Journal of Health Economics 29 (2010) 438–444

Contents lists available at ScienceDirect

Journal of Health Economics

journal homepage: www.elsevier.com/locate/econbase

Stockpiling anti-viral drugs for a pandemic: The role of Manufacturer Reserve Programs☆

Joseph E. Harrington Jr.[a,*], Edbert B. Hsu[b,1]

[a] Department of Economics, Johns Hopkins University, 3400 N. Charles Street, Baltimore, MD 21218-2685, United States
[b] Office of Critical Event Preparedness and Response, Department of Emergency Medicine, Johns Hopkins University, 5801 Smith Avenue, Davis Bldg, Suite 3220, Baltimore, MD 21209, United States

ARTICLE INFO

Article history:
Received 22 September 2009
Received in revised form 12 February 2010
Accepted 18 February 2010
Available online 16 March 2010

JEL classification:
I11
L11

Keywords:
Pricing
Pharmaceutical products
Pandemic

ABSTRACT

To promote stockpiling of anti-viral drugs by non-government organizations such as hospitals, drug manufacturers have introduced Manufacturer Reserve Programs which, for an annual fee, provide the right to buy in the event of a severe outbreak of influenza. We show that these programs enhance drug manufacturer profits but could either increase or decrease the amount of pre-pandemic stockpiling of anti-viral drugs.

1. Introduction

One of the available weapons for fighting pandemic influenza are anti-viral drugs. Currently, four anti-viral medications – oseltamivir, zanamivir, amantadine, and rimantadine – are approved by the U.S. Food and Drug Administration for prevention and/or treatment of influenza. While the efficacy of particular drugs against novel influenza viruses during a pandemic remains uncertain, oseltamivir and zanamivir are the recommended first-line drugs of choice due to resistance patterns of known circulating viruses. Oseltamivir is sold as Tamiflu® by Hoffman-La Roche, while zanamivir is sold as Relenza® by GlaxoSmithKline.

Given the speed by which pandemic influenza can spread, if anti-viral drugs are to play a role in its curtailment, it will require adequate stockpiling of these drugs. For this purpose, the Center for Disease Control has accumulated millions of courses of anti-viral drugs in the Strategic National Stockpile. At the same time, private organizations – such as hospitals – are encouraged to form their own stockpiles. To reduce the upfront outlay to a customer, Hoffman-La Roche and GlaxoSmithKline have each recently developed a Manufacturer Reserve Program (MRP). Launched in June 2008, the Roche Antiviral Protection Program (RAPP) holds one course of Tamiflu in its inventory for an annual reserve fee (which is low relative to the purchase price of the drug).[1] The holder of a RAPP contract has the right to buy a single course at the regular price with delivery within 24–48 h.[2] Thus, rather than immediately purchasing at the regular price to stockpile on its own, an organization can purchase the right to buy and thereby ensure supply. GlaxoSmithKline offers a similar program for Relenza®, called Pandemic Readiness for Employers Program (PREP).

The objective of this paper is to analyze Manufacturer Reserve Programs with regards to their pricing and how they impact the incentives of the drug manufacturers to build inventories in preparation for pandemic influenza. A starting point to our analysis is that an unconstrained purely profit-maximizing drug company would significantly increase the price of its anti-viral drug in response to pandemic influenza, in order to extract some of the pandemic-

☆ The authors are grateful to the referees and the editor, Thomas McGuire, for their comments.

* Corresponding author. Tel.: +1 410 516 7615; fax: +1 410 516 7600.
E-mail addresses: joe.harrington@jhu.edu (J.E. Harrington Jr.), ehsu1@jhmi.edu (E.B. Hsu).
[1] Tel.: +1 410 735 6414.

[1] In the case of one hospital, the annual fee for RAPP was about 7.5% of the cost of buying the drug. The drug has a shelf life of about 5 years.
[2] Details on this plan can be found at www.pandemictoolkit.com/tamiflu-supplyordering/stockpiling-dilemma.aspx.

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doi:10.1016/j.jhealeco.2010.02.004

induced surplus realized by consumers. However, both political and ethical concerns make such a pricing strategy unlikely; drug manufacturers would be subject to intense political pressure not to raise the price of anti-viral drugs in response to the societal calamity of a pandemic. Due to that political and ethical constraint, a drug manufacturer is limited in how much surplus it can extract through the pricing of the drug itself. We show that a Manufacturer Reserve Program is able to extract some of that surplus, though it is not as effective as being able to raise the drug price when there is a pandemic. A second and more important result is that Manufacturer Reserve Programs can either result in an increase or decrease of pre-pandemic stockpiling.

1.1. Related literature

There is a vast literature that explores pricing with demand uncertainty – both at the individual and aggregate level – but none that considers "right to buy" programs.[3] In considering this literature, one can ask how firms and consumers could respond to demand uncertainty which reveals itself over time. One approach is to adjust price as agents learn about demand. Such price adjustment can also be a method for engaging in price discrimination when buyers are heterogeneous. This approach is examined in Courty and Li (2000) and Nocke and Pietz (2007). As we have argued that there are political and ethical constraints limiting the ability to raise price in response to a severe outbreak of influenza, the option of adjusting price over time is not available to a manufacturer of anti-viral drugs.

A second approach to handling demand uncertainty is to ex ante set different prices for different units. The optimality of such an approach is established in Dana (1999). A firm sets price before demand uncertainty is realized which, in our setting, corresponds to setting price before it is learned there is a pandemic. What a firm does is to set multiple prices and limit how much supply is available at each price; for example, providing 10,000 units at a price of $50 and 1,000,000 units at a price of $200. In this way, a firm can effectively charge a higher price in response to a positive aggregate demand shock as the high priced units will only be bought in that demand state. We do not permit such a pricing mechanism in our model because it is equivalent to raising price in response to a severe outbreak, and therefore is likely to be construed as a violation of the political and ethical constraints mentioned above. It is true that there is a similarity between setting two different product prices – with units priced at the higher level only being purchased in the high demand state – and our mechanism of setting one product price and selling the right to buy – which a consumer exercises only in the high demand state. However, the pricing mechanisms are not equivalent because the right to buy is purchased *before* a consumer learns the demand state, while with the multi-price scheme consumers purchase *after* learning the demand state. In fact, we show that the right to buy does not extract surplus as effectively as setting different prices for different demand states.

2. Model

Assume there is one consumer type who, if having developed a need for an anti-viral drug during a pandemic – either for prophylaxis or treatment – values the drug $\bar{v}$.[4] The probability of a pandemic occurring is α and, in that event, the amount of need for the drug, denoted $\tilde{q}$, is random – as it depends on the intensity of the pandemic – and distributed according to the twice differentiable cdf $F : [0, 1] \to [0, 1]$. Assume $F' > 0$, for all $\tilde{q} \in [0, 1]$. Normalizing the population mass to one, $\tilde{q}$ is to be interpreted as the fraction of the population that demands the anti-viral drug in the event of a pandemic. The primary purpose for having pandemic severity be random is so that consumers, even if they know the inventory of the company, are uncertain about availability of supply when there is a pandemic.

The price that the manufacturer can anticipate receiving in the event of a pandemic is fixed at some level, denoted p. What is crucial for the ensuing analysis is that $p < \bar{v}$. The most natural motivation for this assumption is that the manufacturer anticipates some chance of being constrained in how much it can raise price should a pandemic occur. These constraints could be political – as the government limits how much the manufacturer can raise price in the face of a public health emergency – or ethical – as the manufacturer's executives conclude that the morally right decision is to sacrifice profit for the social good. Political constraints could take the form of price caps based on the Medicaid rate, possible prosecution for price gouging or "excessive pricing" (which is an antitrust violation in some countries), or pressure from elected officials (with the looming threat of price regulation). As long as there is some probability that price is constrained then the expected pandemic price will be less than $\bar{v}$. To see why, first note that the optimal pre-pandemic price is naturally less than $\bar{v}$ because consumers value anti-viral drugs less when there is not a pandemic. In the event of a pandemic, the manufacturer will either raise price to $\bar{v}$ (if unconstrained) or price below $\bar{v}$ (if constrained). Hence, if p is the expected pandemic price then surely $p < \bar{v}$.

To simplify the analysis, it is further assumed that the drug price is such that consumers do not find it optimal to stockpile. Thus, consumers will be choosing between buying into an MRP or waiting to purchase in the event of a pandemic. A sufficient condition for a consumer not to find it optimal to stockpile is[5]

$$\bar{v}\alpha \int_0^1 \tilde{q}\, dF(\tilde{q}) - p < 0.$$

This condition is not difficult to satisfy. For example, suppose the value of the drug to a consumer is $50 with seasonal flu and $200 with pandemic influenza. If the drug is priced to meet seasonal demand – in which case, $p = 50$ – then this condition holds as long as the probability that a consumer will need the drug because of a pandemic is under 25%. Consistent with this assumption is that MRPs have been introduced in an environment for which there is very little stockpiling by non-government organizations.

Due to production lags, the drug manufacturer decides on its supply prior to learning whether there is a pandemic. The marginal cost of producing the drug is constant at c. It is assumed that $\alpha p > c$ so the drug manufacturer finds it optimal to stockpile, which it may do on its own or in conjunction with an MRP.[6]

[3] For a general survey, see Stole (2007). There is, of course, a huge finance literature on call options but that work is very different from what is considered here.

[4] While assuming a single type is done for simplicity, it also serves to distinguish the forces we identify from those that are due to consumer heterogeneity and have been identified in other papers dealing with demand uncertainty. For example, work on advance purchase discounts; see Gale and Holmes (1992, 1993) and Dana (1998).

[5] This condition compares stockpiling to not buying the drug and is sufficient but not necessary as a consumer may choose not to stockpile because she prefers to wait and purchase it in the event of a pandemic or buy into an MRP.

[6] Note that we have assumed consumers do not find it optimal to stockpile while the manufacturer does. Even without assuming that the drug manufacturer has lower carrying cost of stockpiling due to scale economies (which would be a natural assumption), firm stockpiling is more efficient than consumer stockpiling because consumers cannot resell. Thus, a consumer may have a unit of the drug and, even if there is a pandemic, not need it; while if the drug manufacturer controls the unit then it can sell it to consumers who need it.