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The effect of health crises on the strategic response of pharmaceutical firms: *the case of paracetamol*

During crises strategy forming obtains a different form. I research strategy forming of the paracetamol industry in times of health crises. I distinguish four health crises: the 2014 Vietnam Measles outbreak, the 2011 Pakistan Dengue outbreak, the 2012 MERS outbreak and the 2009 Swine Flu pandemic. I hypothesise that due to supply chain problems, an upward demand shock and uncertainty, prices of paracetamol rise during health these health crises. Also, I analyse whether these price effects remain after the crises. Additionally, I analyse the probability of entering and exiting both during and after the health crises.

With the use of the difference-in-difference method I find that prices of paracetamol were substantially higher during and after the Vietnam epidemic, while I find negative price effects during the Pakistan epidemic. During the MERS outbreak and Swine Flu outbreak, I find ambiguous price effects. The effect on the probability of exiting is negative in all health crises, while I find some evidence that the probability of entering is positive during health crises.

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1. INTRODUCTION

A crisis is defined as a discontinuity in the normal environment (Smart & Vertinsky, 1984). Due to its sharp contrast to normality a crisis provides a great opportunity for scholars to study effects and interdependencies, both at a macroeconomic level and firm-level. At the time of writing this paper, the world is amid an unprecedented crisis: the COVID-19 pandemic. The first papers have already been published on firm's responses to and economic consequences of the pandemic (e.g. Fernandes, 2020; Guerrieri, Lorenzoni, Straub & Werning, 2020; McKibbin & Fernando, 2020). However, the researchers emphasise that the results and predictions must be interpreted with great caution, because the pandemic is unfolding at extreme speed and the situation changes from day to day (McKibbin & Fernando, 2020). However, the work does uncover how much is still unknown about the effect of health crises on macroeconomic parameters and the strategic behaviour of firms.

Health crises are more common than one might first think, both locally and internationally. For that purpose, the World Health Organization (WHO) was founded in 1948 with the main objective to improve the health of all citizens of the 194 Member States across the six regions (WHO, 2020). Health crises occur in all shapes and forms: from localised and very deathly outbreaks such as Ebola outbreaks in West Africa, to the Swine Flu pandemic in 2009 of which most people infected suffered from mild symptoms and made a full recovery (Lim & Mahmood, 2011). This range of crises makes researching the effects of health crises harder, but simultaneously more necessary: there is still much to understand about the effects of the different health crises.

During the current pandemic, the pharmaceutical industry is gaining a lot of attention as it is linked to vaccination and drug development. Additionally, because supply chain vulnerabilities are uncovered: the temporarily shutting down of Chinese manufacturers and subsequently shortages in medicines emphasised the dependency of the Western world on China regarding its drug-supply (Ranney, Griffeth & Jha, 2020). Also, some areas in the world report that their supply chains are not able to withstand the sudden increase in the demand of medicines that are used to treat patients that have fallen ill with the COV-SARS-2 virus (Premier, 2020). Subsequently, many pharmacies have reported increasing prices of medicines and treatments, among which drugs that are used to treat COVID-19 (Jones & Bourland, 2020; Wood, 2020).

Panic buying has also led to an increase in demand for over-the-counter drugs related to the symptoms of COVID-19. Reports that paracetamol should be used for pain- and symptom relief for COVID-19 have sparked a run on the medicine with pharmacies around the world reporting empty shelves (Day, 2020; Wood, 2020).

These observed dynamics in the pharmaceutical industry during the current COVID-19 pandemic, raise questions on the strategic response of the pharmaceutical industry during past health crises. Therefore, the research question of this study is:

What is the response of pharmaceutical firms to health crises?

As stated, health crises differ at various dimensions. The WHO distinguishes epidemics and pandemics based on the geographical area that is affected by a disease (WHO, 2010b). Moreover, some outbreaks are short-lived, while others take years to fully extinguish. This heterogeneity does make it difficult for scholars to find a definite answer. For that reason, I choose to study four health crises in the recent years: a measles epidemic in Vietnam in 2014, a dengue outbreak in Pakistan in 2011, the world-wide Middle East Respiratory Syndrome (MERS) outbreak in 2012 and the Swine Flu pandemic of 2009.

Additionally, there is a lot of heterogeneity among pharmaceutical firms. I focus on the effects of paracetamol producing firms, for several reasons. First, paracetamol is a medicine that is well-known, has low production costs and of which its patent has expired. This lowers the concern that I find effects that are related to, or diluted by, strategic responses influenced by cost-driven incentives such as patent licensing, buying raw materials or marketing. Second, because of these characteristics of the product, this research sets an interpretable baseline for the future analyses of other pharmaceutical products. Third, paracetamol is one of the products that we have seen being hoarded during the COVID-19 pandemic (Andalo, 2020). Understanding the behaviour of paracetamol producing firms during other health-crises forms a baseline result for the analysis of this hoarding phenomenon and the reaction of the manufacturers.

The remainder of this study is structured as follows: Section 2 explores the contemporary literature on the strategic response of pharmaceutical firms to health crises. I discuss the current literature regarding crises and economic responses to health crises. I explore supply and demand and what past research finds on shocks to normal supply and demand. Also, I analyse pricing and pricing in the pharmaceutical industry. In Section 3, I explain the set-up of the empirical part of this study and form the hypotheses of this study. Section 4 further explains the data, and Section 5 describes the methodology used for the analysis. Section 6 describes the results and Section 7 provides an alternative analysis and validity check of the results. Section 8 provides an in-depth discussion of the results. In Section 9, I discuss the limitations and future recommendations following this study.

2. THEORETICAL BACKGROUND

2.1 Crises

Firms' strategy during crises

In the current literature on strategic responses by firms, the term *crisis* is used in reference to two closely related, although not identical phenomena. Most research on the managing of crises refers to organizational crises, where a crisis is at the far end on the spectrum of internal organizational disruptions (Burnett, 1998; Massey & Larsen, 2006). An example of such a crisis is BP's oil spill of 2010 near the Gulf of Mexico. This produced both financial and reputational harm, prompting the firm to deal with concerns of customers and governments (Bundy, Pfarrer, Short & Coombs, 2017). Indeed, this type of crisis deals with issues such as forming a communication strategy to the public and competitors taking advantage of the situation (Jaques, 2007).

The other phenomenon is best described by Smart & Vertinsky (1984) who define a crisis as a discontinuity in the normal environment. This description is outward focused and similar to the usage of Emery and Trist (1965) who acknowledge a difference between highly complex and uncertain environments and more routinized environments. Examples of this type of crisis are natural disasters, terrorist events and health crises: exogenous events that happen *to* the firm. This is the definition that is used in the context of this paper. However, although the two usages of crisis differ, much of the rationale regarding *crisis management*[1] is closely related. Both deal with a disruptive event that possibly has profound implications on the organization and stakeholders. And, regardless of the magnitude of the crisis, from a firm-level perspective a crisis always requires a proactive strategy. In practice, this means that firms employ defensive and short-term responses, solving problems as they occur (Emery & Trist, 1965; Smart & Vertinsky, 1984).

Strategy formulation during crises is heavily influenced by uncertainty of the environment. Aragón and Sharma (2002) find that a proactive strategy is positively correlated with superior performance, however, uncertainty and complexity in the environment moderate that relationship. During times of uncertainty, firms tend to use instruments which are easily controlled, such as employment and prices, to reduce the risk of default and comprehend and control the uncertainty (Arellano, Bai & Kehoe, 2010). In addition, real option models suggest that added uncertainty may affect real investment decisions (Miller & Park, 2002). Due to the crises, strategic investment decisions can be delayed or abandoned.

[1] C*risis management* is borrowed from the political science discipline and refers to the ad-hoc response of firms (or governments) during crises (Pearson & Clair, 1998).

Economic consequences of health crises

Health crises can have a severe impact on the economy and the labour market. For example, the medieval plague epidemic is associated with rising wage levels (Hatcher, 1977; Hirshleifer, 1987) and declining output levels were reported as the 1918-1919 Spanish flu pandemic emerged (Schultz, 1964). Bloom & Mahal (1997) argue that both these effects are due to the sharp increase in mortality among working people.

Scholars have not settled on the effect of health crises on economic growth and income. For example, Bloom & Mahal (1997) find that the AIDS outbreak in the 80s imposed no significant effect on the economic growth in the USA. However, Haacker (2002), argues that AIDS in Southern African countries has had a substantial negative effect on the per capita income, because the disease affects the mortality rate, and therefore the supply of experienced workers. This, in contrast to the findings of Brainerd and Siegler (2003), who find that the 1918-1919 influenza pandemic had a large and positive effect on the per capita income growth across the USA. They argue that, although counter-intuitive, this finding is in line with neoclassical growth models: because of the reduction of the labour force, the capital per worker in the economy increases, subsequently leading to per capita income growth.

Similarly, labour scarcity is a factor that is described as the driving force behind the effects found by Vendoiro, Feliu & Mascaro (2020). They take a broader approach and analyse the effect the 15 big pandemics of the past centuries have had on economic activity in the medium to long run. They state that macroeconomic effects persist until 40 years after the pandemics, with rates of return on capital declining and real wages being pushed up due to the labour scarcity. They emphasise that these effects are heavily dependent on the fact that many of the past pandemics took a disproportionate toll on the labour force.

Bloom, De Wit and Carangal-San Jose (2005) propose a strategy for governments in dealing with health crises to reduce economic demise as much as possible[2]. They emphasise the importance for governments and international actors to be transparent, and thus to avert panic among the public in the face of prevailing uncertainty of such a health crisis. Leduc and Liu (2016) argue that the effect of a sudden rise in uncertainty has a similar effect on macroeconomic parameters as aggregate demand shocks. Uncertainty raises unemployment and lowers inflation similar to aggregate demand shocks. Moreover, the negative effect of uncertainty on aggregate demand is partly the mechanism driving this similar effect (Leduc & Liu, 2016).

[2] Bloom, De Wit and Carangal-San Jose (2005) specifically model the effects of an influenza outbreak in Asia.

One important source of uncertainty during health crises is the uncertainty regarding changing policies at the level of the federal governments (Jurado, Ludvigson & Ng, 2015). The behaviour of federal governments is a large source of uncertainty driving greater stock price volatility and reduced investment and employment (Baker, Bloom & Davis, 2016). This is particularly true for sectors that are susceptible to economic policies, such as the pharmaceutical sector (Stevens, 2008; Baker, Bloom & Davis, 2016).

2.2 Supply and demand

Supply and demand shocks

To determine the way a crisis affects consumer demand, heterogeneity among crises and firms must be recognised. During the financial crisis of 2008 the falling demand was mainly attributed to rising employment rates (Hall, 2010). During a mad cow disease outbreak in the USA at the end of 2003 all meat-producers suffered from a drop in demand. The announcement on the outbreak by the USA government had a negative effect on the trust of consumers, which substantially lowered demand (Devadoss, Holland, Stodick & Ghosh, 2006). Not only the beef-industry suffered; because of interlinkages among the various sectors, also wholesale and retail stores, restaurants, shipping-firms and complementary food stores experienced a downward demand shock due to the change in consumer sentiment (Devadoss, Holland, Stodick & Ghosh, 2006).

Indeed, negative demand shocks are often (partly) due to the consumer mindset in times of crises (Sapienza & Zingales, 2012). The loss in trust in the economy worked as a catalysator in the 2008 financial crisis, resulting in people saving rather than spending their money, which lowered aggregate demand (Jensen & Johannesen, 2017). Arrow (1972) too points out the importance of truthfulness and consequently trust, arguing that every economic transaction is built on some form of trust. This is also a factor in positive demand shocks. For example, before the first oil crisis in the USA in 1973, the demand levels of oil were spectacularly above what the government had foreseen; it had to import up to 20% more than it had projected (Akins, 1973). With that, the USA dependency on the Middle East grew, which the Arab countries subsequently took advantage of by using this dependency as a political tool in a conflict between Israel and Palestine in which the USA was involved (Mitchell, 2010). The Middle East countries imposed an embargo by cutting its oil supply to the USA, enforcing pressure on the demand for USA domestic oil. This pressure grew even more due to consumer sentiment. The continuously rising oil prices led to consumers hoarding the oil as a result of no longer trusting that there would still be enough or for the same price the day after, resulting in long queues all around the country (Aronson & Gonzales, 1990). In this case the supply went down, and demand went up partly because of a change in consumers' sentiment, resulting in vastly rising oil prices (Mitchell, 2010). Economists account this event as an example of the neoclassical price theory, as oil prices grew rapidly in response to lower supply and higher demand (e.g. McCloskey, 2002).

The oil crisis also shows the world's increasing global intertwinement, with greater interdependence on international supply chains (Tomkins, 2011). Consequently, high-impact events have disruptive effects on the whole supply chain. For example, in 2011 Japan was struck by an earthquake which was followed by a tsunami and a nuclear crisis. This caused supply problems for multiple international companies with production sites in Japan, such as Apple and Toyota (Lohr, 2011).

Responses by firms during shocks

The neoclassical price theory assumes supply and demand to be the driving forces behind pricing. A product experiencing either a negative supply shock or a positive demand shock (or both) results in higher prices which erodes the excess demand (Goodfriend & King, 1997). Subsequently, higher prices can lead to other changes in the dynamic of the industry as less efficient producers see themselves able to achieve a mark-up and enter the industry. This would moderate the price effect, as the excess in demand is (partly) absorbed. However, some argue that *price rigidity* is also to be considered; changing prices is accompanied by menu costs, and sometimes the prices cannot be changed as readily as the increase in demand requires (Levy, Bergen, Dutta & Venable, 1997). In the case of the pharmaceutical industry, it is sometimes ethically not accepted to change the prices as high as the shortage in supply or excess demand would predict (Barton & Emanuel, 2005). In that case, firms are either forced to produce more to absorb the excess demand, or new firms enter the industry to take advantage of the demand shock (Clementi & Palazzo, 2016).

After the shocks: back to equilibrium or hysteresis

Conventional macroeconomic long-term models predict that demand shocks and supply shocks are just that: temporarily shocks that result in changes in prices, output-levels or the number of entries and exits in the short-run, but after the shocks all parameters convert back to their pre-shock equilibrium (Koppl, 2014). However, these shocks may have induced irreversible investments which generates hysteresis[3] (Göcke, 2002). An entry decision by a firm is an example of a firm having made such a decision. During the shock, rising prices and demand trigger entry decisions by firms, resulting in sunk investment costs. Regardless of the price-levels or demand in the industry going down, the firms may stay in the industry because the investments have already been made (Dixit, 1989). Additionally, price rigidity is again to be considered: prices may

[3] Hysteresis occurs when an economic phenomenon persists after the cause of the effect has vanished (Göcke, 2002)

have been changed in response to a raise in demand. Due to menu costs prices are not instantly converted back to normal (Levy, Bergen, Dutta & Venable, 1997).

2.3 Prices

Prices as a strategic tool

Though the neoclassical price theory assumes prices to be subject of supply and demand and cost of production, some scholar criticise the usage of the theory as it fails to recognise the strategic aspect of pricing (Dutta, Bergen, Levy, Ritson & Zbaracki, 2002; Nicholas, 2012). Indeed, many examples exist where prices are used as a strategic tool. For example, *predatory pricing* is when a dominant player in the industry lowers their prices, sometimes beneath cost price, with the purpose of driving out competitors and gaining a monopoly position (Bolton, Brodley & Riordan, 1999). However, this is illegal in many areas, such as the USA and the EU (Nagle, Hogan & Zale, 2017). This line is blurrier when incumbent firms purposely charge low prices to discourage new firms from entering to begin with: so-called *limit pricing* (Besanko et al., 2013, pp 207). A study by price-focused consulting firm Simon-Kucher in 2014 even showed that 72% of all new products fail because of price pressures by incumbents. Hence, some scholars consider pricing to be a strategic capability which determines whether a firm's strategy fails or succeeds (e.g. Dutta, Bergen, Levy, Ritson & Zbaracki, 2002).

Prices in the pharmaceutical industry

The neoclassical price theory assuming prices are merely a result of production costs, supply and demand fails to be true for the pharmaceutical industry. Ellison, Cockburn, Griliches & Hausman (1997) emphasise that the pharmaceutical industry is different from other industries. The industry is characterised by large R&D costs, long clinical trials, high regulatory demands and low success rates (Adams & Brantner, 2006; Pennings & Sereno, 2011; Sullivan, 2019). The average cost of the development of a new drug is estimated to be $2870 million (DiMasi, Grabowski & Hansen, 2016). However, because of the length and the high default rates of the projects, prices of drugs are also more than just a function of these development costs. Most importantly, firms that discover a new medicine can patent the formula, receiving the exclusive right to produce and sell the medicine, providing them with a temporary monopoly position. The patent is granted based on the chemical composition of the drug and its novelty, making the number of substitutes for a similar purpose an additional factor in the pricing strategy of drugs (Lu & Comanor, 1998).

Another important factor in the pharmaceutical industry, is that the prices of pharmaceutical players are often heavily criticised, as they exceed the cost-price by a large margin (Scherer, 1993; Barton & Emanuel, 2005). It is a decades old debate adding another component to the existing uncertainty in the pharmaceutical industry. For example, in 1990 the USA Congress passed a law (the Public Law 101-508) that enabled similar discounted prices for drugs sold to the federal government as were routinely granted to other high-volume purchasers. And in 1993, the USA president Bill Clinton publicly criticised the pharmaceutical industry for its high prices. These criticisms often intensify right after crisis periods (Stevens, 2008; Baker, Bloom & Davis, 2016).

The dynamics in the pharmaceutical industry make that drug manufacturers employ unique strategies to market their products. Grabowski and Vernon (1992) state that a high brand loyalty exists in the pharmaceutical industry, making consumers less sensitive to prices (Grabowski & Vernon, 1992; Ellison, Cockburn, Griliches & Hausman, 1997). Even after patent expiry, the first moving branded drug experiences less price sensitivity compared to its generic competitors (Caves, Whinston, Hurwitz, Pakes & Temin, 1991). Additional patents on the unique shape and colour of products such as Viagra, make that the pill is widely recognised, and that the manufacturer can still charge a premium after the expiration of the patent.

2.4 Prices in the pharmaceutical industry during health crises

Prices in the pharmaceutical industry during health crises

The pharmaceutical industry has experienced much criticism in the last couple of years for having its manufacturers all centred in areas in China and India, making the supply chain vulnerable for disasters in those areas (Srinivasan, 2006; Hafner & Popp, 2011). Health crises impose such a risk on supply chains. For example, manufacturers being forced to temporarily close their doors to prevent spreading of diseases is part of that risk. In more disastrous situations such as the 1918-1919 Spanish Flu pandemic, diseases can cause a decreasing labour force, which creates the additional problem of a shortage of workers (Bloom & Mahal, 1997).

On the demand-side crises also cause interruptions in the pharmaceutical industry. During the financial crisis of 2008, an increase in patients reporting depressions caused a similar increase in the demand for antidepressants (Mattei, Ferrari, Pingani & Rigatelli, 2014; Sicras-Mainar & Navarro-Artieda, 2016). However, heterogeneity within the pharmaceutical industry must be recognised. A drug that treats (symptoms of) the disease that causes a health crisis likely experiences an upward shock in demand. Similarly, a drug that would normally be a close substitute, but does not treat the symptoms of the disease while the substitute does, may experience a downward demand shock. This is the case with paracetamol and aspirin or ibuprofen; all closely related medicines regularly used for pain-relief. However, for some diseases such as some influenza types and dengue fever, the use of aspirin and ibuprofen is advised against (WHO, 2019). Following these shocks to demand, the manufacturers can adjust prices accordingly (see Section 2.2). However, as mentioned, the pharmaceutical industry is often under much scrutiny, and raising prices to meet demand may be met with much resistance from governments and consumers (Section 3.3). Alternatively, manufacturers could start to produce more, or manufacturers of other medicines exploit the peak in demand and enter the market (Clementi & Palazzo, 2016).

Moreover, as described in Section 3.1, a crisis is characterised by a highly uncertain environment (Smart & Vertinsky, 1984). Due to this firms use instruments over which they have control, such as employment-levels and prices (Arellano, Bai & Kehoe, 2010). Pharmaceutical firms during a health crisis have therefore another reason to raise their prices during a peak in demand to overcome economic uncertainty.

Another cause of the uncertain environment is the way governments respond to the crisis. For example, Brazil's approach to its AIDS outbreak aimed at the reduction of the price of AIDS-related medicines. They enforced pharmaceutical companies to make their patented treatments widely available (Nunn, da Fonseca, Bastos & Gruskin, 2009). Although this approach won world-wide acclaim as it has substantially reduced the country's AIDS related mortality (Galvão, 2000; Farmer et al, 2001), it eroded profits for pharmaceuticals. In addition, after crises the pharmaceutical industry is often targeted for cost-reducing policies. Vogler, Zimmermann, Leopold & de Joncheere (2011) show that 23 of the 33 European surveyed countries implemented 89 pharmaceutical-related policies right after the 2008 financial crisis. Most of these policies affected the price pharmaceuticals could ask for the medicines, which directly affected profits. Interestingly, the countries that implemented the most price-reducing policies were also the countries that were hit hardest by the financial crisis, such as Spain, Ireland and Greece (Vandoros & Stargardt, 2013). The height of price-caps are often established through calculating the average of the past prices (Abott, 1995). Ellison and Wolfram (2006) find that in anticipation of price reducing policies firms tend to raise their prices. Similarly, Bhaskarabhatla, Chatterjee, Anurag and Pennings (2017) find that in anticipation of a price-cap on Metformin in India, particularly the large firms seemed to coordinate to manipulate average prices. Therefore, the policy uncertainty during the health crises arguably further drives up the prices in anticipation of policies.

3. EMPIRICAL STUDY

To study the effect of health crises on the prices in the pharmaceutical industry, it is important to consider that all medicines are used for different health improvement purposes and that health crises exist in many forms. This study focuses on the effects on the prices of paracetamol and four health crises: two epidemics and two world-wide outbreaks.

3.1 Epidemics

The WHO defines an epidemic as an abnormal occurrence of an illness in an area (WHO, 2020). However, there exists no absolute number of cases to indicate a threshold to when an outbreak is defined as an epidemic. This is subject to the interpretation of factors like population density, time and exposure of the disease. Epidemics occur regularly and affect many countries around the world (WHO, 2018).

This research focuses on two epidemics: the measles outbreak in Vietnam in 2014 and the dengue fever epidemic in Pakistan in 2011. The two outbreaks have reportedly both been contained to the respective countries and are cited to have had a duration of around one year. The outbreaks being rather localised in both time and space increase the validity of contributing found effects to the relative outbreaks.

Vietnam

In 2014 a measles outbreak in Ho Chi Minh and the rest of Vietnam caused more than 15,000 children to fall ill to the preventable disease (Pham et al., 2014). Measles is a viral disease that is transmitted via droplets and which mainly affects children under the age of 12. Through vaccination a 73% drop in fatalities worldwide between 2000-2018 has been reported (WHO, 2020). However, Coang et al. (2019) show that a significant part of the parents in Vietnam was unaware of the importance of the second vaccination of the two-fold vaccination program. This, in combination with many parents fearing adverse reactions, resulted in a vaccination gap in Vietnam which enabled the disease to get widespread in 2014 (Hai et al, 2016; Coang et al., 2019).

Although measles outbreaks occur relatively often in Vietnam, the 2014 epidemic was much more severe. Also, the outbreak received relatively much attention on social media. Posts accusing the authorities of inadequately reacting to the epidemic and a lack of effort on the vaccination program were widely shared, and as being critical of the government is rare in the country, this further fuelled panic among parents (Radio Free Asia, 2014). The first severe cases were reported in the last quarter of 2013, and the epidemic was reportedly contained around the second half of 2015 (Do et al., 2017).

Pakistan

In 2011 Pakistan experienced a sudden rise in dengue fever cases. Dengue fever is a mosquito-borne viral infection caused by one of four dengue viruses. Transmissions often rise during and after rain-seasons (WHO, 2019).

Pakistan is susceptible to health crises due to its poor health conditions, over-crowded areas and unsafe drinking water. A flood in 2011 is mentioned as a large catalysator for the rise in dengue fever cases which subsequently led to the epidemic (Jahan, 2011). The outbreak lasted from the last quarter of 2010 until the first quarter of 2012.

3.2 Pandemics

If a disease spreads worldwide it is defined as a pandemic (WHO, 2010a). Pandemics are, compared to epidemics, much rarer. The 20th century has known three pandemics, with the Spanish Flu pandemic in 1918-1919 being the most severe[4]. The 21th century counts two official pandemics to date: The Swine Flu[5] pandemic and the COVID-19 pandemic (CDC, 2010; WHO, 2020). However, the world has also known two widely publicised outbreaks, where threat of a pandemic was categorised as a possibility: The Severe Acute Respiratory Syndrome (SARS) outbreak in 2004 and the Middle East Respiratory Syndrome (MERS) outbreak in 2012. While no cases have been reported on SARS since 2004, MERS still emerges in (mainly Middle East) areas from time to time. This research focuses on the Swine Flu pandemic and the MERS outbreak.

Swine Flu

In April of 2009 Swine Flu first emerged. In August of 2010 the WHO announced that the virus had moved into its post-pandemic period (WHO, 2010b). The outbreak initially caused anxiety among the public (Rubin, Amlôt, Page & Wessely, 2009), also because it affected people younger than 65 much worse than the seasonal flu. However, it is estimated that the percentage of people that died due to the infection caused by the Swine Flu virus lies between 0.001 and 0.007 percent of the world population. To put that in perspective: during the pandemics in the 20th century those numbers are estimated to be 0.03 percent for the 1968 pandemic and 1 to 3 percent for the 1918-1919 pandemic (CDC, 2019). Due to the low health risk of the disease, the world's health organisations therefore announced that extensive testing was no longer necessary in July 2009 (CDC, 2010).

MERS

The MERS-CoV virus first emerged in Saudi Arabia in September of 2012, and most cases have been linked to the Middle East. Human-to-human spread is rare, and the virus is often contained by people in close contact with dromedary camels. However, in South Korea a large community-spread outbreak occurred in May 2015 (WHO, 2019). The virus causes Middle East Respiratory Syndrome (MERS) with symptoms like respiratory infection, fever and coughing (RIVM, 2016). The virus stands out for its high mortality rate: around 30% of the people infected have reportedly died from the virus. The high mortality rate is reportedly the reason the virus does not spreading as quickly as other coronaviruses (WHO, 2019).

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[4] The 1918-1919 Spanish Flu pandemic is also referred to as the H1N1 pandemic. The other two pandemics in the 20th century are the 1957-1958 H2N2 pandemic, and the 1968 H3N2 pandemic.

[5] The Swine Flu knows many denominations: The Mexican Flu and 2009/H1N1 are some of the most common alternatives. The latter is not to be confused with the virus that caused the pandemic in the early 20th century. Both were caused by the H1N1 subtype, but this subtype knows many strains which are found in birds, pigs and humans (Gatherer, 2009).

3.3 Paracetamol

This research focuses on the strategic responses to health crises by manufacturers of paracetamol[6]. Paracetamol is particularly fitting in the context of this research because the drug has been recommended for pain relief for measles, dengue, Swine Flu and MERS (WHO, 2004). In the case of dengue fever, the use of another pain reliever such as ibuprofen is even discouraged as both the disease and this medicine thin the blood (WHO, 2019). Additionally, as evident from Section 3.1 and 3.2, none of these health crises are caused by either a shortage of paracetamol or rising prices, which would have caused endogeneity problems to this study. Moreover, all diseases are caused by viruses, which means antibiotics are not an alternative. Therefore, a peak in demand can be assumed to affect paracetamol during the health crises. Furthermore, the patent to paracetamol has passed its expiration date. The drug is widely available in both brand-forms and generics, and a so-called 'over the counter'-drug. This reduces concerns to finding price-effects that are due to patent licensing or monopoly-strategies. Additionally, this makes that the product is a homogeneous product in all countries. Therefore, the results are easier to compare among countries, and the results of this research are easier to extrapolate to other crises.

3.4 Forming hypotheses

During health crises

Following the literature I propose a framework with causes for the rise of the price of paracetamol during the health crises (see Section 2.4). First, I propose that supply chain problems can cause prices to rise during health crises. Second, I argue that due to the decline of the health and the change of consumer sentiment towards paracetamol, the demand of paracetamol rises, which subsequently also causes the prices to rise. Third, I propose that due to increasing economic uncertainty, and in anticipation of possible future price-reducing policies, firms tend to raise their prices (see Figure 3.4.1).

[6] Other commonly used denominations of paracetamol are acetaminophen or APAP.

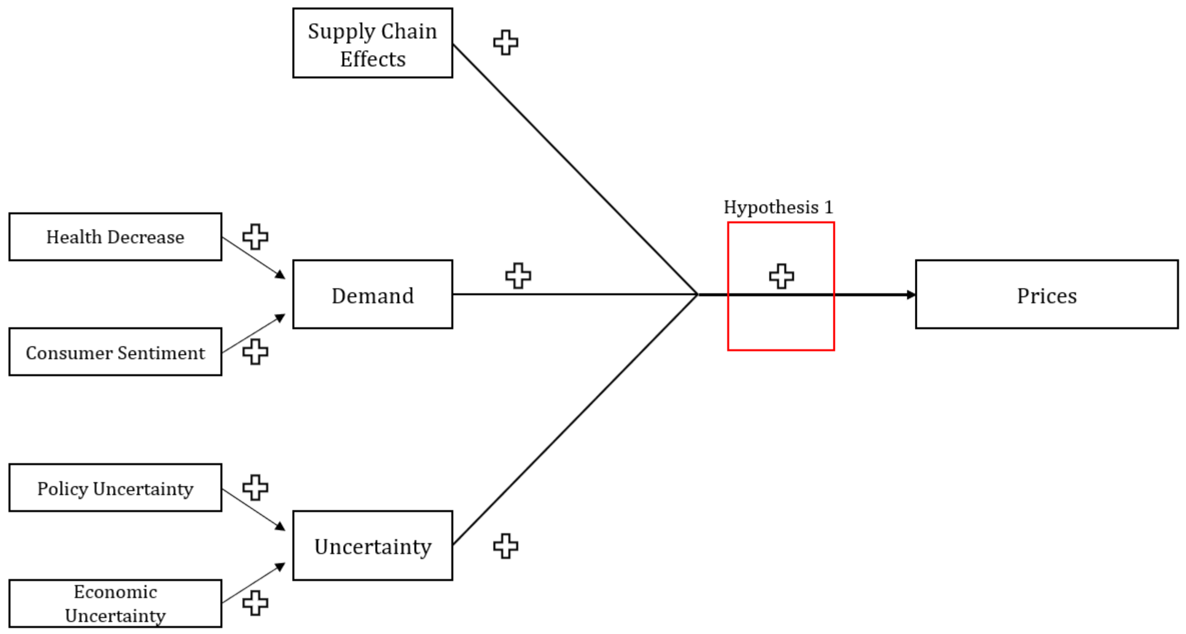

Figure 3.4.1: A visual representation of the mechanisms influencing the price of paracetamol during a health crisis

To test this framework, I hypothesise:

> *H1A: During an epidemic, the average price of paracetamol is higher compared to before the epidemic and in countries without the epidemic.*
> *H1B: During a pandemic, the average price of paracetamol is higher in countries that are more severely affected than in countries that are less severely affected compared to before the pandemic.*

Firms that produce products or medicines closely related to paracetamol, have low switching costs and can easily start producing paracetamol and therefore enter the market (Bernard, Redding & Schott, 2010).

Second, as a result of the price mechanism, higher prices cause the market to be more profitable also for less efficient producers (Foster, Haltiwanger & Syverson, 2008). Third, the barriers to entry set by the incumbents may be lowered due to the health crisis' excess demand for paracetamol (Besanko et al., 2013, pp 207-211).

Most importantly, especially in the pharmaceutical sector increasing prices by a large margin is often accounted as unethical (Spinello, 1992; see Section 2.2). To (partly) overcome the excess demand during the health crises, I expect to find more entries and less exits in the countries that are affected by the health crises. Therefore, I propose the following sets of hypotheses:

H2A: During an epidemic, the probability that a paracetamol manufacturer enters the industry in that country is on average higher than before the epidemic and in countries without the epidemic.
H2B: During a pandemic, the probability that a paracetamol producer enters the industry is on average higher in countries that are more severely affected than in countries that are less severely affected compared to before the pandemic.

H3A: During an epidemic, the probability that a paracetamol manufacturer exits the industry in that country is on average lower than before the epidemic and in countries without the epidemic.
H3B: During a pandemic, the probability that a paracetamol manufacturer exits the industry is on average lower in countries that are more severely affected than in countries that are less severely affected compared to before the pandemic.

After health crises

It is interesting to know whether price- and entry and exit- effects linger after the crises, or even remain. Although the pharmaceutical industry is known to be targeted for price-regulations, to the best of my knowledge paracetamol was not subject of price-regulations after the Vietnam measles outbreak, the Pakistan dengue outbreak, the Swine Flu outbreak nor the MERS outbreak. However, after the crises, possible supply chain effects, upward demand shocks due to a decreasing health and uncertainty can be assumed to be resolved. Nonetheless, the pharmaceutical industry is known for hysteresis, both regarding price effects and other effects such as brand-share effects (Caves, Whinston, Hurwitz, Pakes & Temin, 1991; also see Section 2.2). Most importantly, due to menu costs I expect the prices to not convert back to normal as readily as the former mechanisms are dissolved (Levy, Bergen, Dutta & Venable, 1997; see Section 2.2). Therefore, I propose that the first years after the health crises the price effects remain:

H4A: After an epidemic, the average price of paracetamol is higher compared to before the epidemic and in countries without the epidemic.
H4B: After a pandemic, the average price of paracetamol is higher in countries that are more severely affected than in countries that are less severely affected compared to before the pandemic.

However, with the framework of 3.4.1 in mind, the demand converting back to normal, supply chain problems being dissolved, and uncertainty dissolved, I argue that there is an excess of players in the industry. Moreover, the players in the market during the crises may have had the intention to merely stay temporary. Also, entry decisions will have been speeded up during the health crises, resulting in lower entries afterwards. Therefore I propose:

H5A: After an epidemic, the probability a paracetamol producer enters the market is on average higher than before the epidemic and in countries without the epidemic.
H5B: After a pandemic, the probability a paracetamol producer enters the market is on average higher than before or during the epidemic and in countries without the pandemic.

H6A: After an epidemic, the probability a paracetamol producer exits the market is on average higher than before or during the epidemic and in countries without the epidemic.
H6B: After a pandemic, the probability a paracetamol producer exits the market is on average higher than before or during the epidemic and in countries without the pandemic.

4. DATA

4.1 Data characteristics

I use a firm-level longitudinal dataset on paracetamol. The sample contains quarterly data on the fourth quarter of 2007 up until the third quarter of 2019 (Q4 2007 – Q3 2019). The dataset contains data of retail-paracetamol, which means data on paracetamol for hospitals is not included in the sample. I keep only observations of the paracetamol in tablet form. Hence, data on paracetamol in liquid form is also not included in the sample.

Data on the duration of the epidemics and pandemics and the number of fatalities is retrieved from the World Health Organization (WHO). This entails the total number of fatalities which is counted after the health crisis has resolved. Data of the yearly GDP and CPI levels of the countries is obtained from the World Bank. Data of the GDP and CPI of the year 2019 is missing.

4.2 Dependent variables

Prices

I use the price of paracetamol converted to USA dollars. I standardise the prices so that they reflect the price of one tablet of paracetamol with the strength of 100mg active ingredient. For each manufacturer, I calculate the standardised mean price in each country. This means that for each manufacturer only one observation remains per quarter in a country. To avoid problems with skewed data[7], I take the natural logarithm of the prices. I use the following formula:

$$Ln\ (USA\$\ Price\ per\ 100mg) = Ln\ \left(\frac{100}{Dosage\ strength} * \frac{Price\ of\ Pack}{Number\ of\ Tablets\ in\ Pack}\right)$$

[7] A normal distribution is required for many of the most common statistical methods in order to avoid misleading, wrong or inefficient results (Siegel, 2016).

Entry and exit

To create the binary variable that captures whether a manufacturer enters or exits the market, I leave one observation per manufacturer in a quarter and country in the sample. A presence in the industry is accounted for if a manufacturer produces at least one type of tablet-form paracetamol, regardless of the strength or number of tablets in the pack. Thereafter, the concern rises that incidental missing data from the dataset results in a false entry or exit. Because reasonably it can be assumed that a manufacturer does not re-exit or re-enter in the timespan of a year, I assume that missing data over the time span of a maximum of four quarters is due to data-errors and are therefore not included in the calculation for exits or entries.

The entry variable is coded as 1 if the manufacturer enters the dataset in that time period and zero otherwise. Hence, for the first observation in the sample (Q4 2007) I cannot determine whether the manufacturer has entered the industry in that period. Therefore, that time period is coded as missing.

Similarly, the exit variable is also a binary variable, which takes on the value of 1 if the manufacturer exits the dataset in the next period and zero otherwise. The last observation (Q3 2019) is coded as missing.

4.3 Explanatory and control variables

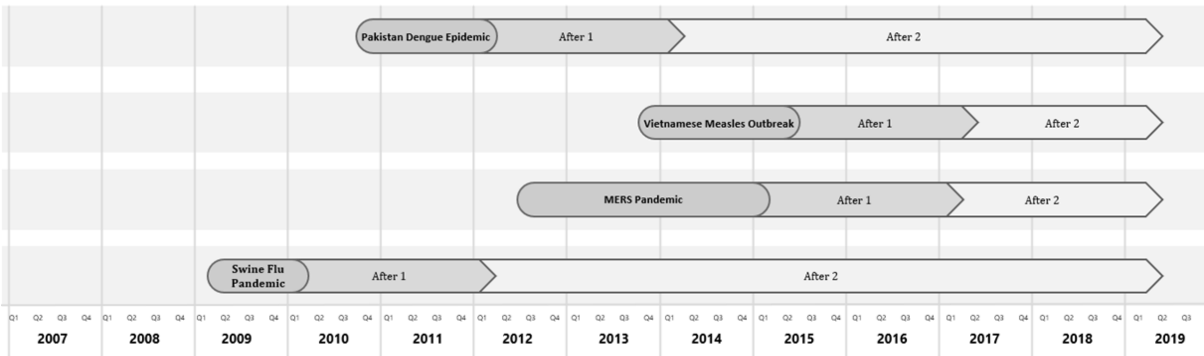

Figure 4.3: A visual representation to show what time periods the during and after variables cover

Pakistan & Vietnam

The binary variables that capture whether an observation occurs during the epidemics, take on the value 1 if that observation takes place in the country of the health crisis and during the health crisis and zero otherwise. Hence, for the dummy that captures the Vietnam measles outbreak, the variable takes on the value 1 if the observation is regarding a Vietnamese manufacturer from Q4 2013 until Q2 2015. The dummy capturing the Pakistan dengue outbreak is coded as 1 if the observation occurs in Pakistan and between Q4 2010 and Q1 2012. (See Figure 4.3)

Swine Flu & MERS

I create two binary variables. The Swine flu variable is coded as 1 if the observation in the dataset occurs during the Swine Flu pandemic: from Q2 2009 until Q1 2010. The MERS variable takes on the value of 1 from Q3 2012 to Q3 2015 and zero otherwise.

Intensity: Deaths

To be able to account for the intensity of the worldwide outbreaks, I collect the number of fatalities for each country due to the pandemics from the WHO. To avoid problems with skewed data, the natural logarithm of the numbers is taken. Because the natural logarithm of zero does not exist, I code all countries as having had 1 extra fatality, so that countries without fatalities will not be excluded from the sample.

GDP & CPI

The numbers on the yearly GDP and the Consumer Price Index (CPI) levels are collected from the World Bank. These variables are used as additional control variables (see Section 5), and for both variables, I take the natural logarithm.

5. METHODOLOGY

5.1 Epidemics

Prices

To test the effect of the epidemics on the price of paracetamol (Hypotheses 1A and 4A), I use the Difference-in-Difference method (Dimick & Ryan, 2014). The method is frequently used to determine the causal effect of policies (e.g. Mckinnon, Harper, Kaufman & Bergevin, 2015; Bhaskarabhatla, Chatterjee, Anurag & Pennings, 2017), but also ideal to estimate the effect of the health crises on prices. The method acknowledges the difference in effects *before* the health crises between the countries affected and the countries not affected by the health crises (Dimick & Ryan, 2014). However, the validity of this method is contingent on the assumption that the price of paracetamol in the countries of the health crises would have moved similar to the countries without health crisis would the former countries not have experienced the health crisis. With the additional controlling for GDP and CPI levels, this assumption is likely to be justified. In addition, it is important to address concerns regarding the exogeneity of the health crises in the models. Following Section 3.1, 3.2 and 3.3, I assume that none of the health crises is (partly) caused by changing prices of paracetamol.

To control for time-invariant differences between countries, I add country fixed effects. Similarly, I add manufacturer fixed effects to account for time-invariant effects among manufacturers. Additionally, I add year fixed effects to control for the world-wide trend of the prices of paracetamol. To test whether the effect after the health crisis remains after the epidemic, I divide the time after the crises in two periods. The first period will cover exactly two years: this will provide a comparable insight of the path of the prices right after the epidemics. Therefore, this effect will show whether right after the crisis hysteresis occurs. To fully determine whether the effect lasts or merely lingers, the second period covers the remaining time that is left in the dataset. I use the ordinary least square regression to estimate the effect of the epidemic on the standardised price for manufacturer k in country i during time t in quarters, with the use of the following model:

$$Price_{k,i,t} = \alpha + \beta_1 * Vietnam_{i,t} + \gamma_1 * Vietnam\ After1_{i,t-1:t-8} + \theta_1 * Vietnam\ After2_{\ i,t-9:t-17} + \beta_2 * Pakistan\ After1_{\ i,t} + \gamma_2 * Pakistan\ After2_{i,t-1:t-8} + \theta_2 * Pakistan_{i,t-9:t-22} + \delta * X_{i,t} + \mu_i + \omega_k + \varphi_t + \varepsilon_{k,i,t}$$ **(Model 1)**

The β_1 and β_2 therefore capture the DiD-effects of the epidemics on the price to test Hypothesis 1A. The γ_1 and γ_2 capture the price effects in the first period after the epidemics, and the θ_1 and θ_2 capture the effects the second period after the epidemics, which tests Hypothesis 4A.

Note that t reflects the time in quarters of a year. For that reason, t-1:t-8 covers two years and t-9:t-17 and t-9:t-22 cover two years and a quarter, and three and a half years respectively (see Figure 4.3). Moreover, the δ captures the effect of other covariates I control for, which are GDP and CPI. I include country-fixed effects (μ_i), manufacturer fixed effects (ω_k) and time-fixed effects (φ_t). To reduce concerns regarding heteroskedasticity, I use robust standard errors.

Probability of entering and exiting

To analyse the probability of exits and entries during and after the health crises, I employ a binary Probit model (Aldrich, Nelson & Adler, 1984). A Probit model, compared to a linear probability model does not allow for values lower than zero, or higher than 1.

To determine the effect of the epidemics on the probability of manufacturer k entering or exiting the industry in country i at time t, I use the following equations:

$$Probability\ of\ Entering_{k,i,t} = \phi(\alpha + \beta_1 * Vietnam_{i,t} + \gamma_1 * Vietnam\ After1_{i,t-1:t-8} + \theta_1 * Vietnam\ After2_{\ i,t-9:t-17} + \beta_2 * Pakistan\ After1_{\ i,t} + \gamma_2 * Pakistan\ After2_{i,t-1:t-8} + \theta_2 * Pakistan_{i,t-9:t-22} + \delta * X_{i,t} + \mu_i + \omega_k + \varphi_t + \varepsilon_{k,i,t})$$ **(Model 2)**

$$Probability\ of\ Exiting_{k,i,t} = \phi(\alpha + \beta_1 * Vietnam_{i,t} + \gamma_1 * Vietnam\ After1_{i,t-1:t-8} + \theta_1 * Vietnam\ After2_{\ i,t-9:t-17} + \beta_2 * Pakistan\ After1_{\ i,t} + \gamma_2 * Pakistan\ After2_{i,t-1:t-8} + \theta_2 * Pakistan_{i,t-9:t-22} + \delta * X_{i,t} + \mu_i + \varphi_t + \varepsilon_{k,i,t})$$ **(Model 3)**

In these equations $\phi(\cdot)$ is the cumulative normal distribution function. Furthermore, β_1 and β_2 capture the effects on the probability a manufacturer k enters (exits) at time t, being in the country of the epidemic and during the epidemic compared to not being in the affected country and/or during the epidemic (Hypotheses 3A and 4A). The γ_1 and γ_2 capture the effects on the probability a manufacturer enters (exits) in the two years after the epidemic took place, while θ_1 and θ_2 capture the effects of the remaining years after the epidemics (Hypotheses 5A and 6A). The δ captures the effect of the GDP and CPI. I include country-fixed effects (μ_i) and year-fixed effects (θ_t). Note that this is an industry-level analysis, and thus manufacturer fixed effects are not relevant. I use clustered robust standard errors. Table 5.2 summaries which models deal with testing which hypotheses.

5.2 Pandemics

Price

For the analysis of the effect of the pandemics on price, I employ a before-after analysis with fixed effects. I include interaction terms with the intensity of the pandemics as proxied by the amount of fatalities (see Section 4.3). I use the ordinary least square regression to obtain the estimates. I use the following equation to determine the effect on the standardised price for manufacturer *k* in country *i* during time *t*:

$$Price_{k,i,t} = \alpha + \delta_1 * SwineFlu_t + \beta_1 * SwineFlu_t * intensity_i + \gamma_2 * SwineFlu\ After1_{t-1:t-8} * intensity_i + \theta_3 * SwineFlu\ After2_{t-9:t-23} * intensity_i + \delta_2 * MERS_t + \beta_2 * MERS_t * intensity_i + \gamma_2 * MERS\ After1_{t-1:t-8} * intensity_i + \theta_2 * MERS\ After2_{t-9:t-23} * intensity_i + \delta * X_{i,t} + \mu_i + \varphi_t + \varepsilon_{k,i,t} \quad \textbf{(Model 4)}$$

Most of interest are the β_1 and β_2 (to test Hypotheses 1B) and the γ_1, γ_2, θ_1 and θ_2 (to test Hypothesis 4B) that capture the effects of the pandemics on the price. I include manufacturer fixed effects (ω_k) and time-fixed effects (φ_t), control for GDP and CPI (δ) and use robust standard errors.

Probability of entering and exiting

To analyse the effect of pandemics, I use a Probit model with similar usage of the intensity variable as in the analysis on price. To determine the effect of the pandemics on the probability of manufacturer *k* entering or exiting the industry in country *i* at time *t*, I use the following equations:

$$Probability\ of\ Entering_{kit} = \phi(= \alpha + \delta_1 * SwineFlu_t + \beta_1 * SwineFlu_t * intensity_i + \gamma_2 * SwineFlu\ After1_{t-1:t-8} * intensity_i + \theta_3 * SwineFlu\ After2_{t-9:t-23} * intensity_i + \delta_2 * MERS_t + \beta_2 * MERS_t * intensity_i + \gamma_2 * MERS\ After1_{t-1:t-8} * intensity_i + \theta_2 * MERS\ After2_{t-9:t-23} * intensity_i + \delta * X_{i,t} + \mu_i + \varphi_t + \varepsilon_{k,i,t}) \quad \textbf{(Model 5)}$$

$Probability\ of\ Exiting_{kit} = \ \phi(= \ \alpha \ + \delta_1 * SwineFlu_t + \beta_1 * SwineFlu_t * intensity_i + \ \gamma_2 * SwineFlu\ After1_{t-1:t-8} * \ intensity_i + \ \theta_3 * SwineFlu\ After2_{\ t-9:t-23} * \ intensity_i \ + \delta_2 * MERS_t + \beta_2 * MERS_t * intensity_i + \ \gamma_2 * MERS\ After1_{t-1:t-8} * \ intensity_i + \ \theta_2 * MERS\ After2_{t-9:t-23} * intensity_i + \delta * X_{i,t} + \mu_i + \ \varphi_t + \ \varepsilon_{k,i,t}\ )$ **(Model 6)**

In these models $\phi(\cdot)$ is the cumulative normal distribution function, β_1 and β_2 capture the effects on the probability a manufacturer enters (exits) during the pandemic (H2B & H3B) and the γ_1 ,γ_2 and θ_1 and θ_2 capture the effects after the pandemics (H5B & H6B). I include manufacturer fixed effects (ω_k) and time-fixed effects (φ_t), control for GDP and CPI (δ) and use robust standard errors.

Model	Tests Hypothesis	Dependent variable	Type of health crisis	Method
1	1A & 4A	Ln Price	Epidemic	DiD
2	2A & 5A	Probability of Entering	Epidemic	Probit
3	3A & 6A	Probability of Exiting	Epidemic	Probit
4	1B & 4B	Ln Price	Pandemic	Before/After
5	2B & 4B	Probability of Entering	Pandemic	Probit
6	3B & 6B	Probability of Exiting	Pandemic	Probit

Table 5.2: Summary table of which models tests which hypotheses, the dependent variables, type of health crisis and econometric method.

6. RESULTS

6.1 Epidemics

Prices

Table 6.1.1: Estimates of the effects on price of paracetamol during and after the epidemics (Model 1)

VARIABLES	(1)	(2)	(3)
	Ln Price per 100mg paracetamol		
Vietnam	0.126***	0.0614**	0.0612**
	(0.0304)	(0.0301)	(0.0302)
Vietnam After1	0.142***	0.0560***	0.0495**
	(0.0190)	(0.0193)	(0.0197)
Vietnam After2	0.140***	0.0147	0.0153
	(0.0175)	(0.0194)	(0.0195)
Pakistan	-0.0588	-0.0575*	-0.0613*
	(0.0359)	(0.0344)	(0.0340)
Pakistan After1	-0.0814***	-0.0871***	-0.0903***
	(0.0264)	(0.0258)	(0.0257)
Pakistan After2	-0.0740***	-0.0947***	-0.0994***
	(0.0234)	(0.0231)	(0.0232)
GDP (ln)		0.299***	0.292***
		(0.0129)	(0.0136)
CPI (ln)			-0.00800***
			(0.00283)
Constant	-7.224***	-15.05***	-14.75***
	(0.0664)	(0.337)	(0.355)
Observations	62,665	52,725	48,137
R-squared	0.908	0.926	0.926
Manufacturer FE	YES	YES	YES
Country FE	YES	YES	YES
Year FE	YES	YES	YES

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

Table 6.1.1 shows the results of the effect of the epidemics on the prices. The first noteworthy thing is that the coefficient of CPI is negative and significant. This goes against what rationally can be expected: rising inflation levels should result in rising prices, including those of paracetamol. I further address this concern in Section 7. Furthermore, as can be expected with manufacturer, country and year fixed effects, the R-squared is large: higher than 0.9 in all columns. Hence, the model has great explanatory power. The addition of the CPI and GDP (Columns 2 and 3) do change the significance-level of the variable that captures the second period after the epidemic for Vietnam from significant (at $p<0.01$) to insignificant. The dummy that captures the effect during the Pakistan epidemic from insignificant to significant (at $p<0.1$). Also, the magnitude of the effects change, especially with regards to Vietnam dummies. Therefore, I assume the coefficients in Column 3 to be closest to the true coefficients.

Column 3 shows that during the Vietnam measles outbreak the price of 100mg of paracetamol increased with approximately 6.3%, ceteris paribus.[8] This result is significant at a 5% significance level over all three columns and in line with the literature and thus supportive of Hypothesis 1A and Figure 3.4.1. In contrast, during the Pakistan epidemic, the price of 100mg paracetamol decreased by 6.3%, ceteris paribus. This result is significant (at $p<0.1$). Therefore, the results show that there is indeed an effect of the epidemics on the prices, however ambiguous. Therefore, I cannot draw conclusions regarding Hypothesis 1A.

The first set of variables after the Vietnam and Pakistan epidemics capture the effects the first two years right after the epidemics. I find that the first two years after the Vietnam epidemic, the effect is positive and significant (at $p<0.05$). The prices are still 5.1% higher than when Vietnam would not have had an epidemic, ceteris paribus. This effect is slightly smaller than during the epidemic, however, the prices during the two years after the Vietnam epidemic remain higher in support of Hypothesis 4A. The first two years after the Pakistan epidemic I also find a similar effect as during the Pakistan epidemic, namely: negative and significant (at $p<0.01$). This means the price of paracetamol was around 9.5% lower after the Pakistan epidemic than what they would have been without the epidemic, ceteris paribus. Therefore, just like *during* the epidemic, I find that *after* the Pakistan epidemic the prices of paracetamol were also lower.

The second set of variables capture whether the effect after the outbreaks remain for the duration of the dataset or extinguishes. Note that for the Vietnam epidemic, this variable covers a period of 2.25 years, and for the Pakistan epidemic this variable covers 3.5 years. The coefficient is positive but insignificant for Vietnam, I can therefore not conclude that the effect is significantly

[8] Note that to convert the coefficients to the percentual increase/decrease I use the following formula: (exp(coefficient)-1) * 100%

different from zero. Hence, I cannot confirm that the positive effect on the price of paracetamol remains for longer than two years. The coefficient is negative and significant for the Pakistan epidemic and translates to an effect of 10.5% on the price of paracetamol. This result, in combination with the insignificant effect from the second period after the Vietnam epidemic, do raise suspicions of an exogenous factor permanently lowering the price of paracetamol simultaneously as the start of the Pakistan epidemic. Alternatively, the manufacturers could have produced relatively more than the rise in demand, which would subsequently resulted in a negative effect on the price. This is also in line with the findings on the probability of entering and exiting the market (see the next paragraph). However, from Figure 6.1 it is evident that for both epidemics the price of paracetamol was lower *after* the epidemics than *during* the epidemics. I can, based on these results, conclude that some form of hysteresis of the effect on the price exists, which is supportive of Hypothesis 4A, however, I cannot establish these effects are positive and can therefore not draw conclusions regarding Hypothesis 4A. However, hereafter I further examine the mechanisms driving the effect on the price of paracetamol in the Vietnam epidemic.

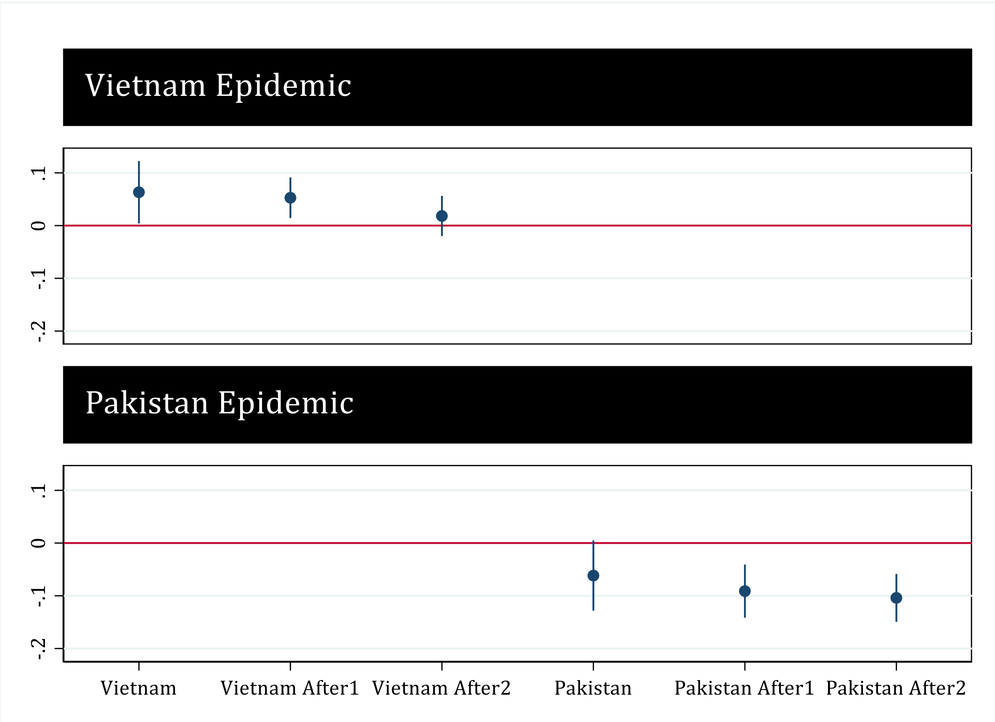

Figure 6.1: Plot of the coefficients of the effects during and after the epidemics of Vietnam and Pakistan of the full model (Table 6.1.1, Column 3).

Prices – Strength

Table 6.1.2: The results of an analysis of the different effects on price by different strengths of paracetamol

VARIABLES	(1) Ln Price per 100mg paracetamol
Vietnam	-0.0106
	(0.0121)
Vietnam * Strength	0.0363***
	(0.0133)
Vietnam After1	-0.142***
	(0.0308)
Vietnam after1 * Strength	0.197***
	(0.0338)
Vietnam After2	-0.0847***
	(0.0305)
Vietnam after2 * Strength	0.161***
	(0.0345)
Ln CPI	-0.00648**
	(0.00265)
Ln GDP	0.288***
	(0.0133)
Constant	-14.61***
	(0.347)
Observations	57,779
R-squared	0.907
Manufacturer FE	YES
Country FE	YES
Year FE	YES

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

The ambiguous effects in Table 6.1.1 do raise questions regarding the mechanisms driving these effects. Figure 3.4.1 shows that I assume the positive effect on prices to have either come from an upward demand shock, supply chain effects, the effect of uncertainty on the prices, or a combination of these three factors. Because during the Vietnamese measles outbreak one specific demographic fell ill, namely children under the age of 12, a unique opportunity is presented to determine whether a peak in demand was a dominant factor for the positive effect on prices during the Vietnam epidemic. Explicitly, children under the age of 12 are strongly advised to take paracetamol with a strength of 500mg or lower (Penna & Buchanan, 1991). Therefore, I create a dummy that takes on the value of 1 in case the tablet is of a strength of 500mg or less, and zero otherwise.

As evident from Table 6.1.2, the positive effects on price as found in Table 6.1.1. only remain significant and positive for paracetamol with a strength of 500mg or lower, during all three time periods. After the epidemic, the effect on the price of paracetamol with a strength higher than 500mg is even negative (at p<0.01). These strong effects seem to confirm that during the Vietnam epidemic an upward demand shock is mainly responsible for the rising prices. If uncertainty or supply chain effects would have dominated, it is reasonable to think not just the tablets of a strength of 500mg or lower would have seen a positive effect on the price, but also the other strengths.

In Pakistan paracetamol is not sold in tablet form in strengths higher than 500mg. However, a similar analysis would not be relevant because the epidemic was caused by the dengue virus which does not affect a specific part of the population (WHO, 2019).

Exits and Entries

Table 6.1.3 shows the results of the analysis of the effects of the epidemics on the probability extra paracetamol manufacturers enter or exit the industry. During the Vietnam epidemic, I find a positive effect (at p<0.1) on the probability of a manufacturer entering the industry in Vietnam (Column 1 and 2). This effect converts to an average marginal effect on the probability of entering of 1.2 percentage points, ceteris paribus, which is a result in support of Hypothesis 2A (see Appendix A). Similarly, I find a positive and significant (at p<0.01) effect on the probability of entering the Pakistan industry during the Pakistan epidemic. The effect translates to an effect of 1.9 percentage points on the probability of entering, ceteris paribus. These findings are supportive of Hypothesis 2A.

I find a negative effect on the probability of exiting during the Vietnam epidemic. In Column 4 this effect is significant at a 10% significance level. This translates to an average marginal effect of approximately 3.8 percentage points decrease on the probability of exiting the Vietnamese market during the epidemic compared to not during the epidemic, ceteris paribus (see Appendix A for average marginal effects). I also find that the probability of exiting was lower during the Pakistan epidemic. The negative and significant (at p<0.1) effect means a 2.4 percentage points decrease on the effect of exiting during the outbreak. These findings are supportive of Hypothesis 3A.

The first two years after the Vietnamese epidemic, I find a negative effect on the probability of entering, which is in line with Hypothesis 5A. However, the effect is insignificant. The effect during the first two years after the Pakistan epidemic is positive and insignificant. The remaining years after the Vietnam epidemic (Vietnam after 2) shows a significant effect on the probability of entering in Column 1, however, after controlling for GDP and CPI this effect too becomes insignificant, which signals that the found effect in Column 1 is likely due to changes in either GDP or CPI levels. The second period after the Pakistan epidemic shows a negative but small and insignificant effect. Therefore, I find no support for Hypothesis 5A.

Table 6.1.3: Estimates of the effects on the probability of entering and exiting during and after the epidemics (Models 2 and 3).

VARIABLES	(1)	(2)	(3)	(4)
	Probability of entering		Probability of exiting	
Vietnam	0.346**	0.313*	-0.725**	-0.613*
	(0.160)	(0.163)	(0.335)	(0.336)
Vietnam After1	-0.196	-0.268	0.0918	0.239**
	(0.208)	(0.215)	(0.0916)	(0.0987)
Vietnam After2	0.213*	0.129	-0.0511	0.104
	(0.125)	(0.148)	(0.0939)	(0.101)
Pakistan	0.527***	0.491***	-0.404*	-0.389*
	(0.168)	(0.168)	(0.236)	(0.236)
Pakistan After1	0.108	0.101	0.161	0.186
	(0.184)	(0.185)	(0.144)	(0.145)
Pakistan After2	-0.0200	-0.0355	-0.103	0.00565
	(0.141)	(0.146)	(0.106)	(0.108)
GDP (ln)		0.209**		-0.386***
		(0.0895)		(0.0793)
CPI (ln)		-0.0228		0.0276*
		(0.0204)		(0.0161)
Constant	-2.066***	-7.388***	-2.196***	7.566***
	(0.0965)	(2.313)	(0.105)	(2.026)
Observations	109,228	82,692	109,228	84,641
Country FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The first two years after the Vietnam epidemic, I find that the probability of exiting was indeed significantly higher (at $p<0.05$ in Column 4). This result is in support of Hypothesis 6A. The marginal average marginal effects on the probability of exiting is 1.5 percentage points, ceteris paribus. The remaining years after the epidemic show a small and insignificant effect on the probability. The first two years after the Pakistan epidemic, I find a positive effect on the probability of exiting, however, also small in magnitude and insignificant. Therefore, I cannot draw conclusions regarding Hypothesis 6A.

Moreover, the positive effect of GDP on the probability of entering and the negative effect of GDP on exiting show that if the GDP increases, the probability of entering increases and the probability of exiting decreases, ceteris paribus. Moreover, the negative coefficient of CPI in Column 2 is insignificant, and in Column 4 the CPI coefficient is positive and significant at a 10% significance level. Therefore, regarding this analysis I find no concerning coefficients for CPI or GDP.

6.2 Pandemics

Table 6.2.1: Estimates of the effects on price of paracetamol during and after the pandemics (Model 4)

VARIABLES	(1)	(2)	(3)
	Ln Price per 100mg paracetamol		
MERS	-0.00441	0.00537	0.0211*
	(0.0112)	(0.0108)	(0.0116)
MERS After1	-0.0295**	-0.0297**	-0.0176
	(0.0149)	(0.0142)	(0.0158)
MERS After2	-0.0190	0.0128	0.0256
	(0.0188)	(0.0175)	(0.0189)
SWINE	-0.0423***	-0.0372***	-0.0284*
	(0.0145)	(0.0142)	(0.0146)
SWINE After1	-0.0297***	-0.0226**	-0.0182
	(0.0107)	(0.0107)	(0.0111)
SWINE After2	-0.0301***	-0.0223**	-0.0192
	(0.0105)	(0.0106)	(0.0137)
MERS * Intensity	0.00856***	0.00444	0.00212
	(0.00325)	(0.00328)	(0.00332)
MERS after1 * Intensity	0.0165***	0.0186***	0.0159***
	(0.00289)	(0.00286)	(0.00309)
MERS after2 * Intensity	0.0217***	0.0221***	0.0211***
	(0.00315)	(0.00356)	(0.00392)
SWINE * Intensity	-0.000561	-0.000827	-0.00133
	(0.00212)	(0.00203)	(0.00218)
SWINE after1* Intensity	-0.000768	-0.00149	-0.000525
	(0.00203)	(0.00195)	(0.00199)
SWINE after2* Intensity	-0.0115***	-0.00910***	-0.00694***
	(0.00188)	(0.00182)	(0.00188)
GDP (ln)		0.295***	0.290***
		(0.0124)	(0.0132)
CPI (ln)			-0.00803***
			(0.00280)
Constant	-7.179***	-14.92***	-14.67***
	(0.0671)	(0.325)	(0.344)
Observations	62,665	52,725	48,137
R-squared	0.908	0.926	0.926
Manufacturer FE	YES	YES	YES
Country FE	YES	YES	YES
Year FE	YES	YES	YES

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

Prices

Similar to the analysis of the effect of epidemics on price, I find a negative and significant effect of CPI on the price of paracetamol. I employ a different method in Section 7 to analyse these findings.

Table 6.2.1 shows the results from the analysis of the effect of the two pandemics on the standardised price of paracetamol. In the full model (Column 3), I observe a positive and significant (at $p<0.1$) effect on the price of paracetamol during the MERS outbreak. Hence, during the outbreak the price increased by 2.1%, ceteris paribus. In contrast, during the Swine Flu outbreak, the price significantly (at $p<0.1$) decreased by 2.8%, ceteris paribus. During both health crises, I do not find that the price increased significantly more in areas that experienced a higher intensity. Therefore, I cannot draw conclusions regarding Hypothesis 1B.

After the MERS outbreak, I find that the worldwide price levels of paracetamol were not significantly different from before the MERS outbreak, once I include CPI in the model (Column 3). However, I do find a positive and significant (at $p<0.01$) effect on the price of paracetamol in the countries that experienced a higher number of fatalities. The first period after the MERS outbreak, the effect on the prices was 1.6% and the remaining period after the MERS outbreak, the effect on the prices was 2.1%, ceteris paribus. This finding supports Hypothesis 4B.

After the Swine Flu outbreak, I find that all effects become insignificant and therefore I cannot conclude that these effects are different from zero (Column 3). This, except for the second time period after the pandemic (*SWINE After 2 * Intensity*), which shows a small and negative effect (at $p<0.01$). However, note that this effect covers a period of almost seven years. Because of the large time period it covers, the small magnitude of the effect and the absence of other effects found after the Swine Flu pandemic, I cannot draw conclusions regarding this effect on the price to the Swine Flu pandemic. Therefore, regarding the Swine Flu pandemic, I cannot draw conclusions regarding Hypothesis 4B.

Entries and exits

During the MERS outbreak, I find negative effects on the probability of entering and exiting the market, although both are not significant. In countries that experienced a higher intensity of the outbreaks, I find that the probability of exiting the market was significantly (at $p<0.05$) lower. This means that the outbreak caused on average a decrease of 4 percentage points on the probability of exiting in these countries. This finding is in support of Hypothesis 3B. The effect on the probability of entering in these countries is positive, but small and insignificant. Therefore, I do not find evidence in support of Hypothesis 2B.

During the Swine Flu pandemic, I find that the effect on the probability of entering and exiting is positive, although insignificant. I do find a positive and significant effect on the probability of entering for countries that experienced the Swine Flu outbreak more intense (Column 1) but with the addition of the control variables the effect becomes insignificant. This finding is in contrast to what I hypothesised in Hypothesis 2B. However, the effect on the probability of exiting is negative and significant (at $p<0.05$). Yet, the magnitude of this effect is small: the coefficient of -0.0402 translates to an average marginal decrease of the probability of 0.1 percentage points, ceteris paribus. Nonetheless, this finding is in support of Hypothesis 3B.

After the pandemics, I find that for both the MERS outbreak and the Swine Flu outbreak, the effect on the probability of entering only the second period after the outbreak (After 2) is positive and significant (at $p<0.05$ and $p<0.01$ respectively). However, due to the insignificant effects in the period prior (*After 1*) I cannot draw conclusions regarding Hypothesis 5B. Regarding the probability of exiting, I find insignificant results for all time periods for both health crises. Therefore, I do not find evidence in support of Hypothesis 6B.

Table 6.1.3: Estimates of the effects on the probability of entering and exiting during and after the pandemics (Models 5 and 6).

VARIABLES	(1)	(2)	(3)	(4)
	Probability of entering		Probability of exiting	
MERS	-0.0857	-0.126	-0.110	-0.0921
	(0.0859)	(0.0964)	(0.0769)	(0.0889)
MERS After1	-0.358***	-0.352**	-0.151	-0.170
	(0.122)	(0.146)	(0.106)	(0.125)
MERS After2	-0.363**	-0.331**	-0.201	-0.207
	(0.144)	(0.167)	(0.132)	(0.153)
SWINE	0.0774	0.135	0.278**	0.188
	(0.150)	(0.173)	(0.141)	(0.155)
SWINE After1	0.0189	0.154	0.339***	0.263**
	(0.119)	(0.138)	(0.114)	(0.119)
SWINE After2	0.0977	0.155	0.197*	0.157
	(0.104)	(0.125)	(0.109)	(0.116)
MERS * Intensity	0.00560	0.0279	-0.421**	-0.404**
	(0.0736)	(0.0724)	(0.172)	(0.172)
MERS after1 * Intensity	0.0689	0.0865	0.000999	-0.0419
	(0.0516)	(0.0540)	(0.0480)	(0.0530)
MERS after2 * Intensity	0.0935*	0.115**	0.0364	0.0311
	(0.0494)	(0.0585)	(0.0407)	(0.0560)
SWINE * Intensity	0.0282*	0.0265	-0.0413***	-0.0402**
	(0.0157)	(0.0180)	(0.0155)	(0.0176)
SWINE after1* Intensity	0.0109	0.00105	-0.00899	-0.000281
	(0.0145)	(0.0155)	(0.0139)	(0.0151)
SWINE after2* Intensity	0.0342***	0.0375***	-0.0132	-0.0101
	(0.0125)	(0.0139)	(0.0118)	(0.0132)
CPI (ln)	0.0342***	0.0375***	-0.0132	-0.0101
	(0.0125)	(0.0139)	(0.0118)	(0.0132)
GDP (ln)		-0.0254		-0.0321
		(0.0594)		(0.0579)
Constant	-1.948***	2.421	-1.687***	3.757**
	(0.0749)	(1.528)	(0.0839)	(1.482)
Observations	109,228	82,692	109,228	84,641
Manufacturer FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

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

7. VALIDITY CHECK

The analysis of the effect of the health crises on prices in Section 6 do raise some questions. The effect of CPI on the price being significant and negative in Tables 6.1.1, 6.1.2 and 6.2.1 is against what common knowledge would dictate. Higher inflation (CPI) should lead to higher prices. The fact that I find a negative and significant effect of CPI on the price of paracetamol is therefore concerning. For that reason, I perform a similar analysis in this section. Recall that for the models employed in Section 6, I calculate the mean price per manufacturer in a quarter and a country and subsequently leave one observation per manufacturer. The disadvantage of that method is that a large amount of variation is not used and that smaller manufacturers receive the same weight in the analysis as larger manufacturers with a multitude of products. Therefore, this section employs a fixed effects model which exploits the variation in the data. Moreover, the method estimates its effects over within variation and therefore accounts for all observed and unobserved time invariant variation. In addition, I control for CPI and GDP which are the time variant characteristics in the model.

Table 7.1: Results of the effects on price of paracetamol during and after the epidemics using the fixed effects method

VARIABLES	(1)	(2)
	Ln Price per 100mg paracetamol	
Vietnam	0.103***	-0.0351***
	(0.0140)	(0.00545)
Vietnam * Strength		0.0540***
		(0.00735)
Vietnam After1	0.0815***	-0.150***
	(0.0142)	(0.0345)
Vietnam After1 * Strength		0.183***
		(0.0380)
Vietnam After2	0.0250	-0.134***
	(0.0163)	(0.0483)
Vietnam After 2 * Strength		0.185***
		(0.0517)
Pakistan	0.00746	0.0354
	(0.0362)	(0.0375)
Pakistan After1	-0.0737*	-0.135***
	(0.0403)	(0.0388)
Pakistan After2	-0.150***	-0.165***
	(0.0577)	(0.0565)
CPI (ln)	0.0296***	0.0240***
	(0.00188)	(0.00192)
GDP (ln)	0.166***	0.192***
	(0.0135)	(0.0131)
Constant	-9.511***	-10.24***
	(0.365)	(0.354)
Observations	191,696	174,713
R-squared	0.012	0.014
Number of panelid	6,017	5,901

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

Table 7.1 shows the results of the effect of price when using a fixed effects model. Here, indeed, the effect of CPI on the price is positive and significant (at p<0.01).

During the Vietnam epidemic, I find a positive effect on the price (at p<0.01, see Column 1) which originates from rising prices of paracetamol of 500mg or lower, with an opposite effect for paracetamol of higher than 500mg paracetamol. Also, these effects remain after the epidemic, similar to the DiD-method of Section 6.1 (see Figure 7.1).

During the Pakistan epidemic, I now find no significant effect on the prices exists during the Pakistan epidemic, while after the epidemic the effect on the price remains negative and significant at a 1% significance level.

Figure 7.1 shows that the coëfficients obtained by the fixed effects model are similar to the coëfficients obtained by the DiD method. I find that during both epidemics the price of paracetamol was higher than after the epidemics. Therefore, employing the fixed effects model further validate the conclusions that are made based on the analysis in Section 6.1.

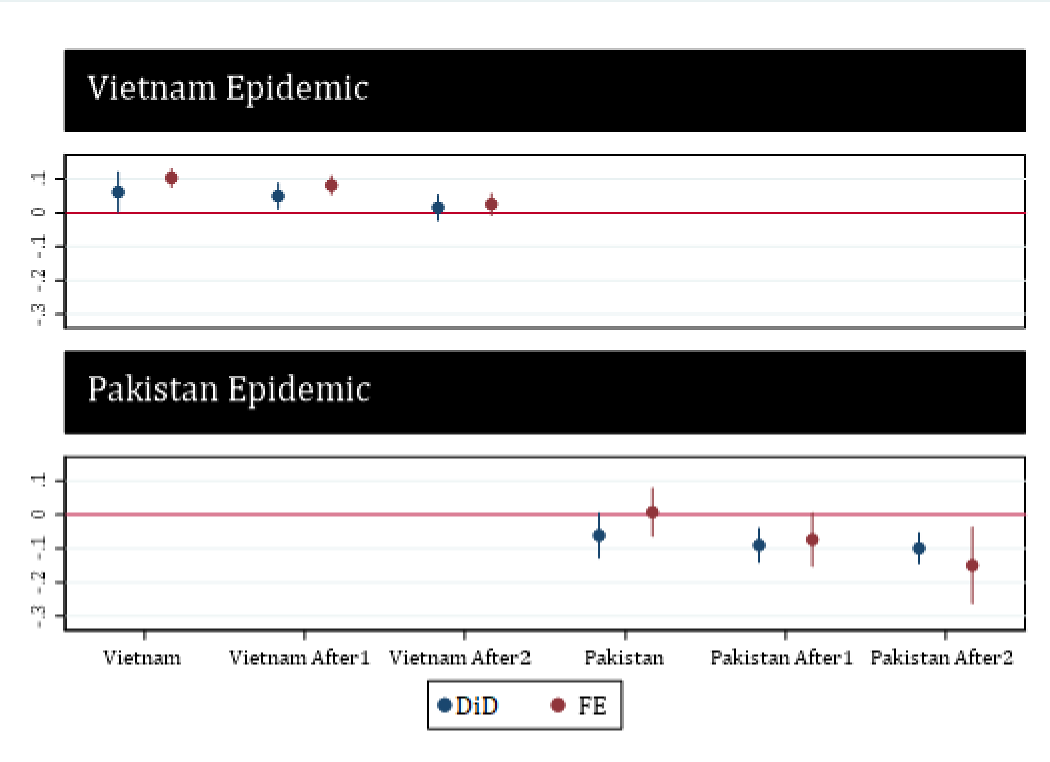

Figure 7.1: Plot of coefficients of the effects during and after the epidemics of Vietnam and Pakistan for both the Difference in Difference method (blue) and the Fixed Effects method (red).

Table 7.2: Results of the effects on price of paracetamol during and after the pandemics using the fixed effects method

VARIABLES	(1)
	Ln Price per 100mg paracetamol
MERS	-0.0272***
	(0.00300)
MERS After1	-0.0959***
	(0.00269)
MERS After2	-0.0775***
	(0.00278)
SWINE	-0.0177***
	(0.00549)
SWINE After1	-0.0218***
	(0.00476)
SWINE After2	-0.0122***
	(0.00469)
MERS * Intensity	-0.00721**
	(0.00317)
MERS after1 * Intensity	0.00243
	(0.00271)
MERS after2 * Intensity	-0.000808
	(0.00306)
SWINE * Intensity	0.00156
	(0.00108)
SWINE after1* Intensity	0.00597***
	(0.000936)
SWINE after2* Intensity	-0.00472***
	(0.000824)
GDP (ln)	0.260***
	(0.00489)
CPI (ln)	0.00280**
	(0.00120)
Constant	-12.01***
	(0.132)
Observations	191,696
Number of panelid	6,017

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The effects I find in Table 7.2 with the use of the fixed effects model with regards to the Swine Flu are relatively similar to the effects I find in Table 6.2.1. During the Swine Flu outbreak, the effect on the price was negative and significant (at p<0.1 and p<0.01, respectively). The small and negative coefficient of *Swine * Intensity* in Table 6.2.1 is small but positive with the use of this method, however, remains insignificant and therefore no different conclusions would be made regarding Hypothesis 1B. After the Swine Flu outbreak, I find a positive and significant effect (at p<0.01). This result is supportive of Hypothesis 4B. However, it has to be noted that the effect is small: The coefficient translates to an effect of 0.6% on the price of paracetamol, ceteris paribus.

The most diverging results stem from the analysis of the MERS outbreak. I find a positive effect and significant on the price of paracetamol during the MERS outbreak in Section 6.2. However, with the use of this alternative method, I find a negative and significant (at p<0.01) result. Moreover, I now find that *during* the MERS outbreak, countries that experienced the outbreak more intense also experienced a negative effect on the price of paracetamol, which is significant (at p<0.05). Moreover, the positive and significant effects from Table 6.2.1 *after* the MERS outbreak in these countries, are negative and insignificant with the use of this method.

Overall, the effects of the MERS pandemic are lower than in Section 6.2. Note that the fixed effects method exploits within-manufacturer variation, and therefore accounts for the size of the manufacturers better than the Before-After analysis of Section 6. Therefore, it is possible that the effects found in Section 6.2 are driven up by small(er) manufacturers charging a higher than average prices. Nonetheless, the validity check shows that the results regarding the MERS outbreak should be interpreted with caution.

8. DISCUSSION & CONCLUSION

Table 8.1: Summary of the results of Section 6

Health crisis	**Hypotheses**					
	H1A	**H2A**	**H3A**	**H4A**	**H5A**	**H6A**
Vietnam	positive*	positive*	negative*	positive*	negative	positive*
Pakistan	negative*	positive*	negative*	negative*	positive	positive
	H1B	**H2B**	**H3B**	**H4B**	**H5B**	**H6B**
MERS	positive	positive	negative*	positive*	positive	negative
Swine Flu	negative	positive	negative*	negative	positive	negative

* p<0.1, p<0.05 or p<0.01

While forming hypotheses, I distinguished epidemics and pandemics as two different sub-categories within the category health crisis. However, if anything is to be taken away from this research, it is that the effect of the different health crises on the prices are all significantly different from each other and that multiple factors are at play when deciding a price, or entry and exit strategy. To answer provide an answer to the research question, *What is the response of pharmaceutical firms to health crises?*, one first has to specify what health crises and fully understand what political, economic and psychological factors were prevailing during the crisis. As evident from Table 8.1, I find the effects to differ from each health crisis. In particular the price effects between the two epidemics stand out. However, there are some interesting insights to be drawn from the results of this study.

Epidemics

The (strategic) responses of pharmaceutical firms during health crises, is a field of which not much previous research exists. Therefore, this research is based on the framework I provide in Figure 3.4.1 which provides three main reasons for an upward price effect on the prices of paracetamol during health crises. These are: supply chain problems, an upward demand shock and uncertainty.

For the case of the Vietnam epidemic, most evidence from this study points towards the upward demand causing the positive effect on the prices of paracetamol. During the Vietnam measles epidemic, I find a clear positive price effect, but only for paracetamol with 500mg active ingredient or less. Because children under the age of 12 are the main demographic that fell ill during the Vietnam epidemic, the price of this strength rising is confirming that assumption. However, it is interesting that the price of paracetamol with more than 500mg active ingredient is significantly lower during the Vietnam epidemic. Following the neoclassical price theory, the price of this sub-group would be unchanged under the assumption that this category did not experience an upward demand shock (Nicholas, 2012). However, an explanation for this phenomenon is that due to a disproportional rise in the demand of paracetamol of 500mg or less, the manufacturers of the close substitute with more than 500mg of active ingredient had to lower their prices to still be competitive in the market. In that case, the manufacturers of the stronger paracetamol used prices as a strategic capability as meant by Dutta, Bergen, Levy, Ritson & Zbaracki (2002). The results regarding the probability of entering during the Vietnam epidemic being higher further substantiate that a peak in demand of paracetamol occurred during the Vietnam epidemic.

An important factor to consider when I assume the peak in demand is partly caused by the (change of) consumer sentiment towards certain products, is the way the media reports on the health crisis. During the Vietnam epidemic, many media outlets reported on the outbreak, and mainly blamed the government for inadequately managing the vaccination program for measles (Radio Free Asia, 2014). During the Pakistan epidemic, I find some anecdotal evidence on hospitals providing care for free to dengue patients (Pakistan Today, 2011). This hints at a different attitude in the two countries towards the two outbreaks, which may be the cause of the difference in price effects. However, during the Pakistan epidemic, I find a positive effect on the probability of entering the industry and a negative effect on the probability of exiting the market. Therefore, another explanation is that the growth of the market was relatively larger than the raise in demand, subsequently leading to lower prices due to higher competition and more supply.

After the Vietnam epidemic, I find that the positive price effects remain for the first two years, after which the effect becomes insignificant. This means that the prices do not instantly convert back to the pre-epidemic levels, although the cause of the price effect (the epidemic) has extinguished. This can be explained by menu-costs; changing prices are accompanied by additional costs which can cause the price-effects to remain after the cause distinguished (Levy, Bergen, Dutta & Venable, 1997). However, over time, the prices seem to convert back to pre-epidemic levels as evident from the *Vietnam After2* coefficient being insignificant.

After the Pakistan epidemic, the prices were lower than during the Pakistan epidemic (see Figure 6.1). However, I find no significant effect on the probability of entering nor exiting the market after the Pakistan epidemic. Therefore, the relative growth of the industry *during* the Pakistan epidemic being larger than the peak in demand, could have contributed to the remaining lower prices. An absence of a lower probability of entering or a higher probability of exiting *after* the epidemic may be due to the fact that irreversible investments had been made during the epidemic to enter or stay in the market. Subsequently, the market reacted with a further decrease in price, rather than manufacturers exiting or refraining from entering the market.

Pandemics

In the framework of Figure 3.4.1 I propose the consumer sentiment as one of the two causes of an upward demand shock. Regarding the Vietnam epidemic, I can establish an upward demand shock by analysing the differences on price of the different strengths of paracetamol. Yet, this does not provide insight on whether this upward demand is mainly due to a change in consumer sentiment or reflective of the actual demand because of the decrease in health. Researching more wide-spread health crises such as the Swine Flu outbreak, or the MERS outbreak provide even more perspective on the mechanisms through which prices do or do not change. I find that the outbreak of MERS had a positive and significant effect on the price of paracetamol, although this price effect was not stronger in areas with more fatalities. Possibly, the demand for paracetamol was affected by media exposure around the world and therefore the effect was not limited to just the areas where the MERS outbreak was severe. The MERS differs from the Swine Flu pandemic, because MERS was reportedly much more dangerous (WHO, 2019a; WHO, 2019b), which could have caused more panic among the public, subsequently leading to a higher peak in demand and higher prices.

A large community spread outbreak of MERS occurred in South Korea in the first half of 2015. Ludolph, Schulz and Chen (2018) find that the mass media reporting on the outbreak in South Korea positively influenced the preventative measures that were taken by the government of Hong Kong. This finding demonstrates that the media play an active role in the perception of the health crises. Also, Choi, Yoo, Noh and Park (2017) find that a higher social media exposure of the disease was positively correlated with a higher risk perception of the MERS outbreak in South Korea. This could explain why rising price levels occurred everywhere, and not merely in the areas that were hit harder; because the media were reporting on it everywhere causing changing consumer sentiment towards paracetamol everywhere and not merely the areas that experienced the outbreaks most intense.

I do find evidence that in the areas that experienced the outbreaks more intense, a lower probability of exiting the market existed, for both the MERS and Swine Flu outbreak. Therefore, the peak in demand can also have fully been absorbed by less manufacturers exiting the industry in these areas than normally would have.

Relating to other health crises: COVID-19

Over the last couple of years multiple news outlets have written on the Western world's increasing dependency on countries like China and India for its supply of medicines (e.g. NOS, 2019; Nawrat, 2020). With the COVID-19 pandemic originating in China these vulnerabilities were instantly uncovered: concerns on medicine shortages instantly grew with the temporary closing of the pharmaceutical manufacturers to prevent the spread of the virus in China. (Ivanov, 2020; Wood, 2020). This instantly prompted the EU to work on preventing wide-spread medicine shortages (European Medicines Agency, 2020).

What is also observed during the COVID-19 pandemic, is how little the supply chain for medicines is able to withstand a sudden peak in demand. Medicines regularly used to treat the patients that have fallen ill with COVID-19 consequently have been in high demand. Premier, an organization that works with hospitals in New York, reports that shortages of drugs regularly used to treat patients already existed before the pandemic. However, the demand of some of the medicines reportedly increased by 66 to 153 percent during a peak of COVID-19 cases in New York (Premier, 2020). Hence, enormous pressure was put on the supply chain of these medicines. Subsequently, many pharmacies have reported increases in shortages of medicines and rising prices (Wood, 2020). Early on, media reported on the effectiveness of paracetamol in relieving the COVID-19 symptoms, especially in comparison to other common pain-relievers such as Ibuprofen and Aspirin (Day, 2020). Panic buying has also led to an increase in demand for over-the-counter drugs related to the symptoms of COVID-19 (Breen & Hannibal, 2020).

Uncertainty has been a contributor to the different reactions by all firms (Altig et al., 2020). The stock market volatility shows the extent of uncertainty in the economies around the world (Alfaro, Chari, Greenland & Schott, 2020). Baker, Bloom, Davis and Terry (2020) predict that the uncertainty following the COVID-19 pandemic will be responsible for at least half of the large output contraction that will follow due to the pandemic. They compare the magnitude of uncertainty induced by the COVID-19 outbreak to the uncertainty that occurred during the Great Depression of 1929-1933.

Following this study, rising changing dynamics in the pharmaceutical industry due to supply chain problems, an upward demand shock and uncertainty seems unavoidable. However, the results from this study show that there is still much unknown on the responses of the firms and the mechanisms at work during and after health crises. Many comparisons are being made to other pandemics and world-wide health scares. However, due to the intensity of the COVID-19 outbreak, it can be of value to look at the more intense but more localised epidemics such as the Vietnam measles outbreak to draw similarities and conclusions.

However, even during the current pandemic, in seemingly similar countries we observe different responses to the COVID-19 crisis. For example, much of the Scandinavian countries reacted proactively to the COVID-19 outbreak with nation-wide lockdowns. However, Sweden employed a totally different approach, with much of the schools and economies staying open in response to the outbreak (Born, Dietrich & Müller, 2020). This means that countries that are closely related may respond totally different, which in turn provoke different responses from the manufacturers in those countries.

9. LIMITATIONS & RECOMMENDATIONS

This study is not exempted from some limitations. First, the DiD-method hinges on the assumption a similar trend would have occurred in Pakistan and Vietnam during the epidemics in case the epidemics had not happened. However, with controlling for GDP and CPI-levels and with similar results using the fixed effects method, these concerns are put to a minimum. Second, the use of cases and deaths regarding the intensity of a pandemic, can be biased and closer to being a proxy for *intensity of the approach*: some countries employ a more intense testing approach than other countries. For example, After July 2009 the world's health organisations determined that testing and reporting the number of cases and fatalities due to Swine Flu was no longer mandatory (CDC, 2010). Third, though I use firm-level data, only the country-location of the manufacturers is known. This means that the found effects can be diluted. For example; Pakistan has 250 million inhabitants, and the outbreak in 2011 was mostly focused in the Lahore area where 11 million people live (=4.4% of the total population). This raises questions on the found effects; I find negative effects on the price of paracetamol during the epidemic, but I cannot rule out that in the Lahore area a positive effect on the price did exist. A study with a bigger focus on the location of the respective manufacturers could perhaps give more insight.

The follow-up studies that can be performed following this study are plentiful. First, a study focusing on merely one disease could exclude heterogeneity concerns of the diseases. For example, dengue outbreaks are common in many tropical countries. A study merely focused on the effect of dengue outbreaks could give more insights in the strategic response of paracetamol manufacturers following outbreaks of dengue fever. Second, future research could account for a more dynamic view of the death toll. In this study, the intensity of the outbreaks in each country are proxied by the number of fatalities, however, this is the total number as reported after the crises. Even though, the outbreaks are likely to intensify, and each country could experience a peak at different times. A more dynamic view of the fatalities could therefore show the response of the manufacturers during each time. Third, a study that focuses on the way the media reports on certain outbreaks could provide more insights in the why behind the different effects on the prices I find in this study. Therefore, I would recommend a study that focuses on the consumer sentiment during the health crises to provide insights in the (strategic) response of the manufacturers.

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11. APPENDIX A

Table 11.1: Estimates of the average marginal effects on the probability of entering and exiting during and after the epidemics of Table 6.1.3 Column 2 and 4.

VARIABLES	(1) Probability of entering	(2) Probability of exiting
Vietnam	0.012*	-0.038*
	(0.006)	(0.021)
Vietnam After1	-0.010	0.015*
	(0.008)	(0.006)
Vietnam After2	0.005	0.007
	(0.006)	(0.006)
Pakistan	0.019***	-0.024*
	(0.006)	(0.015)
Pakistan After1	0.004	0.012
	(0.007)	(0.009)
Pakistan After2	-0.0014	0.000
	(0.006)	(0.007)
CPI (ln)	-0.001	0.002*
	(0.0007)	(0.001)
GDP (ln)	0.008**	-0.024***
	(0.003)	(0.005)

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

Table 11.2: Estimates of the average marginal effects on the probability of entering and exiting during and after the pandemics of Table 6.2.2 Column 2 and 4.

	(1)	(2)
VARIABLES	Probability of entering	Probability of exiting
MERS	-0.0033	-0.092
	(0.0025)	(0.088)
MERS After1	-0.0092**	-0.170
	(0.0038)	(0.125)
MERS After2	-0.0087**	-0.207
	(0.0044)	(0.155)
SWINE	0.0035	0.188
	(0.0045)	(0.155)
SWINE After1	0.0041	0.263**
	(0.0036)	(0.119)
SWINE After2	0.0041	0.157
	(0.0033)	(0.115)
MERS * Intensity	0.0007	-0.403**
	(0.0019)	(0.0172)
MERS after1 * Intensity	0.0023	-0.0419
	(0.0014)	(0.0560)
MERS after2 * Intensity	0.0030**	0.031
	(0.0015)	(0.0561)
SWINE * Intensity	0.0007	-0.0402**
	(0.0005)	(0.0176)
SWINE after1* Intensity	0.00003	-0.0002
	(0.0004)	(0.0155)
SWINE after2* Intensity	0.00108	-0.0101
	(0.0003)	(0.0131)
CPI (ln)	-0.0007	-0.0321
	(0.0007)	(0.0229)
GDP (ln)	-0.0003	-0.2507**
	(0.0025)	(0.0997)

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