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Of Marshallian Scissors & Blades: Demand Shocks, Import Exposure, and Innovation in Indian Influenza-Vaccine Markets

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Abstract

This paper examines the relationship between exogenous shocks in the demand for pharmaceuticals and the structure of India?s vaccine markets. Using a novel dataset of detailed purchasing information for vaccines in the country between 2007 and 2013, and exploiting the occurrence of the 2009-10 global H1N1 pandemic as an exogenous shock to demand for influenza vaccines, we document a significant effect of the demand shock on inventive activity in the influenza vaccine market, leading to a sizable market structure shift in India toward declining import exposure and market share gains by domestic vaccine producers. The declining imports of vaccines produced by multinational pharmaceutical firms occur as a result of a proliferation in new product introductions by domestic firms in influenza vaccine markets. We also document the effects of targeted policies by health authorities aimed at spurring development and introduction of new vaccines in India. Our results contribute to an ongoing debate on the relationship between market size and innovation and offer novel policy implications for innovation and competition in a globalized world.

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ABSTRACT

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Key words: innovation; market size; demand shocks; pharmaceuticals; vaccines; India

1 Introduction

A classic debate in the literature on economics of technological change pertains to the relationship between potential market size and incentives for innovation. Dating back to the seminal work starting with Schmookler (1962, 1966) and Walsh (1984), scholars even today remain divided on whether it is ‘demand-pull’ or ‘technology-push’ that is the primary driver of innovation. Terming the question as a ‘Marshallian scissor that cuts with two blades’, Cohen (2010) documents evidence on both sides of the debate. In addition he calls for the need of careful identification that exploits the exogenous occurrence of demand shifters separated from supply conditions to tease out the effects of market size on innovation.

Over the last decade, a small literature stream has started shedding light on this puzzle by exploring the question in the context of the pharmaceutical industry (Cerda 2007, Dubois et.al 2014, Dranove et.al 2014). This paper builds on the influential work by Acemoglu and Linn (2004) who investigate the effects of increase in the size of market for non-generic drugs in the US and found that positive demand shocks are strong drivers of innovation and new product introductions.[1] Similarly, Finkelstein (2004) finds demand increases causally impact research activity. However, she also finds that targeted health policies (like expanded public health vaccination policies in her case) can also boost the rate of innovation. Relatedly, other researchers have also documented the effects of market size increases on innovation investment and outcomes: Blume-Kohut and Sood (2013) found that Medicare Part D in the U.S. positively affected investments in research activity while Ward and Dranove (1997) pointed out the importance of policy intervention in stimulating research through public funding. To summarize, extant literature have presented some evidence, especially in the pharmaceutical industry context, that market size might be crucial to understanding the pace and trajectory of inventive activity, as profit-

[1] They found that a 1% increase in market size is associated with a 4% increase in the introduction of new products, a result that is robust to introduction of a range of controls for technological opportunity.

maximizing firms respond to incentives created by variation in perceived market size (as a measure of size of possible return on R&D investment) and risk of investment.

That said, much is still unknown about how heterogeneous firms, e.g. multinationals and local producers, respond to demand shocks by adjusting the pace and focus of their inventive activity. In addition, there has been little work exploring the relationship between exogenous changes in market size and innovation in the context of the developing world.

This study adds to the literature by documenting an interesting reversal of fortunes that occurred between multinational and domestic producers in the context of Indian vaccine markets in response to the 2009-10 H1N1 pandemic. Using a novel dataset that tracks, between 2007 and 2013, aggregate purchasing information for 280 vaccine stock keeping units (SKUs) in India sold by multinational and domestic producers across 24 Indian state regions, we document the causal impact of an exogenous demand shock coming from 2009-10 H1N1 pandemic on a reversal of import exposure in India's influenza vaccine markets relative to other vaccine markets in the country. Import exposure, calculated as a share of product revenues sold by multinational firms to total revenues, decreased from 80% in influenza-vaccine markets to just above 60%, by the time the H1N1 pandemic ended in 2010. In contrast, in all other non-influenza vaccine markets, import exposure rises to almost 60% from around 40% pre-pandemic. More importantly, we find that what was behind this significant shift in the structure of the Indian vaccine market were new product introductions from domestic firms (in contrast to multinational firms), leading to declining import exposure and rising domestic producers' market shares. In documenting this finding, we provide new evidence from the developing world on the crucial role of demand-push and exogenous market-shifters in creating incentives for innovation.

An associated issue arises here with respect to the role of the Government of India (GoI), especially in creating incentives for domestic innovation to respond to emergencies such as the H1N1 pandemic. Such governmental responses could create potential conflating effects confounding our baseline findings. We found that local health authorities did respond to the vaccine demand shock by issuing advanced market commitments[2] (a policy mechanism discussed and endorsed by Barder, Kremer, and Williams, 2006) and soft loans[3] to stimulate research in influenza vaccines geared towards resolving the pandemic. Yet, only three firms that launched products were associated with these local policy incentives. Further, we can show in our data that these products captured a miniscule market share in the focal Indian influenza vaccine markets. We can thus argue that the observed increase in capabilities, market share, and new product introductions by domestic vaccine producers in India was primarily due to a response to perceived increase in market size as a result of the H1N1 pandemic as opposed to being a response to GoI's policies. Further, we also document in our empirical findings that new product introductions are not a pan-India feature; indeed they have sub-national variations between richer and poorer regions and therein our findings might have interesting long run welfare consequences.

To summarize, this paper examines the causal effects of a global exogenous shock in demand coming from the 2009-10 H1N1 pandemic on innovation, market structure, and import exposure in India's influenza vaccine markets (relative to other vaccine markets) as manifested through the introduction of new products by domestic Indian firms. These results thus add to the existing literature on firm innovation responses to demand shifters as is documented in prior work (e.g. Schmookler (1962, 1966), Acemoglu & Lynn (2004), and Finkelstein (2004)). Our study also relates to an emerging strand in the literature on international economics that explores the role of large exogenous market shocks (like natural catastrophes or terrorism activities) on global trade (Gassebner et.al (2010), Pelli and Tschopp (2011)) and is related to the literature on the effects of imports on competition and firm behavior in local

[2] Serum Institute of India, Panacea Biotech and Bharat Biotech entered into an advanced market commitment agreement and received INR 100 million (app. $2 million).. See the press release from Ministry of Health and Family Welfare, GoI at http://pib.nic.in/release/rel_print_page.asp?relid=63879 for details.

[3] Department of Biotechnology, Ministry of Science & Technology, GoI approved Panacea Biotec's proposal and awarded financial assistance INR 100 million (app. $2 million) as a long-term loan on concessional rate of interest of 2% per annum. . See http://www.panacea-biotec.com/press_releases/PR22032010.pdf for details.

markets (see Levinsohn (1992), Helpman and Krugman (1989), and Caves et.al (1990) among many others).

Several policy and managerial implications emerge from our paper. The World Health Organization has reported recently that during the last decade there has been a change in the north-south gap in the global vaccines market. While in early 2000, some 82% of global vaccine sales came from industrialized nations, by 2010, non-US markets were growing rapidly in vaccine sales at growth rates of 10-15% per year. Our findings on the key role of market size and rising demand in inducing the development of domestic firm capabilities and leading to new product introductions suggest stimulating demand for vaccines and pharmaceuticals in general might be an important policy goal for health officials in the developing world. However, our findings on largely minor effects of local policies stimulating research and product development in India suggest rethinking current policy approaches might be necessary. In addition, the lasting effects of demand shocks on the reversal of fortunes in the Indian vaccine market away from multinational producers toward domestic firms hold lessons for multinational and domestic firms alike.

The paper proceeds as follows. Section 2 offers a review of the literature that relates to our study. We offer an institutional background in Section 3. Our data is described in Section 4 followed by the empirical framework in Section 5. Results are presented in Section 6 and Section 7 concludes.

2 Literature Review

Our work relates to several important strands in the economic and managerial literature, spanning economics and management of innovation, industrial organization, international trade, and the economics of pandemics and vaccine markets. Specifically, in examining the role of the H1N1 pandemic on rising domestic sales and falling import exposure in Indian influenza-vaccine markets through introduction of new products, we relate to a larger and much debated literature on the role of the market size in incentivizing innovation. Motivated by the key question of whether innovation happens as a result of 'technology-push' or 'demand-pull' (Schmookler 1962, 1966) recent work has explored this question in careful details in the context of the pharmaceutical industry (Cerda 2007, Dubois et.al 2014). Acemoglu & Lynn (2004) show that there is a large effect of potential market size in the U.S. on the entry of non-generic drugs and new molecular entities and that the results hold after controlling for a variety of supply-side factors and changes in technology of pharmaceutical research. Others compare the roles of market forces and health policy on pharmaceutical research (Finkelstein 2004) and investigate the effects of policy interventions like Medicare Part D expansion on research activity (Blume-Kohut and Sood, 2013 & Dranove et.al 2014)[4]. Still others emphasize the moderating role of governmental investment in basic research (Ward & Dranove 1997). Relatedly, the theoretical work of Aghion et al (2002, 2014), Vives (2008), and others document the important role of competition in inducing innovation.

The idea of competition is particularly important since in developing world contexts like ours this very often relates to imports. We thus also relate to the literature that documents the disciplining role of imports in markets. Levinsohn (1993) provides the first empirical evidence with Turkish data of how intensified international competition forces domestic firms to behave more competitively, building on past work by Helpman and Krugman (1989), Caves (1985), Caves et.al (1990), and Rodrik (1988). Many papers thereafter have explored the market disciplining role of trade with data from various country contexts. Krishna and Mitra (1998) investigate returns to scale after the Indian liberalization of 1991 and find that trade liberalization resulted in an increase in competition and associated increase in the growth rate of productivity of incumbent firms. Amiti and Konings (2007) estimate the productivity gains from reducing tariffs on final and intermediate goods in Indonesia and find that lower output tariffs can increase productivity by inducing tougher import competition whereas cheaper imported inputs can raise

[4] Finkelstein (2004) is particularly relevant to our study. She shows in healthcare markets that public policies designed to increase utilization of existing technologies, thereby inducing a market-expansion effect has a significant effect on incentives to develop new technologies. Focusing on vaccine markets like us, she finds that policies played a key role by inducing a 2.5-fold increase in clinical trials for new vaccines.

productivity via learning, variety, and quality effects. In a similar vein, Bernard, Jensen, and Schott (2006) document that in the context of U.S. manufacturing plant survival and growth are negatively associated with the industry's import exposure from low-wage countries.

It is worth noting here that a recent strand in this literature has started unpacking the effects of import competition on the local labor market. David, Dorn, and Hanson (2012) analyze the effect of Chinese import competition between 1990 and 2007 on local U.S. labor markets and find that rising import exposure leads to increasing unemployment, lower labor market participation, and reduced wages in local labor markets. In an earlier work, Macdonald (1994) already had documented that increases in import competition lead to a large increase in U.S. labor productivity growth in highly concentrated industries during 1975-1987. Amiti and Khandelwal (2013) relatedly show with data from imports to U.S. 56 countries across 10,000 products that lower tariffs are associated with quality upgrading for products close to the world quality frontier relative to those that are away from the frontier. Given our discussion in the previous section, an associated question that arises in an economically integrated world is the characterization and understanding of antecedents of import competition, in addition to its effects, which is where our paper aims to make a contribution.

Finally, our paper relates to the literature on the effects of catastrophes on economic activity. There are surprisingly few empirical papers in this area, despite its rising importance with changing contours in the global geopolitical, security, and climate situation. Stromberg (2007) potentially documents some early thoughts on this issue, showing how between 1960 and 2005, the number of disasters has increased by around 5% annually averaged over time. Some recent work extends this idea to show the role of hurricanes in inducing creative destruction (Pelli and Tschopp 2011). The authors show that the incidence of an average hurricane reduces contemporaneous export values disproportionately more for products whose revealed factor intensity is farther away from the country's comparative advantage. Relatedly, using a gravity model on 170 countries between 1962 and 2004, Gassebner et.al (2010) show that an additional disaster reduces imports on average by 0.2% and exports by 0.1% but they also document therein the critical moderating role of political systems. Volpe, Martincus, and Blyde (2013) in an associated work, show the trade effects of domestic infrastructure using Chile's 2010 earthquake as a natural experiment and exploiting the variation within Chile across regions coming from the impact of the earthquake. Expectedly, they find that diminished transportation infrastructure had a significant negative impact on firms' exports. In an interesting paper, Blalock et.al (2007) examines the unintended economic consequences of enhanced security measures after 9/11 in the U.S. that extend beyond the documented reduction in demand for air travel. In another paper that extends to the realm of economic effects of political shocks, Fuchs & Klann (2013) explore the 'Dalai Lama effect' on countries inviting the religious leader on their ability to export goods to China. They find that countries that officially receive the Dalai Lama are punished through a reduction of their exports to China, but that this effect disappears around the second year after the leader's visit to the focal country. Our work also directly relates to a small but important literature on the economic impacts of pandemics. Yoo, Kasajima, and Bhattacharya (2010) here document avoidance responses to the H1N1 pandemic in U.S. and Australia while Parman (2013) shows that the 1918 influenza pandemic resulted in a within-family shift of resources to the elder sibling from that of the child in utero, which resulted in a significant effect on educational attainments of the elder children. In this paper, we contribute to this literature by investigating the effects of one such event (the H1N1 pandemic) on international trade and economic activity in vaccine markets in a large developing country.

Finally, vaccine markets have offered to economic researchers much to ponder about in terms of developing a vibrant pipeline of innovation. Berndt et.al (2007) document that advanced market commitments could play a critical role in the development of new vaccines especially for neglected diseases like malaria and tuberculosis. This paper built on a similar argument proposed by Glennerster et.al (2006) on mechanisms through which one could incentivize R&D for vaccines. Creating and sustaining markets for vaccines has been a particular challenge in not just developing but also developed countries. Some papers have described in detail the role of push and pull strategies and have set out the context for the core problem of insufficient affordable medicines in developing countries (Towse, Keuffel, Kettler, and Ridley, 2011), as well as insufficient ex ante global investment for development of new medicines to fight off potential pandemics (a case in point: the 2014 Ebola outbreak). Danzon et.al (2005) document in the context of flu vaccines in the U.S. that competing producers face high fixed, sunk costs along with relatively concentrated demand and all of this results in higher rates of exits in the U.S. compared to four other industrialized nations. If this is the case with vaccines in a steady state world, one just wonders how the scales are shifted in the face of global demand shocks coming, for example, from events like the H1N1 pandemic of 2009-10. After all, pandemics can potentially have long-run economic effects, as a recent paper showed with differential sibling endowment in the long-run in the face of the 1918 influenza pandemic (Parman 2013). That being said, pandemics might also induce short run positive effects, like for example, a manifestation of positive unintended consequences in public hygiene habits (Aguero & Beleche 2013) or tilting the scales in terms of domestic capability development in vaccine production as we document in our paper.

3 Institutional Background

India, despite having the world's largest birth cohort of approximately 27 million and the world's 2nd largest population of approximately 1.21 billion (Census 2011, Government of India, 2011), distinctly lags behind its global peers in vaccine coverage. A report prepared for the Organization of Pharmaceutical Producers of India (OPPI) highlights the notable difference in per capita vaccine expenditure in India from that of other nations: while the annual per capita vaccine spending in the US is USD 34.40, the per capita vaccine spending in China is USD 0.50, while it is extraordinarily low in India at USD 0.01 per person per year (Bhadoria et al, 2012). Amidst a lack of robust healthcare infrastructure and a dearth of adequate cold chain storage and distribution systems especially in rural regions of the country, an extreme lack of scientific data on disease burden and vaccine efficacy creates difficulties in improving the vaccine coverage in India. It is now well documented that that one of the biggest stumbling blocks in evidence-based national vaccine policy is the lack of reliable epidemiological data on disease prevalence and incidence, pathogen variations and strains and the level of immunity protection against them in various populations in India, with and without vaccination, or before and after vaccination (Madhavi, et al., 2010).

Indian vaccine market comprises of two broad segments: public vaccine market and private vaccine market. Public vaccine market essentially comprises of Universal Immunization Program[5] (UIP) under which the Government of India (GoI) bulk purchases the vaccines for vaccine preventable diseases (tuberculosis, diphtheria, pertussis, tetanus, poliomyelitis, and measles) and makes these essential vaccines available to public free of cost. For almost two decades, UIP had six diseases in the national immunization program. It was only in the 2006-08 period that a major expansion occurred where Hepatitis-B, Japanese encephalitis, and Pentavalent[6] vaccines were added to the UIP. For those vaccines that are not included in the UIP, such as those for Hepatitis-A, Varicella (chicken pox), and others, the decision to use or not to use varies among doctors and patients can depend upon the cost, patients' level of concern, exposure risks to the patient and the doctor, and in the case of pediatric vaccines, the parents' decision (Frost & Sullivan, 2013) .

The private vaccine market[7] in India comprises of vaccines not covered under UIP, such as recurrent optional vaccines for Influenza and Typhoid, and one time optional vaccines for diseases of the developing world like Cholera. Industry reports suggest private vaccine purchases in India exceed public purchases, accounting for approximately 55% of total vaccine purchases in India (Frost & Sullivan, 2013). India's private vaccine market, although still small in size relative to more developed countries,

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[5] The immunization program in India started in 1978 as Expanded Program on Immunization (EPI). In 1985, EPI was modified as UIP, also known as routine immunization (RI).
[6] It protects children from five diseases: diphtheria, pertussis, tetanus, hepatitis b and hib.
[7] For details, please refer to Figure A1 of the Appendix which depicts patterns of pharmaceutical distribution in India. Given that our dataset comes from AIOCD, it reflects the private vaccine market data. Frost & Sullivan's (2013) strategic analysis of Indian vaccine markets estimates the private vaccine market size at USD 160.4 million in 2010 and USD 196.1 million in 2011.

has witnessed growth in recent years owing to rising disposable incomes, increasing health awareness, entry of domestic vaccine makers offering affordable vaccines, endorsement of vaccines by Indian professional organizations such as the Indian Academy of Pediatricians, and the increasing availability of combination vaccines. The latter reason has been the topic of recent interest by scholars, which have raised concerns on how private firms (both domestic firms and MNCs) have started combining non-UIP vaccines with UIP vaccines to get back door entry into India's Universal Immunization Program. They argue that the reason behind the increase in sales of combination vaccines is supply push driven (by producers and industry-driven) rather than demand pull driven (public health reasons) (Madhavi 2006).

Influenza vaccines, the focal market for this study, are an extreme case of limited storability markets as new strains of Influenza virus mutate rapidly with the capacity to cause pandemics. While pharmaceutical companies have been successful in producing effective vaccines to protect against seasonal Influenza epidemics, the current methods are not sufficient to produce large amounts of vaccine rapidly enough to combat a pandemic. As accurate identification of next pandemic strain cannot be assured in advance, vaccine stockpiling may not help. Additionally, the efficacy of available antiviral drugs such as Symmetrel™ and Tamiflu™ is limited by resistant strains and a short opportunity window for effective therapy (Heuer, 2006). Prior to the outbreak of global H1N1 pandemic, Influenza vaccine market in India was dominated by the trivalent Influenza vaccines produced by MNC firms, particularly the products of Sanofi-Aventis and GlaxoSmithKline. Spurred by an exogenous demand shock in the wake of the H1N1 pandemic and partially supported by advance market commitment along with soft loans, India's domestic pharmaceutical firms such as the Serum Institute of India, Zydus Cadila[8], Bharat Biotech and Panacea Biotec developed indigenous monovalent Influenza vaccine manufacturing capabilities and successfully launched H1N1 vaccines. Prior work in US Influenza vaccine market has concluded that government purchasing is not a necessary condition for exit of vaccine producers and the

[8] Zydus Cadila did not enter into an AMC agreement with the GoI, while other three companies did.

existence of few suppliers per vaccine in the US (Danzon & Pereira, 2011). Through our study of influenza vaccine markets in India, and the accompanying effect of the H1N1 pandemic we present supporting evidence of global demand shocks on inversion of import exposure driven through new product introductions by domestic firms. We also document the unexpectedly minor impact of governmental policies as evidenced by the fact the products launched through advanced market commitments contributed to a trivial share of the market.

4 Data

The data for this paper comes from the All India Organization of Chemists and Druggists (AIOCD). It is the largest nodal organization of pharmacists and retailers in India comprising of more than 750,000 chemists across the country. The data range across 71 months from April 2007 to February 2013 and comprise of 280 types of stock keeping units (SKUs)[9] of vaccines being sold in 24 states/regions in India by 31 firms, out of which 8 are multinational corporations (MNCs). The data provides month-wise information on maximum retail prices, cost price to retailers and quantity of vaccine skus sold at retailer's or pharmacist's level in various states across India. These data allows us to observe, at a month-product-state level, the sales, prices, and quantities of all products sold in the private vaccine market in India, along with information about the producers (MNCs and domestic), which will be the focal point of our regression analysis.

We identify the global shock to demand for influenza vaccines due to the 2009-10 H1N1 pandemic using official timelines released by the World Health Organization[10]. Using these data, we identified the onset of the pandemic as June 2009 and the end as August 2010. This allows us to observe the immediate effects of the shock during the pandemic period itself (the "during" period) as well as the

[9] For example, SKUs will be FLUARIX INJECTION 0.5 ML, NASOVAC VACCINE 5 DOSE, VAXIFLU S VACCINE 5 ML, VAXIGRIP VACCINE 0.5 ML, et cetera.
[10] See WHO press statement announcing the start of H1N1 pandemic at http://www.who.int/mediacentre/news/statements/2009/h1n1_pandemic_phase6_20090611/en/ for details. See WHO press statement declaring the end of H1N1 pandemic period at http://www.who.int/mediacentre/news/statements/2010/h1n1_vpc_20100810/en/ for details.

longer term effects after the pandemic had already ended (the "after" period). We have 26 months of market data prior to the shock, 15 months of data in the "during" period, and 30 months of data in the "after" period. Official statistics from Ministry of Health indicates that during the pandemic period, India registered some 46,064 officially recorded cases of H1N1 afflicted patients and 2,694 deaths (see Figure 1). Official statistics may underreport the true incidence of the disease and associated deaths in the country due to a relatively poorly developed public health infrastructure in India.

In our analysis, we define the affected product market space using existing product market designations in our data. Specifically, the affected market is defined as comprising those skus that fall under the umbrella of "influenza vaccines"[11]. This is the market segment that is "treated" by the demand shock, while the rest of the market (other vaccines and other non-vaccine drugs) comprise the "control" group in the difference-in-difference estimation terminology.

Finally, we supplement these data with state-year identifiers and development indicators, which allow us to explore the differential effects of the demand shock on states with differing development characteristics. In order to rank states according to their development levels, we use official data on 2009 state-level gross domestic product per capita available from Government of India's Planning Commission.

5 Empirical Framework

We begin our econometric analysis by specifying a simple functional relationship between the outcomes of interest, the existence of the demand shock, and control variables as follows:

$$y_{it} = \alpha + \beta_1 \cdot shock_{it} + \beta_2 \cdot influenza_{it} + \beta_3 \cdot shock\ X\ influenza_{it} + \beta_4 \cdot X_{it} + \sigma_t + \mu_i + \varepsilon_{it} \qquad (1)$$

where the unit of observation is a product-market-month at the national level in India, shock is an indicator for the presence of the H1N1 pandemic, influenza identifies the affected market segment, X_{it} is

[11] Treated group of vaccines does not include H1B (Haemophilus Influenza Bacteria) vaccines. Our discussions with doctors indicated to us that they might not be relevant for first-line of treatment for H1N1 pandemic.

a vector of control variables, σ_t controls time-specific unobserved heterogeneity and μ_i are product-market-specific fixed effects which control for time-invariant unobserved heterogeneity at the product-market level. The outcome variable of interest is y_{it} which measures import exposure of multinational activity in the market in terms of their revenues, quantities and count of products sold in the market as a share of overall revenues, quantities and count of products sold.

Given that we are exploring the effects of what is a plausibly exogenous shock in demand for influenza vaccines, we can be relatively confident in the consistency of our estimates provided the conditions for a difference-in-difference estimation are met in our data. In our case, this means that variation in the outcomes of interest in the observed product markets in the control and treated groups would be identical in the absence of the shock. As product markets might differ along a variety of characteristics, it is important we account for them in our regression specification. In order to do so, we control for time-variant measures of product market size, as market size has been shown to be highly correlated with a variety of outcomes of interest. In addition, we allow for unobserved time-invariant product-market heterogeneity to account for any unobservable differences between the observed markets that we as econometricians are unable to observe.

If the assumptions for our difference-in-difference analysis thus hold, parameter β_3 in equation (1) will provide us with a consistent and unbiased estimate of the effect of the demand shock on the outcomes of interest. The primary outcomes in which we are interested are measures of import exposure. As noted above, these include the relative share of imported goods in total goods sold as measured by monetary value and by quantity. We proxy the share of imported goods sold in the Indian pharmaceutical markets with sales of products of multinational corporations, the majority of which are produced outside India and imported into the country.

An additional measure of interest that will help us explain the trends we observe in our data is the share of imported products in the total number of products sold in the market. Observing the effect of the demand shock on the relative numbers of imported vs. domestic products for existing and new products (those introduced into the market after the advent of the H1N1 pandemic) will allow us to parse out whether the overall changes in import exposure are due to variations in sales of existing products or whether they are the result of new product introductions into the Indian pharma market as a consequence of the H1N1 pandemic.

However, as most of our measures of interest are expressed as relative shares and are therefore constrained to take on values between 0 and 1, we need to implement appropriate estimation methodologies that allow for constrained dependent variables. In addition to baseline ordinary least squares specifications, we thus also estimate generalized linear model (GLM) fractional logit specifications and fractional logit with fixed effects as these models specifically allow for dependent variables expressed as fractions. We find our results to be qualitatively robust to the exact choice of specification and estimation approach.

6 Results

The results of our econometric analysis point to a dramatic reshaping of the Indian influenza vaccine markets during and after the H1N1 pandemic, relative to the country's other vaccine markets. As is evident from the fixed effects OLS estimation results presented in Table 1, the revenue share of imported drugs falls by 18 percentage points during the pandemic, accelerating to a 32 percentage point decrease in the period after the pandemic subsided. In the overall sample of non-influenza-vaccine markets, we observe no drop in the revenue share of imported goods sold by multinational companies. Reassuringly, these results are qualitatively consistent with estimates from GLM regressions presented in the right-hand columns of Table I.

The quantity-based results presented in Table 2 paint a remarkably similar picture. Again looking at OLS results with fixed effects (though GLM paints an almost identical picture), we find the quantity share of imported products dropping by 32 percentage points during the pandemic, then exhibiting a continued downward trend culminating in a 42 percentage point drop in import exposure in the period after the pandemic had subsided. As is the case with revenue-based measures of import exposure, these results are robust to the choice of specification and estimation technique.

What drove this remarkable reversal of fortunes for foreign producers of influenza vaccines relative to domestic vaccine makers? To gain insight into the economic mechanisms behind our results, we re-estimate the above specifications, but constrain all revenue- and quantity-based measures of interest to be computed based solely on revenues and quantities of products that were already sold in India prior to the onset of the demand shock. We term these to be "existing products". The intuition behind this exercise is simple: if we find that most of the overall effects found in our data are driven by existing products, then the reversal of fortunes came about because domestic firms started outselling multinationals in products they already sold in the market. This would point to differences in prices, desirability, or availability of existing products between domestic and multinational companies being the reason for domestic firms outperforming their multinational peers.

However, this is not what we see in the data. As results presented in Table 4 point out, the reversal of fortunes in domestic products only is non-existing during the demand shock, while explaining less than one third of the overall effect in the period after the demand shock. This is even more evident when we look at quantity-based measures in Table 5: measured in the quantities of existing products, products sold by multinationals did not lose any market share during the pandemic, and their market share losses after the pandemic only account for one quarter of the overall total market share loss.

What this means is that our results are predominantly driven by products introduced to the Indian markets after the onset of the global H1N1 pandemic. In other words, what led to the remarkable observed drop in import exposure were new product introductions by domestic firms. These newly introduced products captured the market previously controlled by imported vaccines produced by multinational enterprises, leading to a sharp reversal of fortunes in the Indian vaccine market in favor of domestic firms.[12]

We can see this even more clearly when we look at the direct share of imported products as a total of all products sold in the Indian market as shown in Tables 3 and 6. The relative share of total imported products dropped by 32 percentage points during the demand shock period and by more than 42 percentage points in the after period. This was led by new product introductions by domestic firms as the relative share of imported existing products only decreased by 12 percentage points during the demand shock period and by no more than 14 percentage points in the after period.

As a robustness check, we also re-estimate all specifications at the state level to account for the possibility that nation-level analysis could have masked significant variation between state-level vaccine market outcomes. What we find is that state-level regressions provide us with even stronger results than what he had found in the nation-level analysis. Accounting for state-level, market-level, and state-market level unobserved heterogeneity, we find no changes in import exposure in existing products, as presented in Table 9. This means that the entirety of import exposure drops measured in Table 7 were due to new product introductions by domestic firms. These results are also robust to the choice of estimation technique, as shown by marginal effects calculated from the last two columns of Tables 7 and 9.

In addition, we ask whether sub-national variations in import exposure in influenza vaccine markets were related to the level of state development. As there is large variation in the level of development among Indian states with rich states such as Karnataka and Kerala exhibiting large educated urban populations whose preferences and willingness to pay for vaccines might have been markedly different than those of largely poorly educated rural populations in poorer states such as Uttar Pradesh and Bihar, we could anticipate brand-name products imported by multinationals holding their market shares

[12] Figure 3 shows a detailed evolution of product introductions in the Indian vaccine markets before, during, and after the H1N1 pandemic.

much better in the former states than in the latter. While we see some evidence consistent with this hypothesis, results presented in Table 8 show that import exposure dropped significantly in both states whose development level is above median and in states with below median development levels. Domestic firms, thus, captured market shares from multinationals with their newly introduced products all over India.

Finally, in light of insights stemming from recent work by Finkelstein (2004) and Dranove et al (2014), among others, which point to the role of health policy in stimulating the pace of innovation in pharmaceutical markets, we could ask to what extent the pace of new product introductions by domestic firms was driven by Indian government's policies aimed at stimulating vaccine supply during the pandemic. As it turns out, virtually the entirety of the results are driven by products of companies who did not receive support from the Indian government during the demand shock. There were only three products launched in response to the H1N1 pandemic that received governmental support via low-interest loans and advanced market commitments.[13] These products captured only a minuscule market share in Indian influenza vaccine markets. Thus, our results are driven by new products introduced by domestic firms in response to a demand shock alone, without government policies conflating the effect.

7 Discussion and Conclusion

Much debated in the literature on economics of technological change, it is still unclear whether it is demand-pull or technology-push that creates incentives for innovation. While some evidence now exists in the literature on the centrality of demand in the context of pharmaceutical industry, much more remains to be done especially in understanding how demand shocks could induce creative destruction and create incentives for innovation in the context of developing economies.

[13] These include Vaxiflu S by Zydus Cadila, Nasovac by the Serum Institute of India, HNVAC by Bharat Bio Tech International, and Pandyflu by Panacea Biotech.

This paper contributes to the above literature by examining the relationship between exogenous shocks in the demand for certain pharmaceutical products, such as influenza vaccines, and the structure of India's vaccine markets. Using a novel dataset of detailed purchasing information for vaccines in the country between 2007 and 2013, and exploiting the occurrence of the 2009-10 global H1N1 pandemic as an exogenous shock to demand for influenza vaccines in India, we document a significant shift in the structure of the influenza vaccine market in India in the direction of declining import exposure over time relative to other vaccine markets. The declining import exposure occurs as a result of new product introductions by domestic firms in influenza vaccine markets relative to other markets. Relatedly, we also document sub-national variations in the evolution of import exposure and new product introductions in Indian influenza vaccine markets. Surprisingly, governmental advanced market commitments seemed to have played no role in this evolution of market structure, a finding that runs opposite to prior work in the context of United States (Berndt et.al (2007)).

Our results contribute to an important debate in the literature on innovation, exploring therein the key role of market size and demand (Acemoglu & Lynn 2004, Finkelstein 2004). In addition, we also contribute to prior work on the role of imports in developing economies (Levinsohn 1993). The results also add to some recent work in the literature on economics of catastrophe and their role in international trade (Volpe Martincus & Blyde 2013). Finally, our findings also relate to the literature on health economics, concerned with pandemics and their effects on public health (Parman 2013, Towse et.al 2011, Yoo et.al 2010).

This paper's findings have implications for both policy and management decision makers. Our results on the key role of market size and rising demand in inducing the development of domestic firm capabilities and leading to new product introductions suggest stimulating demand for vaccines and pharmaceuticals in general might be an important policy goal for health officials in the developing world. However, our findings on largely minor effects of local policies stimulating research and product development in India suggest rethinking current policy approaches might be necessary. In addition, the lasting effects of demand shocks on the reversal of fortunes in the Indian vaccine market away from multinational producers toward domestic firms hold lessons for multinational and domestic firms alike.

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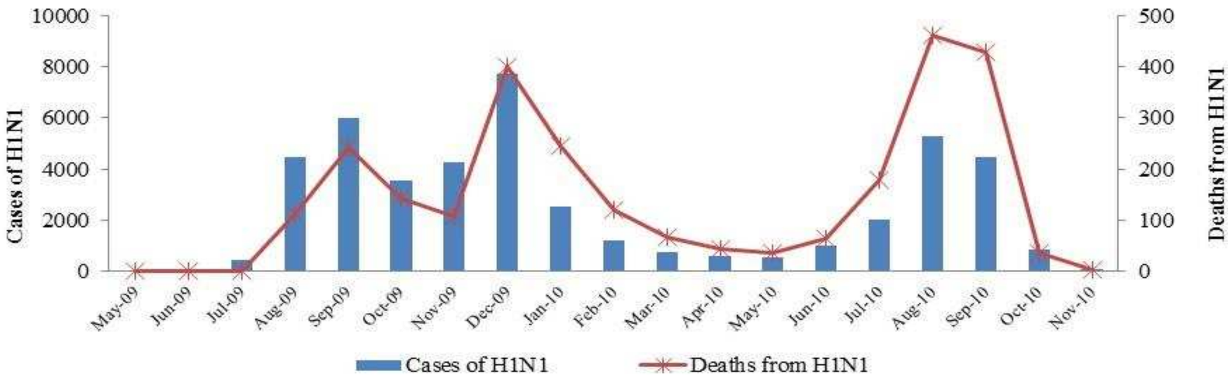
Figure 1: The Impact of H1N1 Pandemic in India



Source: http://mohfw-h1n1.nic.in/

Figure 2: Indian Domestic Capability Development in Influenza-Vaccines

June 2010

- H1N1 vaccine launched: VAXIFLU S
- Type: Egg based inactivated vaccine; injectible
- Multi dose vials and single dose vials
- Manufacturing firm: Zydus Cadila
- Institutional support in development:
  - Central government gave an advance market commitment to various companies making H1N1 vaccines but Zydus Cadila did not enter into AMC with GoI

July 2010

- H1N1 vaccine launched: NASOVAC
- Type: Egg based live-attenuated vaccine; intra-nasal
- Multi dose vials and single dose vials
- Manufacturing firm: Serum Institute of India
- Institutional support in development:
  - Ministry of Health & Family Welfare, GoI gave an AMC of INR 100 million to Serum Institute of India

October 2010

- H1N1 vaccine launched: HNVAC
- Type: Cell based inactivated vaccine; injectible
- Single dose vials
- Manufacturing firm: Bharat Bio Tech International
- Institutional support in development:
  - Ministry of Health & Family Welfare, GoI gave an AMC of INR 100 million to Bharat Bio Tech International

October 2010

- H1N1 vaccine launched: PANDYFLU
- Type: Egg based inactivated vaccine; injectible
- Single dose vials
- Manufacturing firm: Panacea Biotech
- Institutional support in development:
  - Ministry of Health & Family Welfare, GoI gave an AMC of INR 100 million to Panacea Biotech
  - Department of Biotechnology (DBT), Ministry of Science & Technology, GoI awarded financial assistance of INR 100 million to Panacea Biotech in the form of a long term loan at a concessional interest rate of 2% per annum under Biotechnology Industry Partnership Program (BIPP)

Notes: H1N1 pandemic induced demand shock alters the Indian influenza vaccine market. Domestic firms market share increases. The changed market structure remains intact in the post pandemic period. PandyFlu and HNVAC do not appear in our dataset. PandyFlu and HNVAC were launched in the market after WHO declared the start of post H1N1 pandemic period in Aug 2010, while VAXIFLU S and NASOVAC were launched during H1N1 pandemic period.

Figure 3: New Products & Domestic Capability in Indian Influenza-Vaccine Markets

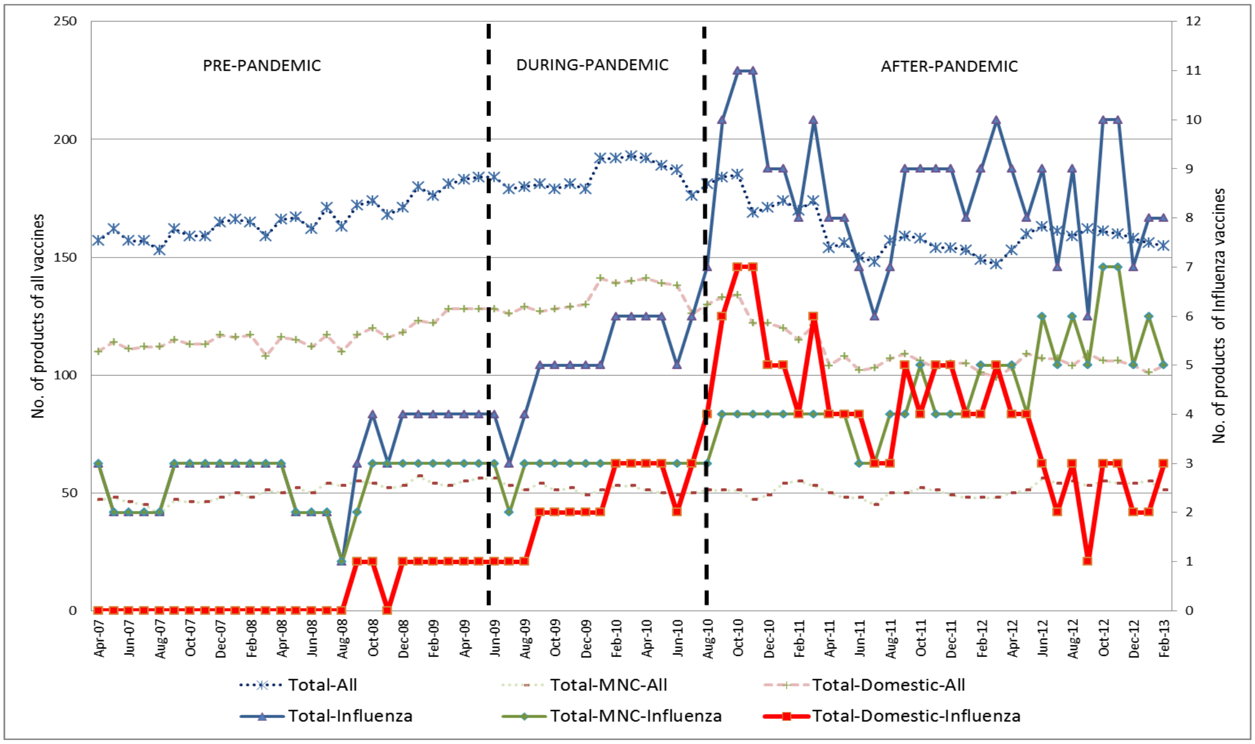
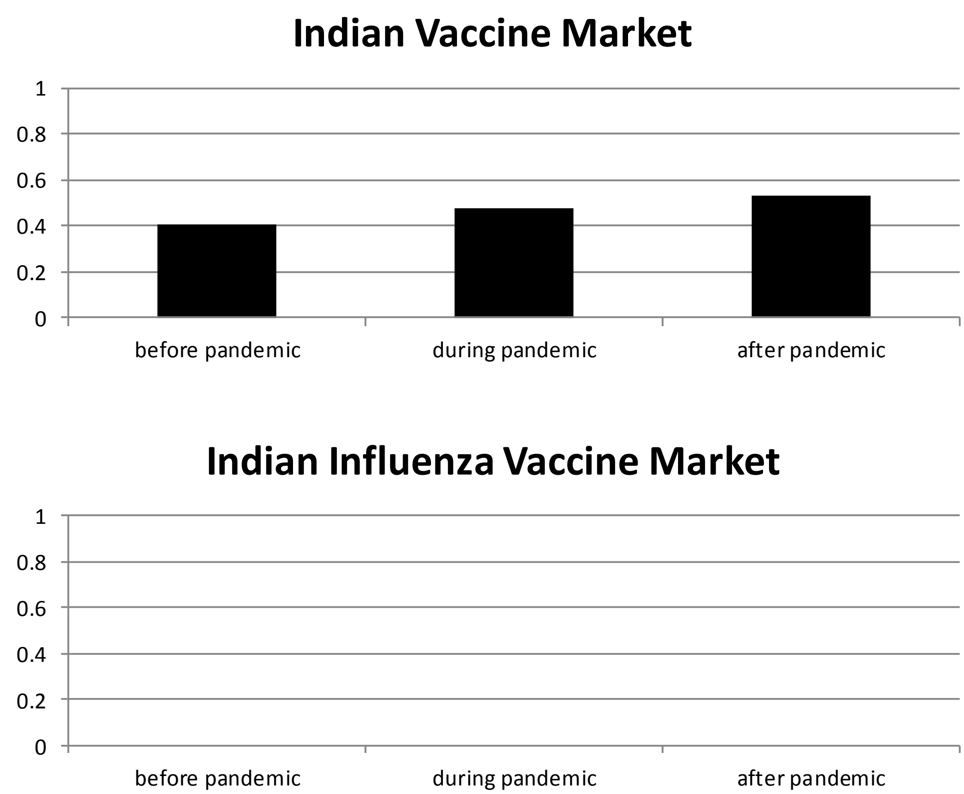


Figure 4: Reversal of Import Exposure in Indian Influenza Vaccine Markets



Notes: Revenue-based measure of import exposure shown. Calculated as the share of products sold by multinational corporations in total value of products sold in a given time period.

Table 1: Decreasing National Import Exposure (In Revenues) With H1N1 Pandemic In Indian Influenza Vaccines Markets

Dependent Variable: Import_Exposure_Revenues

Variables	OLS	OLS FE	OLS FE	GLM-Fractional Logit	XTGEE-Fractional Logit
	(1)	(2)	(3)	(4)	(5)
during_dummy	0.00988	0.00637	0.0475	0.333	0.198
	(0.0551)	(0.0515)	(0.0634)	(0.399)	(0.253)
after_dummy	0.110*	0.0922*	0.0818	1.020*	0.607*
	(0.0567)	(0.0470)	(0.0669)	(0.559)	(0.332)
influenza	0.532***	-	-	4.238***	4.016***
	(0.0857)	-	-	(0.209)	(0.451)
during_inf	-0.198***	-0.184***	-0.183***	-1.917***	-2.288***
	(0.0566)	(0.0539)	(0.0549)	(0.331)	(0.254)
after_inf	-0.349***	-0.321***	-0.320***	-2.777***	-2.939***
	(0.0544)	(0.0495)	(0.0507)	(0.310)	(0.351)
sum_sales_tot	9.27e-10	1.04e-10	3.71e-11	-1.33e-09	2.62e-10
	(1.55e-09)	(9.91e-10)	(1.00e-09)	(7.83e-09)	(3.98e-09)
Constant	0.425***	0.481***	0.453***	-1.258***	-0.234
	(0.0876)	(0.0373)	(0.0578)	(0.324)	(0.385)
Observations	1,365	1,365	1,365	1,365	1,365
R-squared	0.076	0.073	0.094		
Log PseudoLikelihood				-428.6791	
Time Dummies	N	N	Y	Y	Y
Panel Dummies	N	Y	Y	Y	Y
Errors Clustered at Panel Level	Y	Y	Y	Y	Y
Number of panelid	20	20	20	20	20

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

Table 2: Decreasing National Import Exposure (In Quantity) With H1N1 Pandemic In Indian Influenza Vaccines Markets

Dependent Variable Import_Exposure_Quantity

Variables	OLS	OLS FE	OLS FE	GLM-Fractional Logit	XTGEE-Fractional Logit
	(1)	(2)	(3)	(4)	(5)
during_dummy	0.00578	0.00186	0.00770	0.0616	0.0354
	(0.0556)	(0.0513)	(0.0620)	(0.508)	(0.254)
after_dummy	0.0997*	0.0788*	0.0362	0.977*	0.516*
	(0.0572)	(0.0439)	(0.0632)	(0.563)	(0.278)
influenza	0.610***	-	-	5.980***	2.840***
	(0.0894)	-	-	(0.249)	(0.386)
during_inf	-0.163***	-0.148**	-0.147**	-1.803***	-1.360***
	(0.0571)	(0.0521)	(0.0528)	(0.383)	(0.180)
after_inf	-0.321***	-0.288***	-0.287***	-2.769***	-2.015***
	(0.0527)	(0.0439)	(0.0447)	(0.334)	(0.204)
sum_sales_tot	1.09e-09	2.05e-10	1.58e-10	1.37e-09	6.14e-10
	(1.63e-09)	(8.36e-10)	(8.33e-10)	(9.23e-09)	(3.26e-09)
Constant	0.351***	0.414***	0.408***	-2.736***	-0.420
	(0.0910)	(0.0319)	(0.0469)	(0.366)	(0.410)
Observations	1,365	1,365	1,365	1,365	1,365
R-squared	0.094	0.071	0.096		
Log PseudoLikelihood				-377.1006	
Time Dummies	N	N	Y	Y	Y
Panel Dummies	N	Y	Y	Y	Y
Errors Clustered at Panel Level	Y	Y	Y	Y	Y
Number of panelid	20	20	20	20	20

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

Table 3: Decreasing National Import Exposure (In Products Sold) With H1N1 Pandemic In Indian Influenza Vaccines Markets

Dependent Variable: Import_Exposure_Product_Count_Share				
Variables	OLS	OLS-FE	OLS-FE	GLM-Fractional Logit
	(1)	(2)	(3)	(4)
during_dummy	-0.0132	-0.0208	-0.0656*	-0.422*
	(0.0362)	(0.0221)	(0.0365)	(0.223)
after_dummy	0.0806*	0.0483**	-0.0397	0.199
	(0.0440)	(0.0216)	(0.0324)	(0.188)
influenza	0.450***	-	-	2.546***
	(0.0784)	-	-	(0.0782)
during_inf	-0.327***	-0.319***	-0.318***	-1.994***
	(0.0362)	(0.0221)	(0.0221)	(0.132)
after_inf	-0.458***	-0.425***	-0.423***	-2.585***
	(0.0440)	(0.0216)	(0.0213)	(0.139)
Constant	0.470***	0.512***	0.565***	0.246
	(0.0784)	(0.0113)	(0.0248)	(0.152)
Observations	1,168	1,168	1,168	1,168
R-squared	0.055	0.241	0.304	
Log PseudoLikelihood				-370.527
Time Dummies	N	N	Y	Y
Panel Dummies	N	Y	Y	Y
Errors Clustered at Panel Level	Y	Y	Y	Y
Number of panelid		18	18	

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

Table 4: National Import Exposure (In Revenues of Existing Products Sold) With H1N1 Pandemic In Indian Influenza Vaccines Markets

	Dependent Variable: Import_Exposure_Revenues in Existing Products				
Variables	OLS	OLS-FE	OLS-FE	GLM-Fractional Logit	XTGEE-Fractional Logit
	(1)	(2)	(3)	(4)	(5)
during_dummy	0.0115	0.00887	0.0116	0.569	0.338
	(0.0551)	(0.0516)	(0.0625)	(0.352)	(0.226)
after_dummy	0.0837	0.0889*	0.0970	0.971*	0.569*
	(0.0493)	(0.0439)	(0.0661)	(0.515)	(0.308)
influenza	0.538***	-	-	4.769***	3.115***
	(0.0868)	-	-	(0.220)	(0.358)
during_inf	-0.0302	-0.0166	-0.0163	-0.235	-0.204
	(0.0554)	(0.0530)	(0.0543)	(0.346)	(0.206)
after_inf	-0.117**	-0.111**	-0.111**	-1.056***	-0.767***
	(0.0478)	(0.0452)	(0.0464)	(0.301)	(0.182)
sum_sales_tot	1.26e-09	-4.55E-11	-6.75e-11	-3.08e-09	-1.15e-10
	(1.62e-09)	(9.95e-10)	(1.03e-09)	(8.62e-09)	(4.04e-09)
Constant	0.419***	0.476***	0.447***	-1.787***	-0.327
	(0.0889)	(0.0362)	(0.0580)	(0.332)	(0.380)
Observations	1,341	1,341	1,341	1,341	1,341
R-squared	0.110	0.058	0.085		
Log PseudoLikelihood				-412.337	
Time Dummies	N	N	Y	Y	Y
Panel Dummies	N	Y	Y	Y	N
Errors Clustered at Panel Level	Y	Y	Y	Y	N
Number of panelid	19	19	19	19	19

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

Table 5: National Import Exposure (In Quantities of Existing Products Sold) With H1N1 Pandemic In Indian Influenza Vaccines Markets

	Dependent Variable: Import_Exposure_Revenues in Existing Products				
Variables	OLS	OLS FE	OLS FE	GLM-Fractional Logit	XTGEE-Fractional Logit
	(1)	(2)	(3)	(4)	(5)
during_dummy	0.00687	0.00365	0.00190	0.298	0.151
	(0.0555)	(0.0512)	(0.0555)	(0.459)	(0.238)
after_dummy	0.0723	0.0770*	0.0735	0.942*	0.484*
	(0.0509)	(0.0432)	(0.0642)	(0.565)	(0.288)
influenza	0.617***	-	-	8.380***	3.446***
	(0.0909)	-	-	(0.274)	(0.451)
during_inf	-0.0257	-0.0114	-0.0110	-0.213	-0.171
	(0.0557)	(0.0521)	(0.0531)	(0.403)	(0.206)
after_inf	-0.106**	-0.0996**	-0.0992**	-1.091***	-0.739***
	(0.0479)	(0.0438)	(0.0447)	(0.350)	(0.176)
sum_sales_tot	1.45e-09	1.45e-10	1.32e-10	-9.29e-10	6.01e-10
	(1.70e-09)	(7.92e-10)	(7.96e-10)	(9.28e-09)	(3.18e-09)
Constant	0.344***	0.406***	0.400***	-5.132***	-0.531
	(0.0927)	(0.0326)	(0.0479)	(0.390)	(0.417)
Observations	1,341	1,341	1,341	1,341	1,341
R-squared	0.130	0.056	0.085		
Log PseudoLikelihood				-356.966	
Time Dummies	N	N	Y	Y	Y
Panel Dummies	N	Y	Y	Y	N
Errors Clustered at Panel Level	Y	Y	Y	Y	N
Number of panelid	19	19	19	19	19

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

Table 6: National Import Exposure (In Shares of Counts of Existing Products Sold) With H1N1 Pandemic In Indian Influenza Vaccines Markets

	Dependent Variable: Import_Exposure_In_Count_For_Existing Products			
Variables	OLS	OLS FE	OLS FE	GLM-Fractional Logit
	(1)	(2)	(3)	(4)
during_dummy	-0.00878	-0.0174	-0.0489	-0.314
	(0.0359)	(0.0215)	(0.0331)	(0.200)
after_dummy	0.0546	0.0446**	-0.0168	0.0626
	(0.0367)	(0.0196)	(0.0201)	(0.151)
influenza	0.450***			2.664***
	(0.0786)			(0.0740)
during_inf	-0.133***	- 0.125***	-0.123***	-1.082***
	(0.0359)	(0.0215)	(0.0215)	(0.127)
after_inf	-0.156***	- 0.146***	-0.144***	-1.220***
	(0.0367)	(0.0196)	(0.0187)	(0.129)
Constant	0.470***	0.504***	0.558***	0.132
	(0.0786)	(0.0100)	(0.0240)	(0.144)
Observations	1,144	1,144	1,144	1,144
R-squared	0.083	0.101	0.179	
Log PseudoLikelihood				-366.05
Time Dummies	N	N	Y	Y
Panel Dummies	N	Y	Y	Y
Errors Clustered at Panel Level	Y	Y	Y	Y
Number of panelid	17	17	17	17

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

Table 7: State-Market Level Import Exposure (In Shares of Revenues of MNCs) With H1N1 Pandemic In Indian Influenza Vaccines Markets

	Dependent Variable: Import Exposure in Each State-Vaccine-Panel pair in Terms of Revenues				
	(1)	(2)	(3)	(4)	(5)
Variables	OLS	OLS-FE	OLS-FE	GLM-Fractional Logit	XTGEE-Fractional Logit
during_dummy	0.0498***	0.0310***	0.0761***	0.489***	0.232***
	(0.0134)	(0.0114)	(0.0222)	(0.111)	(0.0873)
after_dummy	0.0912***	0.0615***	0.127***	0.738***	0.434***
	(0.0148)	(0.0125)	(0.0228)	(0.113)	(0.0908)
influenza	0.451***	-	-	2.113***	1.544***
	(0.0367)	-	-	(0.236)	(0.251)
during_inf	-0.332***	-0.311***	-0.308***	-1.633***	-1.484***
	(0.0499)	(0.0493)	(0.0496)	(0.227)	(0.205)
after_inf	-0.348***	-0.296***	-0.295***	-1.687***	-1.429***
	(0.0427)	(0.0440)	(0.0441)	(0.226)	(0.210)
sum_sales_tot	1.56e-08***	1.47e-09	1.26e-09	6.15e-08**	5.77e-09
	(4.89e-09)	(4.01e-09)	(4.00e-09)	(2.53e-08)	(1.61e-08)
Constant	0.388***	0.447***	0.418***	-17.45***	-0.200**
	(0.0206)	(0.00926)	(0.0183)	(2.398)	(0.0970)
Observations	23,908	23,908	23,908	23,908	23,908
R-squared	0.036	0.026	0.031		
Log Pseudolikelihood				-14006.122	
Time Dummies	N	N	Y	Y	Y
Panel Dummies	N	Y	Y	Y	N
Errors Clustered at Panel-State Level	Y	Y	Y	Y	N
Number of panel_state_id	439	439	439	439	439

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

Table 8: Import Exposure (In Shares of Revenues of MNCs) With H1N1 Pandemic In Indian Influenza Vaccines Markets: Variation By State Development

	Dependent Variable: Import Exposure in Each State-Vaccine-Panel Pair in Terms of Revenues			
	Above Median Development States		Below Median Development States	
	OLS FE	GLM -Fractional Logit	OLS FE	GLM -Fractional Logit
	(1)	(2)	(3)	(4)
during_dummy	0.0598*	0.321**	0.0703**	0.732***
	(0.0315)	(0.148)	(0.0287)	(0.166)
after_dummy	0.104***	0.761***	0.121***	0.710***
	(0.0304)	(0.147)	(0.0327)	(0.177)
influenza	-	1.750***		2.738***
	-	(0.252)		(0.382)
during_inf	-0.249***	-1.169***	-0.387***	-2.414***
	(0.0551)	(0.225)	(0.0871)	(0.352)
after_inf	-0.278***	-1.378***	-0.315***	-2.247***
	(0.0633)	(0.251)	(0.0574)	(0.399)
sum_sales_tot	3.56e-10	7.01e-08**	4.20e-09	3.56e-08
	(4.60e-09)	(3.27e-08)	(4.59e-09)	(3.92e-08)
Constant	0.436***	-0.431	0.393***	-18.04***
	(0.0257)	(0.368)	(0.0243)	(2.161)
Observations	13,557	13,557	10,351	10,351
R-squared	0.036		0.036	
Log Pseudolikelihood		-8025.798		-5952.916
Panel Dummies	N	Y	N	Y
Time Dummies	Y	Y	Y	Y
Errors Clustered at Panel_State Level	Y	Y	Y	Y
Number of panel_state_id	243	243	196	196

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

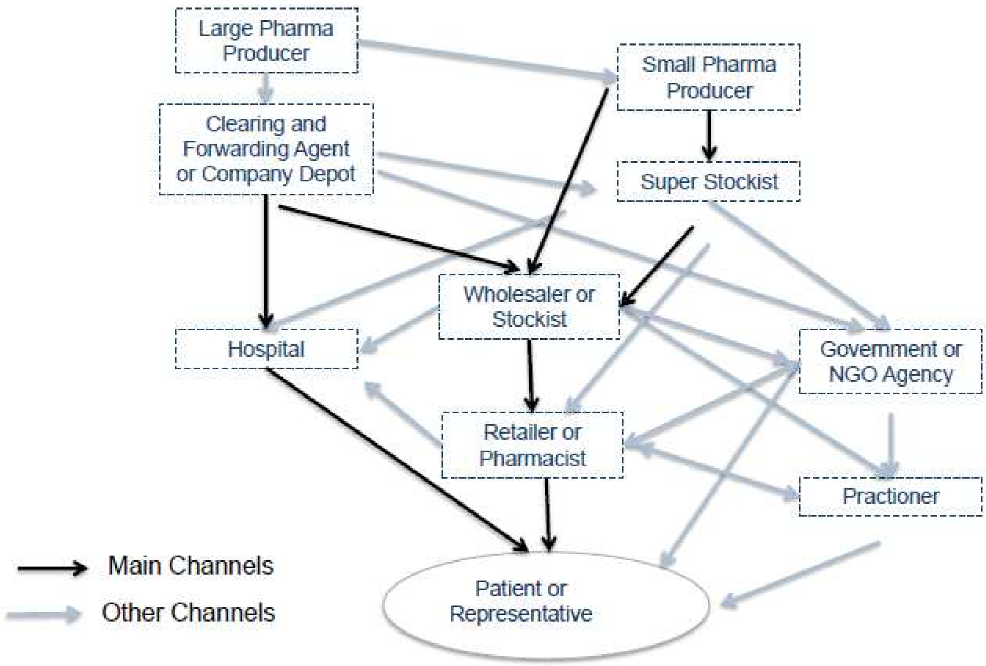
Table 9: Import Exposure (In Shares of Revenues of MNCs) With H1N1 Pandemic In Indian Influenza Vaccines Markets for Existing Products

	Dependent Variable: Import Exposure in Revenues in State-Panel Pairs & For Existing Products				
	(1)	(2)	(3)	(4)	(5)
Variables	OLS	OLS FE	OLS FE	GLM - Fractional Logit	XTGEE-Fractional Logit
during_dummy	0.0532***	0.0340***	0.0785***	0.599***	0.332***
	(0.0134)	(0.0113)	(0.0222)	(0.109)	(0.0865)
after_dummy	0.0972***	0.0687***	0.115***	0.764***	0.472***
	(0.0149)	(0.0127)	(0.0227)	(0.119)	(0.0964)
influenza	0.451***	-	-	2.117***	1.459***
	(0.0368)	-	-	(0.239)	(0.261)
during_inf	0.00454	0.00795	0.00852	0.343	0.183
	(0.0457)	(0.0426)	(0.0426)	(0.489)	(0.299)
after_inf	-0.0201	0.00963	0.00933	0.445	0.384
	(0.0375)	(0.0364)	(0.0362)	(0.379)	(0.256)
sum_sales_tot	1.58e-08***	1.25e-09	1.08e-09	6.50e-08**	5.00e-09
	(5.24e-09)	(4.30e-09)	(4.30e-09)	(2.70e-08)	(1.73e-08)
Constant	0.388***	0.444***	0.412***	-17.47***	-0.277***
	(0.0208)	(0.00958)	(0.0184)	(1.258)	(0.0978)
Observations	23,494	23,494	23,494	23,494	23,494
R-squared	0.068	0.019	0.024		
Log Pseudolikelihood				-13532.3927	
Panel Dummies	N	Y	Y	Y	N
Time Dummies	N	N	Y	Y	Y
Errors Clustered At Panel_State Level	Y	Y	Y	Y	N
Number of panel_state_id	426	426	426	426	426

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

Appendix

Figure A1: Patterns of Pharmaceutical Distribution in India



Note: Authors' schematic depiction of pharmaceutical distribution channels in India.