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Information asymmetry and equilibrium monitoring in education

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ABSTRACT

We develop a theoretical and computational model of school choice and achievement that embeds information asymmetries in the provision of education. Because school effort is unobservable to households and policymakers, schools have an incentive to under provide effort. This moral hazard affects both public and private schools, although public schools are subject to an additional distortion because of limited competition and fixed funding. Household monitoring of schools can mitigate moral hazard, but some households may free-ride on the monitoring of others. Using our calibrated model we simulate two policies aimed at raising achievement: public monitoring of public schools and private school vouchers. Our results indicate that in large scale settings no single tool may suffice. The reason is twofold: a) no tool raises achievement or welfare for all households; and b) since the extent of moral hazard is endogenous, the application of each tool has unintended consequences that limit its own effectiveness. Results also indicate that setting the policy parameters for public schools at the levels preferred by the majority of households may mitigate the distortions. Nonetheless, the current actual values of these parameters seem to match more closely the preferences of public schools than the preferences of parents.

1. Introduction

An educated population is a fundamental ingredient for a well-functioning democracy and a crucial driver of growth in the modern economy. Thus, education has both private returns that accrue to the individual, and public returns that accrue to society. For this reason, the policymaker often has a minimum goal of basic academic proficiency for every student in the economy. Many students, however, do not meet this goal, even after substantial public spending in the marketplace for education.

In this paper we focus on an information-based explanation for the lack of academic achievement, namely the information asymmetries among the policymaker, households, and schools. In particular, school effort (from a school's administration or teachers) is not fully observable to parents or policymakers, and this creates a potential moral hazard problem as the school has an incentive to under provide effort. Parental involvement in schools can function as a monitoring device to mitigate moral hazard. However, since monitoring is a public good, it may itself introduce an additional distortion if households free-ride on the monitoring of others. This externality can in turn lead to the under-provision of monitoring relative to socially optimal levels.

Concerns about underachievement among K-12 students in the United States has prompted an aggressive federal response in recent years, starting with No Child Left Behind in 2002 and continuing with programs such as Race to the Top. Individual states and districts have implemented similar programs, all of which contain incentives linking outcomes for schools and teachers to student achievement. These incentives would not be needed if school and teacher effort were perfectly observable, in which case the policymaker would establish the socially desired effort and would reimburse the cost of effort to schools and teachers. In contrast, the policymaker currently relies on indirect measures of school and teacher effort such as student assessments. The very existence of these programs points to the information asymmetry among schools, parents, and the policymaker as one possible explanation for underachievement.

Furthering the concerns about underachievement is the disappointing performance of U.S. students in international assessments relative to other OECD countries (see, for instance, Fleischman et al., 2010). At the same time, international evidence shows that student achievement is higher in countries with more competition and public assistance for school choice, external and/or exit exams, and greater parental interest in education (Wößmann, 2007). Hence, policies such as these, which mitigate moral hazard through greater monitoring and competition might motivate greater school effort and raise the U.S. standing in international assessments.

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Although information asymmetry is central to other economic problems facing policymakers and market participants, such as the regulation of natural monopolies and banking (Laffont and Tirole, 1993; Freixas and Rochet, 2008), to our knowledge we are the first to model moral hazard in school effort and its concomitant private monitoring in an equilibrium setting of education provision. Large-scale policies that address underachievement, such as public school accountability and private school vouchers, have been subject to extensive empirical research (e.g., Figlio and Ladd, 2008; Zimmer and Bettinger, 2008), yet researchers have rarely modeled the information asymmetries underlying such policies.

Thus, we develop a theoretical equilibrium model of household school and monitoring choice in the presence of information asymmetry. We calibrate the computational version of the model to 2000 data from the United States and use it to conduct policy analysis. In our model, the production of educational achievement requires three inputs: school effort, household learning effort, and peer quality. School effort is not observable to households or the policymaker in public or private schools and is hence under-provided (as in Holmstrom, 1979). This hurts achievement directly and also indirectly by making other inputs less productive.

Faced with moral hazard, households have the option to exert costly effort to monitor the school; monitoring mitigates but does not eliminate moral hazard. However, households vary in their costs and benefits from monitoring. In addition, they have incentives to free-ride on the monitoring of others. The underlying agency or hidden action problem, along with the concomitant free-riding associated with household monitoring, is one friction in our model.

The second friction is the limited competition faced by public schools. Public schools are chosen by households that do not have the ability or the willingness to pay for private schools. Yet while free entry and exit discipline private schools and eliminate their rents, the policymaker restricts entry and exit of public schools. In addition, the policymaker sets a fixed per-pupil funding for public schools and thus allows them to potentially reap a rent.

Moreover, the endogenous sorting of households across schools can aggravate the effect of these frictions. For instance, some high-income, high-ability households may choose private schools and monitor them because they anticipate low public school effort, in part due to free-riding in monitoring in public schools. This may prevent public schools from attracting the very households that would provide monitoring and may lead them to provide low effort. In other words, the extent of moral hazard and the intensity of household monitoring are endogenous and vary across schools.

Using our calibrated model, we have computed the equilibrium in a variety of scenarios. Our analysis highlights the distortions introduced by these frictions in the equilibrium behavior of households and schools, and how these distortions vary along with policy parameters. For instance, moral hazard leads to lower effort and achievement in all schools but especially in public schools, where limited competition and fixed funding aggravate the problem.

A theme of our findings is that the choice of policy parameters for public schools affects the equilibrium moral hazard, achievement and welfare. One policy parameter in our model is the effort standard for public schools, from which the schools may deviate when choosing their actual effort. This deviation measures the distortion due to moral hazard. A higher standard forces the schools to exert more effort and allows them to attract high-income, high-ability students; these, in turn, monitor the schools and force them to exert further effort.

Given that public schools have limited entry and fixed funding, eliminating their effort distortion depends critically on the choice of the effort standard. While we do not model the determination of the effort standard or other policy parameters, we have analyzed household preferences over them. Results indicate that the current effort standard is very close to that which maximizes public school rent, yet is lower than the standard preferred by the majority of households. Similarly, the current funding is higher. In other words, public schools may currently have more influence over policy parameters than the households themselves.

In the policy arena, two alternative approaches are usually discussed to address underachievement. The first is regulation-based mechanisms, which attach consequences to academic outcomes. The second is market-based mechanisms, which provide households with additional school choices. Schools are disciplined by the regulator in the first case and by the market in the second. Hence, we have simulated two policies: public monitoring of public schools (a regulation-based mechanism, inspired by actual public school accountability), and private school vouchers (a market-based mechanism).

According to our simulations, private school vouchers raise achievement among voucher users. Since vouchers enhance private school choice and rely on competition, they lower the fiscal cost of a given school effort. However, their reliance on private monitoring makes them ineffective for low-income, low-ability households, for which the cost of the monitoring required in private schools may be prohibitively high. Vouchers further hurt these households by inducing higher-ability, higher-income households to switch into private schools, thus lowering the peer quality and monitoring in public schools. Public monitoring can be more effective than vouchers for these households, as it can raise public school effort and attract high-ability, high-income households into public schools. However, public monitoring can also crowd out private monitoring in public schools, and not relying directly on competition, its fiscal cost can be unnecessarily high. In addition, it raises the issue of who monitors the monitor.

As these tradeoffs between public monitoring and vouchers indicate, no tool dominates the other. Yet an additional reason why neither tool provides a full solution is that the information asymmetry is embedded in an equilibrium setting. Attempts to solve the information problem may affect household and school choices, the interaction of which determines the extent of moral hazard and household monitoring. Thus, in equilibrium policies may magnify the original distortion they attempt to fix or even create new ones. While the tradeoffs among policy tools and their unintended consequences may render a single tool less effective or even counterproductive, they suggest a role for thoughtful combinations of tools. Our simulations indicate that combinations are indeed preferable to single tools.

Our work contributes to two distinct literatures. First, we contribute to the education literature by modeling school moral hazard and household monitoring as an equilibrium response. Equilibrium models in education have been used to analyze policies such as private school vouchers and public school finance reform (e.g. Epple and Romano, 1998; Ferreyra, 2007; Nechyba, 1999), although not to study school effort or household learning and monitoring efforts. While some researchers have modeled the role of student learning effort in achievement (Blankenau and Camera, 2009; De Fraja and Landeras, 2006; MacLeod and Urquiola, 2009; Albornoz et al., 2010), and others have empirically studied parental involvement (McMillan, 2000; Walsh, 2010), to our knowledge we are the first to model household monitoring.

Other researchers have explored information-driven distortions in education. McMillan (2005) studies a rent-seeking public school (see Rangazas, 1997; Chakrabarti, 2008 for a similar model). He assumes that school effort is observable but not contractible (i.e., the policymaker can observe school effort yet he cannot attach any consequences to it). Information asymmetries and monitoring are absent in his model. In Acemoglu et al. (2008), schools provide a multi-dimensional effort ("good" effort which increases students' human capital and "bad" effort which increases outsiders' perception of the amount of good effort exerted), which leads schools to under provide good effort. Neither household monitoring, which could mitigate the misallocation of school efforts, nor household sorting are present in this model. Ahn (2009) and Hansen (2010) study teacher effort in light of accountability and career incentives respectively, yet do not model household monitoring or school choice. Neal (2011) analyzes the design of performance pay in education. He motivates the problem and interprets the evidence using partial equilibrium models that do not incorporate household monitoring.

The second literature to which we contribute is the agency literature. Well-known agency problems (for instance, Holmstrom, 1979; Sappington, 1983) have been studied in bilateral, partial equilibrium settings as opposed to an equilibrium setting such as ours. Monitoring and its associated free-riding have been studied in professional partnerships (Miller, 1997; Huddart and Liang, 2003, 2005), where monitoring is performed by the very partners whose productive effort is subject to moral hazard. Although our work relates to the literature on incentives problems in government procurements (Laffont and Tirole, 1993), we do not model the determination of funding or policy mandates, nor do we search for the optimal contract between the public school and the policymaker (which is likely to be extremely complex). Rather, we focus on policies that are commonly discussed to address underachievement even though they may not be optimal.

The remainder of this paper is organized as follows: Section 2 presents the model, Section 3 describes the computational version of the model, Section 4 analyzes the equilibrium of the model, Section 5 discusses policy simulations, and Section 6 concludes.

2. The model

We embed information asymmetry about school effort into an equilibrium model of school choice. There are three categories of players in our model: households, public and private schools, and the policymaker. In this one-period model,[1] the timeline of events is as follows:

1. The policymaker exogenously establishes two policy parameters for public schools — funding level and school effort standard (more on the effort standard below);
2. Households choose a school for their children. Conditional on this choice, they choose their monitoring effort, learning effort and consumption;
3. Schools choose school efforts.

To capture the agency conflict between households (and the policymaker) and schools, we distinguish between the school's *effort standard* (or *promised effort*) and the school's *actual effort*. The effort standard is the school input promised by the school to the parents, whereas actual effort is the effort delivered by the school. Our assumption of unobservable school effort is motivated by the fact that in reality, neither the parents nor the policymaker are present in the school to observe school effort all the time.[2] As a consequence, the school can deliver less effort than it promises *even though* households anticipate this behavior, in accordance with the basic insight from the moral hazard literature (e.g., Holmstrom, 1979). Although parental monitoring can mitigate moral hazard, it cannot completely eliminate it. Hence, the effort distortion persists.

In addition to an effort distortion, moral hazard introduces a cost distortion. In our model, the household's cost to procure a given school effort from a private school is higher than the actual cost of effort to the school. It includes a tuition premium – an agency cost – which cannot be competed away. Although they charge zero tuition, public schools reap a similar rent, further enhanced by their fixed funding and restricted entry.

2.1. Households

The economy is populated by a finite number of households. Each household has one child who must go to school. Households are heterogeneous in income, y, and ability, μ. There are a finite number of income types, I, and a finite number of ability types, J. Thus, there are $H=I\times J$ household types, each representing an (income, ability) combination. In the computational version of the model we assume one household per type, in which case the total number of households in the economy equals H. The model can be extended to more than one household per type without loss of generality.

Household preferences are described by the following utility function:

$$U = c^{\beta}s - \rho_a \frac{a^2}{2\mu} - \rho_m \frac{m^2}{2\mu} \tag{1}$$

where c is numeraire consumption, s is school achievement, a is household learning effort, m is household monitoring effort (the roles of a and m in the production of achievement are described below), and $\rho_m,\ \rho_a,\ \beta>0$.[3] Households incur disutility from exerting school and monitoring efforts, and this disutility represents the cost of effort. Importantly, the marginal cost of effort varies among households, and is higher for lower-ability households. In the computational version of the model, we assume that monitoring is a binary choice: $m\in\{0, 1\}$.

Households maximize utility (1) subject to the following budget constraint:

$$(1-t)y = c + T \tag{2}$$

where t is income tax rate and T is private school tuition ($T=0$ in public schools). Although the household procures consumption and school effort in the market, learning and monitoring efforts are privately produced at a direct utility cost. They cannot be outsourced and are thus “off-budget,” as we assume that education requires some inputs that only the agent can provide.[4]

[1] In reality, education occurs over an extended period of time, only at the end of which achievement may be measured perfectly. We equate this period to our model's one period. Hence, our model does not capture the interim actions that may actually take place over that period. For instance, households may use sequential enrollment choices to discipline schools and mitigate moral hazard. This interesting extension is beyond the scope of this paper.

[2] For instance, a school may claim to offer a highly stimulating learning environment, a novel and rigorous curricula, highly qualified teachers, profound intellectual engagement, individualized instruction, state-of-the-art teaching methods and facilities, etc. Most of these claims are not observable if parents are not at the school all the time. Even if parents were at the school all the time, these claims might not be easily measurable.

[3] We normalize the coefficient on school achievement in the utility function to one in order to facilitate the calculations. Changing this coefficient simply amounts to re-scaling the other parameters.

[4] De Fraja and Landeras (2006) model the cost of effort in a similar fashion. It could be argued that the household might outsource its learning or monitoring effort to a third party. Since this party's effort would be subject to moral hazard and require monitoring, we simplify by assuming that learning and monitoring efforts cannot be outsourced. Although some might argue that the opportunity cost of time spent in monitoring is lower for low-income households, these households are more likely to be headed a single parent, who may have less time to monitor. A complete modeling of this problem would endogenize labor supply and income depending on parental characteristics and human capital. Our modeling choices reflect the desire to avoid these complications.

The production of child achievement, s, is as follows:

$$s = e^{\eta_1} q^{\eta_2} a \tag{3}$$

where e is school effort, q is the school's peer quality (defined as the school's average ability), and $\eta_1, \eta_2 > 0$.[5,6]

2.2. Private schools

School effort can be provided by private or public schools that incur a production cost equal to Ae^{λ} (with $A>0$ and $\lambda>1$), which can be viewed as the teaching and administrative cost of running a school. We model private schools as competitive firms that can select their students and charge them a uniform tuition (e.g., Ferreyra, 2007; McMillan, 2005; Nechyba, 1999). Since there are no fixed costs to providing school effort, and households have incentives to join a school with households of equal or higher ability and income according to Eq. (3), in equilibrium each private school is attended by households of a single type. Thus, the peer quality q for a private school attended by a household of ability μ is equal to μ.

Consider a household of a particular type, and the competitive market for schools that cater to it. If there were no moral hazard, each school in this market would offer its profit-maximizing effort given the market tuition. Since competition would drive profits to zero, in equilibrium the tuition would be equal to the cost of effort, and the household would choose a school whose effort maximizes household utility given the effort's production cost.

However, in the presence of moral hazard, the household cannot observe the effort provided by the schools. Instead, the schools catering to this particular household type promise an effort equal to e^{pri}, which denotes the effort standard or promised effort. Taking as given the market tuition T for this e^{pri}, each school in this market chooses its actual effort e, which may be different from e^{pri}. Such deviation is costly to the school. A school's profit is given by:

$$\pi^{pri} = T\left(e^{pri}\right) - Ae^{\lambda} - \frac{\alpha m}{2}\left(e^{pri} - e\right)^2 \tag{4}$$

where $\alpha>0$ and m denotes the monitoring effort exerted by the household.[7] Eq. (4) captures the tradeoff facing the school when choosing actual effort for a given effort standard. The school has an incentive to choose an actual effort below its promise in order to lower its production cost, hence exploiting the information asymmetry to its advantage. However, doing so imposes the cost of deviating from the promise, a cost which rises with greater household monitoring. In other words, household monitoring disciplines the school's incentive to under provide effort. The quadratic cost for the effort deviation implies that small deviations from e^{pri} are costless to the school, leading to a non-zero (downward) effort distortion in equilibrium.[8] Thus, household monitoring raises school effort, but not up to the promised level.

The optimal effort chosen by the school is:

$$e^* = f\left(e^{pri}\right) \in \operatorname{argmax}\left[T\left(e^{pri}\right) - Ae^{\lambda} - \frac{\alpha m}{2}\left(e^{pri} - e\right)^2\right] \tag{5}$$

which, in turn, yields $e^{pri} = f^{-1}(e)$. In other words, for each standard e^{pri} set by the school (or requested by the consumers) there is a corresponding effort level e effectively provided by the school. This relationship is direct — the higher the effort standard, the greater the cost of deviating from it holding actual effort constant, and the greater the incentive to provide effort. Since households understand schools' incentives, they correctly anticipate that a higher effort standard is associated with higher actual effort. Thus, we can view the effort standard as a device that mediates transactions for effort given that effort itself is not observable.

Competition drives each private school's equilibrium profit to zero: $\pi^{pri} = 0$. To see why, consider two schools with the same tuition but different effort standards. Understanding the direct relationship between effort standard and actual effort, a household choosing between the two schools will attend the one with the higher effort standard. This will drive the other school out of the market. Thus, in equilibrium the school that caters to this household will make zero profit, and similarly for the private schools catering to other household types.

After substituting the first-order condition from Eq. (5) and given $\pi^{pri} = 0$, the equilibrium tuition T^* for each e^{pri} (and the corresponding actual e) becomes:

$$T^*\left(e^{pri}\right) = A\left[f\left(e^{pri}\right)\right]^{\lambda} + \frac{\alpha m}{2}\left(e^{pri} - f\left(e^{pri}\right)\right)^2 = A(e^*)^{\lambda} + \frac{A^2\lambda^2}{2\alpha m}(e^*)^{2(\lambda-1)}. \tag{6}$$

As a result, the equilibrium tuition covers the production cost of effort *as well as* an agency cost, even though the private school market is competitive. This is consistent with the standard intuition of agency theory (Holmstrom, 1979; Grosman and Hart, 1983) by which the price of any given effort is higher than its actual production cost in the presence of moral hazard.

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[5] Due to lack of data, very few studies (if any) estimate achievement functions incorporating *all* these inputs. Stinebrickner and Stinebrickner (2008) document that extra study time has large, positive effects on achievement. In a structural framework, De Fraja et al. (2010) find that school and household effort affect achievement positively, higher ability children exert higher effort, and parental effort is positively correlated with household income and SES (see, also, Bonesrønning, 2004; Datar and Mason, 2008, and Houtenville and Conway, 2008). Complementarity of school and household effort creates a multiplier effect for policies that affect school effort by indirectly affecting household effort. Although school and household effort are complements in production, in equilibrium they can behave as substitutes (see, for instance, Section 5.1, which illustrates that the increase in school effort induced by public monitoring may lead to a *decrease* in household effort). Even if we modeled school and household effort as complements, they might still behave as substitutes in equilibrium (detailed notes are available under request). Bonesrønning (2004) and Datar and Mason (2008) find evidence of complementarity. Houtenville and Conway (2008) show that school resources seem to crowd out parental effort, though the crowd-out effect is inconsequential.

[6] Since higher-ability households have lower marginal cost of learning effort, they choose to exert higher learning effort. Hence, in equilibrium, achievement is an increasing function of household ability. De Fraja et al. (2010) document the direct relationship between effort and ability. We focus on household effort rather than ability as an input for achievement in order to highlight the role of effort as a choice, and a choice than can be affected by environmental elements such as school effort, peer quality and policy parameters (Howell et al., 2006 illustrate the sensitivity of learning effort to voucher use). Household ability, in contrast, is invariant to changes in the environment. We model peer quality as a function of average peer ability rather than effort to avoid potential multiple equilibria. Since own effort is a function of own ability, higher peer ability leads, in equilibrium, to higher peer effort. See Cooley (2010) for a partial equilibrium model of peer quality as a function of peer effort.

[7] As explained before, households choose monitoring m before schools choose effort e. This timing is critical for monitoring to play a role in the model. If the school chooses its effort first, the household has no incentive to choose positive monitoring because it will not affect the level of school effort, which has already been chosen. If school effort and household monitoring are chosen simultaneously, there is no pure strategy equilibrium with positive monitoring. To see why, consider a strategy pair of positive effort and positive monitoring. Given that the household monitors, the school does not benefit from deviating to zero effort. Yet given a positive school effort, the household can only benefit by deviating to zero monitoring. Hence, only our timing choice yields a role for monitoring. This timing choice follows the moral hazard literature, in which the agent is a Stackelberg follower and moves after the principal. See, for instance, Holmstrom (1979) and Grosman and Hart (1983).

[8] This cost may include monetary losses such as fines for failing to follow regulations or loss of future income due to damaged reputation, and non-monetary losses such as psychological aversion to breaking promises. The key to our cost assumptions is that the marginal cost is zero at zero deviation, and is increasing in monitoring.

In our model, moral hazard is introduced in a reduced-form fashion. As Eq. (4) shows, household monitoring enters directly into the school's objective function, thus reducing the effort distortion.[9] In a fully specified agency model, the principal provides the agent with effort incentives by conditioning payoff explicitly on output measures, which are informative of the agent's effort. Yet since these measures are noisy, the agent requires compensation for the ensuing risk. Monitoring lowers the noise and hence the risk placed on the agent for a given incentive rate. This allows the principal to raise the incentive rate and thus obtain greater effort from the agent. In other words, monitoring leads to greater effort (see Appendix A for an extension to an output-based model). Our reduced-form model captures this positive effect of monitoring on effort while allowing for a tractable representation of equilibrium aspects in monitoring, household sorting across schools, the school market, etc.[10]

2.3. Public school

In addition to private schools, a public school exists in this economy.[11] All households are eligible to attend the public school. Public school effort is also subject to a moral hazard problem. The public school effort standard, e^{pub}, is set exogenously by the policymaker. As in McMillan (2005), the policymaker sets per-student funding, X. The public school chooses effort e to maximize its profit:

$$\pi^{pub} = \left(X - Ae^{\lambda}\right)N - \frac{\alpha M}{2}\left(e^{pub} - e\right)^2 \quad (7)$$

where N is total enrollment and M is the sum of monitoring efforts from households attending the public school. In contrast with private schools, monitoring at the public school is a public good.[12] As long as some households monitor, it may be optimal for another household to free-ride on others' effort and not provide its own. This potential free-riding leads to the under provision of household monitoring in the public school and adds a distortion relative to private schools.

The limited competition faced by the public school adds yet another friction. Free entry of private schools ensures that each private school's tuition T is tied to the school's effort standard e^{pri} (and, indirectly, to actual school effort e), and leads to zero private school profit. In contrast, public school funding X is determined exogenously and is not necessarily tied to the public school effort standard e^{pub} or actual effort e. Hence, for a given e^{pub} a sufficiently high X may lead to public school rents ($\pi^{pub}>0$) in equilibrium. These rents, in principle, could be eliminated by the entry of another public school with the same funding but a higher effort standard (and hence higher effort). Since there is no free entry of public schools, the rents persist. The only competition faced by the public school comes from private schools, and is limited because not every household is able or willing to attend private schools.

2.4. Model summary and equilibrium

To summarize the model, consider the problem facing a household with income y and ability μ. The household must choose a school (public or private) as well as its consumption, learning effort and monitoring effort while taking the tax rate, private schools' tuition and promised efforts, public school funding and effort standard, public school peer quality, and other households' school and monitoring effort choices as given. Importantly, the household correctly anticipates the level of effort that each school will optimally provide in response to a given monitoring level and makes its choices accordingly.

If attending a private school, the household chooses c, e^{pri}, a, m to maximize utility (1) subject to the budget constraint (2), the anticipation of school effort (5), the school effort pricing function (6), and the achievement function (3). Note that in the absence of household monitoring the school would choose to provide $e=0$, leading to zero household achievement and utility. Thus, a household that attends a private school always chooses a positive level of monitoring. Given that we assume one household per type and hence per private school, monitoring in private schools is a private good.[13] In other words, we focus on the monitoring *gap* between public and private schools rather than the absolute level of monitoring in each school.[14]

If attending public school, the household chooses c, a, m to maximize utility (1) subject to the budget constraint (2), the achievement function (3), and the anticipation of the school's effort choice: $e \in argmax\ \pi^{pub} = (X - Ae^{\lambda})N - \frac{\alpha M}{2}(e^{pub} - e)^2$. This constraint reflects the household's recognition that its choice for m affects M and hence the public school's optimal e. The household chooses the school (public or private) that maximizes its utility (in case of a tie, it chooses public school).

For the sake of tractability, in our computational representation we assume binary monitoring. Thus, m equals 1 if the household chooses private school and m equals 0 or 1 if the household chooses public school. The household chooses its optimal m depending on its

[9] Input-based monitoring has empirical support. In the developing world, Duflo et al. (2009) provide evidence that parental involvement in school management (a proxy for parental monitoring) improves teacher effort, and Duflo et al. (2007) provide evidence that input-based monitoring improves output (Duflo et al., 2007). In the developed world, the Ofsted Reports in England exemplify a public monitoring of schools that evaluates inputs and output. For an example of the evaluator's attention to inputs such as teaching quality and practices, see http://www.ofsted.gov.uk/oxedu_reports/download/%28id%29/116266/%28as%29/134943_345339.pdf.

[10] Note that in an output-based model, noise in the performance measure does not hinder the principal's ability to anticipate the agent's choice; it simply creates risk for the agent and thus the need to be compensated for it. Hence, even if our achievement measure included noise, the household would still be able to anticipate schools' effort choices. Thus, the basic elements of our model would remain unchanged.

[11] Assuming one public school is equivalent to assuming one public school district with multiple public schools and open enrollment. The Chicago Public Schools district, with its extensive public school choice program (Cullen et al., 2006), is a good example of this setting. A multi-district setting would be an interesting extension yet outside the scope of this paper, as it would necessitate the treatment of housing markets and voting over policy parameters. We assume, instead, that for exogenous reasons the policymaker has issued only one public school license and restricts further entry. See footnote 14 for possible rationalizations of this decision.

[12] Although both monitoring and peer effects are sources of externalities in the public school, they differ in several ways. Household monitoring is a choice variable and hence sensitive to the environment, whereas a household's contribution to peer quality (i.e., its ability) is not. A school's peer quality is only affected by student sorting across schools, whereas monitoring is also affected by households' monitoring choices within a given school. Peer quality does not affect school effort, but parental monitoring does. As in Nechyba (1999) and Ferreyra (2007), peer quality enables us to match private school attendance in our computational exercise.

[13] If there is more than one household per type, a given private school may contain multiple households (of the same type). In this case, a household's monitoring effort may depend on other households' monitoring, and free-riding may arise in private schools. Thus, some households may leave their current private school and start a new, smaller private school to mitigate free-riding. Without fixed costs, this leads to one household per private school in the limit. If there were fixed costs, private schools would serve more than one household each and this would lead to free-riding in monitoring in private schools. However, the extent of free-riding would be lower than in public school given the higher income and/or ability of private school households, and hence their greater likelihood of monitoring. See above for further details.

[14] If we allowed public schools to have only one student each, then monitoring in public schools would also be a private good. We do not model one-student public schools for the following reasons. First, one of the goals of the policymaker in providing public education may be the mixing of students within a common school for the sake of social integration and/or peer effects (low-ability students, for instance, can benefit from mixing with high-ability peers). See Rangazas (1997) for a discussion of these and related motives. Second, if public schools had one student each, then households with high monitoring costs would not monitor their schools and would hence obtain zero school effort. This would undermine the policymaker's goal of a minimum achievement for every student in the population. In contrast, if these households attended schools with other households who do monitor, they would obtain positive school effort. Hence, creating larger public schools may be viewed as a mechanism used by the policymaker to mitigate moral hazard for households with high monitoring costs.

monitoring costs and benefits. As discussed above, monitoring costs are higher for lower-ability households. Monitoring benefits are higher for higher-ability and/or higher-income households for the following reasons: since school effort and household learning effort are complements, monitoring benefits a household because it raises achievement directly (by raising school effort) and indirectly (by leading to an increase in learning effort). The indirect effect is larger for higher-ability households, for whom the cost of learning effort is lower. Hence, higher ability households benefit more from monitoring. Since achievement is a normal good, higher-income households have higher demand for school effort and are more willing to monitor. Hence, higher income households benefit more from monitoring. In other words, monitoring (net) payoffs are higher for higher-ability, higher-income households.

An equilibrium consists of a set of household and school choices satisfying the following: (a) household rationality: conditional on other households' choices, no household has an incentive to deviate from its own optimal choices; (b) school rationality: each school chooses school effort to maximize its own profit, and the school is open only if its profits are non-negative; and (c) market clearing: each household attends one and only one school and total tax revenue equals total public school funding: $t\sum_i^H y_i = XN$.

Since the model does not have a closed-form solution, we rely on computations to study and apply the model. We have established conditions sufficient to determine whether an allocation is an equilibrium and have developed an algorithm that relies on them in order to compute the equilibrium.[15] In Appendix B we characterize the equilibrium and prove some of its properties. In equilibrium, private school attendance is more prevalent among high income households, who are more willing and able to pay tuition. It is also more prevalent among high ability households because of their greater gains from segregating from lower-ability peers in public school. Since higher income and/or ability increases the net payoff from monitoring, and private school attendance is only rational for households who monitor, higher income and/or ability further increase the likelihood that a household attends private school.[16]

2.5. Policymaker and policy alternatives

In our policy analysis, we consider two alternative programs: public monitoring of public school and private school vouchers. Public monitoring is inspired by public school accountability programs that provide incentives for public schools to raise achievement while attaching consequences to school outcomes. We operationalize this alternative by introducing a public monitoring effort, M_0, which changes the public school profit function as follows:

$$\pi^{pub} = \left(X - Ae^{\lambda}\right)N - \frac{\alpha(M+M_0)}{2}\left(e^{pub} - e\right)^2. \quad (8)$$

Since we assume that public monitoring is costly, the state budget constraint changes to

$$t\sum_i^H y_i = XN + \kappa M_0 \quad (9)$$

where κ is the unit cost of public monitoring.[17]

Vouchers are tuition subsidies for private schools. We consider universal and income-targeted vouchers. We assume that they are funded by the state through income taxes, and that the voucher dollar amount can depend on household income as denoted by the voucher function $v(y)$. With universal vouchers, $v(y) = v$ for all y. A household may supplement the voucher with additional payments toward tuition but cannot retain the difference when the tuition is lower than the voucher level. Hence, the tuition is never set below the voucher level. Under vouchers, the household attending a private school faces the following budget constraint:

$$(1-t)y = c + \max(T - v(y), 0). \quad (10)$$

To summarize, in this section we have described our theoretical model and stated properties of the equilibrium. The next section provides details on the computation of the equilibrium.

3. Computational version of the model

To analyze the model, we must first choose adequate values for the parameter vector $\theta = (\beta, \eta_1, \eta_2, \lambda, A, e^{pub}, \alpha, \rho_a, \rho_m)$. Hence, we calibrate our model to 2000 data for K-12 education in the United States. The calibration strategy is to compute the equilibrium at alternative parameter points in order to find the point that minimizes a well-defined distance between the predicted equilibrium and the observed data. Since the equilibrium does not have a closed-form solution, we solve it for a tractable representation of the economy using a numerical algorithm. In this section we describe this representation, our calibration strategy, and the fit of our model to the data. Appendix C provides further details on these matters.

Our computational representation of the economy includes five income types, whose incomes equal the 10th, 30th, 50th, 70th and 90th percentile of the 2000 national income distribution for households with children in grades K through 12. This distribution comes from the 2000 School District Data Book. All dollar amounts are expressed in dollars of 2000. We include five ability levels, equal to the 10th, 30th, 50th, 70th and 90th percentile of the IQ distribution (a normal distribution with a mean of 100 and a standard deviation of 15). We assume that income and ability are independently distributed.[18] Our setting yields twenty-five household types and one household per type, yet our results are robust to the inclusion of more types. We set per-pupil spending in public school, X, equal to the observed national average of $7000. Since our computations assume binary monitoring effort m, total monitoring in public school M equals the number of public school households that monitor.

To calibrate the model, we choose the parameter point that best matches the observed values of nine variables of interest. Appendix C offers further details on the construction of these variables. The first is

[15] We conjecture that our equilibrium is unique, and this conjecture is supported by the fact that we have never found multiple equilibria in our computational application although our algorithm is capable of finding all the equilibria for a given parameter point. See Appendix C for a description of the algorithm.

[16] Income-based sorting across schools is largely due to the normality of the demand for achievement and hence school effort and peer quality. Our utility function, multiplicative in consumption and achievement, delivers this normality. Ability-based sorting is largely driven by the role of peer quality in achievement. These types of utility and production functions are common in the literature (see Epple and Romano, 1998; Nechyba, 1999; Ferreyra, 2007). Income- and ability-based sorting across schools is strengthened by the role of monitoring, as described above. Heterogeneity in monitoring payoffs across households drives heterogeneity in household monitoring behavior.

[17] Modeling M_0 as an additive term is quite general. Since public monitoring changes the marginal benefit of private monitoring, which differs among households, aggregate private monitoring M can rise or fall in response to M_0 depending on the parameters of the problem. Thus, our formulation allows for public and private monitoring to behave either as substitutes or complements (see Section 5). Hassrick and Schneider (2009) and Figlio and Kenny (2009) suggest that parents with low monitoring payoffs may view public and private monitoring as substitutes.

[18] We have experimented with positive, low correlations between income and ability in light of recent evidence from the UK that suggests that this correlation might be on the order of 0.2 (Gregg et al., 2007). Since such low correlations do not alter our results, we have retained a zero correlation for computational simplicity.

fraction of households with children in private schools (equal to 0.16 according to the 2000 School District Data Book). The second is average income for households with children in private schools (equal to $82,800 according to the 2000 School District Data Book). The third is average private school tuition (equal to $5000 according to US Department of Education, 2002). The fourth is proportional difference between average public and private school teacher salaries (equal to 0.44 according to the 1999–2000 Schools and Staffing Survey). When we compute predicted salaries we work with teacher compensation rather than salaries, as we assume that public school profits are re-distributed among teachers.

The fifth variable is difference between average effort among private v. public school teachers (equal to zero standard deviations according to the 1999–2000 Schools and Staffing Survey). In the absence of perfect measures for school effort, we use number of hours worked by teachers. The sixth variable is difference in average achievement between private and public school students (equal to 0.45 standard deviations according to the 2000 National Assessment for Educational Progress). The seventh variable is difference in average ability between private and public school students (equal to 0.76 standard deviations according to Epple et al.'s (2004) calculations based on the National Education Longitudinal Survey).

The eighth variable is difference in average student effort between private and public schools (equal to 0.5 standard deviations according to the 2004 Digest of Education Statistics). In the absence of good empirical measures for student effort, we use average number of hours spent doing homework per week among high school students in 2004. The ninth variable is the fraction of households who monitor in public schools. Normalizing the private school average to 1 since our model views private schools as a benchmark of full parental monitoring, we arrive at a public school monitoring rate of 0.76 based on the 1999 Digest of Education Statistics.

We use z_j to denote the observed values of the variables we are matching, $j=1\ldots9$. As we search over the parameter space, for each value of the parameter point θ we compute the equilibrium, from which we extract the predicted values $\hat{z}_j(\theta)$, $j=1\ldots9$, for the variables listed above. Thus, we choose the value for θ that minimizes the following distance between the data and the model's predictions:

$$L(\theta) = \sum_{j=1}^{9} w_j \left(z_j - \hat{z}(\theta)\right)^2 \tag{11}$$

where the distance for variable j is weighed by a factor w_j which is inversely related to the precision in the variable's measurement. In particular, the first four variables are measured with greater precision than the others in the sense that their empirical counterparts are more adequate (for instance, for the fifth through eighth variable we are likely to observe a lower bound for the actual construct of interest). The non-linearity of the model and the coarseness of our household representation prevent us from matching the data exactly.

Table 1 shows the calibrated parameter values[19] and Table 2 lists the observed and predicted values for the matched variables. As expected given their measurement, the first four variables are matched better than the following four, and the fifth through eight variables are over predicted. Overall, however, we are encouraged by the model's fit to the data.

[19] Appendix C explains the identification of our parameters. Even though changes in one parameter trigger changes in several endogenous variables in an equilibrium model, we can still identify computationally the first-order effects of parameter changes given the variables matched in the calibration. See the appendix for further details.

Table 1
Parameter values.

Parameter	Definition	Value
β	Coefficient of consumption in utility	6.351
η_1	Elasticity of achievement with respect to school effort	0.843
η_2	Elasticity of achievement with respect to peer quality	2.754
λ	Elasticity of teacher salary with respect to teacher effort	2.044
A	Monotonic transformation of teachers' reservation utility	1.280
e^{pub}	Public school's promised effort	0.663
α	Agency cost	9.939
ρ_a	Disutility of household learning effort	4.06E+06
ρ_m	Disutility of household monitoring	2000

4. Analyzing the equilibrium

In this section we first analyze the equilibrium of our model computed at our calibrated parameter values (henceforth called “benchmark” or “baseline” equilibrium). A central contribution of our paper is modeling information frictions in education. To highlight their role, we analyze the equilibrium that would prevail if there were perfect observability in the economy. In this case, school effort would be observable (with $e^{pub}=e$ and $e^{pri}=e$ in public and private schools, respectively) and monitoring would be unnecessary. Since the difference between promised and actual effort captures the agency conflict in our model, in this section we also investigate the equilibrium response to changes in the public school effort standard.

4.1. Benchmark equilibrium

Column 1 of Table 3 displays the benchmark equilibrium, in which 84% of households attend public school. As the top panel of Fig. 3 shows, high-ability, high-income households attend private schools. Although both income and ability affect household monitoring in our model, income plays a stronger role than ability from a quantitative perspective. All private school households monitor, yet the lowest-income households in public school do not monitor. The model's prediction of greater monitoring among higher income households has empirical support (see US Department of Education, 2002, Table 25; Walden, 1996), which lends further validity to our model since the positive correlation between monitoring and income was not used in the calibration.

Our model enables us to study how public and private schools spend their revenue. The public school spends 59% to cover its total cost (44% pays for teacher effort, and 15% pays for agency costs), and

Table 2
Predicted and observed values.

Variable	Observed value	Predicted value
Fraction of households with children in private schools	0.16	0.16
Average income for households with children in private schools	$82,800	$90,400
Average private school tuition	$5000	$4900
Difference in teacher salary between public and private school	0.44	0.53
Difference in teacher effort between private and public school	0	1.26
Difference in achievement between private and public school	0.45	1.56
Difference in ability between private and public school	0.76	1.45
Difference in student effort between private and public school	0.5	1.28
Monitoring rate in public school	0.76	0.76

Note: Measurement of each variable is described in the text. Dollar amounts rounded to the nearest hundred.

Table 3
Equilibrium with imperfect and perfect observability.

	Imperfect observability (1)	Perfect observability (2)
Fraction Hhs. in public school	0.84	0.96
Average income	$57,600	$57,600
Public school	$51,300	$55,000
Private school	$90,400	$119,400
Average ability	100	100
Public school	97	99
Private school	116	119
Monitoring rate	0.80	0.00
Public school	0.76	0.00
Private school	1.00	0.00
Average spending per student	$6700	$7000
Public school	$7000	$7000
Private school (tuition)	$4900	$6400
Average promised school effort		
Public school	0.66	0.66
Private school	0.69	0.71
Average actual school effort	0.51	0.67
Public school	0.50	0.66
Private school	0.55	0.71
Public school profit	$60,800	$35,600
Average teacher compensation		
Public school	$6000	$7000
Private school	$3900	$6400
Average use of school revenues		
Public school		
Salaries	0.44	0.79
Agency cost	0.15	0
Rent	0.41	0.21
Private school		
Salaries	0.79	1
Agency cost	0.21	0
Rent	0	0
Avg. household learning effort	0	0.06
Public school	−0.20	−0.06
Private school	1.07	3.08
Average achievement	0	0.09
Public school	−0.25	−0.09
Private school	1.31	4.37
Income tax rate	0.1	0.12
Aggregate welfare	8.34E+12	1.03E+13

Note: Dollar amounts are rounded to the nearest hundred. For "Average use of school revenues", we display the fraction of revenues that pays for salaries, agency cost or rent. In the imperfect observability (benchmark) equilibrium, achievement and learning effort are normalized to have zero mean and unit standard deviation. In all columns and tables, achievement and learning effort are measured in units of standard deviation of their benchmark equilibrium distributions.

captures the remaining 41% as a rent. Private schools, in contrast, enjoy zero profits and spend almost 80% of their revenue in teacher effort, hence using their funding more efficiently. Note that the persistence of the effort distortion gives rise, in equilibrium, to agency costs both in public and private schools.

Column 2 of Table 3 describes the equilibrium under perfect observability. As standard agency intuition would indicate, school effort under perfect observability is higher (by approximately 30%) than in the presence of moral hazard. Under perfect observability monitoring is not necessary, which makes private schools more attractive since private schooling requires monitoring. However, the higher effort exerted by the public school under perfect observability makes the public school more attractive. The net outcome of these forces is that only the highest-income, highest-ability type remains in private school. Greater school effort leads to greater household learning effort, and both to higher achievement in the economy.

From a policy perspective, the superiority of the perfect observability outcomes means that bringing the economy closer to those outcomes may enhance welfare and achievement. Since parental monitoring mitigates moral hazard, policies that lower private monitoring costs can help. For instance, many argue that the greatest contribution from No Child Left Behind has been creating and disseminating vast amounts of information on public schools, which have presumably helped parents' monitoring.[20] Moreover, the literature documents that parents are indeed responsive to that kind of information (Figlio and Lucas, 2004), including low-income parents (Hastings and Weinstein, 2008). In what follows we take private monitoring costs as given and study additional policies that seek to mitigate moral hazard.

4.2. The role of public school effort standard in equilibrium choices

While we assume that public school funding is fixed, perhaps for political or institutional reasons, the public school effort standard (e^{pub}) is likely more flexible. For instance, a district's board of education may promise more engaging teaching while keeping funding constant. From Eq. (7) it follows that a change in the public school effort standard alters public school effort and hence household choices. Thus, the top panel of Fig. 1 depicts the equilibrium value of public school profit for alternative values of e^{pub} (recall that our calibrated e^{pub} is equal to 0.66). The bottom panel depicts the equilibrium actual public school effort, fraction of households attending public school, and public school monitoring rate as a function of e^{pub}.

For low values of effort standard, profits are positive but flat. Only 20% of households attend public school. These households, located at the bottom of the income distribution, do not have the ability to pay for private school and have low monitoring payoffs. Thus, they choose to attend public school and not monitor. This, in turn, allows the public school to deliver zero effort and enjoy a rent of $7000 per student.

As the value of the effort standard rises, profits first rise and then fall. However, public school attendance, effort and monitoring rate rise steadily. The non-monotonic path of profits is explained as follows. For a given actual effort, a higher effort standard raises the cost of effort deviation for the school and motivates greater school effort. This, in turn, attracts more students into the school — students from higher-income, higher-ability households. As these households join the school they also engage in monitoring, which in turn forces greater school effort. While higher attendance increases revenue and rents for a given school effort, higher effort and monitoring reduces rents and profits. As long as the first effect dominates, profit is increasing in effort standard; the reverse happens when the second effect dominates, eventually leading to negative profits (a situation not displayed in Fig. 1, as it is not an equilibrium).

The top panel of Fig. 1 also suggests that in an environment where funding is not flexible, the policymaker can in principle eliminate or at least minimize rents by choosing the appropriate effort standard, equal to 0.85 in our setting. As we will see later, an effort standard of 0.85 is also what households would choose if they were able to do so. This standard is certainly higher than that implied by the data, equal to 0.66.

Similarly, the top panel of Fig. 1 suggests that if the public school were able to choose its optimal effort standard, it would maximize profit at $e^{pub}=0.60$. The school's optimal standard is quite close to that implied by the data, indicating that public schools might play a strong role in the actual determination of effort standards. The profit-maximizing effort standard is high enough to attract a sufficiently large number of students, yet low enough to attract relatively few high-ability, high-income households who monitor the school.

The choice of effort standard has clear achievement and distributional impacts. Column 2 of Table 4 shows the equilibrium when the effort standard minimizes public school rent. For comparison, column 1 shows the benchmark equilibrium (which is very close to the

[20] We have conducted simulations for $\rho_m=0$, i.e. zero private monitoring costs. Relative to the benchmark equilibrium, public school effort, attendance and achievement are higher. Details are available upon request.

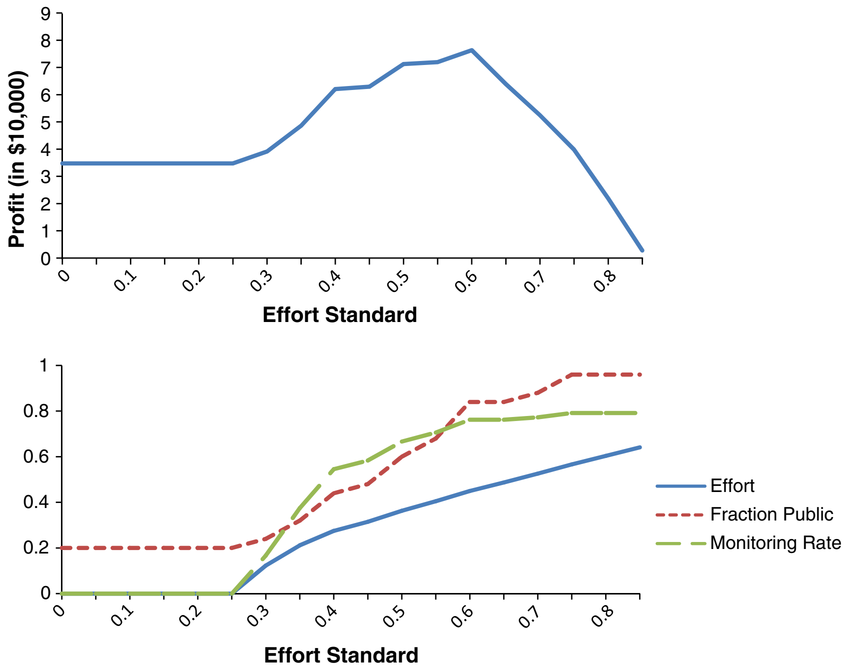

Fig. 1. Public school profit, effort, attendance and monitoring under imperfect observability.

equilibrium under the public school's optimal effort standard). As column 2 shows, in the zero-profit equilibrium, public school effort, attendance and monitoring are higher than in the baseline, and the public school use revenues more efficiently. Greater school effort raises student effort and hence achievement. Relative to other households, achievement gains accrue at a higher rate to the low-

Table 4
Equilibrium with imperfect and perfect observability for alternative public school effort standards.

	Imperfect observ. (1)	Imperfect observ., zero profit (2)	Perfect observ. (3)	Perfect observ., zero profit, low e^{pub} (4)	Perfect observ., minimum profit, high e^{pub} (5)
Fraction public school	0.84	0.96	0.96	0	0.96
Avg. income public school	$51,300	$55,000	$55,000	n/a	$55,000
Avg. ability public school	97	99	99	n/a	99
Monitoring rate pub. school	0.76	0.79	0.00	n/a	0.00
Avg. spending per student	$6700	$7000	$7000	$3500	$7000
Public school	$7000	$7000	$7000	n/a	$7000
Private school	$4900	$6400	$6400	$3500	$6400
Avg. promised school effort					
Public school	0.66	0.85	0.66	Up to 0.15	0.70
Private school	0.69	0.80	0.71	0.50	0.71
Avg. actual school effort	0.51	0.64	0.67	0.50	0.70
Public school	0.50	0.64	0.66	n/a	0.70
Private school	0.55	0.64	0.71	0.50	0.71
Public school profit	$60,800	$3000	$35,600	n/a	$19,900
Avg. use of school revenues					
Public school					
Salaries	0.44	0.74	0.79	n/a	0.88
Agency cost	0.15	0.25	0	n/a	0
Rent	0.41	0.02	0.21	n/a	0.12
Private school					
Salaries	0.79	0.79	1	1	1
Agency cost	0.21	0.21	0	0	0
Rent	0	0	0	0	0
Avg. learning effort	0	0.04	0.06	0.48	0.08
Avg. achievement	0	0.04	0.09	0.60	0.12
Public school	−0.25	−0.10	−0.09	n/a	−0.05
Private school	1.31	3.52	4.37	0.60	4.37
Proportion of Hhs.					
With higher achievement		0.88	0.92	0.64	0.92
Among low-income Hhs.		1	1	0.20	1
Income tax rate	0.1	0.12	0.12	0	0.12
Aggregate welfare	8.34E+12	9.35E+12	1.03E+13	3.55E+13	1.10E+13

Note: Columns (1) and (3) are the same as columns (1) and (2) from Table 3, respectively. Column (5) corresponds to the value of e^{pub} that yields the lowest non-negative public school profit under perfect observability. "Hh." is short for "household"; "low-income" means income = 10th percentile. "Proportion of households with higher achievement" is calculated relative to the benchmark equilibrium.

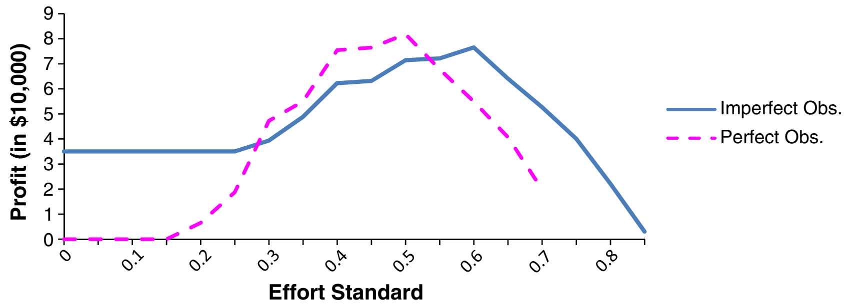

Fig. 2. Comparing public school profit under perfect and imperfect observability.

income, low-ability segment which constitutes captive demand for the public school. Although taxes are higher to pay for more public school students, welfare is also higher.

4.3. *Effort standard, fixed funding and observability*

As Fig. 2 shows, the behavior of public school profit with respect to the effort standard is qualitatively the same with or without perfect observability (recall that under perfect observability, the effort standard equals the actual effort). This is because the effort standard induces a tradeoff — on the one hand, a higher effort standard raises enrollment and hence total revenue; on the other hand, it raises effort cost.[21] Moral hazard preserves this pattern but raises school profit relative to perfect observability when the standard is very low or very high. When the standard is very low, the extra profit comes from the public school's captive audience of low-income, low-ability households that do not monitor (under perfect observability, these households would attend private schools because of their greater effort; in so doing they would not be deterred by their low monitoring payoff because monitoring would be unnecessary). When the standard is very high, the extra profit comes from the lower effort cost. For intermediate values of the standard, public school profit is lower than under perfect observability mostly because of the cost of effort deviation.

In an environment with perfect observability and inflexible funding, consider the two zero-profit cases presented in Table 4. In the first case, a low effort standard (less than or equal to 0.15; see column 4) induces zero public school attendance and thus eliminates public school profit. In the second case, a high effort standard (equal to 0.7; see column 5) induces high public school attendance yet minimum profits. If we view column 4 of Table 4 as the first best because neither information nor funding distortions exist, then it follows that the first best can be attained without public schools. Not surprisingly, of all the scenarios presented in this paper, this one commands the highest aggregate welfare. Yet relative to the other perfect observability scenarios (columns 3 and 5), in the first best the lowest-income, lowest-ability households obtain *lower* achievement and utility given the absence of public schools with mandated effort standards — left to their own devices, these households choose a lower school effort (and achievement) than the policymaker would choose for them. Thus, effort standards play a role when the policymaker has a minimum-proficiency goal for every student *even if* effort is observable.

If, in contrast, we were to consider a first best in which public schools do exist, then we would view the perfect observability, minimum profit equilibrium with high e^{pub} as the first best (column 5 of Table 4). Relative to this first best, the baseline average effort is about 30% lower (compare the actual effort of 0.51 in column 1 to 0.70 in column 5). Assuming that funding is fixed, most of this effort distortion would disappear if effort were observable (compare the actual effort of 0.51 in column 1 to 0.67 in column 3). This might not seem useful from a policy perspective because observability is hardly a policy parameter. However, almost the same reduction in effort distortion would be accomplished by raising the effort standard up to the level needed to eliminate public school profit (compare the actual effort of 0.51 in column 1 to 0.64 in column 2). In other words, when school effort is not observable and public schools have limited entry yet fixed funding, the appropriate choice of public school effort standard is critical to eliminating the under provision of effort relative to the first best.[22]

To summarize, in this section we have quantified the effort and achievement distortions due to the lack of observability. We have also studied the equilibrium response of households and schools to changes in the public school effort standard. Now we turn to specific policies.

5. Policy analysis

In this section we study the effects of public monitoring of public schools and private schools vouchers, when applied separately or in conjunction. Then we explore the distribution of household preferences over policy parameters for public schools.

5.1. *Public monitoring*

In order to simulate public monitoring, we need to choose values for its level (M_0) and unit cost (κ). Hoxby (2002a) argues that accountability is a low-cost policy. While this may be true for a mere testing system, we consider a kind of monitoring with actual impact on school effort, which might entail detailed evaluations of public school performance, direct observation of classroom and administrative practices, etc. Appendix C describes how we calibrate M_0 and κ in the absence of direct information about the cost of this type of monitoring, and how we calculate the monitoring intensity m_0 based on M_0.

Columns 2 through 9 of Table 5 describe the equilibrium for several combinations of public monitoring intensity and unit cost. Not surprisingly, the more intense the public monitoring, the greater the effort for any given unit cost. Other researchers have documented that public monitoring increases school effort (Rouse et al., 2007; Chiang, 2009).

5.1.1. *The crowd-out of private monitoring*

Public monitoring affects household school and monitoring choices, as shown in Fig. 3. Relative to the benchmark equilibrium, public monitoring raises public school attendance by raising public

[21] See McMillan (2005) for a similar tradeoff in a model without moral hazard.

[22] We assume that changing public school effort standard is costless and does not affect the cost of deviating from the standard, α. These assumptions may not hold in reality. For instance, a low standard (such as the requirement that teachers merely come to the school) is easy to verify and may thus entail a severe punishment.

Table 5
Public monitoring of the public school.

	Imperfect observ. (1)	Very low cost, medium intensity (2)	Very low cost, high intensity (3)	Low cost, medium intensity (4)	Low cost, high intensity (5)	Moderate cost, medium intensity (6)	Moderate cost, high intensity (7)	High cost, medium intensity (8)	High cost, high intensity (9)
Fraction public school	0.84	0.92	0.96	0.92	0.96	0.96	0.96	0.96	0.96
Monitoring rate public school	0.76	0.78	0.79	0.78	0.79	0.79	0.75	0.75	0.58
Average ability public school	97	98.33	99.2	98.33	99.2	99.2	99.2	99.2	99.2
Actual public school effort	0.50	0.55	0.57	0.55	0.57	0.55	0.57	0.55	0.56
Public school profit	$60,800	$55,700	$54,900	$55,700	$54,900	$58,000	$55,400	$58,600	$57,400
Public school use of revenues									
Salaries	0.44	0.54	0.58	0.54	0.58	0.54	0.57	0.54	0.55
Agency cost	0.15	0.11	0.09	0.11	0.09	0.11	0.10	0.11	0.11
Rent	0.41	0.35	0.33	0.35	0.33	0.35	0.33	0.35	0.34
Avg. achievement	0.00	−0.02	−0.02	−0.08	−0.10	−0.18	−0.23	−0.27	−0.33
Public School	−0.25	−0.17	−0.16	−0.20	−0.21	−0.26	−0.29	−0.32	−0.36
Private School	1.31	1.66	3.42	1.35	2.60	1.88	1.31	0.86	0.26
Proportion of households that gain achievement		0.84	0.84	0.84	0.64	0	0	0	0
Among low-income Hhs.		1	1	1	0	0	0	0	0
Among public–public Hhs.		1	1	1	0.76	0	0	0	0
Among private–private Hhs.		0	0	0	0	0	0	0	0
Among private–public Hhs.		0	0	0	0	0	0	0	0
Income tax rate	0.10	0.11	0.12	0.13	0.15	0.18	0.21	0.25	0.31
Aggregate welfare	8.34E+12	7.90E+12	7.73E+12	5.93E+12	5.01E+12	2.95E+12	1.80E+12	1.02E+12	3.24E+11
Proportion of households that gain welfare		0.88	0.88	0	0	0	0	0	0

Note: Column (1) is the same as column (1) in Table 3 — the benchmark equilibrium for imperfect observability, with no public monitoring. Very low-, low-, moderate- and high-cost monitoring correspond to values of γ equal to 0.01, 0.10, 0.3 and 0.6 respectively. Medium and high-intensity monitoring correspond to values of m_0 equal to 0.5 and 0.75, respectively. For an explanation on the calibration of γ and m_0, see Appendix C. "Proportion of households who gain achievement" and "Proportion of households who gain welfare" are calculated relative to the benchmark equilibrium. "Public–public Hhs." are the households who attend public school in the benchmark equilibrium and under public monitoring; "Private–private Hhs." attend private schools in both cases, and "Private–public Hhs." attend private schools in the benchmark equilibrium but switch into public school under public monitoring.

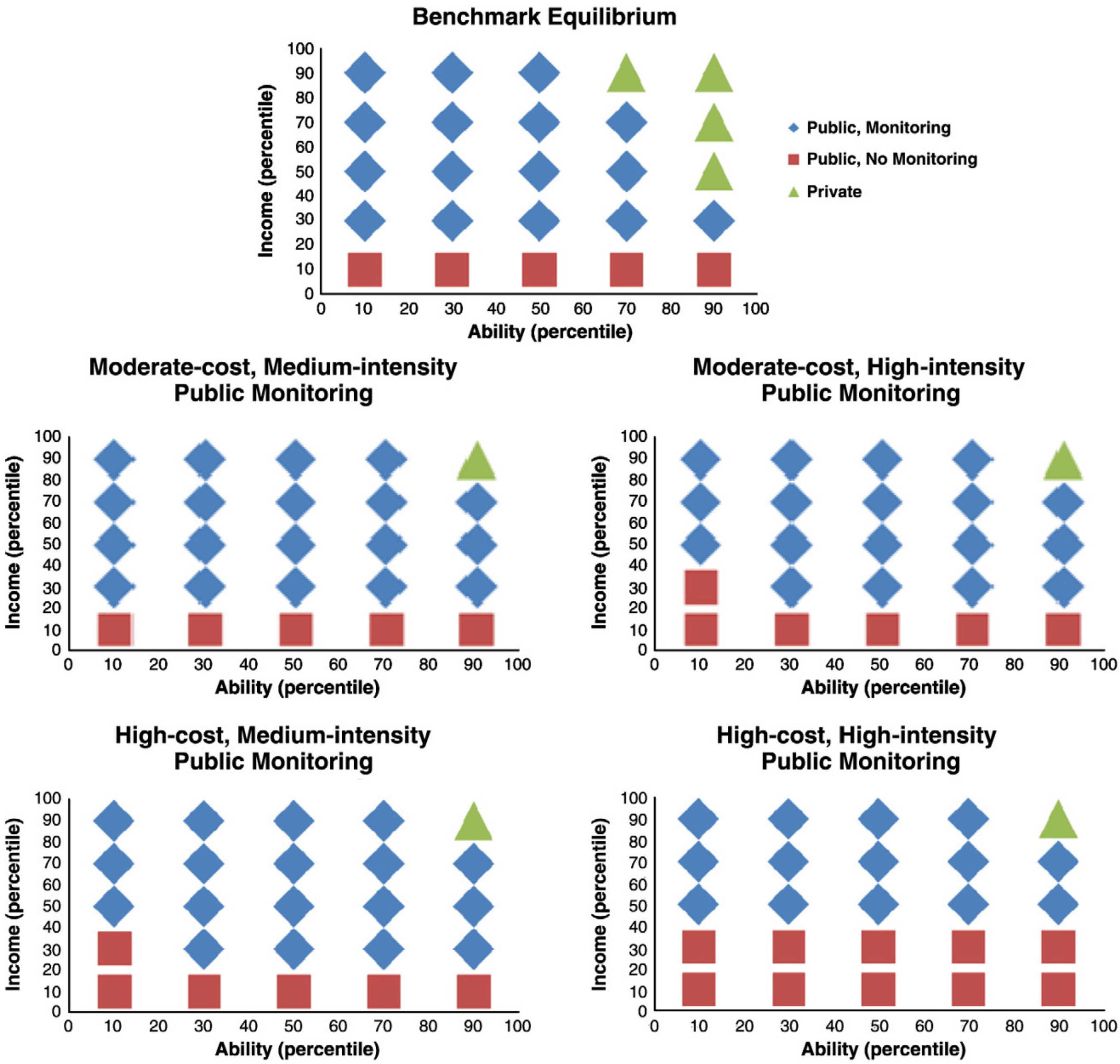

Fig. 3. Household school choice and monitoring under public monitoring. Note: each (income, ability) combination represents a household. Benchmark Equilibrium is the equilibrium for imperfect observability. "Public, Monitoring" means that the household attends public school and monitors; "Public, No Monitoring" means that the household attends public school and does not monitor; "Private" means that the household attends private school (and hence monitors). Moderate- and high-cost monitoring corresponds to values of γ equal to 0.30 and 0.60 respectively. Medium and high-intensity monitoring corresponds to values of m_0 equal to 0.5 and 0.75, respectively.

school effort, as only the highest-ability, highest-income households remain in private school. However, the impact of public monitoring on household monitoring depends on several forces. On the one hand, public monitoring raises public school effort, hence attracting high-ability, high-income households away from private schools. The fact that these households monitor the public school can intensify private monitoring, further increasing public school effort. On the other hand, public monitoring can crowd out private monitoring and thus lower it. The entry of high-income, high-ability households into the public school can induce households for whom monitoring is more costly to free-ride on the newly arrived households and no longer monitor, also leading to a decrease in private monitoring.

The net outcome of these effects depends on the fiscal cost of public monitoring. When this cost is not too high the first effect prevails, yet the second and third effects dominate otherwise. For instance, Fig. 3 shows that while public monitoring increases public school attendance and the number of monitoring households by attracting high-income, high-ability households into the public school, it also causes low-income households to stop monitoring when the fiscal cost of monitoring rises.[23,24]

[23] Recall that monitoring benefits are increasing in income. The taxes levied to pay for public monitoring lower households' disposable income and hence their monitoring benefits. Depending on its size, this effect can lead low-income households to stop monitoring. Although public monitoring in reality might not seem costly enough to double or triple the benchmark fiscal burden as in the last columns of Table 5, we emphasize that *effective* public monitoring might actually be quite costly.

[24] Our crowd-out results are reminiscent of the crowd-out of voluntary contributions to the provision of public goods studied by Warr (1982) and Roberts (1984), among others. To our knowledge, the response of private to public monitoring has not been studied empirically. The closest evidence comes from Figlio and Kenny (2009), who document that when a school receives a low grade in the Florida accountability system, parents reduce their donations to the school since they perceive it as poorly run. This response is more pronounced among schools serving low-income or minority families. These parents, who tend to have less first-hand information about the school's effectiveness, rely more on school grades and are more responsive to them. Thus, public monitoring seems to crowd-out private monitoring more among disadvantaged parents, which is consistent with our model.

Table 6
Private school vouchers, and comparisons with other policies.

	Benchmark eqbrm. (1)	Universal low voucher (2)	Universal high voucher (3)	Income-targeted low voucher (4)	Income-targeted high voucher (5)	Very low cost, high intensity monitoring (6)	Vouchers and public monitoring (7)
Fraction public school	0.84	0.36	0.2	0.64	0.68	0.96	0.64
Fraction of eligible Hhs. using voucher		0.64	0.80	0.30	0.40	n/a	0.36
Avg. income public school	$51,300	$38,000	$13,400	$49,300	$55,800	$57,600	$48,200
Avg. ability public school	97	91	100	94	95	99.2	93.22
Monitoring rate public school	0.76	0.44	0.00	0.69	0.71	0.79	0.50
Avg. actual school effort	0.51	0.49	0.53	0.50	0.53	0.57	0.60
Public school	0.50	0.42	0.00	0.48	0.49	0.57	0.63
Private school	0.55	0.53	0.66	0.53	0.61	0.63	0.53
Public school profit	$60,800	$31,800	$35,000	$48,100	$50,600	$54,900	$27,700
Public school use of revenues							
Salaries	0.44	0.31	0	0.41	0.42	0.54	0.25
Agency cost	0.15	0.18	0	0.16	0.15	0.11	0.72
Rent	0.41	0.5	1	0.43	0.43	0.35	0.13
Private school avg. use of revenues							
Salaries	0.79	0.79	0.79	0.79	0.79	0.79	0.79
Agency cost	0.21	0.21	0.21	0.21	0.21	0.21	0.21
Rent	0	0	0	0	0	0	0
Avg. achievement	0	0.16	0.13	0.05	−0.02	−0.02	0.06
Proportion that gains achievement		0.52	0.64	0.36	0.16	0.84	1
Among low-income Hhs.		0	0	0	0	1	1
Among public–public Hhs.		0	0	0	0	1	1
Among private–private Hh.		1	1	1	0	0	1
Among private–public Hhs.		n/a	n/a	n/a	n/a	0	n/a
Among public–private Hhs.		0.75	0.75	1	1	n/a	1
Income tax rate	0.1	0.08	0.12	0.09	0.1	0.12	0.12
Aggregate welfare	8.34E+12	1.41E+13	1.21E+13	9.85E+12	7.88E+12	7.73E+12	9.53E+12
Proportion that gains welfare		0.52	0.48	1	0.16	0.88	0.36

Note: Column (1) is the benchmark equilibrium for imperfect observability. Low and high vouchers are for $3500 and $7000, respectively. Column (6) is the same as column (3) in Table 5 ($\gamma=0.01$, $m_0=0.75$). Proportion of households who gain achievement and welfare are computed relative to the benchmark equilibrium. Column (7) features universal vouchers for $3500 and very low cost, very high intensity public monitoring ($\gamma=0.01$, $m_0=4$).

5.1.2. Public monitoring and achievement

An important question is whether public monitoring raises public school achievement. The answer to this question depends again on the net effect of two forces. On the one hand, public monitoring raises public school effort and peer quality, both of which enhance achievement. In addition, greater peer quality and school effort induce greater household learning effort. On the other hand, the fiscal cost of public monitoring lowers disposable income and hence the demand for household learning effort. Only when the unit cost of accountability is low does the first effect prevail. Hence, low-income households – often the intended beneficiaries of these policies – only gain when these policies cost little.[25]

Households that remain in private schools lose achievement because they pay higher taxes to fund public monitoring and hence purchase less school effort and exert less household learning effort. Households that switch from private into public schools induced by public monitoring also lose achievement because of the loss of disposable income (that leads to lower household effort) and peer quality. Though the effect of public monitoring on *average* achievement is negative, most households gain achievement if the cost of public monitoring is sufficiently low. Overall, the effects of public monitoring on achievement illustrate the complexity of the outcomes induced by a policy tool when applied in a large-scale setting.

5.2. Private school vouchers

Table 6 shows the effects of universal and income-targeted vouchers (columns 2–3 and 4–5, respectively). All households are eligible for the former, yet only households with an income below the threshold (equal to median household income in these simulations) are eligible for the latter. We consider $3500- and $7000-vouchers ("low" and "high" vouchers, respectively). Although in reality income-targeted vouchers are politically more feasible given their lower eligibility, universal voucher simulations are of interest because they show the effects of an unrestricted voucher. Fig. 4 depicts voucher effects on school choice and monitoring.

We begin by analyzing universal vouchers. Not surprisingly, they increase private school attendance. However, low-income, low-ability households remain in public school because monitoring a private school would be prohibitively costly for them. These households lose good peers and monitors as higher-ability, higher-income households depart from public school. Thus, public school effort[26] and achievement fall.

Many voucher users gain school effort, peer quality or achievement. The higher their income or ability, the more likely they are to gain. Those who switch into private schools have access to higher school effort and better peers than they had in public school. Overall, more than half of the population gains achievement in these simulations. While private schools use funding more efficiently than the public school by being subject to free entry, the public school becomes more inefficient — under a high voucher it is no longer monitored and thus offers zero effort, which means that its full funding constitutes rent.

Some of the losses inflicted by universal vouchers upon the low-income, low-ability segmented are tempered by income-targeted vouchers. In our simulations, 40% of the households are eligible for these vouchers, yet only the highest-ability, highest-income eligible households use the voucher because the monitoring required in private schools is too costly for the others. Public school monitoring rate falls with income-targeted vouchers though not as much as with

[25] The empirical evidence on the effect of accountability on achievement is quite mixed (see, for instance Figlio and Ladd, 2008). Due to the lack of data, the literature does not disentangle the role of school and household (or student) effort in school-based accountability.

[26] This result contrasts the standard argument that by creating competition, vouchers would raise public school effort. The reason is that in our model, the public school takes attendance and monitoring as given when choosing effort. Hence, a policy that reduces household monitoring (without compensating with greater public monitoring) also reduces school effort. Nonetheless, if the public school were able to choose e^{pub}in our model, then the school would optimally raise e^{pub} in order to mitigate enrollment losses due to the voucher.

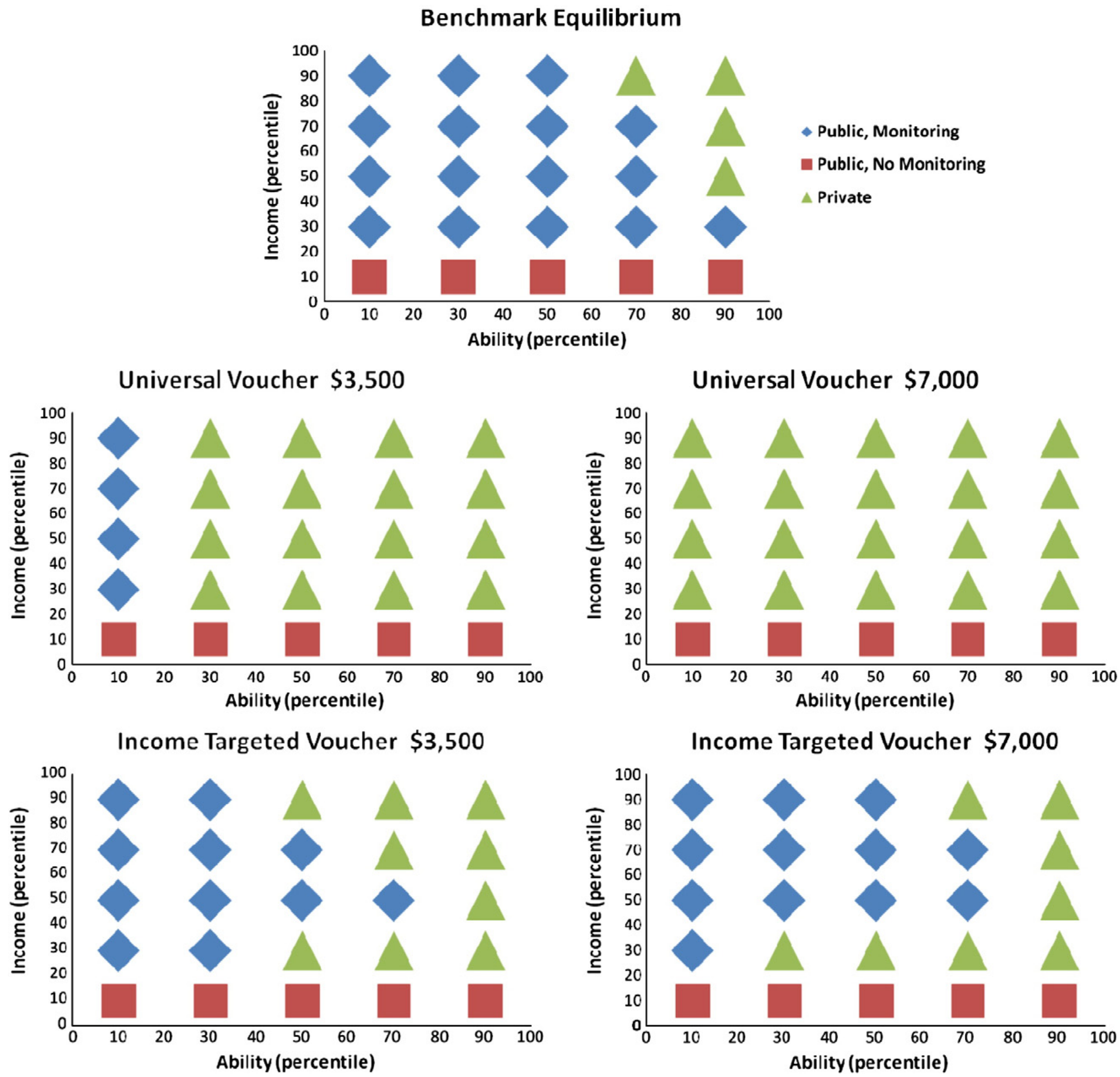

Fig. 4. Household school choice and monitoring under private school vouchers. Note: Benchmark Equilibrium is the equilibrium for imperfect observability.

universal vouchers because fewer households leave public school, which means that public school effort does not fall as much either. All voucher users gain achievement.

A theme of these voucher simulations is the inability of vouchers to improve outcomes for the lowest income and ability segment because of informational frictions, as having to monitor in private schools (while losing the benefits of free-riding on public school monitoring) is too costly for those households. This raises the question of whether vouchers would be more effective in the absence of informational frictions. As Table 1 in Appendix D shows, under perfect information voucher use is indeed higher and more low-income households gain achievement. This suggests that under informational frictions vouchers may need to be supplemented by some form of public monitoring, as discussed below.

5.3. Regulation or markets?

In public debates, regulation and markets are often presented as substitute approaches to discipline public schools and raise achievement. In what follows we argue against this — both mitigate moral hazard, yet their achievement and distributional implications are quite different. Moreover, each one has unintended consequences.

Public monitoring relies on the logic that monitoring mitigates moral hazard. As the public school raises its effort it attracts higher-ability households, whose monitoring further enhances the school's competitiveness. Vouchers also mitigate moral hazard, as they allow households dissatisfied with public school effort to choose their preferred promised effort in a school subject to full private monitoring. Yet the critical feature of vouchers is that they rely directly on competition, since they give households the means to choose other schools. Moreover, vouchers lower the fiscal cost of a given school effort because competition eliminates rents from private schools.

Both public monitoring and vouchers have the potential of raising achievement for the majority of the population. However, (low-cost) public monitoring generally benefits low-income students while vouchers hurt them. In other words, public monitoring and vouchers are not substitutes for some households. Since vouchers rely on

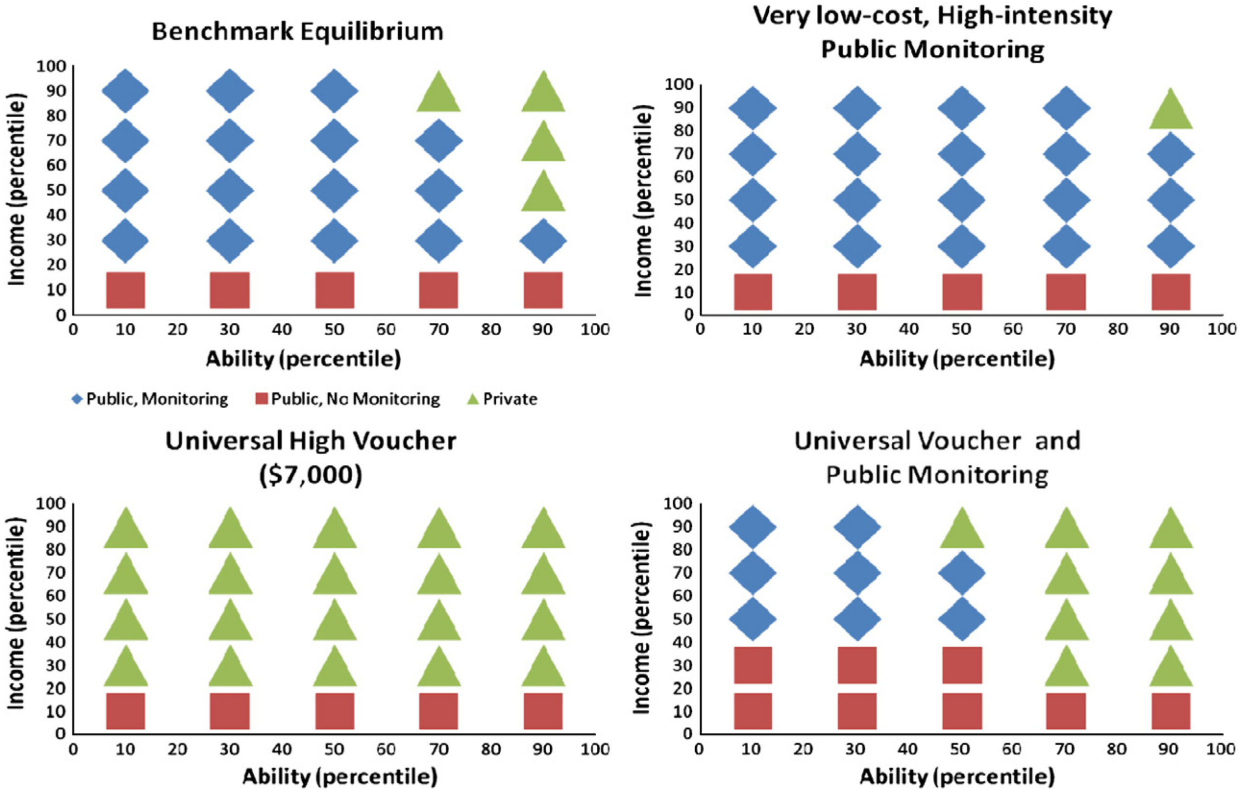

Fig. 5. Comparing policy tools. Note: "Very low-cost, high-intensity public monitoring" corresponds to $\gamma=0.01$, $m_0=0.75$; "Universal voucher and public monitoring" corresponds to a $3,500-voucher and $\gamma=0.01$, $m_0=4$.

private rather than public monitoring, households with low monitoring payoffs may be better served by public monitoring.

While this may suggest the superiority of public monitoring, we wish to offer three caveats. First, public monitoring benefits more households than vouchers only when its cost is very low. Second, since public monitoring does not rely on competition it may not be capable of eliminating rents without further manipulation of policy parameters such as public school funding or effort standard. Third, public monitoring can substitute for the monitoring that some households are not willing or able to provide. The question is who monitors the monitor. In other words, delegating monitoring on another party (the policymaker, in this case) does not eliminate moral hazard; it simply creates another layer for it.

These tradeoffs between regulation- and market-based mechanisms imply that neither option provides a complete solution to underachievement, as neither is unambiguously better. Yet another, more subtle aspect of the problem limits the effectiveness of any given mechanism — namely, that the extent of moral hazard is endogenous to household and school choices. When parents exert greater monitoring the school provides more effort and thus attracts more households, many of which monitor the school and force it to provide further effort. This equilibrium interdependence between moral hazard and household and school choices means that policies against moral hazard are likely to trigger unintended effects on those choices, thus rendering the policies less effective or even counterproductive. For instance, the crowd-out effect of public monitoring illustrates how a policy that is effective in partial equilibrium may be less effective in general equilibrium because of the unintended effects of its own implementation.

Two lessons emerge. The first is that given the trade-offs between policies and the unintended effects of any single tool, under achievement may require a thoughtful *combination* of tools. Examples are private school vouchers supplemented with public monitoring for private schools, or private school vouchers combined with public monitoring for public schools.[27] Column 7 of Table 6 and Fig. 5 illustrate one such combination — vouchers for $3500 coupled with very intense public monitoring for public school (assuming a very low unit cost of monitoring). To facilitate comparisons, this policy requires an income tax rate of 0.12, same as universal high vouchers (column 3) and very low cost, high-intensity monitoring (column 6).

At the same fiscal cost as these alternatives, the policy combination delivers achievement gains for a greater proportion of the population. Although the public school still loses households to private schools because of the voucher, effort in public school rises because of public monitoring. This, in turn, keeps more households in public school and prevents the sudden decline of peer quality. Moreover, on average students receive greater school effort than in any of the voucher or public monitoring policies presented in the paper, all of which have at least as high a fiscal cost. Nonetheless, the intense public monitoring crowds out private monitoring in the public school relative to the benchmark equilibrium.

The inferiority of single tools relative to a combination is illustrated by the voucher program in Chile (Hsieh and Urquiola, 2006). Despite being decades-old, this program has not lifted achievement significantly. In Chile, private schools have not been subject to public monitoring, and some voucher users may not have monitored the schools either. Current efforts to revamp the program in Chile include tighter public monitoring of private schools (Lara et al., 2009), thus recognizing the need to combine policy tools.[28]

[27] Neal (2009) argues in favor of policy combinations on the grounds that when households can exercise school choice, they have greater incentives to monitor the school.

[28] Since most voucher programs draw upon excess capacity in existing private schools, voucher users often join schools where parents are active monitors. The Milwaukee voucher program is the only program in the US that has spurred substantial entry of new schools to serve voucher students, most of whom presumably have high monitoring costs. The case of a few unscrupulous new entrants has contributed to the recent implementation of extensive public regulation for the program (see http://www.schoolinfosystem.org/pdf/2010/02/2010VoucherBrief.pdf).

Table 7
Household preferences over policy parameters.

Parameters of choice	Monitoring cost (γ) (1)	Public school households			Private school households			Fraction public school (8)	Distribution depicted in Fig. 6? (9)
		e^{pub} (2)	X (3)	m_0 (4)	e^{pub} (5)	X (6)	m_0 (7)		
1. None	n/a	0.66	$7000	0	0.66	$7000	0	0.84	
2. e^{pub}	n/a	***0.85***	$7000	0	***≤0.20***	$7000	0	0.60	Yes
3. e^{pub}, X	n/a	***0.65***	***$4000***	0	***≤0.20***	***$1000***	0	0.60	Yes
4. m_0	$\gamma=0.01$	0.66	$7000	***1.7***	0.66	$7000	***0***	0.88	
5. m_0	$\gamma=0.03$	0.66	$7000	***0.4***	0.66	$7000	***0***	0.88	
6. m_0	$\gamma=0.05$	0.66	$7000	***0.3***	0.66	$7000	***0***	0.84	
7. m_0	$\gamma\geq0.1$	0.66	$7000	***0***	0.66	$7000	***0***	0.84	
8. e^{pub}, m_0	$\gamma=0.01$	***0.80***	$7000	***0.85***	***≤0.20***	$7000	***0***	0.60	Yes
9. e^{pub}, m_0	$\gamma=0.03$	***0.85***	$7000	***0.05***	***≤0.20***	$7000	***0***	0.60	Yes
10. e^{pub}, m_0	$\gamma=0.05$	***0.85***	$7000	***0.05***	***≤0.20***	$7000	***0***	0.60	Yes
11. e^{pub}, m_0	$\gamma\geq0.1$	***0.85***	$7000	***0***	***≤0.20***	$7000	***0***	0.60	Yes
12. e^{pub}, X, m_0	$\gamma=0.01$	***0.60***	***$4000***	***1.20***	***≤0.20***	***$1000***	***0***	0.60	Yes
13. e^{pub}, X, m_0	$\gamma=0.03$	***0.60***	***$3500***	***0.15***	***≤0.20***	***$1000***	***0***	0.60	Yes
14. e^{pub}, X, m_0	$\gamma=0.05$	***0.60***	***$3500***	***0.15***	***≤0.20***	***$1000***	***0***	0.60	Yes
15. e^{pub}, X, m_0	$\gamma\geq0.1$	***0.65***	***$4000***	***0***	***≤0.20***	***$1000***	***0***	0.60	Yes

Note: "Fraction public school" is the fraction of households that prefers public schools under its preferred parameter combination. Row 1 corresponds to the benchmark equilibrium. In each row, values in bold and italics correspond to cases in which households are allowed to choose the corresponding policy parameter, and the remaining values are from the benchmark equilibrium. For instance, row 2 corresponds to the case in which households are allowed to choose e^{pub} only. In this case, $e^{pub}=0.85$ is preferred by public school households, $e^{pub}\leq0.2$ is preferred by private school households, and X and m are equal to $7000 and 0 respectively. $\gamma<0.10$ represents very low monitoring costs; $\gamma\geq0.10$ represents low, moderate or high costs.

Another combination of markets and regulations is currently illustrated in the U.S. by charter schools, which provide households with market-based school choices yet are regulated by chartering agencies. These agencies oversee charter operations and occasionally close charters for academic or financial reasons.

The second lesson from our analysis is the following. Since the answer to moral hazard is monitoring, a particularly effective policy may be to lower monitoring costs for households, particularly those at the bottom of the distribution. Our model views these costs as given, yet in reality they may be a function of elements such as the availability and quality of school-related information. Lower private monitoring costs would reduce the need for public monitoring and would make market-based mechanisms – which rely on private monitoring – more attractive.

5.4. Household preferences over policy parameters

As we have seen thus far, the extent of moral hazard, the intensity of private monitoring, and the resulting household sorting across schools are heavily influenced by the public school policy parameters e^{pub} (effort standard), X (funding per student), and m_0 (public monitoring intensity). Thus, whoever determines the value of these parameters exercises an influential role. Since in the real world these parameters might reflect household preferences, perhaps expressed through voting, it is of interest to study household preferences over these parameters. Given that some parameters may be harder to alter than others, at least in the short run, we have explored preferences over e^{pub}, (e^{pub}, X) pairs, m_0, (e^{pub}, m_0) pairs, and (e^{pub}, X, m_0) triplets.[29]

Table 7 shows the outcome of this exercise. To facilitate comparisons, row 1 presents the benchmark equilibrium, computed for the current e^{pub} of 0.66, the observed X and $m_0=0$. A theme in this exercise is the presence of two most preferred bundles — one preferred by households who choose public school, and the other preferred by households who choose private schools. Hence, columns 2–4 and 5–7 characterize the bundle preferred by public and private school households, respectively, and column 8 shows the fraction of households who prefer public school. In other words, columns 2–4 and 5–7 contain information on how households might vote in a poll over policy parameters, and column 8 shows the fraction that would support the bundle preferred by public school households. In this spirit, in what follows we refer to bundles as "chosen" or "preferred" in that hypothetical poll. In addition, Fig. 6 displays the distribution of preferences among households that prevails for most instances of this exercise, as indicated in column 9.

5.4.1. Preferences over effort standard

As row 2 shows, public school households prefer $e^{pub}=0.85$, whereas private school households prefer $e^{pub}\leq0.20$. Illustrating a theme of this analysis, the e^{pub} preferred by public school households is that which minimizes public school profits and maximizes public school effort rate (see Fig. 1), whereas the e^{pub} favored by private school households minimize public school attendance and hence the tax burden. In our calibrated model, the majority of households prefer an e^{pub} of 0.85 (see Fig. 6). Note that is the e^{pub} that would be established by a policymaker interested in minimizing rents (see Section 4.2).

5.4.2. Preferences over effort standard and funding

When households are allowed to choose both X and e^{pub} (row 3), two preferred bundles emerge: ($e^{pub}=0.65$, $X=\$4000$) and ($e^{pub}<=0.2$, $X=\$1000$), preferred by the same households that prefer $e^{pub}=0.85$ and $e^{pub}\leq=0.20$ in the previous instance,

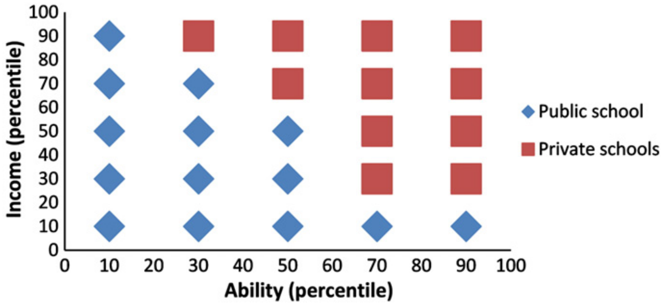

Fig. 6. Household preferences over policy parameters. Note: all the household types depicted as "public school" prefer one set of policy parameters, and all the household types depicted as "private schools" prefer another. See the text and Table 7 for the specific sets they prefer.

[29] To study preferences over e^{pub}, we computed the equilibrium for values of e^{pub} between 0 and 1.2. For each household, we found the value of e^{pub} corresponding to the equilibrium in which the household attains its highest utility — that is, the household's preferred e^{pub}. In a similar fashion we studied preferences over the other policy parameters or combinations thereof. When studying preferences over X, we computed the equilibrium for values of X between $1000 and $1200, thus eliminating zero funding for public schools as an option for households.

respectively. Thus, when allowed to choose funding as well as effort standard, households that prefer public school choose a lower effort standard yet also a concomitantly lower funding relative to when they can only choose the effort standard. In both cases the outcome is greater public school effort and lower public school rent.

These preferences convey an interesting message. If one believes that in reality funding can be hardly altered by households, then the fact that the current effort standard is lower than households' preferred standard suggests that public schools may bias the standard downward. If, on the other hand, one believes that in reality households can affect both funding and effort standard, then the fact that the current effort standard is almost the same as households' preferred level yet funding is higher suggests that public schools may bias funding upward. Both stories point to potential bargaining power on the part of public schools.

5.4.3. Preferences over public monitoring

Row 4 summarizes household preferences for m_0 when its cost is very low. Most households prefer intense public monitoring in this case; only private school households prefer no monitoring. Although preferences over m_0 are similar for slightly higher costs, the monitoring intensity preferred by the majority falls rapidly and becomes zero (see rows 5–7). This finding persists even when households can choose other parameters in addition to m_0 and is consistent with Table 5, which shows that no household gains welfare by having public monitoring unless its cost is very low.

5.4.4. Preferences over effort standard and public monitoring

Since raising the effort standard and introducing public monitoring are two options that raise public school effort, households may view them as substitutes. Hence, we studied preferences for (e^{pub}, m_0) combinations for alternative costs of public monitoring (rows 8–11). When households can choose m_0 in addition to e^{pub} and public monitoring costs are very low, they choose a slightly lower e^{pub} and compensate with high m_0 (compare row 8 with row 2). Similarly, when they can choose e^{pub} in addition to m_0 and public monitoring costs are very low, they support higher e^{pub} but lower m_0 (compare rows 8–10 with rows 4–6). In other words, households are indeed willing to trade effort standard for public monitoring. Private school households prefer $m_0 = 0$ regardless of its cost.

5.4.5. Preferences over effort standard, public monitoring and funding

Rows 12–15 summarize preferences when households are allowed to choose all policy parameters — perhaps in the long run, when short-term political and/or contractual rigidities disappear. When households can choose X in addition to e^{pub} and m_0, they choose lower e^{pub} and lower X. Once again they prefer a lower standard in exchange for greater consumption, and they compensate for the lower standard with higher public monitoring.

A few lessons emerge from this analysis. First, household preferences over policy parameters are split along the lines of school choice. Households that prefer private schools choose policy parameters that minimize public school attendance and hence the fiscal burden, whereas households that prefer public school choose parameters that maximize public school effort and minimize rents. These households view public monitoring and effort standard as substitutes and are willing to optimally lower one while raising the other. Importantly, these households are willing to use public monitoring only when its cost is low. Second, aggregate preferences are sensitive to the demographic balance in the population. For instance, in an economy comprised mostly of high-ability, high-income households the majority might attend public school (where the peer quality would be high) and thus might choose higher values of e^{pub} and X than those in our baseline. Third, the current effort standard is below the level that households would choose and the current funding is above. In other words, at their current values public school policy parameters seem to better reflect the preferences of public schools than those of parents.[30] To the extent that these findings are informative of the policymaker's preferences, they cast additional doubt on the effectiveness of public monitoring, which hinges critically on setting appropriate values for policy parameters.

6. Concluding remarks

In this paper we have focused on the information asymmetry among the policymaker, households, and schools and its role on academic under achievement. We have built a moral hazard model of school effort and embedded it within an equilibrium model in which households sort across schools and exert learning and monitoring efforts. From a policy perspective, we have focused on policies to raise achievement and on whether they address the distortions created by the underlying information frictions. Our analysis highlights the fact that neither market- nor regulation-based mechanisms alone may solve the underachievement problem. None is better for all households, and since moral hazard interacts with equilibrium choices, each has unintended consequences undermining its effectiveness. In the contest between regulation- and market-based mechanisms, the winner seems to be a thoughtful combination of both.

Our analysis also indicates the importance of setting policy parameters at the socially optimal levels. The current level of parameters better reflects the preferences of public schools than those of households. If this is at all indicative of the preferences of the policymaker and of kind of public monitoring that the policymaker would conduct, then the most effective channel to mitigate moral hazard in schools may be policies that encourage *private* monitoring — for instance, by lowering private monitoring costs for households.

We view our model as a building block to study information-related problems in education. Designing and evaluating more specific policies would require an extension of our model to accommodate for measurement of school and teacher value added, teacher heterogeneity and teacher sorting, and incentives induced by measurement problems. While many of these problems have been analyzed in managerial settings (e.g. Holmstrom and Milgrom, 1991; Liang, 2004; Dutta and Reichelstein, 2005), the education context is quite unique because of the interaction between household and school choices, the nature of the achievement production, and the unintended implications of large-scale policies. By developing the first equilibrium model of education provision with information asymmetries we hope to have provided an initial framework to handle those issues.

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[30] Fischel (2009) examines social capital in school districts and points out that parental influence on governance is lower in large-city districts, where other interest groups play a greater role. This reduces parents' opportunities to interact with other parents and erodes local social capital. In our model, this insight is captured by policy parameters that mostly reflect public school's preferences and thus aggravate moral hazard, making the public school incapable of attracting the very households that would contribute to "social capital" and monitor the school.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at doi:10.1016/j.jpubeco.2011.07.012.

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