1 = 0$; first column), and reductions in the net markups by 25% and 50% ($\Delta_1 = -0.25$ and -0.5; second and third columns). Note that if pharmacies have no other variable retail costs than wholesale costs, these relative net markup reductions amount to absolute reductions in the regulated gross markups by respectively 7% and 14%. On the other hand, if the other variable retail costs are 10%, the net markup reductions correspond to absolute gross markup reductions of 4% and 7.9%.

The first column of Table 5 shows the predictions under the three entry regimes, assuming no changes in markups[19]. The total number of pharmacies is predicted to increase from 1455 to 2077 (or +43%) under partial entry deregulation, and to 3035 (or +109%) under full free entry. The current entry restrictions, which Table 1 documented to be binding in more than 80% of the markets, are thus also economically important. Furthermore, the first column shows that entry deregulation would also have indirect effects on the physicians. Their number would increase from 4201 to 4232 (or +1%) under partial entry deregulation, and to 4489 (or +7%) under full free entry. These effects stem from our earlier finding that the entry decisions of pharmacies and physicians are strategic complements. Finally, the first column shows how the geographic coverage of health care services changes after entry deregulation. For example, full free entry would drastically reduce the number of markets in which there is no pharmacy, from 250 to 104.

Policy makers have warned against too simple conclusions regarding the effects of liberalizing entry regulations. According to the public interest view the high regulated markups and tight entry restrictions ensure a sufficient coverage of pharmacies in the less attractive areas, without triggering excessive entry elsewhere. To evaluate this view, it is therefore important to look at the effects of simultaneously liberalizing entry and lowering markups. The second and the third columns of Table 5 show the results. If the net markups are reduced by factors of 25% and 50% without liberalizing the entry restrictions (second and third columns of panel a), then the total number of pharmacies drops to respectively 1363 and 1191. The geographic coverage would also decrease. For example, the number of markets without any

[19] The model predicts the status quo outcomes reasonably well. For example, Table 1 showed that there are 246 (154) markets without any pharmacy (physician), whereas the model predicts that there are 250 (142) such markets.

pharmacy would increase by 12% to 279 if net markups were lowered by 50%. In contrast, panel b and panel c show that the number of pharmacies would no longer decrease if the markup reductions are accompanied by a sufficient liberalization of the entry restrictions. For example, the number of pharmacies increases from 1455 to 1836 if a 50% net markup reduction is combined with full free entry. Furthermore, geographic coverage is no source of concern under these combined policies: the total number of markets without any pharmacy always drops. Even if a net markup reduction of 50% is combined with partial entry deregulation, the number of markets without a pharmacy would drop from 250 to 241. The indirect effects on physicians are small but, if anything, the availability of physicians increases when entry liberalization is combined with a lowering of the markups.

Table 5. Summary entry predictions under alternative regulatory policies*

	net markup change		
	$\Delta_1 = 0$	$\Delta_1 = -0.25$	$\Delta_1 = -0.5$
Panel a - no change in entry restrictions ($\phi = 1$)			
number of pharmacies	1455	1363	1191
number of physicians	4201	4175	4125
number of markets without pharmacy	250	252	279
number of markets without physician	142	142	144
Panel b - maximum number of pharmacies doubles ($\phi = 2$)			
number of pharmacies	2074	1840	1488
number of physicians	4232	4207	4152
number of markets without pharmacy	189	202	241
number of markets without physician	144	144	144
Panel c - full free entry in pharmacy market (ϕ is large)			
number of pharmacies	3035	2493	1836
number of physicians	4489	4394	4261
number of markets without pharmacy	104	139	200
number of markets without physician	108	116	122

*

This discussion strongly indicates that the public interest motivation for combining high markups and tight entry restrictions as a way to ensure geographic coverage has little empirical support. The government could in fact ensure a higher geographic coverage (in the sense of number of markets with at least one pharmacy) by simultaneously liberalizing entry and lowering markups. To explore this further, it would be interesting to know the optimal number of firms and the required policies to ensure this. A complete welfare analysis is however not possible within our empirical framework, but we can address a related question that sheds partial light on this issue. We ask how the entry restrictions can be liberalized (through ϕ) and the net markup can be reduced in such a way that the total number of pharmacies in the country remains constant at the current predicted level of 1454. We then also compute the associated reductions in the absolute gross markups and the number of markets without any pharmacy.

Table 6 shows the results from this policy experiment. The first and second columns show the combinations of entry restrictions and net markups such that the total number of pharmacies in the country remains constant. To illustrate, raising the maximum allowed number of pharmacies by 75% ($\phi = 1.75$) requires net markups to drop by 49.2%. In general, as entry restrictions are liberalized, the net markups should drop to keep the total number of pharmacies constant. With full free entry, we obtain the maximum drop in net markups of 62.4%. To know how the government could reduce the regulated gross markups in absolute terms, the third and fourth column consider the case in which there are no other variable retail costs than wholesale costs ($\mu_1 = \rho_1$), and the case in which these amount to 10% ($\mu_1 = \rho_1 - 10\%$). Gross markups can drop by a large amount, even if there are other variable retail costs. If entry would become fully free, then the regulated gross markups can decrease by between 9.9% and 17.5% in absolute terms without changing the total number of pharmacies. Finally, in this policy reform experiment availability is no issue. The last column shows that the number of markets without any pharmacy essentially remains similar to the status quo level of 250. These findings imply that the government can generate substantial budgetary savings from liberalizing entry without reducing the total number of pharmacies or inducing problems of geographic availability. In fact, given that the per capita expenditures on drugs are currently € 110, the annual savings to consumers (tax payers) appear to be substantial.

Table 6. Entry restrictions, markups and geographic coverage – keeping the total number of pharmacies constant*

degree of entry restriction ϕ	net markup drop by factor Δ_1	absolute gross markup drop		number of markets without pharmacy
		$\mu_1 = \rho_1$	$\mu_1 = \rho_1 - 10\%$	
1	0	0%	0%	250
1.25	-0.281	-7.9%	-4.4%	244
1.5	-0.424	-11.9%	-6.7%	249
1.75	-0.492	-13.8%	-7.8%	248
2	-0.519	-14.5%	-8.2%	244
2.25	-0.559	-15.6%	-8.8%	257
2.5	-0.573	-16.0%	-9.0%	254
large	-0.624	-17.5%	-9.9%	252

*

6 Conclusions

To be written.

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8 Appendix

This Appendix first characterizes the multiplicity of Nash equilibria outcomes when the entry decisions of firms of different types are strategic complements, and subsequently briefly presents the parallel case of strategic substitutes.

8.1 Characterization of multiplicity of Nash equilibria

If the entry decisions by firms of different types are strategic complements, i.e. Assumption 2(a) holds with strict inequality, then (n_1, n_2) may show multiplicity with other equilibrium outcomes of the general form $(n_1 + m_1, n_2 + m_2)$. The three Claims below show that the multiplicity can be characterized in a simple way if Assumptions 1 and 2 are satisfied. Taken together, these Claims imply that the areas of ε for which (n_1, n_2) shows multiplicity with any other Nash equilibrium outcome are simply given by the areas of overlap with (n_1+1, n_2+1) and $(n_1 - 1, n_2 - 1)$.

Define $A(n_1, n_2)$ as the set of ε for which (n_1, n_2) is a Nash equilibrium outcome, as given by the conditions (2) in the text. Furthermore, define $B(n_1, n_2, m_1, m_2)$ as the set of ε for which both (n_1, n_2) and $(n_1 + m_1, n_2 + m_2)$ are a Nash equilibrium, i.e. $B(n_1, n_2, m_1, m_2) = A(n_1, n_2) \cap A(n_1 + m_1, n_2 + m_2)$, where m_1 and m_2 are positive or negative integers.

Claim 1. *$B(n_1, n_2, m_1, m_2)$ is empty if $m_1 \neq m_2$.*
((n_1, n_2) may only show multiplicity with Nash equilibrium outcomes of the form $(n_1 + m, n_2 + m)$, where m is a positive or a negative integer.)

Proof: Suppose to the contrary that there are also equilibrium outcomes of the form $(n_1 + m_1, n_2 + m_2)$, where $m_1 \neq m_2$. There are several cases:

(i) If $m_1 > 0$ and $m_2 < 0$, then $\varepsilon_1 \leq \pi_1(n_1+m_1, n_2+m_2) \leq \pi_1(n_1+m_1, n_2) \leq \pi_1(n_1+1, n_2)$, by the conditions for (n_1+m_1, n_2+m_2) to be a Nash equilibrium, by Assumption 2(a) and by Assumption 1.

(ii) If $m_1 > 0$ and $m_2 > 0$, and $m_1 > m_2$, then $\varepsilon_1 \leq \pi_1(n_1 + m_1, n_2 + m_2) < \pi_1(n_1 + m_1 - m_2, n_2) \leq \pi_1(n_1 + 1, n_2)$, by the conditions for $(n_1 + m_1, n_2 + m_2)$ to be a Nash equilibrium, by Assumption 2(b), and by Assumption 1.

(iii) If $m_1 > 0$ and $m_2 > 0$, and $m_1 < m_2$, then $\varepsilon_2 \leq \pi_2(n_1 + m_1, n_2 + m_2) < \pi_2(n_1, n_2 + m_2 - m_1) \leq \pi_2(n_1, n_2 + 1)$, by the conditions for $(n_1 + m_1, n_2 + m_2)$ to be a Nash equilibrium, by Assumption 2(b), and by Assumption 1.

(iv) If $m_1 < 0$ and $m_2 > 0$, then $\varepsilon_2 \leq \pi_2(n_1+m_1, n_2+m_2) \leq \pi_2(n_1, n_2+m_2) \leq \pi_2(n_1, n_2+1)$, by the condition for $(n_1 + m_1, n_2 + m_2)$ to be Nash, by Assumption 2(a) and by Assumption 1.

(v) If $m_1 < 0$ and $m_2 < 0$, and $m_1 > m_2$, then $\pi_2(n_1, n_2) \leq \pi_2(n_1, n_2 + m_2 - m_1 + 1) < \pi_2(n_1+m_1, n_2+m_2+1) < \varepsilon_2$, by Assumption 1, by Assumption 2(b), and by condition for $(n_1 + m_1, n_2 + m_2)$ to be Nash.

(vi) If $m_1 < 0$ and $m_2 < 0$, and $m_1 < m_2$, then $\pi_1(n_1, n_2) \leq \pi_1(n_1 + m_1 - m_2 + 1, n_2) < \pi_1(n_1 + m_1 + 1, n_2 + m_2) < \varepsilon_1$, by Assumption 1, by Assumption 2(b), and by the condition for $(n_1 + m_1, n_2 + m_2)$ to be Nash.

In all cases we have obtained a contradiction with the conditions (2) for (n_1, n_2) to be a Nash equilibrium outcome.

Claim 2. *$B(n_1, n_2, 1, 1)$ and $B(n_1, n_2, -1, -1)$ are not empty.*
((n_1, n_2) shows multiplicity with $(n_1 + 1, n_2 + 1)$ and $(n_1 - 1, n_2 - 1)$.)

Proof: The set $B(n_1, n_2, 1, 1)$ is given by the conditions (3) in the text. Since we assume that Assumption 2(a) holds with strict inequality, this set is not empty. A similar reasoning applies to the set $B(n_1, n_2, -1, -1)$.

Claim 3. *$B(n_1, n_2, m, m) \subset B(n_1, n_2, 1, 1)$ if $m > 1$, and $B(n_1, n_2, m, m) \subset B(n_1, n_2, -1, -1)$ if $m < -1$.*
(While (n_1, n_2) may also show multiplicity with $(n_1 + m, n_2 + m)$ for $m > 1$ or $m < 1$, the areas of multiplicity are a subset of those with $(n_1 + 1, n_2 + 1)$ and $(n_1 - 1, n_2 - 1)$.

Proof: The set $B(n_1, n_2, m, m)$ is given by:

$$\begin{aligned} \pi_1(n_1 + 1, n_2) &\leq \varepsilon_1 \leq \pi_1(n_1 + m, n_2 + m) \\ \pi_2(n_1, n_2 + 1) &\leq \varepsilon_2 \leq \pi_2(n_1 + m, n_2 + m), \end{aligned} \tag{11}$$

which may or may not be empty. Since the left-hand-side in (11) is the same as in (3), and the right hand side in (11) is less than in (3) by Assumption 2(b), we have $B(n_1, n_2, m, m) \subset B(n_1, n_2, 1, 1)$ if $m > 1$. A similar reasoning applies to show that the set $B(n_1, n_2, m, m) \subset B(n_1, n_2, -1, -1)$ if $m < 1$.

8.2 Strategic substitutes

The case in which entry decisions by firms of different types are strategic substitutes may be summarized by the following assumption, replacing Assumption 2.

Assumption 2*. (Entry decisions by firms of different types are strategic substitutes or independent)

(a)
$$\pi_1(n_1, n_2 + 1) \leq \pi_1(n_1, n_2)$$
$$\pi_2(n_1 + 1, n_2) \leq \pi_2(n_1, n_2)$$

(b)
$$\pi_1(n_1 + 1, n_2 - 1) < \pi_1(n_1, n_2)$$
$$\pi_2(n_1 - 1, n_2 + 1) < \pi_2(n_1, n_2)$$

Assumption 2*(a) says that payoffs are decreasing or independent of the number of firms of the other type, so that entry decisions by firms of different types are (weak) strategic substitutes. Assumption 2*(b) says that the extent of strategic substitutes between firms of different types is weaker than that between firms of the same type. Hence, payoffs decrease when there is one more firm of the same type and one less firm of the other type.

As in the case of strategic complements, the market configuration (n_1, n_2) is a Nash equilibrium outcome if ε satisfies (2). Assumption 1 again guarantees that (n_1, n_2) is observed with positive probability. Furthermore, there may again be multiple Nash equilibrium outcomes (when Assumption 2*(a)). Following a parallel reasoning to the case of strategic complements, the areas of multiplicity are simply given by the areas of multiplicity with the Nash equilibrium outcomes $(n_1 + 1, n_2 - 1)$ and $(n_1 - 1, n_2 + 1)$. For example, the area of multiplicity with $(n_1 + 1, n_2 - 1)$ is given by:

$$\begin{aligned} \pi_1(n_1 + 1, n_2) &\leq \varepsilon_1 \leq \pi_1(n_1 + 1, n_2 - 1) \\ \pi_2(n_1 + 1, n_2) &\leq \varepsilon_2 \leq \pi_2(n_1, n_2), \end{aligned} \tag{12}$$

and similarly for $(n_1 - 1, n_2 + 1)$.

To obtain a unique equilibrium outcome, we again impose additional structure to the entry game. We assume that firms enter sequentially, i.e. conditional on observing all previous entry decisions, and impose the subgame perfect Nash equilibrium refinement. In contrast with the case of strategic complements, the specific ordering of entry matters. In our application, it is perhaps most natural to assume that type 1 firms (pharmacies) make their entry decisions before type 2 firms. In this case, an additional pharmacy will enter and thereby preempt entry of an additional physician, so that the market structure with the highest number of pharmacies will prevail. As a result, (n_1, n_2) will be a subgame perfect Nash equilibrium outcome if and only if (i) ε satisfies conditions (2) and (ii) does not satisfy conditions (12). Assuming that ε has a bivariate density $f(\cdot)$, the probability that the market configuration (n_1, n_2) is observed as the unique subgame perfect equilibrium outcome is:

$$\begin{aligned}\Pr(N_1 &= n_1, N_2 = n_2 \mid N_1 < \overline{N}_1) = \int_{\pi_1(n_1+1,n_2)}^{\pi_1(n_1,n_2)} \int_{\pi_2(n_1,n_2+1)}^{\pi_2(n_1,n_2)} f(u_1, u_2) \mathrm{d}u_1 \mathrm{d}u_2 \\ &- \int_{\pi_1(n_1+1,n_2)}^{\pi_1(n_1+1,n_2-1)} \int_{\pi_2(n_1+1,n_2)}^{\pi_2(n_1,n_2)} f(u_1, u_2) \mathrm{d}u_1 \mathrm{d}u_2, \qquad (13)\end{aligned}$$

when entry restrictions are not binding. When entry restrictions are binding, one can follow the same reasoning as under strategic complements to obtain the same probability of observing (n_1, n_2) as the unique subgame perfect equilibrium outcome, given by (6).

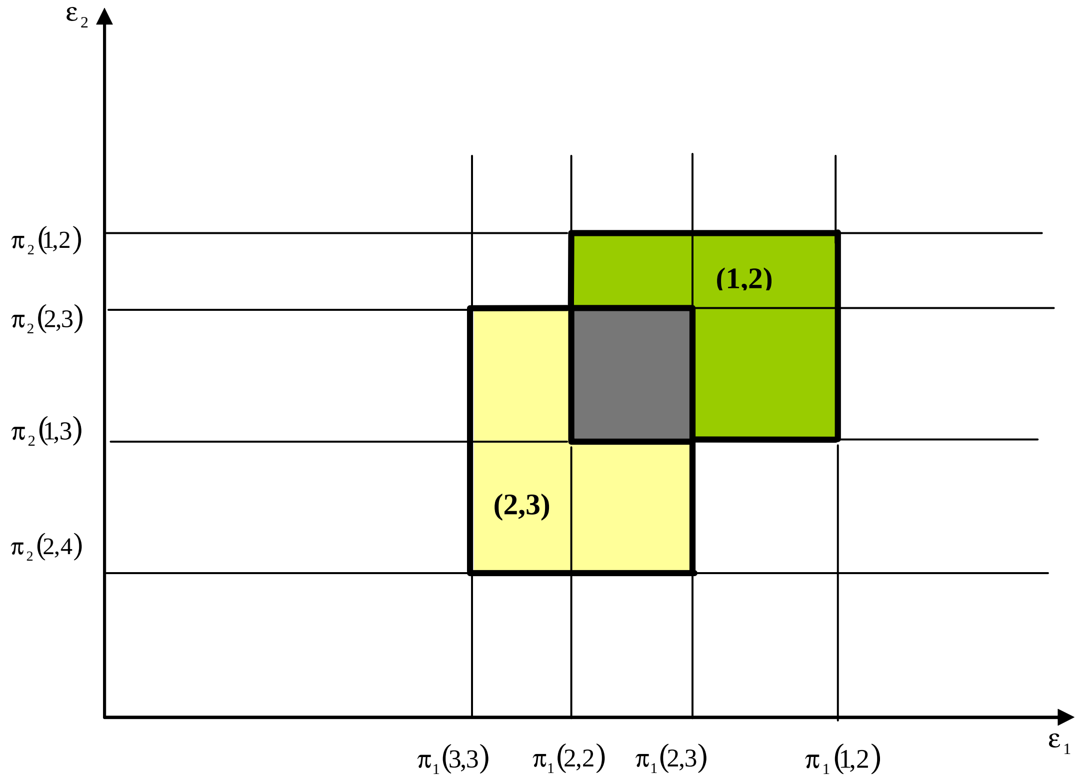

Figure 1. Nash equilibria with strategic complements

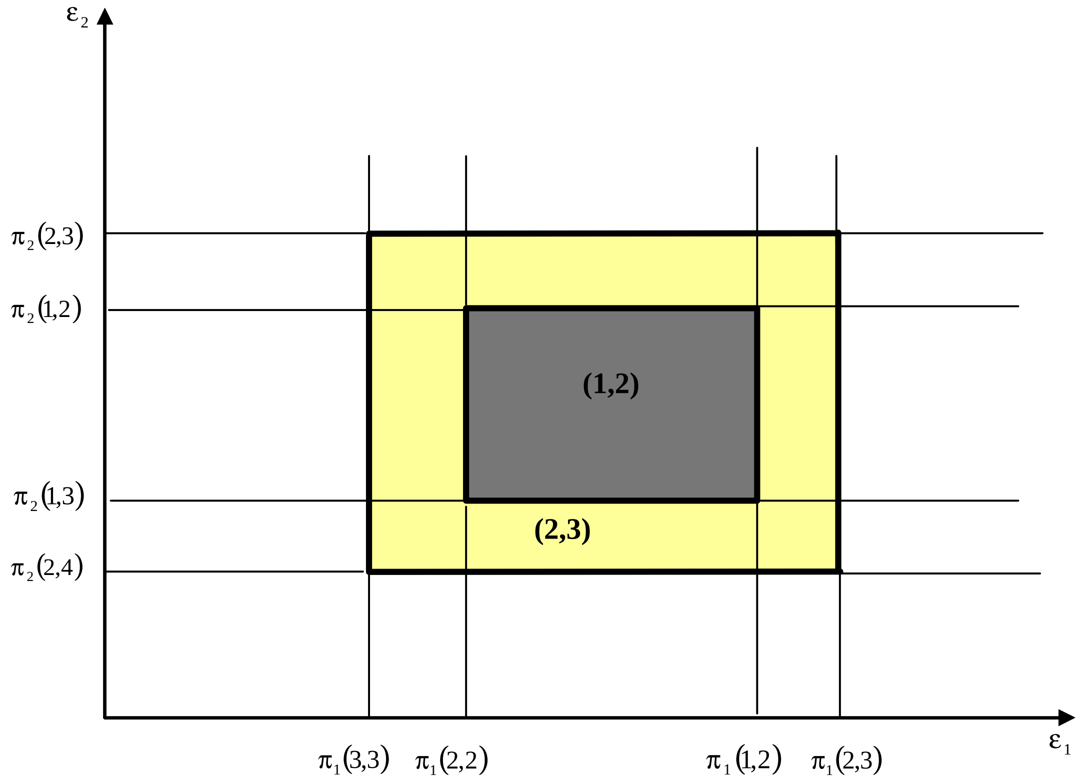

Figure 2. Nash equilibria – strong strategic complementarities