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An Experimental Investigation of Mixed Systems of Public and Private Health Care Finance

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Abstract

This paper presents the results of a revealed-choice experiment testing the theoretical predictions of a model of a mixed system of public and private finance. In the context of a mixed system of health care finance, we investigate behavioural responses to changing the public sector allocation rule (needs-based vs. random), the supply of health care resources, and the size of the public health care budget on the following outcomes: the equilibrium market price for health care resources, the number of individuals who purchase private insurance, the probability of health treatment in the public system for those without private insurance, the health status of individuals left untreated, and the incomes of individuals who receive treatment. Our findings are generally consistent with the predictions of the theoretical model, although individuals consistently exhibit greater willingnesses-to-pay for private insurance than predicted resulting in a larger than predicted amount of private insurance being purchased. A commonly used risk-aversion measure only partially explains this observed deviation. We also find that, relative to a system of public financing only, a mixed system of health care finance results in higher health care prices and sicker, poorer people being left untreated.

Keywords: Experiment; Health Care Finance; Public Health Care; Rationing; Needs-based allocation.

JEL Classifications: I13, C92

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1. Introduction

Worldwide debate rages on over the role of public and private finance in the provision of private goods, and in no area more so than health care. The presence and extent of supplementary (or parallel) private insurance in mixed systems of finance is a source of considerable policy controversy in many public health care systems. Many governments (e.g., UK) have reduced or eliminated public subsidies to private insurance, while others (e.g., Australia, Portugal) continue to publicly subsidize individuals' purchases of private insurance, in part based on the belief that private insurance will reduce pressure on the public system (Mossialos and Thomson 2004). In Canada, the Supreme Court struck down a law in the province of Quebec prohibiting the provision of parallel private insurance, citing in its argument the lack of evidence that such insurance harms the performance of the public system (Flood et al. 2005). The impact of supplementary private insurance on health system outcomes depends on the complex interaction of both demand and supply-side factors in both the insurance and health care service markets.¹

The demand for supplementary private insurance has been a focus of analysis because of its importance for understanding the dynamics of mixed systems of finance. Demand analyses have focused particular attention on the role of public sector wait times in driving demand for supplementary private insurance, both because the costs of long waits suggest that they should matter (e.g., Johannesson et al. 1998) and because survey data suggest that they do matter (e.g., Harmon and Nolan 2001). Demand analyses that examine the impact of area-level wait lists on individual demand for supplementary private insurances have found a positive relationship (e.g., Besley et al. 1999, Jofre-Bonet 2000). More recently, using micro-data and imputed individual-specific estimates of both expected wait time and the probability of experiencing a long wait, Johar et al. (2011) found that the probability of experiencing a long wait seemed particularly important in driving demand for a subset of the population. Concomitant with the question of how access to publicly financed care affects demand for supplementary private insurance has been the important question of how the size of the supplementary private insurance sector affects outcomes in the public system, including wait times, quality, and costs. Evidence on this question is limited and equivocal (again, see reviews in Propper and Green 2001 and Tuohy et al. 2004). The recent experience in Australia following the dramatic expansion of the supplementary private insurance sector (in response to government incentives) indicates that the private insurance sector had little or no impact on wait times in the public system or on restraining expenditures in the public system (Hopkins and Zweifel 2005). However, many Australian studies, like much of the literature more generally, suffer

¹ Propper and Green (2001) and Tuohy et al. (2004) summarize various arguments regarding the impact of supplementary private insurance and review relevant empirical evidence.

from poor quality data on key outcomes (like wait times) and weak research designs.

This paper contributes to the literature on mixed systems of finance by using experimental economic methods to study the demand for private supplementary insurance and how the public and private sectors interact to determine access to care through both the public and private sectors. Specifically, we test the theoretical predictions of the Cuff et al. (2012) model of mixed public and private finance under different public health care rationing rules. Cuff et al. predict that an individual's willingness-to-pay (WTP) for private supplementary insurance that guarantees access to needed health care should depend in part on the individual's perceived access to health care in the public system, which in turn depends on the public allocation rule. Hence, the size of a privately financed health care system will depend critically on how public health care resources are allocated.

This paper uses a novel incentivized revealed-choice experiment to investigate behavioural responses to the introduction of private insurance in parallel to an existing public health insurance system. Within the experiment, the public and private insurance sectors interact to determine the size of the private insurance sector, the probability of treatment in the public system, and the severities and incomes of those treated in each sector. We describe the environment in detail below. The choices of a population of income-differentiated subjects endogenously determine outcomes in the parallel public and private health insurance markets in a setting in which the supply of health care resources is insufficient to treat all members of society. In addition, the government is constrained by its budget, which limits its ability to purchase resources to treat those seeking care in the public system. As a consequence, the public system must ration access to care in the public system. How the public system rations care and the likelihood of receiving care in the public system affects the WTP for private insurance, which in turn endogenously determines the price of the health care resource and the number of individuals treated privately. We are particularly interested in how the market price of health care resources and care-seeking between the public and private systems are affected by changes in: (i) the public health care sector allocation rule (needs-based versus random), (ii) the total quantity (supply) of health care resources in the economy, and (iii) the public health care budget.²

The paper also makes a methodological contribution. Although health economists commonly use stated-preference experiments, including discrete choice experiments and contingent valuations to elicit willingness-to-pay of individuals for private insurance (San Miguel et al. 2002; Ryan et al. 2008; Louviere and Lancsar 2009), they have seldom used incentivized revealed-

² As discussed below, to maximize the external validity of our laboratory experiment to the field, we use a market trading institution based on the sealed bid-offer auction shown by Smith et al. (1982) to converge towards the competitive market equilibrium with as few as six traders.

preference experiments.³ This is surprising given that controlled laboratory experiments have been used in other fields of economics, most notably for the evaluation of alternative market pricing mechanisms and for the evaluation of market-based environmental policies such as emission trading permits (Cason and Plott 1996). The laboratory methodology is useful to evaluate theories of behavior as well as to investigate the effects of alternative policy designs prior to their implementation. As such, they have considerable potential for identifying the impact of alternative institutional arrangements on health system outcomes and for informing our understanding of a number of important questions in health economics. It is not the goal of experiments to re-create the full complexity of the naturally occurring environment. Rather, laboratory experiments create simplified environments to capture essential features of the problem found in the field to generate data for testing specific economic, ethical or behavioural theories. Experimental studies empirically test theories of how people will behave in contexts that share essential features of our naturally occurring environment, providing insight not attainable through other methods and complementing research evidence from other sources such as observational studies.

The paper is organized as follows. Section 2 gives an overview of the theoretical model of mixed public and private health care finance based on Cuff et al. (2012) and outlines the main theoretical predictions. Section 3 discusses the laboratory implementation of the theoretical model and Section 4 presents the experimental results. We discuss our findings and conclude the paper in Section 5.

2. Theoretical Model

Cuff et al. (2012) model the determination of the health care market equilibrium with parallel public and private health care finance involving a population of N individuals that differ continuously along two dimensions: income (Y) and severity of illness (s). Incomes are distributed in the population over the interval $[Y_{min}, Y_{max}]$ according to the cumulative distribution $G(Y)$ and severity is distributed in the population over the unit interval according to the cumulative distribution $F(s)$.⁴ Both the

³ Unlike the experimental environment presented here, in which the decisions of many subjects interact to determine the insurance market outcome, Hennig-Schmidt et al. (2011), Schram and Sonnemans (2011) and Buckley et al. (2012) investigate health models using incentivized single-subject preference elicitation experiments with no interaction between subjects. Hennig-Schmidt et al. (2011) investigate alternative physician remuneration schemes, Schram and Sonnemans (2011) study factors that influence insurance plan switching and Buckley et al. (2012) study the effect of public system performance and whether the decision is framed in neutral or health terms on an isolated individual's WTP for insurance. Fan et al. (1998) also investigate physician remuneration in a laboratory environment, however some of their treatments involve fees that were determined by a quantity decision aggregated over all subjects in the experiment.

⁴ Income and severity are assumed independently distributed, but the results are robust to allowing for a negative correlation between income and severity (Cuff et al. 2012).

distributions and support of income and severity are known by everyone and the size of the population is normalized to one.

All individuals in the population become ill. Illness affects an individual's health status and ability to work and, consequently, income. Denoting full health as h , the more severe the illness the greater is the health loss. The non-monetary health loss of illness depends only on severity, is the same for all individuals with the same severity and is independent of income. The more severe the illness, however, the greater is the amount of time the individual is unable to work and the greater is the individual's income loss. The income loss is assumed to be proportional to the individual's severity; that is, if not treated, the income loss is equal to sY . An individual's utility is separable in income and health status and thus, the expected utility of an individual with income Y and an illness severity of s is $\int [u((1-s)Y) + v((1-s)h)]dF$, where u is the sub-utility of income function and v is the sub-utility of health status.

A health care treatment is available, however, that can cure an individual's illness immediately and completely (regardless of severity level). An individual who receives treatment suffers no income or health loss. While all individuals in society would like to be treated, the supply of the health care resource (H) used to produce the health care treatment is fixed and insufficient to treat all individuals in society.

Treatment can be obtained through either the public insurer or a private insurer. There is no difference in the quality of health care services provided by the public and private insurers: health outcomes are identical and treatment in both requires one unit of the health care resource to produce one unit of health care. The market for the health care resource is competitive. The public insurer and the private insurers both contract with suppliers of health care resources to provide treatment to the insurers' respective beneficiaries. The public insurer bids for health care resources according to its ability-to-pay, as determined by the public health care budget. Private insurers bid for health care resources according to their willingnesses-to-pay, which are based on individuals' willingnesses-to-pay for private insurance that guarantees access to care regardless of severity level.⁵ The public and private sectors compete directly for the limited supply of health care resource and there is a market-clearing equilibrium price (P) for the health care resource at which all of the health care resource is allocated to insurers and, thereby, to the population.

2.1 Public Health Care Financing Only

⁵ Private insurers charge a single price for health insurance equal to the market-clearing price. In this sense, the private health insurance contracts are actuarially fair in aggregate since the private insurers earn zero profit; but at the individual level, price does not necessarily equal a person's expected loss of not being treated.

As a benchmark, consider first a system of health care financing with only a public insurer. Given the limited supply of the health care resource, the public insurer must ration access to publicly insured services. Cuff et al. (2012) consider two different public allocation rules: needs-based allocation and random allocation.

Under the needs-based allocation rule, the public insurer rations health care according to need (defined by severity of illness), treating the most severe cases first. Allocation according to need is the stated objective of many publicly financed health care systems (van Doorslaer et al. 1993), including Canada's (Marchildon 2005). Such systems use a number of devices in an attempt to allocate services according to need, including for example, General Practitioner (GP) gatekeepers who control access to specialist care, diagnostic services, prescription drugs and other services based on the nature and severity of the patient's condition. Specialists can analogously ration access to advanced procedures on the basis of patient need.

Under the random allocation rule, the public insurer rations health care randomly so that the probability of treatment by the public insurer is independent of severity. No system deliberately rations randomly, but because of informational and organization problems, some randomness of access can arise even in systems that strive to allocate health care according to need.⁶ Random allocation, in a sense, represents a lower bound of other forms of allocation mechanisms that use some (possibly imperfect) information about individuals, including information on their need for health care (Wijkander 1988). In reality, allocation is likely a mixture of these two extreme rules – needs-based allocation and random allocation – where the weight given to each depends on the emphasis placed on need and the specific institutional arrangements of the public health care system.

The public insurer has an exogenously determined fiscal budget, denoted by B , that is independent of the public allocation rule. The public insurer would like to treat as many people as possible. Denote M as the number treated by the public sector. The public insurer's ability-to-pay per treatment is given by B/M . Since the public insurer is the only demander of health care resources, $M = H$ and the equilibrium price per unit of resource that clears the health care resource market is $P^0 = B/H$. Any increase in the public insurer's budget or decrease in the supply of health care resources will increase the market price for the health care resource. The public insurer purchases all available health care resources, so H individuals are treated and $I-H$ individuals remain

⁶ A recent survey of MRI clinics in Canada, for example, found that few sites had documented criteria to guide triaging decisions and most had limited processes to determine whether prioritization was being performed consistently, making it, "... entirely possible that patients with the same medical indication for an MRI examination, at the same centre, could be placed in different prioritization categories, with very different wait times." (Emery et al. 2009, p. 82).

untreated, regardless of the size of the public insurer's budget.

Who receives treatment from the public insurer depends on how the public insurer rations health care. Under random allocation, the proportion of individuals treated (or, the probability of treatment) is given by H , and the expected severity level of those treated (and of those untreated) is simply the unconditional expected severity level, $E(s)$. Under needs-based allocation, the public insurer specifies a severity threshold s_0 such that all individuals with severity above this severity threshold are treated and all those with severity less than this threshold are not treated. The severity threshold is given by $s_0 = F^{-1}(1 - H)$. The expected severity conditional on being treated is equal to $E(s | s > s_0)$. Since the public sector targets resources at high severity patients, the expected severity of the treated under needs-based allocation is greater than the unconditional mean, $E(s)$. Under either public rationing rule, the likelihood of treatment in a pure public system is independent of income.

2.2 Mixed Public and Private Health Care Financing

Now suppose that supplemental private insurance is introduced, so individuals can purchase private insurance that guarantees them access to health care treatments regardless of a person's realized severity level.⁷ Individuals do not know their severity level when they decide whether to purchase private insurance and are assumed to maximize their expected utility when deciding whether to purchase private insurance. Without loss of generality, we assume that the marginal utility of income is unity and suppress the part of utility arising from the individual's health status.⁸ An individual who purchases private insurance pays a premium, P , in return for guaranteed treatment regardless of severity, resulting in a utility of $Y - P$. In contrast, an individual who relies on the public insurer and does not purchase private insurance has an expected utility of $\pi Y + (1 - \pi)[1 - E(s | \text{no public care})]Y$, where π is the probability of receiving public health care and $E(s | \text{no public care})$ is the individual's expected severity conditional on not being treated publicly. Hence, $[1 - E(s | \text{no public care})]Y$ is the individual's expected income if they do not receive public health care.⁹ An individual's maximum

⁷ Purchasing private insurance in the model can be interpreted as shortening treatment wait time as only a portion of patients relying on the public system will be treated in any given period, while all purchasers of private insurance are guaranteed to be treated within the period. This is consistent with the empirical evidence that private health insurance policyholders experience shorter wait times for both elective treatments and acute hospital care (Schwierz et al. 2011; Lungen et al. 2008).

⁸ Assuming a linear utility of income function simplifies the analytics of the model and the qualitative results hold even with a strictly concave utility of income function (Cuff et al. 2012). We focus exclusively on the income costs of not being treated because in a laboratory environment it is difficult to manipulate health status directly without violating human ethics guidelines.

⁹ In Cuff et al. (2012), individuals form expectations over the probability of treatment by the public insurer and these expectations are confirmed in equilibrium. Alternatively, one can think of individuals taking the probability of treatment as given and this probability being determined in equilibrium. We adopt the latter approach here.

willingness-to-pay for private insurance is the amount of money that equates expected utility without private insurance to utility with private insurance:

$$WTP = (1 - \pi)E(s | \text{no public care})Y.$$

An individual's WTP for private insurance is decreasing in the probability of being treated publicly and increasing in the expected income loss from not being treated by the public insurer. Both these factors depend on how the public insurer allocates its health care resources.

Under random allocation, the expected severity of those who do not receive public treatment is simply the unconditional expected severity level $E(s)$. Therefore, under a random allocation rule, the WTP of an individual with income Y is $WTP^R = (1 - \pi^R)E(s)Y$, where “R” denotes random allocation. Under needs-based allocation, only individuals with severity above a specified severity threshold, denoted by s_N , receive public treatment and the probability of receiving public treatment is $\pi^N = 1 - F(s_N)$, where “N” denotes needs-based allocation. The expected income loss from not being treated is $E(s | s < s_N)$. Therefore, under a needs-based allocation rule, the WTP of an individual with income Y is $WTP^N = (1 - \pi^N)E(s | s < s_N)Y$.

An individual's WTP is always increasing in income regardless of allocation rule. Therefore, if the price of private insurance (or, equivalently the price of a unit of health care resource) is P , then all individuals with income greater than P will purchase private insurance and all individuals with income less than P will not. Further, under either allocation rule, a reduction in the probability of public treatment will increase an individual's WTP for private insurance and therefore increase the demand for private insurance.¹⁰

Both the price of the health care resource and the probability of treatment in the public system are determined in equilibrium. The two equilibrium conditions are: (i) the health care resource market clears; and (ii) the available health care resources in the public system meet the rationed demand in the public system. Cuff et al. (2012) show that the equilibrium price of health care is higher, the equilibrium probability of treatment in the public health care system is lower, and the equilibrium number of individuals who purchase private insurance is greater when the public insurer rations by random allocation than when it rations by need. This follows because, for a given probability of treatment by the public insurer, the individuals' willingnesses-to-pay for private insurance are higher under random allocation than under needs-based allocation. Consequently, the demand for the health care resource via private insurance is greater under random allocation, causing the equilibrium price of health care to be higher. Given the higher price, the public insurer can

¹⁰ This result is consistent with empirical findings that increased public wait times lead to increased demand for private insurance (Pizer and Prentice 2011).

afford to purchase less of the health care resource, lowering the probability of treatment in the public system. Thus, the market outcome under a parallel system of health care financing depends on the allocation method used by the public insurer.

The allocation rule will also affect whom the public insurer treats. The average severity of those treated will be higher under needs-based allocation than under random allocation because the public insurer treats the most severe cases under needs-based allocation. Further, those remaining untreated will have lower average severities under needs-based allocation than under random allocation. Finally, under needs-based allocation, the average severity of those treated privately will be higher than the average severity of those who do not receive treatment but these average severities will be the same under random allocation. Regardless of the allocation method, however, the average income of those treated through private insurance will be higher than those treated by the public insurer because willingness-to-pay for private insurance is increasing in income.

Cuff et al. (2012) also examine how changes in the size of the public insurer's budget and in the supply of the health care resource affect the equilibrium price of insurance and the probability of treatment by the public insurer.

Change in the fixed supply of health care resources. An increase in the total supply of health care resources will always decrease the market price for private insurance regardless of the public allocation rule. The lower price enables the public insurer to purchase more health care resources and increases the probability of receiving public health care under either allocation rule with an increase in the supply of health care resources.

Change in the size of the public insurer's budget. With an increase in the size of the public insurer's budget, the public insurer can afford more health care resources. This increases the demand for health care resources and pushes up the price of health care resources. At the same time, an increase in the budget increases the number of individuals who can be treated by the public insurer for a given price of the health care resource, pushing up the probability of treatment in the public system and reducing the individuals' willingnesses-to-pay for private insurance. This reduction in the demand for private health care pushes down the equilibrium price of the health care resource. The net effect on the equilibrium price is ambiguous and may differ depending on the allocation method (Cuff et al. 2012). The probability of treatment by the public insurer, however, is unambiguously increasing in the size of the public insurer's budget regardless of the allocation rule.

We use a laboratory experiment to test the theoretical predictions of Cuff et al. (2012) regarding how changes in the public allocation rule, the public budget, and the supply of health care resources affect the equilibrium price of private insurance and the equilibrium probability of

treatment in the public system. Table 1 summarizes the above theoretical predictions assuming the specific parameters used in the laboratory environment described below.

3. Laboratory Implementation

To determine the effect of a change in the public allocation rule, public budget and the supply of health care resources on the equilibrium price and probability of treatment in the public system, the laboratory experiment exogenously sets the public sector's allocation rule to be random allocation or needs-based allocation, the public sector budget at one of two levels, and the total supply of health care resource at one of two levels. All three effects are tested using a between-subject (between-session) design that exposes each subject to only one public allocation rule, one public budget, and one quantity of health care resources. This 2x2x2 factorial design leads to eight distinct treatments based on the possible combinations of exogenous treatment variables.¹¹ Parameter values for the exogenous treatment variables were chosen so as to generate equilibrium benchmark outcomes for the eight treatments that differed sufficiently to enable us to identify treatment effects using standard statistical methods. A total of 32 sessions (four for each treatment) with 30 decision periods in each session were conducted. In each session, all 10 subjects saw the same public allocation rule, public budget, and quantity of health care resource. This kept the environment easy to understand and eliminated the possibility of confounding and sequence effects.

To create an environment corresponding to the theoretical environment of Cuff et al. (2012), the experimental scenario asked subjects to imagine they and the nine other subjects in their session were workers in a small country (i.e., the population of the country, N , is 10).¹² In this country:

- All workers get sick and need health care treatment to restore their health and avoid missing work time.
- Sickness varies in severity and severity determines the proportion of work time a worker will miss if left untreated. The only cost of sickness is lost income and, ultimately, lost consumption.
- All sickness is treatable and a treatment cures the sickness immediately, resulting in no loss of work time.
- Treatment requires one unit of the health care resource regardless of the severity of the illness.

¹¹ We use the term treatment in two distinct ways: experimental treatment, referring to each combination of the experimental parameters, which are exogenously varied during the experiment; and health care treatment to cure sickness, which is an outcome of interest. We have tried to make clear by the context which meaning is intended in each instance that we use the term.

¹² Note that Cuff et al. (2012) assumes continuity throughout, while our lab environment is a discrete environment. We discuss below modifications required by working in a discrete environment.

- The supply of the health care resource is not sufficient to treat everybody (i.e., $H < 10$). Hence, in each decision period some workers will not receive treatment and will miss some work.
- The country has both a private insurer, which treats only workers who purchase private insurance at the start of the period — before they know their severity —, and a public insurer, which provides care free of charge to workers who do not purchase private insurance and which rations care according to the stated allocation rule. Health care provided by the private insurer and the public insurer is, in all other respects, identical.
- Because there are not enough health care resources to treat all workers, the private insurers and the public insurer bid against one another in a market to obtain health resources. The private insurer bids for health care resources based on how much the workers are willing to pay for private insurance. The public insurer has a fixed budget provided by the government and bids according to its maximum ability to pay. A price that clears the health care resource market is then determined.
- If a subject purchases private insurance, the subject is guaranteed treatment, does not miss any work and does not lose any income, but must pay for private insurance out of their income. If a subject does not purchase private insurance, two outcomes are possible: (a) the subject is selected for public treatment, the treatment is free and the subject loses no income; (b) the subject is not selected for public treatment, remains sick, misses work in accordance with their severity and loses the associated income.

Each session proceeded as follows. Subjects were told the public allocation rule (random or needs-based), the lab dollar (L\$) value of the public budget (L\$430 or L\$720), the supply of the health care resource ($H = 5$ or $H = 8$) and their randomly assigned incomes in lab dollars. Each subject received a randomly assigned, unique income that remained constant throughout the 30-period sessions and was drawn from a distribution with 10 values that ranged from L\$50 to L\$950 in increments of L\$100, with an average income across subjects of L\$500. A subject's assigned income is their maximum possible employment income for each period.

At the beginning of each decision period, the subjects were reminded of their incomes, the public allocation rule, the total public budget, and the total amount of health care resources available. Subjects were also informed of the number of people who received treatment by each of the private and public insurers in the previous period.¹³ Subjects were then asked to state how much they were

¹³ In addition to following computerized instructions and answering a few comprehension questions regarding the basic framework of the experiment, all subjects participated in a practice round prior to the start of the experiment.

willing to pay for private insurance (note that this was before subjects learned their randomly assigned level of sickness severity for the period). These WTP values were then used by the private insurers to bid for resources, the public insurer bid for resources based on its budget, and the market price of the resource, or equivalently the market price of insurance (since treatment requires one unit of the resource), was determined.

3.1 Determination of Equilibrium

The public insurer submitted a schedule of bids according to its ability-to-pay, seeking to purchase as many units of the health care resource as possible. It was willing to pay its entire budget for one unit of the health care resource, half its budget for each of two units, and so on. The WTP schedule for the public insurer was given by $\{B/1, B/2, \dots, B/H\}$. The private insurer submitted a schedule of bids according to subjects' WTP_i , for $i=1, \dots, 10$. The willingness-to-pay schedule for the private insurer was given by $\{WTP_1, WTP_2, \dots, WTP_{10}\}$.

To clear the market, the schedule of public bids and private bids were combined and sorted from highest to lowest: $\{Bid_1, Bid_2, \dots, Bid_k\}$, with Bid_1 being the highest WTP and Bid_k being the lowest WTP , where $k=10+H$. The H units of the health care resource were allocated to Bid_1 through Bid_H and sold at a market price equal to the midpoint between Bid_H (the lowest accepted bid) and Bid_{H+1} (the highest rejected bid). Therefore, the market-clearing price was $P=(Bid_H + Bid_{H+1})/2$. This pricing institution can be thought of as a sealed bid uniform-price call auction involving limit orders using a mid-point price rule.¹⁴ Unlike other pricing institutions, such a call auction works well in our demand-centred environment with a fixed supply constraint.

If a subject's submitted WTP was greater than the market price of insurance, they purchased private insurance at the market price (which may have been lower than their WTP). Given the market price, the fixed supply of the health care resource was then allocated between the private insurer and the public insurer in accordance with the number of private insurance contracts purchased.

At this point, each subject was assigned a sickness severity level randomly drawn from a uniform distribution between 0.01 and 1.00 (in increments of 0.01). Each subject's treatment status was then determined. Those who purchased private insurance were treated regardless of their severity level. For those who relied on the public system, treatment status was determined by the public allocation rule. If the rule was needs-based allocation, those with the greatest severity (among those relying on the public system) received treatment; if the rule was random, subjects were

¹⁴ Cason and Friedman (1997) found that call auctions using a mid-point price rule rather than a ceiling- or floor-pricing rule better induced subjects to reveal their true underlying values.

randomly chosen for treatment regardless of their severity level. Each subject's final income was then determined. For those who purchased private insurance, final income was assigned income less the price of insurance; for those treated for free by the public insurer, final income equaled assigned income; and for those who did not receive treatment, final income equaled assigned income times one minus their severity level (i.e., $(1 - s)Y$). At the end of a session, each subject's cumulative payout in lab dollars was converted into Canadian dollars using a conversion rate provided to subjects at the beginning of the session.

Given the discrete nature of the experiment with ten subjects in each session, the determination of the equilibrium probability of treatment in the public system and the calculation of expected severities have to be addressed.

Determination of the Equilibrium Probability of Treatment. In this environment, the probability of treatment in the public system has a discrete finite distribution. Because the people who purchase private insurance do not require public health care, the probability of treatment in the public system is simply equal to the proportion of individuals without private insurance (regardless of allocation rule) and is given by $\pi = (H - N_r)/(10 - N_r)$, where N_r is the number of health care resources purchased by the private insurer. Therefore, the maximum willingness-to-pay of an individual with given income Y can be written as $WTP = (1 - \pi)E(s | no public care)Y = ((10 - H)/(10 - N_r))E(s | no public care)Y$. The individuals' and public's willingnesses-to-pay along with the fixed supply of health care resources determine the market-clearing price, P . Finally, the discrete number of individuals with WTP s greater than P determines the number of individuals who purchase private insurance and thus, the probability of treatment in the public system.

Calculation of Expected Severities. The expected severity of an individual who is not treated in the public system will depend on the allocation rule. Severity is uniformly distributed among individuals on the discrete interval $[0.01, 1]$.¹⁵ If the public sector allocates treatments randomly, an individual's expected severity, if not treated, is $E^R(s | no public care) = 0.505$. However, if the public sector allocates treatments on the basis of need, determining an individual's expected severity if not treated is more complicated. Assuming a continuous-uniform severity distribution with support on the unit interval, the expected severity if not treated under needs-based allocation is simply $E^N(s | no public care) = (1 - \pi^N)/2$. However, the experimental environment differs from the continuous theoretical model because it involves: (i) 10 discrete individuals instead of a continuum of individuals, (ii) discrete severities in increments of 0.01, and (iii) a truncated support on the unit interval $[0.01, 1]$ instead of full support on the unit interval $[0, 1]$. Therefore, the expected severity of an untreated individual in

¹⁵ A value of zero was not included in the severity distribution to eliminate a possible "full health" focal point for subjects.

the experiment requires the calculation of the expected severity of the $10 - H$ individuals who did not receive public treatment given the $10 - N_r$ individuals who rely on the public insurer. Thus, an individual would want to know the expected severity of the lowest $k = 10 - H$ untreated subjects given the $n = 10 - N_r$ random severities chosen on a discrete uniform interval $[0.01, 1]$ that did not purchase private insurance. Such an expected severity (i.e. one that meets requirements (i), (ii) and (iii) above) is given by a shifted beta distribution and not by a continuous uniform distribution as described above.¹⁶ This change will cause the predicted individual *WTPs* to slightly increase since they are a function of $E(s|no\ public\ care)$. However, the parameter sets for the experiment were chosen so that the equilibrium predictions for the number of private contracts and the probability of being treated by the public system are the same regardless of whether subjects correctly use the shifted beta distribution (which seems unlikely) or naively form expectations consistent with the much more straightforward assumption of the continuous uniform distribution.¹⁷

3.2 Public-Financing-Only Counterfactual

Cuff et al. (2012) compare the theoretical mixed financing model with a model of public financing only in which individuals are not able to purchase private insurance. Because there are no *WTP* decisions for subjects to make in the environment with public financing only, it is not necessary to run a separate experiment to identify the outcomes in an environment with public financing only. For our parameter set involving random and needs-based allocation, health care resources (either $H = 5$ or $H = 8$), and a public sector health care budget ($B = 430$ or $B = 720$), we can determine the outcomes of a public financing only “experiment” using the raw data underlying our 32 laboratory sessions. Namely, for each subject in each period, we know their income, randomly drawn severity, and randomly drawn place in queue (required for sessions involving a public sector random allocation rule), in addition to the exogenous treatment variables. From this we can calculate the counterfactual outcome of a health system that involves public financing only. This kind of paired

¹⁶ A beta distribution, $B(m, n + 1 - m)$, represents the distribution of the m^{th} -lowest values from a draw of n on the unit interval $[0, 1]$. The expected value of the beta-distribution is given by $m/(n + 1)$. However, the expected value of the k lowest values from a drawing of n is equal to $(k + 1)/(2(n + 1))$, where in our context $k = 10 - H$ (i.e. the number of untreated individuals) and $n = 10 - N_r$ (i.e. the number of individuals without private insurance). Simulations with the beta distribution show that drawing from a discrete $[0.1, 1]$ interval instead of the unit interval $[0, 1]$ simply increases the expected value by 0.005. Therefore, the expected severity of the untreated under needs-based allocation is $E(s|untreated) = (10 - H + 1)/(2(10 - N_r + 1)) + 0.005$.

¹⁷ Smith et al. (1982) discuss the rationale for supporting Nash versus competitive equilibrium predictions in sealed bid-offer auctions similar to the one used here. The authors find that over a short number of periods, experimental markets using this institution converge close to the competitive equilibrium, even with as few as 6 traders. We chose parameter values for H and B such that there is a unique Nash equilibrium prediction for each experimental treatment and that this equilibrium is also a competitive equilibrium. Therefore, regardless of whether subjects were behaving as price-takers as we would expect in a large field setting or if they believed they could manipulate the market, once the market converges to the predicted equilibrium in this environment, no subject would have an incentive to change their *WTP* in order to influence the public and private insurance market allocation.

analysis is only possible with experimental data since it necessarily holds everything constant in the environment except for one thing: it removes the possibility for purchasing private insurance. We refer to this exercise as a public-financing-only counterfactual to emphasize that the outcomes are not behaviourally driven but are mathematically determined. The results of the public-financing-only treatments are presented in column 4 of Table 2 (Table 3 is only applicable to mixed financing) and Columns 4 and 5 of Tables 4 and 5.

3.3 Data Collection

Thirty-two sessions of 10 participants each were administered in the McMaster University Experimental Economics Laboratory. The experiments were run using the z-Tree software program (Fischbacher 2007). The McMaster University Research Ethics Board approved the protocol with respect to the use of human subjects. Sessions included 15 minutes of onscreen instructions, examples and a practice period followed by the main 30-period session and a short questionnaire. Sessions lasted, on average, 70 minutes. Subjects' average earnings were \$25.50 (Canadian dollars) and they were paid privately in cash following the session. After taking part in the mixed system of health care financing environment, subjects participated in an individual non-strategic risk-preference elicitation task. The task used a multiple price-list design based on the lottery choice instrument reported in Holt and Laury (2002).¹⁸ The instrument asks subjects to choose between a safe and risky lottery while changing the fundamental probabilities involved in the lotteries to gradually shift the expected payoff to favour either the safe lottery or the risky lottery. The number of safe lottery choices individuals make can be used as measures of their risk aversion. The results from this risk-elicitation instrument are used to gain insight into observed deviations from the risk neutral assumption made in the Cuff et al. (2012) model.

4. Experimental Results

We begin by examining the impact of the exogenous treatment variables — resource allocation rule, supply of health care resource, and public sector budget — on the market price for insurance and the probability of being treated by the public system. The statistical analysis presented is based on the 32 independent session observations (four per each experimental treatment combination).

4.1 Market Price of Insurance

We examine two aspects of the market price of private health insurance. First, we compare the observed and predicted changes in market price associated with changes in experimental treatment

¹⁸ Unlike the risk elicitation instrument described by Holt and Laury (2002), the one used here did not show the lottery list in order of expected payoff difference; the choices were scrambled. For a detailed comparison of risk elicitation exercises see Harrison and Rutström (2008).

(allocation rule, supply of the health care resource, and public budget). Second, we compare the observed mean price to the prices derived from the counterfactual of a public-financing-only system with no private insurance.

Columns 1-3 of Table 2 present information on the market price. The top panel (a) presents aggregated information on the mean price for each treatment dimension; the lower panel (b) presents disaggregated information for each combination of experimental parameters. The table presents results based on all periods and results based on only the last ten periods. A comparison reveals no meaningful difference between them, indicating that any learning effects are small. In the discussion below we focus on the results for all periods.

The first row of panel (a) presents the overall means: the overall mean market price across all periods and treatments is L\$173.27. The aggregate data in panel (a) also show that the observed market price is always greater than the predicted market price and this is also true for most treatments in panel (b). The observed market price is significantly greater than predicted at the 5% level for all treatments listed in panel (b) except for the two treatments under random allocation with a budget of 430, for which there is no significant difference. In addition, there are significant market price differences across the three exogenous variables: the public sector allocation rule, the supply of health care resources, and the size of the public health care budget. We examine each in turn.

Impact of the Allocation Rule on Market Price. As predicted by the model, Table 2 panel (a) shows that the market price was higher under random allocation than under needs-based allocation: the mean price of private insurance under the needs-based rule was L\$163.07; the mean market price under random allocation was L\$183.48. The difference in price between the two allocation rules (L\$20.41) is statistically significant (t-test, $p < 0.001$). Although the observed difference is in the direction predicted by the theory, the observed difference is less than the predicted difference of L\$55.43 (t-test, $p < 0.001$). The disaggregated results in panel (b) of Table 2 confirm that the mean price of private insurance is higher for each experimental treatment with random allocation than in the corresponding case with needs-based allocation.

Impact of Health Care Resource Supply on Market Price. The mean market price when the supply of the health care resource was low ($H = 5$) was L\$238.68; the mean market price when $H = 8$ was L\$107.86. The difference in the mean prices (L\$130.82) is statistically significant (t-test, $p < 0.001$). Although the observed difference is in the direction predicted by the theory, the observed difference is marginally significantly more than the predicted difference of L\$120.29 (t-test, $p = 0.059$). The disaggregated results presented in panel (b) of Table 2 are also consistent with the theoretical

predictions: the mean price is higher for each treatment with a supply of 5 units of the health care resource than in the corresponding treatment with a supply of 8 units.

Impact of the Size of the Public Health Care Budget on Market Price. The mean market price for private insurance when $B = 430$ was L\$157.73; the mean market price when $B = 720$ was L\$188.82. The difference in mean prices was L\$31.09 and is statistically significant (t-test, $p < 0.001$). However, the observed difference is in the opposite direction of the predicted difference (–L\$7.89) and is statistically significant (t-test, $p < 0.001$). The disaggregate results in panel (b) of Table 2 provide some insight into this finding. When the prediction is that an increase in public budget will result in an increase in market price, the behavioural evidence supports the prediction (L\$28.82 of the L\$34.23 price increase is realized for $H=8$ under needs-based allocation). However, when the prediction is that a public budget increase will result in a market price decrease, we find that the market price increases in every case (a L\$32.49 price increase was observed when a L\$52.04 price reduction was predicted for $H=5$ under needs-based allocation, a L\$22.39 price increase was observed when a L\$12.81 price reduction was predicted for $H=5$ under random allocation and a L\$40.67 price increase was observed when a L\$0.94 price reduction was predicted for $H=8$ under random allocation). The increased budget in these three cases increases the likelihood of being treated in the public system and therefore should result in individuals being willing to pay less for private insurance. At the same time, the higher public budget allows the public insurer to bid more for health care resources. The predicted net effect on the equilibrium price is negative. The deviation in the observed market price from the predicted price appears to result from subjects not appreciating the extent to which a larger public budget will increase their chance of public treatment and thus they do not reduce their *WTP* for private insurance by the amount predicted by the theory. Instead, subjects are found to increase their *WTP* for private insurance when the public budget increases in these three treatments, which is consistent with an (erroneous) instinct to compete with the public sector insurer to guarantee they get to the front of the queue with the private insurer.

Public-Financing-Only Counterfactual. Column 4 in Table 2 shows the mean market price for health care resources when there is only a public insurer. The market price under public financing only is independent of the allocation rule and is determined by the public insurer's budget divided by the number of health care resources. Table 2 panel (a) shows that the overall mean market price for health care resources is higher under mixed private financing (L\$173.27) than under public financing only (L\$87.28) for a mean difference of L\$85.99. The mean market price is significantly higher under mixed private and public financing for all eight experimental treatment combinations (t-tests, all p -values < 0.01) as shown in panel (b) of Table 2.

4.2 The Probability of Being Treated by the Public System and Number of Private Health Care Contracts

Two additional outcome measures of interest are the probability of being treated by the public system (π) and the number of private health care resources purchased (N_p). Depending on the exogenously set value for number of health care resources (H), π and N_p are related by the identity $\pi = (H - N_p)/(10 - N_p)$. We focus our analysis on the probability of being treated by the public sector, π , which depends on the public sector allocation rule, the supply of health care resources, and the public health care budget.

Table 3 is structured in a similar manner as Table 2 and presents information on the predicted mean probability of treatment in the public system and the mean observed probability of public treatment both across all 30 periods and only for the last 10 periods. Focusing first on the aggregate results in panel (a), a number of patterns are notable. First, the observed probability of public treatment is lower than predicted in all treatments. Subjects systematically purchase more private insurance contracts than predicted. The observed probability of public treatment is significantly lower than predicted at the 5% level for all treatments listed in Table 3 panel (b) except for the two treatments under random allocation with a budget of 430. In addition, there are significant differences in the probabilities of being treated in the public sector across the three exogenous variables: the public sector allocation rule, the supply of health care resources, and the size of the public health care budget. We examine each in turn.

Impact of the Allocation Rule on Probability of Public Treatment. As stated above, subjects tend to purchase more private insurance than predicted. Panel (a) in Table 3 shows that this tendency was substantially larger for need-based allocation than for random allocation. Considering all 30 periods, the mean difference in proportion between the observed mean probability of public treatment and the predicted probability was almost 20% for need-based allocation treatments and only approximately 9% for random allocation treatments. As predicted by the model, panel (a) shows that the probability of public treatment was higher under needs-based allocation than under random allocation: the mean probability of public treatment under the needs-based rule was 0.501; the mean probability of public treatment under random allocation was 0.459. The difference in probability between the two allocation rules (0.042) is statistically significant (t-test, $p < 0.001$). Although the observed difference is in the direction predicted by the theory, the observed difference is less than the predicted difference of 0.098 (t-test, $p < 0.001$). The disaggregated results in panel (b) of Table 3 confirm that the mean probability of public treatment is higher for each experimental treatment with needs-based allocation than in the corresponding case with random allocation.

Impact of Health Care Resource Supply on Probability of Public Treatment. The mean probability of public treatment when the supply of the health care resource was low ($H = 5$) was 0.261; the mean probability of public treatment when $H = 8$ was 0.699. The difference in the mean probabilities

(0.438) is statistically significant (t-test, $p < 0.001$) and is not significantly different from the predicted difference of 0.428 (t-test, $p = 0.340$). The disaggregated results presented in panel (b) of Table 3 are also consistent with the theoretical predictions: the mean probability is higher for each treatment with a supply of 8 units of the health care resource than in the corresponding treatment with a supply of 5 units.

Impact of the Size of the Public Health Care Budget on Probability of Public Treatment. The mean probability of public treatment for private insurance when $B = 430$ was 0.440; the mean probability of public treatment when $B = 720$ was 0.520. The difference in mean probabilities was 0.08 and is statistically significant (t-test, $p < 0.001$). Although the observed difference is in the direction predicted by the theory, the observed difference is less than the predicted difference of 0.132 (t-test, $p < 0.001$). From the disaggregate results in panel (b) of Table 3, the differences in probabilities when budget increases are always in the predicted direction except for when the budget increases from L\$430 to L\$720 under needs-based allocation and $H = 8$, in which case the probability of being treated publicly increases from 0.698 to 0.748 even though it was predicted to be 0.8 in both cases.

Public-Financing-Only Counterfactual. When there is only a public insurer, the probability of treatment is simply given by the number of health care treatments divided by the total number of individuals ($H/10 = 0.5$ or $H/10 = 0.8$) and therefore, it is independent of both the allocation rule and the public budget. The last two rows of panel (a) in Table 3 show that the mean probability of treatment by the public insurer is lower under mixed public and private financing than when there is public financing only. This is true even for needs-based allocation treatments under mixed financing in which the predicted outcome is that no one will buy private health insurance. Table 3 panel (b) shows that, under needs-based allocation, when $B = 430$ and $H = 8$ and when $B = 720$ for both $H = 8$ and $H = 5$, the predicted probability of public treatment is consistent with zero private insurance contracts being purchased. Rearranging the identity given above for π to get $N_r = (H - 10\pi)/(1 - \pi)$, we can substitute in the observed probabilities of public treatment to calculate the mean observed number of private contracts over the 30 periods. Even though the prediction is that no one will purchase private insurance, on average 3.38, 2.06 and 2.48 private contracts are sold under the three treatments mentioned above, respectively.

4.3 Severity Levels and Health Care Treatment Status

Columns 1-3 in Table 4 present the mean severity for individuals treated publicly, treated privately, and who received no treatment for each combination of public budget, health care resource endowment, and allocation rule, under mixed private and public financing. The results in Table 4 are consistent with the theoretical predictions outlined in Section 2. Under needs-based rationing, for

each of the four combinations of exogenous treatment variables, the average severity levels are statistically different from each other and the rank ordering of average severity levels is public treatment, private treatment and no treatment (t-test, all p-values < 0.05). For example, in sessions with $H = 5$ and $B = 430$, the respective values are 0.854, 0.490, and 0.423. However, under random rationing, for two combinations of the exogenous treatment variables ($B = 430$, $H = 8$ and $B = 720$, $H = 5$) we observe no statistical difference in the severity levels of those treated publicly, those treated privately, and those not treated (t-test, all p-values > 0.25). In each case, the mean severity level is close to the model's prediction of 0.505. For the other two treatment combinations, the differences by treatment status are statistically significant, but again they clearly cluster around 0.505 as predicted (t-test, all p-values < 0.05). We also observe the expected effects of changes in the supply of the health care resource and of changes in the public budget. An increase in the supply of the health care resource under needs-based allocation reduces the average severity of those treated publicly (e.g., from 0.807 to 0.622 when H changes from 5 to 8 and the public budget is L\$720) and, as expected, under random allocation it has no impact.

Public-Financing-Only Counterfactual. Columns 4 and 5 in Table 4 present the mean severities for those treated and those not treated under public only financing. The most striking finding is the large difference between the severities of those left untreated with need-based allocation under public-only finance (which is 0.209 on average from column 5) and those left untreated under mixed financing with needs-based allocation (which is 0.293 on average from column 3). In fact, the average severity level of those not treated is significantly higher under mixed private financing than under public only financing for all four treatment combinations of public sector budget and health care resource level under needs-based allocation (t-tests, all p-values < 0.05). As predicted, under random rationing there is no significant difference between average severity levels of those left untreated between mixed and public only financing scenarios (however the difference is marginally significant at the 10% level for the treatment with $B = 720$ and $H = 8$).

4.4 Income Level and Insurance Status

Table 5 presents summaries of income for different treatment categories in much the same way Table 4 summarizes severities. The theoretical model predicts the average income of those who obtain private insurance will be greater than the average income of those who do not obtain private insurance. The results presented in columns 1-3 of Table 5 are consistent with this prediction. For every combination of experimental parameters, the average income of those with private insurance significantly exceeds the average income of those without private insurance (t-test, all p-values < 0.02). For example, with $H = 5$, $B = 430$, and needs-based allocation, the average income of those treated privately (L\$728) is significantly higher than the average income of those not treated (L\$376).

The relationship between income and willingness-to-pay for insurance is investigated further in the regression framework reported below in section 4.5.

Public-Financing-Only Counterfactual. Columns 3 and 5 in Table 5 show that the average income level of those left untreated is lower under mixed private financing (L\$410) than under public financing only (L\$503) under both rationing rules, for a mean income difference of 23%. The mean untreated income level is significantly lower under mixed private financing for all eight treatment combinations of allocation rule, public sector budget and level of health care resources (t-tests, all p-values < 0.05 except for needs-based allocation when $B = 720$ and $H = 8$ for which $p = 0.052$).

4.5 Regression Analysis of Individual Willingness-to-pay for Private Insurance

We consistently observe individuals willing to pay more for insurance than predicted by the theoretical model (which assumes decision-makers are risk neutral) and consequently, more individuals purchase private insurance than predicted. In this analysis, we investigate the relationship between an individual's risk attitude and willingness-to-pay (WTP). Our concern is whether risk aversion can explain why WTP values are higher than predicted. As previously described, the risk-aversion measure used was derived from a Holt and Laury (2002) neutrally framed lottery choice task that provides an individual index of risk aversion. We normalized the index for each individual so that it ranges from -3 to +4 in integer values with negative values signifying risk-loving preferences, positive values signifying risk-averse preferences and a value of zero signifying risk-neutral preferences. In addition, we examine whether subjects were inappropriately influenced by past severity draws and their incomes. The theoretical model predicts WTP will be proportional to income and this proportion will be constant across all incomes. We therefore analyze the ratio, $WTP/Income$, as our dependent variable in our analysis.

Table 6 presents the results from this analysis. Column 1 presents results for the entire sample. Contrary to the model's predictions, the ratio of WTP to income does vary with income. As predicted, $WTP/Income$ is not influenced by lagged severity. Finally, an individual's measure of risk aversion is not systematically related to $WTP/Income$.

However, only subjects with predicted WTP close to the price margin have an incentive to reveal their true underlying value for insurance (these are typically the high income subjects). We therefore conduct a sub-group analysis only on subjects with income of 450 or greater.¹⁹ Column 2 of Table 6 reports the sub-group analysis. Column 2 shows the allocation rule and number of health care resources are significant determinants of subject WTP while the public sector budget treatment

¹⁹ This is an *ad hoc* cut-off based on the fact that some treatments have 3 to 6 people purchasing insurance. Our findings are unchanged if the cutoff is moved to 350, 250, or 550, with the exception that, for some of these other cut-offs, the lagged severity variable sometimes becomes marginally significant.

factor is not significant. This likely reflects our earlier finding that the experimental results on market price for health resources did not support the theoretical predictions for changes in public sector budget. Also, the allocation rule effect on WTP is only marginally significant with a coefficient of -0.061, which is only 42% of its average predicted value when changing from random to needs-based allocation. This smaller-than-predicted effect is likely a result of both deviations of behaviour in the subject's formation of optimal WTP (assuming all variables are known) and in the subject's formation of expectations of the relevant variables.²⁰ This latter aspect pertains to determining the probability of public treatment based on how WTP values affect the market price of the health resource, which in turn affects how many people the public system can treat with its fixed budget.

For the sub-group analysis, two important changes in the results occur: income no longer significantly affects $WTP/Income$ (consistent with the model's prediction) and an individual's measure of risk aversion is now significant. The coefficient of 0.015 on the risk-attitude variable indicates that, on average, for each unit increase in the normalized Holt-Laury measure for an individual, that individual's $WTP/Income$ will increase by 1.5%. Therefore, on average, a person with the highest degree of risk aversion (measured by a scale value of 4) will have a $WTP/Income$ value 6% higher than a risk-neutral person.

Although this effect of risk attitudes can, in part, explain some of the deviation between predicted WTP and observed WTP , it can explain only a small portion of this discrepancy. Other possible explanations are that risk attitudes related to health differ from risk attitudes related to lotteries over money (from which our risk-attitude measures were derived) and that individuals are unable to calculate the expected losses under the two allocation rules (there is much general evidence on people's difficulty with quantitative reasoning, especially with respect to probabilities). These are important issues to investigate in future research.

6. Discussion and Conclusions

This paper has presented a novel approach, incentivised revealed-choice experiments, to investigate the impact of alternative health care financing arrangements on important health system outcomes, including the equilibrium price of health care resources (or equivalently, the price of private insurance), the equilibrium probability of treatment for those individuals without private insurance, and the average severities and incomes of those individuals treated and not treated. The results represent an explicit test of the predictions of a recent model of mixed systems of finance (Cuff et al.

²⁰ Buckley et al. (2012) elicited WTP in a setting where the probability of public treatment was fixed but calibrated their behavioural findings to predict the general equilibrium effect of an allocation rule change. They found a calibrated allocation rule effect of 71% of the theoretical prediction, suggesting individuals with full information have lower than predicted WTP s. In that experiment, individuals calculated their WTP under uncertainty regarding the probability of public treatment.

2012) and more generally provide new insight into a number of aspects of the mixed systems of finance.

The results are broadly consistent with theoretical predictions of Cuff et al., especially regarding the impact of changing the three exogenous treatment variables of concern: the public sector allocation rule, the supply of the health care resource and the size of the public budget. The magnitudes of the observed effects, however, differ notably from those predicted by the model. Overall, *WTP* for supplementary private insurance was greater than predicted, and this was particularly the case under needs-based allocation, which led to a smaller-than-predicted difference in outcomes between needs-based and random allocation.²¹ Our work demonstrates that this finding was not a result of high degrees of risk aversion (risk aversion explains only a small proportion of the *WTP* premium that we observe). The smaller-than-expected difference between needs-based and random allocation presents a policy challenge. Both observational studies (e.g., Besley et al. 1999; Jofre-Bonet 2000; Johar 2011) and the experimental study of Buckley et al. (2012) indicate that demand for supplemental private insurance responds to access barriers in the public system, whether measured by wait lists, wait times, or the probability of a long wait. Conditional on a given wait time, demand for such private insurance should be less in a well-functioning system that prioritizes patients by need and treats them accordingly. Yet our subjects under-appreciated the value to them of a well-functioning public system that prioritizes treatment on the basis of need. Conveying to the general public information on performance within the public system, in terms of proper prioritization and the associated benefits, presents a much greater policy challenge than information on wait times alone.

In some treatment parameter combinations, the effect of an increase in the public health care budget was actually the opposite of that predicted. Because an increase in the public budget increases the ability of the public insurer to secure access to health resources, increasing its ability to offer treatment to those in need, this should lead to a decrease in the demand for supplemental private insurance (and therefore private sector demand for the resource) and, in some contexts, a subsequent decrease in the market price of the resource. We observe, however, that an increase in the public budget is associated with an increase in the market price in all contexts. It appears that subjects failed to appreciate the implication of an increased public budget for access to public care and, through their demand for private insurance, created a bidding war for the resource between the public and private sectors that led to an eventual increase in input prices. This dynamic is consistent with the argument that supplementary private insurance leads to higher input prices and therefore

²¹ This result also confirms that the *WTP* premium found in Buckley et al. (2012) was not a result of the price elicitation mechanism used in that experiment.

inflationary pressures that can increase expenditures in the public system. Combined with the above-noted finding regarding the less-than-expected difference between needs-based and random allocation, the observed behavior suggests that subjects do not fully recognize and understand the market interactions between the public and private sectors. This contrasts with the finding that, if anything, subjects respond more than expected to an increase in the supply of the health care resource. Inferring the impact on access of such a supply increase does not require sophisticated and subtle analysis of market interaction, and subjects respond strongly to this change.

The comparison of outcomes under mixed public and private finance with those under the policy counterfactual of a pure publicly financed system confirm the prediction that mixed finance is associated with higher health care prices, better access for those with higher income, a weaker relationship between need and receipt of treatment (and equivalently, greater severity among those who do not receive treatment). These findings reflect outcomes in a static environment with a given supply of health care resources and so do not provide insight into the possibility that, as some argue, a stronger private sector may draw more resources into the health care sector, but they do provide a cautionary message regarding some of the possible negative equity and expenditure effects of expanding the size of the supplemental private insurance sector.

Finally, the study demonstrates the potential role of laboratory-based experimental studies in health economics. As demonstrated in other areas of economics, such studies offer considerable scope for testing health economic theory, for investigating the impact of proposed policies, and for better understanding a wide range of health system behaviours. Combined with evidence derived using observational methods and other complementary methodologies, experimental studies can help generate the research evidence required to inform health policy.

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Table 1: Theoretical Predictions from Cuff et al. (2012) in the Laboratory Environment

Exogenous Treatment Variables	Equilibrium Market Price	Equilibrium Probability of Public Health Treatment
Change from Random Allocation Rule to Needs-based Allocation Rule	$P^R > P^N \geq P^O$	$\pi^R < \pi^N \leq \pi^O$
<u>Mixed Financing: Random Allocation Rule</u>		
Increase in Supply of Health Care Resources (H)	decrease in P^R	increase in π^R
Increase in Size of Public Budget (B)	decrease in P^R	increase in π^R
<u>Mixed Financing: Needs-Based Allocation Rule</u>		
Increase in Supply of Health Care Resources (H)	decrease in P^N	increase in π^N
Increase in Size of Public Budget (B)	decrease in P^N for $H=5$ increase in P^N for $H=8$	increase in π^N for $H=5$ no change in π^N for $H=8$
<u>Public Financing Only: Both Allocation Rules</u>		
Increase in Supply of Health Care Resources (H)	decrease in P^O	increase in π^O
Increase in Size of Public Budget (B)	increase in P^O	no change in π^O

Note: $P^O=B/H$ and $\pi^O=H/10$ are the equilibrium price and probability of public health care treatment in a pure publicly financed system, respectively. Both are independent of the public allocation rule.

Table 2: Market Prices for Health Care Resources

Panel (a) Aggregate Experimental Treatment Predictions and Session Means				
Mixed Financing				Public Financing Only
Exogenous Treatment Variables	Predicted Mean Equilibrium Market Price	Observed Mean Market Price (Periods 1 to 30)	Observed Mean Market Price (Periods 21 to 30)	Mean Market Price
	(1)	(2)	(3)	(4)
	Overall	143.65	173.27	174.74
Needs-Based Allocation	115.93	163.07	160.16	87.28*
Random Allocation	171.36	183.48	189.31	87.28*
Low Budget ($B = 430$)	147.59	157.73	161.45	66.06*
High Budget ($B = 720$)	139.70	188.82	188.02	108.50*
Low Health Resources ($H = 5$)	203.79	238.68	244.84	106.67*
High Health Resources ($H = 8$)	83.50	107.86	104.63	67.89*

Panel (b) Experimental Treatment Predictions and Session Means						
Public Budget (B)	Quantity of Health Care Resource (H)	Allocation Rule	Predicted Equilibrium Market Price	Observed Mean Market Price (Periods 1 to 30)	Observed Mean Market Price (Periods 21 to 30)	Mean Market Price
430	5	Needs	190.00	212.66	218.58	81.34*
		Random	250.00	237.26	254.23	81.34*
	8	Needs	50.77	82.82	77.00	50.77*
		Random	99.59	98.16	95.99	50.77*
720	5	Needs	137.96	245.15	238.95	132.00*
		Random	237.19	259.65	267.60	132.00*
	8	Needs	85.00	111.64	106.11	85.00*
		Random	98.65	138.83	139.43	85.00*

Note: An asterisk (*) indicates that the mean market price under public financing only is statistically significantly different from the mean market price under mixed financing (both for periods 1-30 and 21-30) at the 1% level.

Table 3: Probability of Being Treated in the Public System (π)

Panel (a) Aggregate Experimental Treatment Predictions and Session Means					
Exogenous Experimental Treatment Variables			Mixed Financing		
			Predicted Mean	Observed Mean	Observed Mean
			Equilibrium	Probability of	Probability of
			Probability of	Being Treated	Being Treated
			Being Publicly	(Periods 1 to	(Periods 21 to
			Treated	30)	30)
			(1)	(2)	(3)
Overall			0.549	0.480	0.481
Needs-Based Allocation			0.598	0.501	0.508
Random Allocation			0.500	0.459	0.454
Low Budget ($B = 430$)			0.483	0.440	0.440
High Budget ($B = 720$)			0.615	0.520	0.523
Low Health Resources ($H = 5$)			0.335	0.261	0.253
High Health Resources ($H = 8$)			0.763	0.699	0.710
Panel (b) Experimental Treatment Predictions and Session Means					
Public Budget (B)	Quantity of Health Care Resource (H)	Allocation Rule	Predicted Equilibrium Probability of Being Publicly Treated	Observed Mean Probability of Being Publicly Treated (Periods 1 to 30)	Observed Mean Probability of Being Publicly Treated (Periods 21 to 30)
430	5	Needs	0.290	0.224	0.214
		Random	0.170	0.188	0.167
	8	Needs	0.800	0.698	0.717
		Random	0.670	0.650	0.661
720	5	Needs	0.500	0.335	0.342
		Random	0.380	0.295	0.288
	8	Needs	0.800	0.748	0.759
		Random	0.780	0.701	0.701

Note: The probability of being treated in the public system is equal to $(H - N_p)/(10 - N_p)$, where N_p is the number of health care resources purchased by private insurers.

Table 4: Mean and Standard Deviation of Session Severity, by Experimental Treatment

Public Budget (<i>B</i>)	Quantity of Health Care Resource (<i>H</i>)	Allocation Rule	Mixed Financing			Public Financing Only	
			Treated Privately	Treated Publicly	Not Treated	Treated Publicly	Not Treated
			(1)	(2)	(3)	(4)	(5)
430	5	Needs	0.490 (0.035)	0.854 (0.010)	0.423 (0.036)	0.739 (0.022)	0.283** (0.009)
		Random	0.539 (0.021)	0.451 (0.019)	0.505 (0.005)	0.511 (0.013)	0.512 (0.012)
430	8	Needs	0.516 (0.050)	0.655 (0.016)	0.208 (0.044)	0.612 (0.021)	0.144** (0.019)
		Random	0.480 (0.039)	0.504 (0.017)	0.507 (0.028)	0.500 (0.013)	0.484 (0.075)
720	5	Needs	0.518 (0.031)	0.807 (0.015)	0.356 (0.021)	0.740 (0.006)	0.267** (0.011)
		Random	0.506 (0.014)	0.487 (0.030)	0.502 (0.014)	0.487 (0.019)	0.512 (0.011)
720	8	Needs	0.529 (0.030)	0.622 (0.020)	0.183 (0.020)	0.605 (0.017)	0.145** (0.010)
		Random	0.475 (0.008)	0.500 (0.018)	0.547 (0.015)	0.497 (0.009)	0.514* (0.023)

Note: A double asterisk (**) indicates that the “not treated” mean severity under public financing only is statistically significantly different from the “not treated” mean severity under mixed financing at the 5% level. A single asterisk (*) indicates the difference is statistically significant at the 10% level.

Table 5: Mean and Standard Deviation of Session Income Level, by Experimental Treatment

Public Budget (<i>B</i>)	Quantity of Health Care Resource (<i>H</i>)	Allocation Rule	Mixed Financing			Public Financing Only	
			Treated Privately	Treated Publicly	Not Treated	Treated Publicly	Not Treated
			(1)	(2)	(3)	(4)	(5)
430	5	Needs	728 (36)	380 (60)	376 (19)	483 (12)	517** (12)
		Random	720 (32)	348 (29)	368 (22)	497 (8)	504** (8)
430	8	Needs	629 (52)	447 (12)	428 (50)	503 (9)	490** (36)
		Random	604 (24)	422 (49)	416 (17)	500 (9)	501** (37)
720	5	Needs	777 (19)	395 (58)	409 (18)	499 (16)	501** (16)
		Random	723 (51)	444 (41)	394 (21)	519 (18)	481** (18)
720	8	Needs	701 (85)	444 (26)	457 (53)	495 (9)	519* (37)
		Random	693 (45)	400 (12)	429 (22)	498 (3)	507** (13)

Note: A double asterisk (**) indicates that the “not treated” mean income under public financing only is statistically significantly different from the “not treated” mean income under mixed financing at the 5% level. A single asterisk (*) indicates the difference is statistically significant at the 10% level.

Table 6: Pooled OLS Models of the Ratio of WTP for Private Insurance to Income

VARIABLES	<i>Dependent Variable</i>	
	<i>WTP/Income</i> <i>(All Incomes)</i>	<i>WTP/Income</i> <i>(Incomes ≥ 450)</i>
	(1)	(2)
Need-based Allocation	-0.085* (0.045)	-0.061* (0.035)
High Budget ($B = 720$)	-0.018 (0.047)	-0.038 (0.043)
High Health Resources ($H = 8$)	-0.201*** (0.039)	-0.211*** (0.044)
Degree of Risk Aversion	0.014 (0.009)	0.015** (0.007)
Income	-0.001*** (0.000)	-0.001 (0.001)
Income Squared	0.000* (0.000)	0.000 (0.000)
Lagged Severity	0.011 (0.014)	0.014 (0.012)
Interactions:		
Need-based x High Budget	0.021 (0.066)	0.043 (0.048)
Need-based x High Resources	0.087 (0.062)	0.034 (0.050)
High Budget x High Resources	0.069 (0.061)	0.063 (0.054)
Need-based x High Budget x High Resources	-0.107 (0.087)	-0.068 (0.062)
Constant	0.612*** (0.059)	0.633** (0.283)
N	3,200	1,600
R-squared	0.22	0.35
Adj. R-squared	0.22	0.34

Note: Robust standard errors are below coefficients in parentheses (*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$).