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RESEARCH ARTICLE

Estimating the effects of legalizing drug e-commerce

Stanislav V. Spektor [1], Karina A. Ionkina [1, 2]

1 *Faculty of Economics, M. V. Lomonosov Moscow State University, Moscow, 119991, Russia*

2 *Center for Research on Competition and Economic Regulation of the RANEPA, Moscow, 119571, Russia*

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Abstract[1]

With the technological development the e-commerce channel began to spread to all sectors of the economy. In 2020 with the introduction of sanitary and epidemiological restrictions because of COVID-19 pandemic, many countries lifted the ban of drug e-commerce. Such changes are interesting from the point of view of health economics, and the opening of this sales channel significantly reduces transaction costs and increases the physical availability of drugs, especially in regions with low population density. The article attempts to evaluate the effects of legalization of online sales of drugs on price level and the degree of market concentration (the concentration of the 5 largest companies is used as a proxy), and also uses new methods to estimate the effects of legalizing e-commerce on drug markets. High rates of industry and drug market concentration can lead to a noticeable decrease in the availability of goods. Legalizing e-commerce can be seen as a way to reduce market concentration by facilitating market entry for small firms. The effects of lifting the ban on remote drug sales are estimated using regression analysis on panel data, cross-country matching, and synthetic control. Empirical estimates provide an overall picture of the effects of legalizing online drug sales. After allowing remote drug sales market concentration decreases, indicating a reduction in information asymmetry and switching costs. This effect is particularly important for countries with a high proportion of pensioners, for whom the switching costs are noticeably higher ceteris paribus. Allowing distance trade, due to reducing information asymmetry, drug pricing also slows down, that is, in addition to increasing physical accessibility, opening this channel also increases economic accessibility.

Keywords

drug e-commerce, competition, concentration, pricing, pensioners, panel data, synthetic control

JEL codes: L16, L81, I18

1 The article was prepared as part of the implementation of the state task of the RANEPA

Introduction

E-commerce in general is an important trade channel, crucial to population. Drug e-commerce is no exception and is playing more significant role in health economy. Firstly, it performs informational role, decreasing information asymmetry. With online pharmacies, buyers get easier access to information about drugs and their prices, can compare different medicines and their cost in different places, which in turn allows the population to purchase more suitable goods at a lower price. Secondly, drug e-commerce decreases transaction costs for the purchase of goods (primarily time and transport), which is especially important for remote communities which often do not have the necessary medicines readily available. However, e-commerce can also be associated with negative externalities, primarily in selling of substandard and counterfeit drugs to the buyer. It is possible to control traditional pharmacies at a lower cost, while opening a traditional pharmacy for an unscrupulous seller, on the contrary, is more difficult because of the high requirements for staff, space and storage of goods. Since the legalization of online drug sales can be associated with a number of negative effects, it is important to study possibilities of their occurrence. Global experience shows that in recent decades many countries have lifted bans on drug e-commerce (Fig. 1).

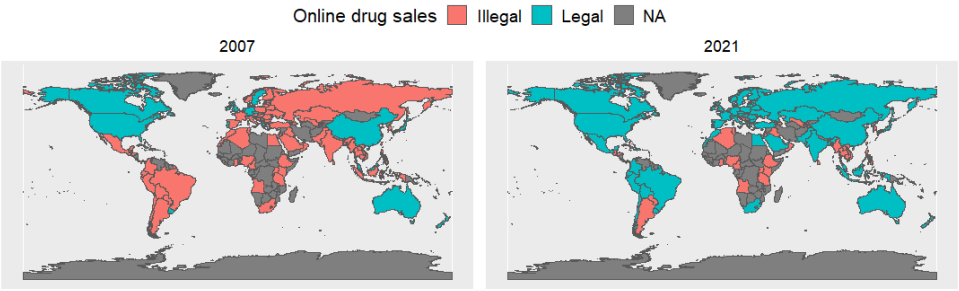

Figure 1. Country policies regarding online drug sales in 2007 and 2021. *Source*: made by the authors based on the analysis of international experience.

The e-commerce market for drugs was growing rapidly before the pandemic, at about 20% per year, with a growth rate of 32,4% (Statista, 2022). The largest markets are China (the online commerce market is $17 billion, according to Euromonitor), the United States ($13.5 billion), Japan ($2.1 billion), Germany, and the United Kingdom ($1.9 billion each). In all these countries online trade of drugs has been allowed for several decades and the market is developed on par with offline trade and occupies a significant share in population purchases. For example, 22.2% of all OTC (over the counter) drugs in Germany are bought online, in China – 12.4%, in UK – 10.6%, in the USA – 4.3%, in Japan – 3%. In Russia, the market volume, according to Euromonitor[1] (Euromonitor... 2022), is about $0.53 billion. With the share of online purchases of over-the-counter drugs at 6.6%. As the Covid-19 pandemic spreads around the world in 2020 the demand for online shopping skyrocketed. Many countries, including Russia, began to change legislation so that people can get access to the goods they need. The sphere of trade in medicines was no exception, as restrictions on the remote trade were lifted by many countries. Such changes are a striking example of the re-

1 In April 2022, the company ceased operations in Russia and data is no longer available to Russian users.

moval of administrative barriers, which has a strong impact on markets in general, on the competition, and on barriers to entry into the market. This paper evaluates the effects of the legalization of online trade in medicines.

This article aims to estimate the effects of lifting the ban on remote sale of OTC and prescription drugs, including the effect on the prices level and the state of competition.

Current studies in legalizing of e-commerce in medicine

The development of e-commerce is influenced by many different factors, many of which are hard to track. Nevertheless, such factors as the use of computers and smartphones by households, the level of trust in online stores, GRP (gross regional product), GNI (gross national income), retail trade turnover have a significant quantitative impact on the involvement of regions in e-commerce (Lola & Bakeev 2021), as well as on R&D spending (Lucero Ortiz et al. 2020).

The drug market has its own specifics. Despite high demand for goods, entering the market for offline pharmacies in rural areas is difficult. Due to highly differentiated demand pharmacies incur high costs for purchasing all necessary pharmaceuticals (Arentz et al. 2016). E-commerce partly solves this problem. As studies show, rural residents are more involved in purchasing online than urban (Cárdenas et al. 2017), however it applies primarily to wealthy knowledge workers who actively use the Internet (Martínez-Domínguez & Mora-Rivera 2020).

Hypothesis 1: The concentration of producers is positively related to the share of pensioners in the country's population and e-commerce channel decreases market concentration ceteris paribus.

The main drug market types are oligopoly (Craig & Malek 1995) and monopolistic competition (Dave et al. 2017), depending on the country. Product on the market is differentiated and sellers compete for sales volumes, and concentration on the market is low for monopolistic competition and high for oligopoly. Market concentration is closely related to the concept of market power and, in drug market, where buyers do not possess market power, market concentration can be seen as proxy for market power (Shastitko & Pavlova 2017). Evaluating market power is important for determining dominant position of sellers and producers, the abuse of which can lead to overpricing for buyers.

For the drug market antimonopoly policy is extremely important since a cartel can become one of the triggers for a situation where vital medicines would not be available to the consumer. In the drug market, a manufacturer can have high market power even though market concentration is relatively low, as dominance can arise due to high switching costs for the buyer (Shastitko & Pavlova 2017), which applies for the drug market, where market power, where personal experience is one of leading factors in drug purchases (Cîrstea et al. 2017). Therefore, access to information about substitutes is especially important for this market, where market power can be high at low concertation rates. In addition, switching costs grow with the age of consumer (Duijmelinck & Van de Ven 2016; Kiser, 2002), for the most vulnerable population, pensioners, reducing these costs is especially important. It is important to note that in addition to high switching costs, pensioners have a lower propensity to online purchases, which can lead to weaker legalization effects and higher market concentration in countries with older population, therefore, a significant factor in the estimated effect is the involvement of pensioners in online services use. However, market concentration can also be seen as the high efficiency of the firm (Davis & Garcés 2010).

The advent of e-commerce should reduce information asymmetry. The development of this channel lowers transaction costs of finding a product (Goldmanis et al. 2010), i.e. it is easier for the consumer to learn about more products. In general, market concentration of large recognizable brands is lower in online trade compared to offline (Zhang & Demirkan 2021).

Speaking about negative externalities, online pharmacies can be represented by two types of sellers: high and low type, conscientious and unscrupulous. According to Mavlanova et al. (2012), high type pharmacies that sell high-quality, non-counterfeit goods submit more signals that are associated with costs which are easily verified, such as confirmation of good faith from a third party (most often a government agency), requirement for prescriptions, the presence of a pharmacy geotagged. Thus, the problem of information asymmetry in the online pharmaceutical market is solved through signaling.

Hypothesis 2: Remote trade of medicines reduces the price level in both the short and long term.

As the e-commerce market develops, the overall price level decreases, and the greater the decrease, the greater the competition in the market (Freebairn 2001). Prices in e-commerce are a reliable indicator of prices in the market as a whole (Cavallo 2017). The spread between online and offline prices is not statistically significant, though they are not perfectly synchronized, with prices in online responding faster to different supply and demand shocks. Those assumptions are confirmed in several markets: food, clothing, housing, electronics, office supplies, pharmaceuticals. Despite this, the price elasticity of demand is lower in online commerce is significantly lower than in offline commerce (Zhang & Demirkan 2021).

Data and methods

To test the hypotheses, we collected data from Euromonitor International (Euromonitor… 2022) on the characteristics of drug market in 77 countries and data from the World Bank on socioeconomic and demographic characteristics of the countries[1].

Data on the market share of producers and brands were transformed into statistical indicators: concentration indices on 15, 10 and 5 biggest companies, Herfindahl-Hirschman Index (HHI), used to measure industry concentration. HHI values, though, can distort information about competition between producers and competition in markets: the index will be higher if the structure of the industry has a large asymmetry [2]. In addition, for most countries, information is available only on the shares of the largest producers, not for all of them, due to incomplete data, the calculation of the index is impossible. Therefore, the concentration indices of the five firms, CR5, calculated as the sum of the market shares of the five largest producers, will be used to assess the effects. This will make it possible to assess

1 There are several limitations in the available data. Firstly, Euromonitor International provides data rounded to the first decimal place. Secondly, statistics on producers and goods do not have all producers and goods on the market in them, but only a fixed number of the largest producers. Third, there are gaps in the World Bank data on country profiles, making it difficult to assess effects. In order not to exclude observations from the database, the gaps in the share of the urban population and the share of Internet users were filled in as an average between two years, considering that these shares grow slowly without strong volatility and shocks.

2 For example, if concentration index is the same in two markets, where there are five companies with 20% share each, and where there is 1 company with 60% market share and 4 companies with 10% share. HHI will be two times higher in the second market.

changes in the popularity of drugs and manufacturers without the shocks of market asymmetry. An increase in the index value indicates an increase in the shares of the largest manufacturers, and, as a result, the growth of market concentration. Also based on Thomson Reuters legal notes and data on sales channels data of the presence of ban on remote drug trade was added. The difference between remote and electronic trade is that remote trade includes any method of selling goods at a distance (for example by mail), while electronic trade includes trading of goods and services over the Internet (Zwass 2022). In this paper distance trade is equated with e-commerce, since nowadays it occupies almost the entire distance trade market (at least 90%), even in underdeveloped countries.

In general, according to descriptive statistics, countries that have long adopted e-commerce in medicines, countries that have lifted the ban relatively recently and countries that have not lifted it, differ in their characteristics. According to the descriptive statistics presented in Table 1, in some characteristics, including the share of Internet users, the share of urban population, the number of drugs and companies in the market, countries that lifted the ban from 2007 to 2021 are closer to countries that legalized distance drug trade before 2006. In other ways, such as healthcare expenditure, manufacturers, and brands consolidation, they are closer to countries that have not lifted the ban. In terms of GDP per capita, drug price index, share of pensioners, life expectancy, these countries occupy an intermediate position.

Comparing the data before and after the ban lift the effects are uncertain, for example, price dynamics did not change after the ban lift (Fig. 2).

According to correlation matrix (Fig. 3), distance trade is legalized in more developed countries (correlation between GDPs per capita and distance trade dummy variable is 0.51). It is also important to note the negative correlation between the price index and the availability of online trade and the positive correlation with the growth rate of the drug market in the country.

Table 1. Descriptive statistics by country in 2019

	Ban lifted before 2006			Ban was not lifted			Ban lifted after 2006		
	mean	se	n	mean	se	n	mean	se	n
GDP per capita	43,191.2	5,875.29	16	5,350.71	1,064.61	33	21,890.04	2,744.48	51
Internet user share	85.48	2.61	13	56.06	4.47	25	76.48	2.68	49
Price index	1.02	0.01	10	1.07	0.04	17	1.04	0.01	26
Urban population	76.67	2.91	16	54.47	3.61	33	73.47	2.32	51
Brand HHI	56.89	12.48	14	122.35	16.04	34	107.47	15.95	51
Brand number	88	5.97	14	38.35	5.13	34	76.06	4.22	51
Brand CR5	11.91	1.10	14	17.86	1.45	34	16.31	1.10	51
Producer HHI	713.91	90.33	14	555.52	66.83	34	562.82	44.34	51
Producer number	65.71	4.08	14	37.29	4.12	34	61.98	2.98	51
Producer CR5	49.35	3.69	14	40.98	2.37	34	41.90	1.62	51
Health expenditure	10.25	0.75	12	5.47	0.36	33	6.75	0.33	50
Pensioner share	19.43	1.03	12	6.86	0.88	33	12.64	0.90	51
Life Expectancy	81.89	0.47	12	71.59	1.19	34	77.16	0.62	51

Source: authors' calculation based on Euromonitor and World Bank data.

Figure 2. Price index for medicines in countries where distance selling of medicines was legalized in 2014-2016. *Source*: authors' calculation based on Euromonitor data.

Figure 3. Correlation matrix. *Source*: authors' calculation based on Euromonitor and World Bank data.

Empirical analysis is carried out on data that have several limitations, such as missing observations, a high difference between the characteristics of countries, but these limitations are not critical for the methods chosen by the authors, regressions on panel data and synthetic control.

Before econometric estimation, propensity score matching was made (Rosenbaum 2006). The purpose of this matching is to balance the sample as countries with different distance trade policy, according to descriptive statistics (Table 1), differ from each other significantly, therefore direct comparison may give incorrect estimates. The meaning of the method is to match each observation in the treated group (in this case it is the countries that lifted the distance drug trade ban) to one or several observations from the control group (countries that never lifted the ban). For this a logistic regression is made that estimates probability of being in treated group based on control variables. For econometric estimation models on panel data, pool, fixed and random effects were made. Regressor variables:

- Log (GDP_per_capita) – natural logarithm for GDP per capita;
- Internet_users – share of internet users;
- Urban - share of urban population;
- Year_i – dummy variable for year after ban lift, where i is number of years after lift (Year_0 – first year, when ban was lifted);
- Dist_trade – dummy variable equal to one, if distance drug trade is allowed;
- Health_exp – share of GDP expenditure on healthcare;
- Pensioners – share of population older than 65;
- Life_exp – Life expectancy.

Matching allows us to overcome endogeneity arising from self-selection problems (e.g., when legalization is introduced to those countries with high market concentration, inflation, low population density), countries from the impact group are compared to countries from the control group with similar characteristics, so similar observations are compared. The variables of interest in this model are Dist_trade variables and Year variables with lags. Lags are added to the models to test, whether the legalization effect is delayed or immediate, and whether it is short or long term. If the coefficients for Year_i and Dist_trade are significant with different signs, then a delayed effect is observed, that is, the influence of electronic commerce increases over the years. If the coefficient for Year_i is significant, while the one for for Dist_trade is not, then the effect is short-term.

The assessment is also carried out using the method of synthetic control.

The essence of the method consists in comparing cases for individual countries under the treatment effect with countries without treatment effect. Technically, the method is needed to create a synthetic copy of the country under study, comparing with it the countries from the control group by selected characteristics (Abadie 2021). Based on the pretreatment data (in this case, before the legalization of e-commerce in drugs), the country is matched with a combination of countries from the control group, which in the aggregate will be identical or similar in characteristics. The dynamics of the variable of interest for the synthetic clone after the period of impact shows how the variable would have changed without any impact.

To estimate the effect of the synthetic control, the sample was drawn from the countries where there was no effect, i.e., those countries where distance selling of drugs was prohibited during the study period. The appendix presents the countries selected for synthetic control. An important limitation of the synthetic control method, given the available data, is that the control countries (except South Korea and Croatia) are underdeveloped, so they may be ill-suited for the synthesis of developed countries. In order to overcome this limitation, only those countries for which the synthetic control fitting turned out to be sufficiently accurate

are included in the assessment of the average impact effect. To estimate the quality of the synthetic control we use Fit Index (Adhikari & Alm 2016). Index itself shows how much the estimation obtained by the synthetic control is better than the score in its absence. The closer the index is to 0, the more precise the control is. The 1-FitIndex value provides information similar to that provided by R^2 in regression analysis. The results obtained by the synthetic control are double verified for their reliability. First, those countries are selected for which the fit index is less than 0.1 (similar to the 10% significance level), and then the remaining countries pass a placebo test, the meaning of which is to check whether the effect is the cause of the changes, or the effect is due to the peculiarities of the calculation of the estimate.

One of the sources of endogeneity may be effects associated with the COVID-19 pandemic, which, as mentioned above, was the reason for the legalization of drug e-commerce in several countries. The synthetic control method overcomes this problem by comparing the dynamics of the dependent variable to that of a synthetic clone consisting of countries also affected by the pandemic. In addition, most of the countries studied in this research had legalized e-commerce by 2020.

The drug market is quite specific, its structure is influenced by many factors, for example, the launch of new drugs or the entry of generics into the market. Therefore, to analyze changes in this market, the OTC (over the counter) segment is taken, in which generics prevail and there are no supply shocks like those listed above.

Results

Market concentration

Hypothesis 1: producer concentration is positively related to the share of pensioners in the population of the country, and e-commerce channel decreases market concentration ceteris paribus.

Econometric estimation

To estimate the influence of e-commerce legalization on market concentration, the values of the coefficients for the variables Dist_trade, Year_i, Pensioners*Dist_trade in this equation are studied:

$$CR5 = \beta_1 log\left(GDP\_per\_capita\right) + \beta_2 Internet\_users + \beta_3 Urban + \sum_{i=0}^{4} \gamma_i Year_i +$$
$$+ \beta_4 Dist\_trade + \beta_5 Health\_exp + \beta_6 Pensioners + \beta_7 Pensioners^2 +$$
$$+ \beta_8 Life\_exp + \beta_9 Pensioners * Dist\_trade + \varepsilon,$$

After model specification tests (Breusch-Pagan, Hausman, Wald test) the fixed effects model has best specification. According to estimation results (**Table 2**) hypothesis is confirmed, as the coefficients in Pensioners*Dist_trade are negative and significant. In general, the effect on producer concentration is negative, but delayed. The coefficients at the lag variables of ban lifting are positive and significant, but they decrease with each year (that is, the effect of lowering the concentration in the first year is weaker by 1.412 percentage points, in the second year - by 1.465, in the fourth year - by 1.016), until the market comes to a new equilibrium, which is associated with a decrease in concentration. It is also worth noticing that the effect increases as the proportion of pensioners increases. As mentioned

before, concentration positively correlates with share of pensioner population due to the increasing switching costs with age. Distance trade partially solves this problem by reducing information asymmetry and switching costs. The average effect of online drug trade legalization reaches 3 percentage points (the coefficient in Pensioners*Dist_trade is -0.24 and the average share of pensioners is 12.64%). Despite model being significant as well as variables of interest, the estimation requires additional clarification.

Table 2. Estimation of concentration rate for 5 biggest producers

	CR5	
	FE unmatched	**FE matched**
Log (GDP_per_capita)	-0.516	-0.842
	(0.666)	(0.647)
Share of internet users	0.052***	0.059***
	(0.015)	(0.016)
Share of urban population	0.494***	0.549***
	(0.123)	(0.126)
Year_0	1.579***	1.412***
	(0.582)	(0.517)
Year_1	1.526***	1.465***
	(0.553)	(0.475)
Year_2	0.954*	1.063**
	(0.518)	(0.448)
Year_3	0.627	0.540
	(0.471)	(0.413)
Year_4	1.143**	1.016**
	(0.453)	(0.405)
Distance trade legalized	1.122	1.168*
	(0.762)	(0.691)
Health expenditure	-0.030	-0.004
	(0.203)	(0.214)
Share of pensioners	1.030**	0.777
	(0.474)	(0.515)
Share of pensioners^2	-0.012	-0.006
	(0.013)	(0.015)
Life expectancy	-0.056	-0.230
	(0.213)	(0.228)
Share of pensioners *Distance_trade legalized	-0.242***	-0.230***
	(0.051)	(0.040)
Observations	724	724
R^2	0.266	0.263
Adjusted R^2	0.138	0.135
F Statistic (df = 14; 616)	15.917***	15.079***
Note:	*p<0.1, **p<0.05, ***p<0.01	

Source: authors' calculation based on Euromonitor and World Bank data.

The treatment effect was also estimated for concentration of certain medicine brands. More detailed estimation results can be found in the appendix (**Table 5**). According to the estimation, the concentration of the most popular drug brands increases in the short run, but then tends to decrease in the long run. There is no strong significant effect of the share of the pensioners in the country's population.

Synthetic control estimation

To clarify the hypothesis testing, treatment effect is estimated using synthetic control. For each synthesized country (in total there are 16 synthesized) fit index was calculated. Due to the method limitations described in the beginning of the chapter, those countries whose fit index was less than (the threshold is 0.08)[1] were filtered out. (**Fig. 4**)

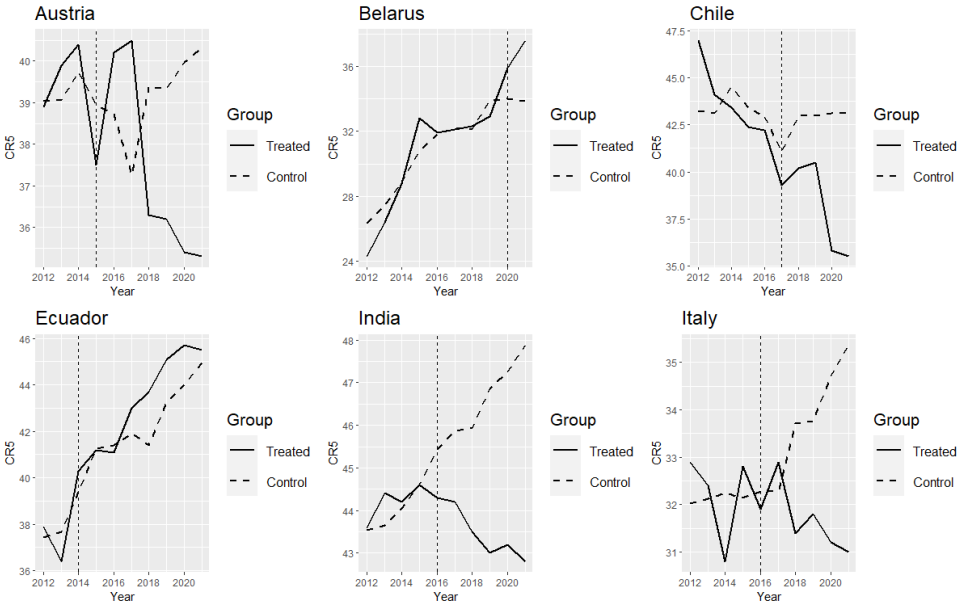

Figure 4. The effects of distance drug trade legalization on producer concentrations obtained by synthetic control. *Source*: authors' calculation based on Euromonitor and World Bank data.

Placebo tests

To verify results, a placebo test was conducted for each of the synthesized countries: the treatment effect was "shifted" forward and backward for several years. If the change of concentration occurred due to the legalization, the new synthetic control results would be slightly from the original. Thus, out of 6 countries filtered by fit index only 4 remained: Austria, India, Belarus and Ecuador (**Fig. 5**).

Distance drug trade legalization effect is multidirectional for studied countries. In India the concentration dropped immediately by 1 percentage point and 5 years later the decrease reached 5 percentage points. In Austria the effect was delayed, in first years the concen-

1 Here and below, the threshold indicates the largest Fit Index among the indices less than 0.1, which indicates a more accurate control.

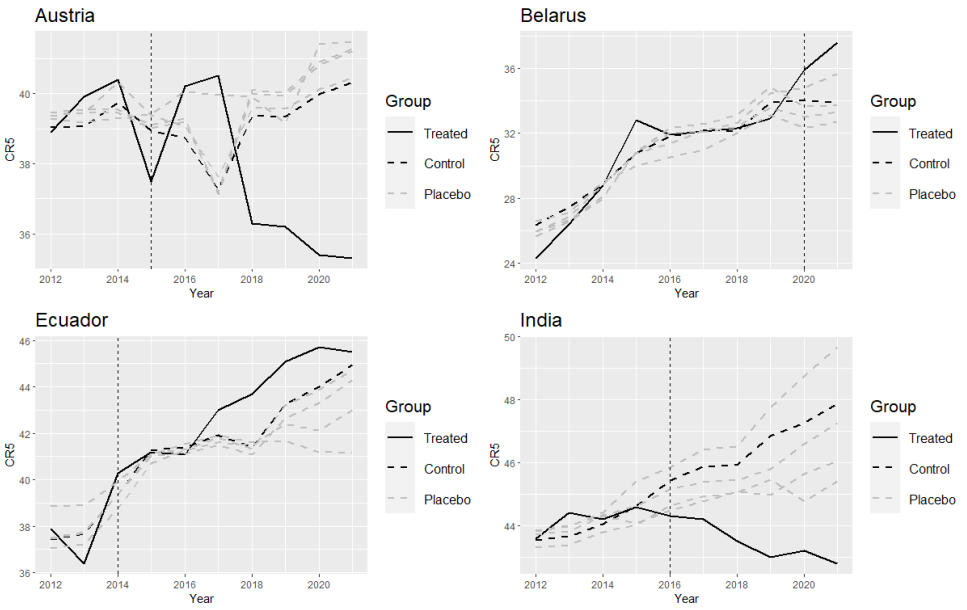

Figure 5. Placebo-tests for producer concentration. *Source*: authors' calculation based on Euromonitor and World Bank data.

tration increased by 2.5 percentage points and 5 years later it also decreased by 5 percentage points, in Ecuador 3 years after the ban lift concentration decreased by 0.5 percentage points. In Belarus after the ban lift concentration increased by 3 percentage points, but, as the measure was adopted in 2020 it is impossible to estimate the long-term effect. The multidirectional effect can be explained by differences in the institutional environment between countries. For example, the negative effect for Austria can be explained by a greater choice between drug manufacturers (Euromonitor tracks 92 producers) and the population getting access to a larger assortment, while in Ecuador the number of manufacturers available to the population is smaller (50 according to Euromonitor), the involvement in online purchases is lower (about 60% of the population of Ecuador use the Internet, in Austria the figure is up to 89%), which is why the effect of the legalization of online drug trade on the market concentration was estimated to be positive.

We also apply synthetic control to assess concentration of brands. Analogically for each synthesized country fit index was calculated and countries with quality fit (the threshold is 0.08) were filtered out. This leaves 4 countries to calculate the average treatment effect: India, Morocco, Panama, South Africa (**Fig. 6**).

Placebo tests

To verify the results, a placebo test for each synthesized country was calculated. 3 out of the 4 countries selected by the fit index passed the placebo-test: India, Morocco, South Africa (**Fig. 7**).

In general, with the legalization of online drug trade brand concentration decreases. In India the decrease reached 3 percentage points in the long-term, in Morocco – up to 1 percentage point and in South Africa the decrease is about 1.5 percentage points in the long

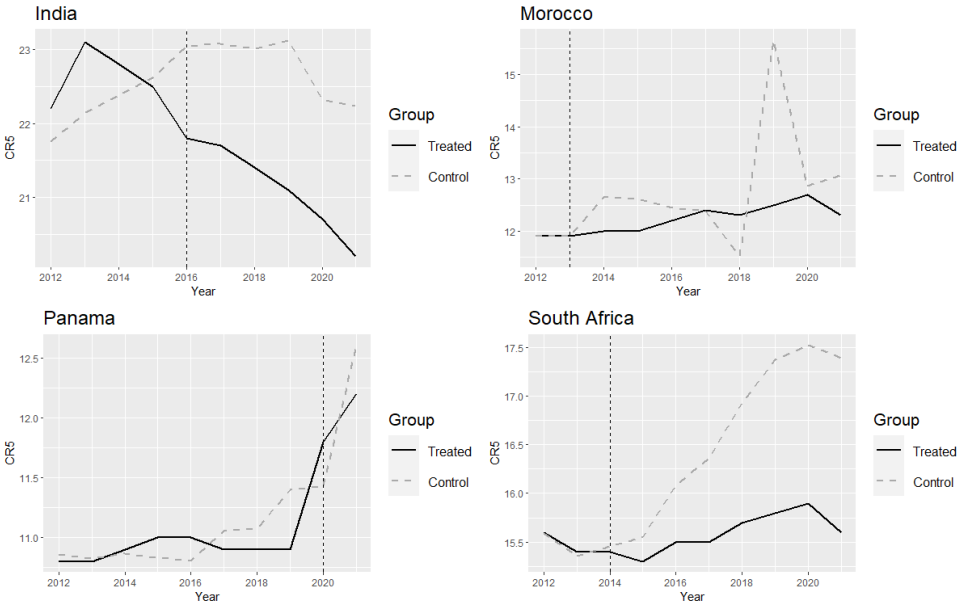

Figure 6. The effects of distance drug trade legalization on brand concentration obtained by synthetic control. *Source*: authors' calculation based on Euromonitor and World Bank data.

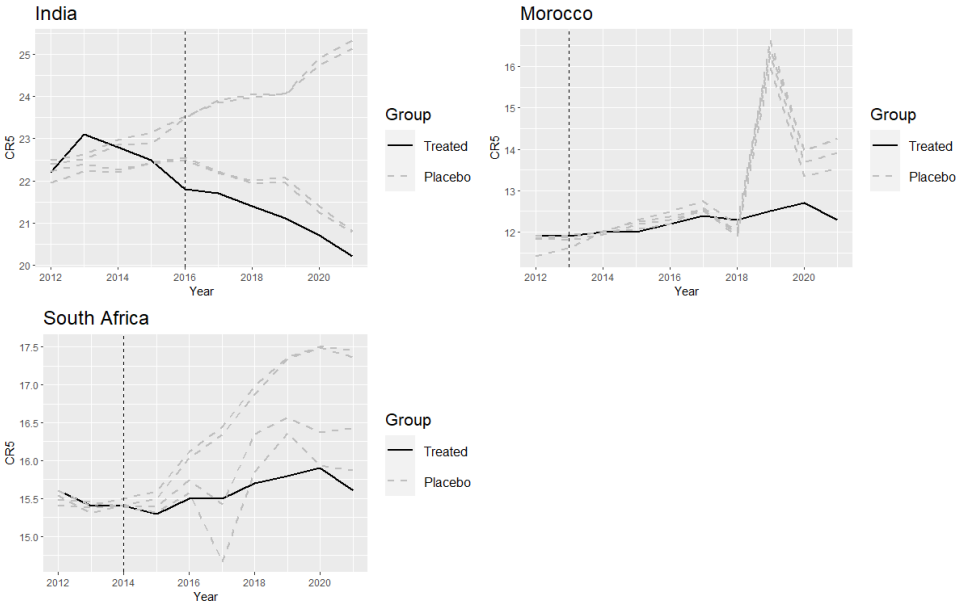

Figure 7. Placebo test for brand concentration. *Source*: authors' calculation based on Euromonitor and World Bank data.

term. In general, with the legalization of online commerce, the concentration of the most popular drugs is decreasing. Thus, the concentration decreased by 3 p.p. in India, by 1 p.p. in Morocco, and by 1.5 p.p. in South Africa.

Once e-commerce of medicines is legalized, information asymmetry decreases, and the availability of pharmaceuticals form less popular producers increases. This effect can be traced through a decrease in both producer and brand concentration. Customers find new, more suitable drugs and begins to purchase them.

Prices for medicines

Hypothesis 2: Distance trade of medicines reduces the price level in both short and long term.

Econometric estimation

To estimate the effect of e-commerce legalization on market concentration, we consider the values of the coefficients for the variables Dist_trade, Year_i, Pensioners*Dist_trade in the following equation:

$$Price\_index = \beta_1 GDP\_per\_capita + \beta_2 Internet\_users + \beta_3 Urban +$$
$$+ \sum_{i=0}^{4} \gamma_i Year_i + \beta_4 Dist\_trade + \beta_5 Health\_exp + \beta_6 Pensioners + \beta_7 Pensioners^2 +$$
$$+ \beta_8 Life\_exp + + \beta_9 Life\_exp^2$$

After model specification tests the best model is pooling regression. According to the estimation results (Table 3) the hypothesis cannot be unequivocally confirmed. The only statistically significant coefficient in the model for the Dist_trade variable of interest was obtained in the pooling regression. Thus, it is most likely that the effect of online drug trade legalization is instant and negative, medical goods inflation slows down by 1.4 percentage points, which is a high indicator for the average inflation of 104.75% and the median of 102.75%. Therefore, we need another estimation method to test the hypothesis.

Table 3. Estimation of drug price growth

	price_index	
	Pool matched	**Pool unmatched**
GDP_per_capita)	-0.00000	-0.00000
	(0.00000)	(0.00000)
Share of internet users	-0.0002	-0.0002
	(0.0002)	(0.0002)
Share of urban population	0.001***	0.001***
	(0.0002)	(0.0002)
Year_0	-0.019	-0.019
	(0.013)	(0.018)
Year_1	-0.010	-0.012
	(0.012)	(0.016)

	price_index	
	Pool matched	**Pool unmatched**
Year_2	0.006	0.005
	(0.012)	(0.016)
Year_3	0.005	0.005
	(0.011)	(0.016)
Year_4	-0.004	-0.005
	(0.012)	(0.017)
Distance trade legalized	-0.014**	-0.007
	(0.007)	(0.008)
Health expenditure	0.001	-0.001
	(0.001)	(0.001)
Share of pensioners	0.006	0.016***
	(0.004)	(0.004)
Share of pensioners^2	-0.0003*	-0.001***
	(0.0002)	(0.0001)
Life expectancy	0.038**	0.025***
	(0.018)	(0.009)
Life expectancy^2	-0.0003**	-0.0002***
	(0.0001)	(0.0001)
Constant	-0.217	0.246
	(0.669)	(0.310)
Observations	616	616
R^2	0.122	0.144
Adjusted R^2	0.102	0.124
F Statistic (df = 14; 601)	10.230***	7.208***
Note:	*p<0.1, **p<0.05, ***p<0.01	

Source: authors' calculation based on Euromonitor and World Bank data.

Synthetic control estimation

To check the assumption that the legalization of online drug trade slows down the price growth, synthetic control method can be used. For each synthesized country (in total 21 of them) fit index was calculated and, similarly to previous estimations, countries with quality fit (threshold if 0.08) were filtered out. This leaves 15 countries to calculate the average treatment effect (**Fig. 8**).

Placebo tests

To verify the results placebo tests were conducted. Out of 15 countries only 6 passed the placebo test: Bangladesh, Bolivia, Chile, Finland, India, Morocco (**Fig. 9**).

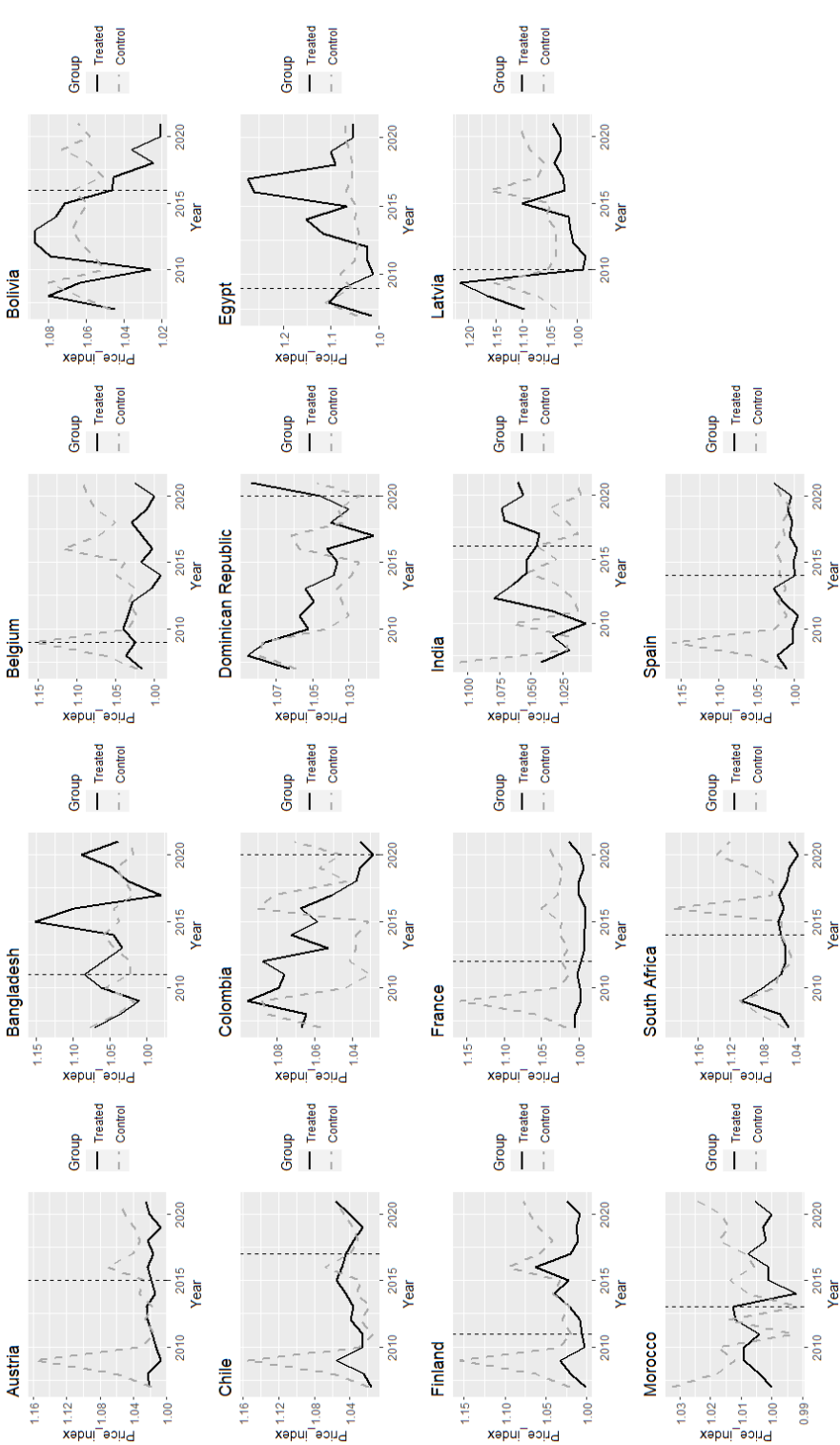

Figure 8. The treatment effects for medical goods inflation obtained using synthetic control. Source: authors' calculation based on Euromonitor and World Bank data.

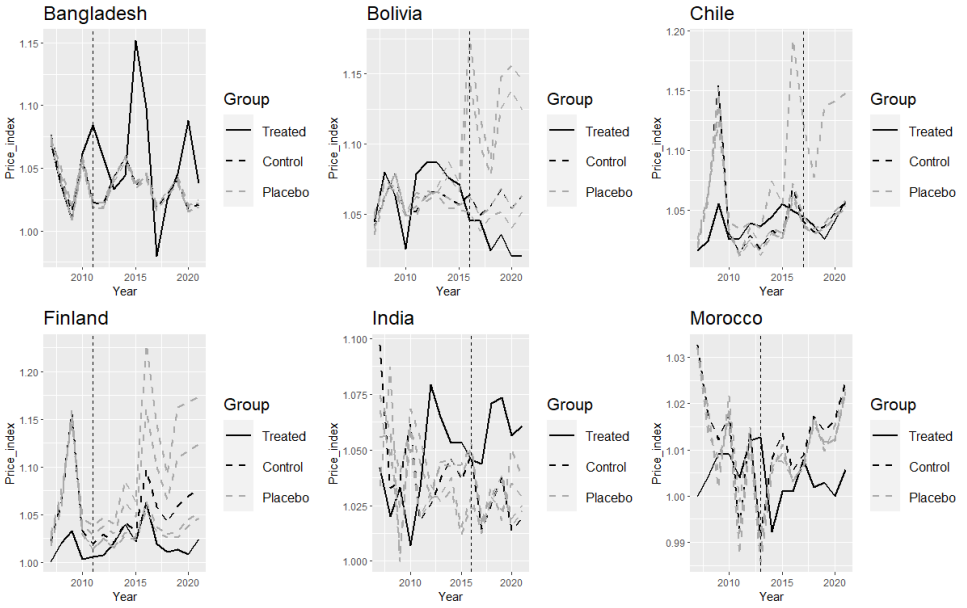

Figure 9. Placebo tests for drug inflation. Source: authors' calculation based on Euromonitor and World Bank data.

It is worth noting that, even though the visual dynamics for Morocco and Chile are different, the Fit Index value is less than 0.08, and the placebo test is passed. The legalization effect for studied countries is heterogenous. Among countries that lifted online drug trade ban before 2017 medical goods inflation slowed down in Chile (by 0.1 percentage points), Bolivia (by 5 percentage points), Finland (by 0.5 percentage points) and in Morocco (by 2 percentage points). In India, however, the inflation accelerated, approximately by 4 percentage points, and in Bangladesh – by 2.5 percentage points. The heterogeneity of the effect, as in the case of market concentration, may be due to differences in the institutional environment and infrastructure of countries (both countries are developing, but Bolivia is at a higher stage of development, in India's GDP growth is 7-8% per year, while Bolivia's is 4-5%, and the urbanization rate in India half that of Bolivia, 35% and 70% respectively). Drug inflation depends on many factors, which in turn determine the direction of the effect. However, as can be seen from the estimates obtained by synthetic control and panel data models, the effect of the legalization of online drug trade on the price index is negative in most cases.

As mentioned before, information asymmetry decreases with online drug trade legalization, the population receives more information about goods and their value. As a result, price competition increases, and the prices for medicines in different pharmacies flat out.

Comparing prices in border cities with different online drug trade policies

In addition to econometric methods, the legalization effect can be estimated by direct comparison of prices in pharmacies in cities near borders of countries with different online trade policies. The paper compares exactly the prices in permitting prescription trade for several

reasons. First, you can only get information about the price of a particular drug if you can buy it [1]. Secondly, this analysis allows to draw some conclusion of the effects that come with legalization of distance trade of all medicines, not only OTC ones. As consumers get access to more products, the competition should increase and, therefore, the effects should be similar to those previously described.

The list of chosen medicines and links to the pharmacy websites can be found in the appendix (Table 7). Before the comparison prices were converted to euros at the exchange rate at the time of data collection (no exchange rate shocks were observed during data collection). Then prices were adjusted by Cost-of-Living Index (Numbeo 2022).

The difference and the ratio of prices are compared. As can be seen (Fig. 10), prices for the same drugs in countries with different legislation in the pharmaceutical industry vary widely. Moreover, the result of a medicines sample showed that exactly half of the drugs are cheaper in countries where online sale of prescription drugs is allowed, and half – in countries where it is prohibited. The median value of the ratio is 1.004, and of the difference – 0,018, and the mean – 1.081 and -0.811 respectively.

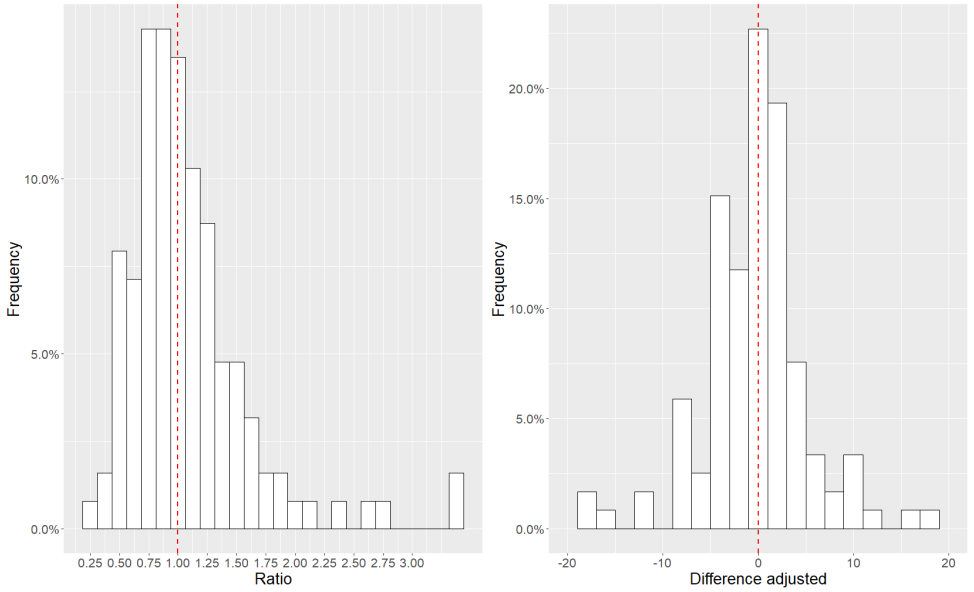

Figure 10. The difference (right) and ratio (left) of the price of medicines in countries where prescription trade is prohibited and allowed. Source: authors' calculations based on the collected data on drug prices. The red dotted line indicates a ratio equal to 1 and a difference equal to 0.

However, the difference in prices varies a lot depending on the category. Medicines were collected in 6 groups:

1. Sore throat, flu, nasal, n = 22;
2. Allergies, eyes, n = 16;
3. Intestines, laxatives, digestives, oral, n = 26;
4. Analgesic, headache, n = 16;

1 If online trade is prohibited in the country, there is no pharmacy website to find information of the price.

5. Blood circulation, sugar, pressure, n = 16;
6. Antidepressants, hypnotics, sedatives, n = 8.

This method has several limitations. While there are enough variables (n = 126) to compare drugs in all categories together, there are not many to compare them in individual categories. It is also worth noting that in the category "Analgesic, headache" and "Antidepressants, hypnotics, sedatives" there are predominantly non-prescription medicines, sample doesn't include strong painkillers and antidepressants acting as narcotics were not included due to the lack of public information about their price in the countries with prohibited online sale of prescription drugs.

Fig. 11 shows the price ratio of medicines in countries with legal and illegal online prescription drug trade. As mentioned above, prices are lower in all categories except for the categories "Blood circulation, sugar, pressure" and "Intestines, laxatives, digestives, oral". Comparing ratios allows to estimate not the absolute but the relative difference in prices, that is how significant the spread is. In general, the spread is the same in all categories. Prices on most drugs differ by about 25% and the total spread reaches up to 75% with some exceptions (right "tails" in categories "intestines, laxatives, digestives, oral", "antidepressants, hypnotics, sedatives").

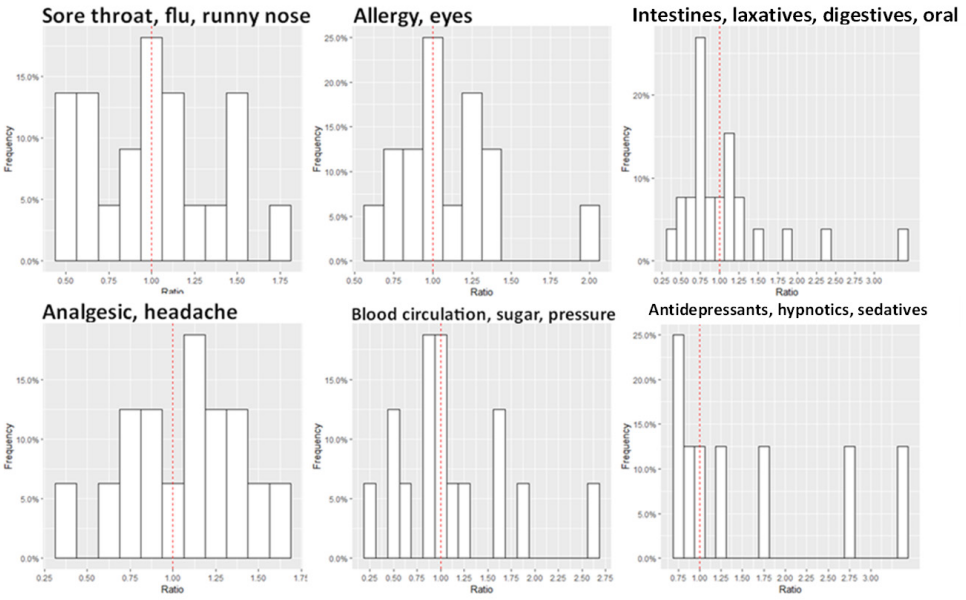

Figure 11. The price ratio of medicines in countries where prescription online trade is prohibited and allowed. *Source*: authors' calculations based on the collected data on drug prices in R. The red dotted line indicates a ratio equal to 1.

The differences in categories can be explained by different policies regarding prescription drugs. For example, in Paraguay[1] (MSPBS 2022) the list of prescription drugs is much shorter than in Brazil (Anvisa 2022). Despite relatively high price spread some conclusions can be

1 It is possible to purchase drugs online in the country, but it is unknown how legal this option is. According to Euromonitor data in all categories share of distance trade channel is 0, therefore the country is in the control group.

drawn. As mentioned before, in 4 out of 6 categories prices are lower in countries with legal online prescription drug trade, and in one category ("Blood circulation, sugar, pressure") exactly the half of medicines is cheaper (and, therefore the other half is more expensive) and in one category "Intestines, laxatives, digestions, oral") prices are higher in the country with legalized prescription drug trade. Besides mentioned restrictions and limitations this tendency may be explained by the fact that the share of prescription drugs is higher in the categories that turned out to be cheaper in countries with legal online prescription drug trade. As a result of such policy the consumer has more choice, and competition in the online market is noticeably higher and prices are lower. Conversely, in categories where the share of prescription drugs is low, legalizing online sales does not increase competition as much and, as a consequence, prices decrease insignificantly.

The obtained estimates indicate that with online medicine trade legalization prices decrease. Opening new sales channel decrease information asymmetry, as a result of which the prices of medicines are smoothed out.

Legalizing online sales of prescription drugs has a particular impact on price. With the lifting of the ban, prices go down, and in categories where the proportion of prescription drugs is high, the decline is greater. However, this conclusion is formulated at the level of a hypothesis and requires verification in further studies.

Conclusions

In general, the hypotheses are partially confirmed. Hypothesis 1 about the decrease in market concentration with lifting online drug trade ban is confirmed. Based on estimates the manufacturer concentration decreases, plus the higher share of pensioners the greater decrease.

Hypothesis 2 about price level decrease is confirmed partially. Based on econometric estimation prices are reducing. However, regarding the quality of data and constructed models it can only be stated that medical goods inflation slows down. Besides, comparing border cities it can be concluded that with legalizing online prescription drug trade prices decrease more in categories with the higher share of prescription pharmaceuticals.

Empirical estimations obtained in previous sections allow to formulate an overall picture of the consequences of online drug trade legalization. After the ban lift a new sales channel opens. Its formation takes several years, during which short term effects appear. Consumers start purchasing the medicines they got used to, which leads to increase in brand concentration. The information asymmetry gradually decreases, as a result, price growth slows down and prices for some drugs are likely to decrease.

4 years after distance trade legalization the market is formed, and long-term effects start taking place. The generic manufacturers (smaller producers out of the 5 biggest firms) enter the market, concentration of brands drops and returns to its previous values. Producer concentration, in turn, starts going down, as consumers get more information about the drugs on the market and choose drugs that are more suitable for them. Drug prices continue to rise, but the rate of increase is lower than before the ban lift.

The limitations of this study are the low quality of some data used[1], meaning that conclusions can only be drawn regarding the direction of some effects rather than their exact significance.

1 More about the limitations and restrictions can be found in the section 2

For further research in the field of e-commerce it is possible to study the impact on geographic boundaries of the market, namely, to analyze shares of foreign producers before and after the e-commerce drug legalization. Finally, with more detailed database of manufacturers and drugs[1] it is possible to estimate legalization effect on market entry barriers.

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1 The Euromonitor database used does not track everything, but only a fixed number of the largest companies and drugs on the market.

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Appendix

List of collected variables:

- drug market volume;
- market distribution by sales channels;
- the share of manufacturing companies in the drug market;
- market share of drugs;
- drug price indices and medical services;
- share of population using the Internet;
- GDP per capita;
- share of the urban population in the total population of the country;

- share of pensioners in the country's population;
- life expectancy;
- the share of obese people in the country's population;
- the share of the population that consumes alcohol;
- the share of health care expenditures in GDP.

Prior to evaluation, control variables were tested for multicollinearity using the VIF coefficient (Variance Inflation Factor). As can be seen (Table 2), despite high correlation, the values of each VIF coefficient are less than 10, which indicates the absence of multicollinearity.

Table 4. VIF coefficients for variables

	GVIF	Df	GVIF^(1/(2*Df))
Log (GDP_per_capita)	6.24	1.00	2.50
Internet_users	4.56	1.00	2.14
Urban	2.76	1.00	1.66
factor(Year)	1.41	5.00	1.04
Dist_trade	2.00	1.00	1.42
Health_exp	2.24	1.00	1.50
Pensioners	2.89	1.00	1.70
Life_exp	3.23	1.00	1.80

Table 5. Countries for synthetic control

1. Algeria	2. Ghana	3. Oman
4. Angola	5. Guatemala	6. Paraguay
7. Argentina	8. Honduras	9. Philippines
10. Azerbaijan	11. Iraq	12. Serbia
13. Bosnia and Herzegovina	14. Jordan	15. South Korea
16. Cambodia	17. Kenya	18. Tanzania
19. Cameroon	20. Laos	21. Thailand
22. Cote d'Ivoire	23. Lebanon	24. Tunisia
25. Croatia	26. Myanmar	27. Uzbekistan
28. El Salvador	29. Nigeria	30. Vietnam
31. Ethiopia		

Table 6. CR5 for most popular brands

	brand_CR5			
	Pool matched	Pool unmatched	FE matched	FE unmatched
	(1)	(2)	(3)	(4)
Log (GDP_per_capita)	-4.898***	-3.709***	0.331	0.313
	(0.529)	(0.507)	(0.295)	(0.310)

	brand_CR5			
	Pool matched	Pool unmatched	FE matched	FE unmatched
	(1)	(2)	(3)	(4)
Share of internet users	-0.075***	-0.019	0.008	0.016**
	(0.020)	(0.020)	(0.008)	(0.007)
Share of urban population	0.089***	0.118***	-0.072	-0.083
	(0.023)	(0.021)	(0.059)	(0.057)
Year_0	-1.666	1.030	0.388	0.235
	(1.272)	(1.454)	(0.249)	(0.270)
Year_1	0.004	1.231	0.467**	0.443*
	(1.110)	(1.428)	(0.221)	(0.257)
Year_2	0.151	1.098	0.392*	0.264
	(1.103)	(1.375)	(0.207)	(0.241)
Year_3	-0.212	0.469	0.475**	0.377*
	(1.112)	(1.325)	(0.190)	(0.219)
Year_4	-0.280	0.102	0.529***	0.270
	(1.159)	(1.342)	(0.185)	(0.211)
Distance trade legalized	-0.295	-2.587*	-0.678**	-0.589*
	(1.188)	(1.346)	(0.323)	(0.354)
Health expenditure	0.276*	0.406***	0.311***	0.143
	(0.146)	(0.140)	(0.103)	(0.094)
Share of pensioners	1.036***	1.326***	-0.531**	-0.390*
	(0.209)	(0.197)	(0.246)	(0.220)
Share of pensioners^2	-0.051***	-0.055***	0.003	0.001
	(0.009)	(0.008)	(0.007)	(0.006)
Share of pensioners *Distance_trade legalized	0.094	0.024	0.041**	0.033
	(0.089)	(0.105)	(0.018)	(0.024)
Life expectancy	0.674***	0.245***	0.653***	0.537***
	(0.074)	(0.072)	(0.112)	(0.099)
Constant	4.044	18.000***		
	(4.713)	(4.403)		
Observations	724	724	724	724
R^2	0.189	0.239	0.113	0.121
Adjusted R^2	0.173	0.224	-0.041	-0.032
F Statistic	32.598*** (df = 14; 709)	15.922*** (df = 14; 709)	6.892*** (df = 14; 616)	6.036*** (df = 14; 616)
Note:		*p**p***p<0.01		

Table 7. List of medicines

	Medicine name	Category	Countries	Medicine name	Category	Countries
1	Nurofen	Sore throat	BEL_NET	Oxalate	Antidepressant	PAR_BRA
2	Cetrizine	Allergy	BEL_NET	Mirtazapine	Antidepressant	PAR_BRA
3	Zyrtec	Allergy	BEL_NET	Valdispert	Hypnotic	BEL_NET
4	Tempocol	Intestines	BEL_NET	Rennie	Digestive	BEL_NET
5	Gaviscon	Digestive	BEL_NET	Forlax	Digestive	BEL_NET
6	Creon	Digestive	BEL_NET	Imodium	Digestive	BEL_NET
7	Fucithalmic	Eyes	BEL_NET	A.Vogel	Sore throat	BEL_NET
8	Benzac	Dermatology	BEL_NET	Strepsils	Sore throat	BEL_NET
9	Physiomer	Flu	BEL_NET	Otrivin	Nasal	BEL_NET
10	Xylocaine	Painkiller	BEL_NET	Corsodyl	Dental	BEL_NET
11	Instillagel	Painkiller	BEL_NET	Voltaren	Painkiller	BEL_NET
12	Bisadoyl	Laxative	BEL_NET	Allergo Comod	Allergy	BEL_NET
13	Moviprep	Laxative	BEL_NET	Loratadine	Allergy	BEL_NET
14	Baxter NaCl	Insulin	BEL_NET	Spidifen	Headache	BEL_NET
15	Nurofen	Sore throat	BEL_GER	Curaspot/ Benzacnen	Dermatology	FRA_GER
16	Xylocaine	Painkiller	BEL_GER	Duofilm	Dermatology	FRA_GER
17	Instillagel	Painkiller	BEL_GER	Lercadipine	Pressure	PAR_BRA
18	Moviprep	Laxative	BEL_GER	Alopurinol	Digestive	PAR_BRA
19	Corsodyl	Dental	BEL_GER	Praroxetine	Antidepressant	PAR_BRA
20	Gaviscon	Digestive	BEL_GER	Pradaxa	Blood	PAR_BRA
21	Cinnarizine	Blood	BEL_GER	Temisartan	Pressure	PAR_BRA
22	Zaffranax	Antidepressant	BEL_GER	Nebivolol	Pressure	PAR_BRA
23	Strepsils/Dolo Dobendan	Sore throat	FRA_GER	Levetiracetam	Antiepileptic	PAR_BRA
24	Aspirin	Headache	FRA_GER	Rivaroxaban	Blood	PAR_BRA
25	Pyralvex	Oral	FRA_GER	Tadalafil	Intime	PAR_BRA
26	Alka Seltzer	Headache	FRA_GER	L Arginin	Pressure	AUS_GER
27	Gaviscon	Digestive	FRA_GER	Microlax	Intestines	AUS_GER
28	Curaspot	Eyes	FRA_GER	Iberogast	Intestines	AUS_GER
29	Korodin	Blood	AUS_GER	Lactostop	Intestines	AUS_GER
30	Antistax	Blood	AUS_GER	Buscopan	Digestive	AUS_GER
31	Hylo-Komod	Eyes	AUS_GER	Neurexan	Hypnotic	AUS_GER
32	Femannose	Kidneys	AUS_GER	Orthomol	Dermatology	AUS_GER
33	Fenistil	Allergy	AUS_GER	Systane	Eyes	DEN_GER
34	Fenistil	Allergy	AUS_GER	Strepsils/Dolo Dobendan	Sore throat	DEN_GER
35	Hoggar	Hypnotic	AUS_GER	Imodium	Digestive	DEN_GER

	Medicine name	Category	Countries	Medicine name	Category	Countries
36	Lasea	Hypnotic	AUS_GER	Movicol	Digestive	DEN_GER
37	Emser	Flu	AUS_GER	Voltaren	Painkiller	DEN_GER
38	Grippostad	Flu	AUS_GER	Daosin	Allergy	DEN_GER
39	Aspirin	Headache	AUS_GER	Telfast	Allergy	DEN_GER
40	Bepanthen	Dermatology	AUS_GER	A.Vogel	Sore throat	DEN_GER
41	Strepsils	Sore throat	SWE_FIN	Hirudoid	Blood	DEN_GER
42	Bafucin	Sore throat	SWE_FIN	Otrivin	Nasal	DEN_GER
43	Ibumax	Flu	SWE_FIN	Sinupret	Nasal	DEN_GER
44	Physiomer	Flu	SWE_FIN	Gelo Revoice	Sore throat	DEN_GER
45	Dymista	Flu	SWE_FIN	Prolacsan	Dental	DEN_GER
46	Itulazax	Allergy	SWE_FIN	Corsodyl	Dental	DEN_GER
47	Slinda	Contraception	SWE_FIN	Ibutop	Painkiller	DEN_GER
48	Asacol	Intestines	SWE_FIN	Istillagel	Painkiller	DEN_GER
49	Priorin	Hair	SWE_FIN	Laxoberal	Laxative	DEN_GER
50	Vagiscan	Intime	SWE_FIN	Bepanthen	Dermatology	DEN_GER
51	Arthrotec	Arthritis	SWE_FIN	Canesten	Intime	DEN_GER
52	Kaleorid	Blood	SWE_FIN	Fenistil	Allergy	CZE_GER
53	Sideral	Maternity	SWE_FIN	Rennie	Digestive	CZE_GER
54	Apracur	Flu	PAR_BRA	Imodium	Digestive	CZE_GER
55	Enterogermina	Digestive	PAR_BRA	Aspirin	Painkiller	CZE_GER
56	Tamsulon	Intime	PAR_BRA	Venoruton	Blood	CZE_GER
57	Xarelto	Blood	PAR_BRA	Hylo gel	Eyes	CZE_GER
58	Piascledin	Bones and joints	PAR_BRA	Hylo-Komod	Eyes	CZE_GER
59	Buscopan	Anti-inflammatory	PAR_BRA	Lactulose	Intestines	CZE_GER
60	Micardis	Pressure	PAR_BRA	Voltaren	Painkiller	CZE_GER
61	Atorvastina	Blood	PAR_BRA	Otrivin	Nasal	CZE_GER
62	Duphalac	Digestive	PAR_BRA	Nasivin	Nasal	CZE_GER
63	Cefalexina	Antibiotic	PAR_BRA	Bromhexin	Flu	CZE_GER

Visited online-pharmacies:

- Belgium: https://pharmacy-medi-market.be/pharmacie (Antwerp)
- Netherlands: https://www.efarma.nl/
- Germany: https://www.elsass-apotheke.de/ (Aachen), https://www.centralapotheke-online.de/ (Munich), https://medikamente.apotheken.de/ (Saarbrücken), https://www.tablettenshop24.de/ (Dresden), https://apo2u.com/ (Flensburg)
- France: https://pharmacy-medi-market.be/ (Metz)
- Austria: https://www.servusapotheke.at/ (all over Austria)
- Sweden: https://www.apoteket.se/ (all over Sweden)

- Finland: https://www.yliopistonapteekki.fi/ (throughout Finland)
- Czech Republic: https://www.benu.cz/ (Usti nad Labem)
- Denmark: https://www.webapoteket.dk/ (Kolding)
- Brazil: https://www.drogaraia.com.br/ (Cascawell)
- Paraguay: https://www.puntofarma.com.py (Ciudad Del Este)

Information about the authors

- Spektor Stanislav Viktorovich — Analyst at the Consumer market development Center, Faculty of Economics, M. V. Lomonosov Moscow State University, Moscow, 119991, Russia. Email: spektor@econ.msu.ru
- Ionkina Karina Alexandrovna — Researcher, Competition and Industrial Policy Department, Faculty of Economics, M. V. Lomonosov Moscow State University, Moscow, 119991, Russia, Junior Researcher, Center for Competition and Economic Regulation Research, RANEPA, Moscow, 119571, Russia. Email: kaionkina@econ.msu.ru