Negative Externalities in Day Care: Optimal Tax Policy Response*

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Abstract

Systematic pediatric evidence shows that the morbidity rates for children in day care are increasing in the group size. Sick children are usually cared for at home by parents. This creates a negative externality of parents' labor force participation. The social optimum implies lower group size than the non-intervention market equilibrium. We study the optimal tax policy. The cost of labor force participation should be increased. This can be done by either or both a *tax* on day care services and a home care *allowance*. The cost of providing day care should be decreased by a *subsidy* to entrepreneurs running day care centers. This policy will decrease the group size. It is, however, not necessarily the case that this will decrease labor force participation. We also study the optimal regulation of the group size when the optimal tax policy is not possible to implement.

JEL: D1, D62, H23, I12, J13 and J21.

Keywords: negative externalities, infections, day care centers, optimal taxation, Pigouvian taxes, regulation

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1 Introduction

Most working parents have probably faced the following situation: The child is ill in the morning and must stay at home instead of attending the regular out–of–home day care. Parents are aware of the financial consequences of this; while attending the child at home one parent will probably lose some income.[1] The loss will depend on, i.a., the availability of social insurance and alternative forms of child care.[2] Such costs are taken into account when parents decide whether or not to participate in the labor force.[3] There may, however, also be social cost associated with participation in the labor force. We focus on one particular social cost. Children attending day care centers are ill more often than children cared for in other ways:[4]

> "Children in child care centers, especially those younger than 36 months of age, appear to have greater numbers of reported illnesses and greater numbers of illness and bed days than children cared for in their own homes. These findings persist in multiple studies, despite differences in study design, method of collecting the major variables, and the location of the study."
> Landis and Chang (1991, p. 710)

The medical reason for this is that children are in close contact, they use the same toys, the same hygienical facilities, etc. (Laborde et al., 1994). Hutchinson (1992) reviews several studies. They show that the probability of infectious organism transmission is lower if day care is organized in smaller groups. Transmission is particularly low if children are cared for in same–age groups. It does not matter, on the other hand, if day care centers are large or small.[5] Collet et al. (1994a,b), however, report that the infection risk is higher in small day care centers than in child care at home. An explanation for this may be that children are

[1] In general not only parents but also older siblings may take care of a sick child. As an example Pitt and Rosenzweig (1990) studies how child morbidity affects the allocation of time within the family. This may give rise to difference in human capital accumulation between siblings of different sexes.

[2] In some countries alternative forms of care exist for sick children; see for instance Landis and Chang (1991); Giebink (1993); Giebink et al. (1994).

[3] Other private costs are expenditure on medical care, medicine etc.

[4] See Uldall (1990), Landis and Chang (1991) and the references quoted therein, Hutchinson (1992) and references quoted therein, Möttönen and Uhari (1992), Osterholm et al. (1992), references quoted in Reves and Pickering (1992), Thacker et al. (1992), Reves et al. (1993), Jorm and Capon (1994), Louhiala et al. (1995), and Holmes et al. (1996). Barros et al. (1999) is an exception in reporting that group size does not matter for the incidence of respiratory infections.

[5] Hutchinson (1992) recognizes other ways of infection control. One is specialization of certain functions of the staff, e.g., changing diapers versus preparing food.

in larger groups in small day care centers compared to at home. At the same time, the risk is lower in large day care centers than in small. The reason may be that children often are divided into homogeneous age groups in large day care centers. Also, larger day care centers are more often built specially for their purpose. The problems of hygiene has, therefore, received special attention during the design.[6]

There may, however, also exist positive effects of illness. Reves et al. (1993) and Collet et al. (1994a,b) report that longer time in day care increases the protection against repeated infections. This is the result even after controlling for age. Early infections may protect against allergies in later life. Krämer et al. (1999) find that children who start attending day care centers at a young age have fewer allergies later on in life. The comparison group are children who started at an older age. These findings, however, only apply for children with no siblings.

In this paper we are concerned with these indirect effects of higher risks to be ill for children attending out–of–home day care. Our main assumption is that increased group size in day care implies a higher risk that a child will become ill. The assumption is based on the evidence reported above. If parental labor force participation increases, *ceteris paribus*, the average number of children in each group in the day care centers will increase. This will increase the risk for each child to become ill. This means (on the average) that increased parental labor force participation only is associated with a negative externality. On the other hand, if the number of day care centers increases, *ceteris paribus*, the number of groups in day care will increase. This will decrease the number of children in each group. The risk of becoming ill will decrease for each child.

We also assume that parents and day care center entrepreneurs neglect these indirect effects, as is standard in neoclassical microeconomic models. This means, on the one hand, that labor force participation is associated with a negative externality. On the other hand, the reducing the group size at day care centers is associated with a positive externality. Our focus is on the character of the optimal Pigouvian taxes and subsidies that are implied by the social optimum. In our model, however, the Pigouvian solution and the second best tax solution coincide.

Our first main result concerns labor force participation in the social optimum. The cost of labor force participation for the marginal participating parental household should be raised above the private cost of participation. This will make households take the negative externality that their participation causes into ac-

[6]Cordell et al. (1997) reports higher morbidity rates for day care homes (12 or less children) than for day care centers (more than 12 children). There is, however, no control for group size within day care centers. Data are based on reports from the day care facility. It is likely that policies regarding keeping mildly ill children at home differs between the two day care categories. This affects not only reported but also actual morbidity rates. Parents of illness–prone children may tend to enroll at day care centers which may not require such children to stay home. This may create a selection bias.

count. Second, the cost of running day care centers should be reduced below the private cost. Entrepreneurs will then take the positive externality of starting a day care center into account. The group size is smaller in the social optimum than the non–intervention market equilibrium, but labor force participation need not be smaller.

The simplest way to implement a policy to reach the social optimum is through a Pigouvian tax on day care services. This is equivalent to a tax on labor force participation in our model. Second, there should be a Pigouvian subsidy for running day care centers. Such a Pigouvian policy will in our model exactly balance the government's budget. It is, however, possible to use any combination of a tax on day care services and a home care allowance. This allowance is only paid to households not participating in the labor force. The only requirement is that the cost of participating in the labor force reaches the social optimum. This policy will decrease the group size. It is, however, not necessarily the case that labor force participation will decrease as the number of day care centers may increase.

These results can be compared with traditional economic arguments for the *subsidizing or publicly providing* day care: Several contributions have studied the relation between availability of day care and parents decision to enter the labor force. Bergstrom and Blomquist (1996) model the increase in the tax base that higher labor force participation of parents leads to. Increased labor force participation may also reduce equilibrium wages, as modelled by Lundholm and Ohlsson (1998). These papers also analyze the potential conflict between parents and non–parents which is not present in the present paper. Blomquist and Christiansen (1995) focus on the distributional aspects of public provision of good such as day care. In all these contributions some subsidy or public provision is Pareto efficient. These contributions do not, however, study whether the intervention should be directed to the demand or supply side.

Our paper focuses an additional argument for public intervention in the day care market. We conclude that there are reasons for giving households incentives to demand less day care. Day care suppliers should be encouraged to reduce group size.

Pediatricians have discussed how to deal with the problems created by the increased illness of children at day care centers. One objective of these measures is to solve the problem of day care for sick children. This, however, reduces the cost of labor force participation of parents. Parents may get stronger incentives to participate in the labor force. These measures may, therefore, aggravate the problem of negative externalities. Other courses of action would be to enhance hygiene practices to reduce the incidence of infectious diseases.[7]

[7] See Landis and Chang (1991), Barros et al. (1999), Huskins (2000) and Pönkä et al. (2004).

A second objective is to reduce the spread of the infectious diseases. This reduces morbidity rates and, therefore, improves social welfare. Measures with this objective concern changes in how day care is produced. This type of measures may, therefore, be more in line with the economic conclusions of this paper.

The paper continues with Section 2 that introduces the model. It also describes the labor force participation decision and the decision to run day care centers. The social optimum is discussed in Section 3. In Section 4 we interpret this optimum in terms of a structure of an optimal (Pigouvian) policy. The second best policies are discussed in Section 5. Section 6 concludes.

2 Model

2.1 The supply of day care

Consider price taking entrepreneurs who differ in their ability to run day care centers efficiently. This ability is measured by a fixed cost parameter $\gamma \in [0, \infty)$. This fixed cost represents the alternative cost, in time or financial resources, for entrepreneurs to start the day care center. Day care entrepreneurs own the capital, human or financial, to make this investment. The distribution of fixed costs is described by the cumulative distribution function $R : [0, \infty) \to [0, 1]$ defined by $R(\gamma)$. We assume that R is continuously differentiable and strictly increasing on its entire support. This means that R has a density function r such that $r(\gamma) > 0$ $\forall \gamma \in [0, \infty)$. Entrepreneurs will choose day care capacity g (i.e., the number of children at their day care center) to maximize profits π. There is only one group at each day care center. Capacity will, therefore, equal group size g. Profits are given by[8]

$$\pi = \begin{cases} 0 & \text{if } g = 0 \text{ and} \\ \upsilon_p g - \frac{1}{2}g^2 - \gamma & \text{if } g > 0, \end{cases} \tag{1}$$

where υ_p is the producer price for day care for one child, $\upsilon_p g$ is total revenues at capacity g, and $\frac{1}{2}g^2$ is the variable cost at capacity g. This means that the variable cost depends on the group size for which the day care center is designed, not the number of children actually attending day care.

Let g^* be the profit maximizing choice given that some day care is produced. The first order condition is $g^* = \upsilon_p$. The profit function is $\frac{1}{2}\upsilon_p^2 - \gamma$ for entrepreneurs

[8] In reality there may be a distinction between out–of–home day care and no–nanny day care (i.e., a single person cares for a child outside the home). In this model we make no distinction between the two. We focus on the group size in day care; i.e., a day care worker takes care of several children in a day care center. Only if there are sufficiently many day care centers, the group size decreases close to nanny day care (or for that case, home day care). The negative externality will then disappear.

who decide to run day care centers. Hence, only the most efficient entrepreneurs will decide to be on the day care market. Let $g(\upsilon_p, \gamma)$ be the profit maximizing day care capacity at the producer price υ_p for entrepreneur γ so that

$$g(\upsilon_p, \gamma) = \begin{cases} 0 & \forall \gamma > \tilde{\gamma} \text{ and} \\ g^* = \upsilon_p & \forall \gamma \leq \tilde{\gamma}, \end{cases} \tag{2}$$

where the cost threshold for entry, $\tilde{\gamma} := \frac{1}{2}\upsilon_p^2$, is given by zero profits for the marginal profit maximizing entrepreneur. $R(\tilde{\gamma})$ entrepreneurs will, therefore, enter the day care market at any given producer price υ_p. Each day care center has the capacity to receive υ_p children. The total supply of day care, at the market price υ_p, can be written as $S(\upsilon_p) := R(\tilde{\gamma})\, g^* = R\left(\frac{1}{2}\upsilon_p^2\right)\upsilon_p$.

2.2 The demand for day care

Consider risk–neutral families with one child in which one spouse works full time. The other spouse either participates in the labor force or stays at home taking care of the child. If the child becomes ill the second spouse stays home temporarily and takes care of the child.[9] If the second spouse does not participate in the labor force he gets utility from staying home with his child. The monetary measure of this utility is $z > 0$.[10] If instead the second spouse participates in the labor force the family earns the income $y \in [0, \infty)$. At the same time there is a loss of $z > 0$.[11]

The distribution of income is described by the cumulative distribution function $F : [0, \infty) \to [0, 1]$ defined by $F(y)$. We assume that F is continuously differentiable and strictly increasing on its entire support. This means that F has the density function f such that $f(y) > 0\ \forall y \in [0, \infty)$.

The family commits itself to purchase full time day care service for the child if the second spouse participates in the labor force. The consumer price of day care is υ_c. Let $x \in \{0, 1\}$, where $x = 1$ denotes that he participates in the labor

[9] We abstract from that in reality there is always some ambiguity whether the child is ill or not. Even sick children may in reality attend day care. The day care center may have an economic incentive to provide day care for a child even if the child has an acute illness. We also abstract from the possibility that parents may become ill.

[10] We model the second spouse's choice as an either/or choice. Hence, we abstract from the possibility of part time job, part time home day care. This means that we abstract from the possibility that the externality is heterogeneous over households. However, given all other assumptions of the model (e.g., linear utility and a fixed cost for labor force participation) the second spouse would always choose either full time home day care or full time work even if it would be possible to choose a mix. Part time work under a day care constraint, although studying different problems, is analyzed by Lundholm and Ohlsson (1998, 2002).

[11] Alternatively, therefore, $z > 0$ can be interpreted as a fixed real cost of labor force participation.

force and $x = 0$ that he does not participate. The payoff of the labor participation decision is described by a function $U : \{0, 1\} \to \mathbb{R}$ defined by

$$U(x) = \begin{cases} z & \text{if } x = 0 \\ py - \upsilon_c & \text{if } x = 1, \end{cases} \tag{3}$$

where p is the probability that the child is well. One should note that this means that income is reduced due to work absence when the child is sick, whereas the day care fee is not.

Our main assumption is that this probability is determined by the average group size in day care g. The group size is defined as the ratio between the total number of children in day care and the total number of day care centers. We make the following assumption regarding the probability:[12]

Assumption 1. *The probability p that the child is well is a function $p : [1, \infty) \to [0, 1]$ defined by $p(g)$ such that $p' < 0$, $p(1) = \overline{p}$ and $\lim_{g\to\infty} p(g) = 0$.*

Each household has to make its decision given its expectation of the group size, g^e. We assume that this expectation is common to all households. A household with income y will choose whatever alternative, $x(y)$, that maximizes its payoff given its expectation g^e; i.e.,

$$x(y) = \begin{cases} 0 & \text{if } p(g^e)y - \upsilon_c < z \text{ and} \\ 1 & \text{if } p(g^e)y - \upsilon_c \geq z. \end{cases} \tag{4}$$

The expected income $p(g^e)y$ is strictly increasing in y. There exists a unique, finite and strictly positive income threshold for labor force participation for every probability $p(g^e) \in (0, 1]$. This threshold, $\tilde{y}(g^e, \upsilon_c + z)$, is defined by

$$p(g^e)\tilde{y} - \upsilon_c - z = 0, \tag{5}$$

such that all households with income below $\tilde{y}(g^e, \upsilon_c + z)$ will not participate in the labor force. All household with higher income than $\tilde{y}(g^e, \upsilon_c + z)$ will participate in the labor force. In the case of $p(g^e) \to 0$ then $\tilde{y} \to \infty$ by Assumption 1. If $p(g^e) = 1$ then $\tilde{y} = z + \upsilon_c$. In the former case the share of households $F(\upsilon_c + z)$ will not participate in the labor force. Therefore, threshold income is a function $\tilde{y} : [0, \infty) \to [\upsilon_c + z, \infty)$, defined by $\tilde{y}(g^e, \upsilon_c + z)$.

The demand for day care, given the consumer price υ_c and expected group size g^e, is

$$D(g^e, \upsilon_c + z) = 1 - F(\tilde{y}) = 1 - F\left(\frac{\upsilon_c + z}{p(g^e)}\right).$$

[12]One should note that the probability that the child is sick, i.e., $1 - p$, is independent of the number of individuals carrying the disease.

It follows from equation (5) and Assumption 1 that a unique rational expectation regarding group size exists. Hence

$$g^e = g^* = \upsilon_p, \tag{6}$$

taking the first order condition the profit maximizing entrepreneurs into account. The demand for day care will, therefore, be

$$D(\upsilon_p, \upsilon_c + z) = 1 - F\left(\frac{\upsilon_c + z}{p(\upsilon_p)}\right).$$

2.3 Equilibrium in the day care market

Equilibrium in the day care market is given by the market clearing condition. The quantity demanded, given the consumer and producer prices, must equal the quantity supplied, given the producer price. Putting the different parts together reveals that we have a model with three equations. The system is

$$1 - F(\tilde{y}) = R(\tilde{\gamma})\upsilon_p, \tag{7a}$$

$$p(\upsilon_p)\tilde{y} - \upsilon_c - z = 0, \tag{7b}$$

$$\frac{1}{2}\upsilon_p^2 - \tilde{\gamma} = 0, \tag{7c}$$

i.e., the day care market equilibrium condition (7a), the indifference condition for the marginal household (7b), and the zero profit condition for the marginal entrepreneur (7c).[13] Hence we have a system with three equations and four endogenous variables $(\tilde{y}, \tilde{\gamma}, \upsilon_p, \upsilon_c)$. It remains to specify how producer and consumer prices are related. Once this is added, the number of equations equals the number of endogenous variables.

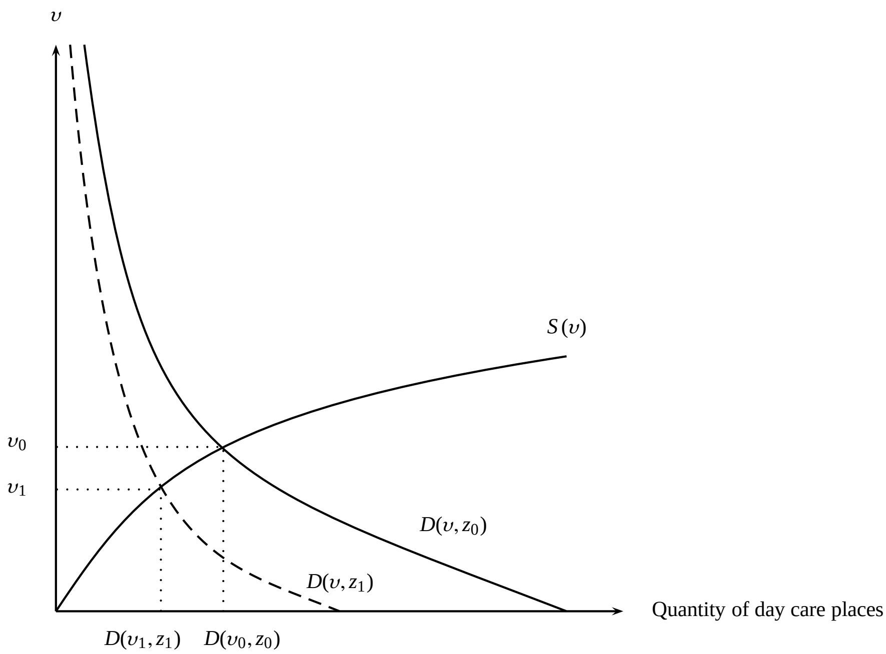
Suppose first that there is no difference between consumer and producer prices $(\upsilon_c = \upsilon_p := \upsilon)$. The system now contains three endogenous variables and three equations. It is well–defined. We can collapse it into one equilibrium condition which can solved for the equilibrium price υ:

$$D(\upsilon, z) = S(\upsilon) \quad \Longleftrightarrow \quad 1 - F\left(\frac{\upsilon + z}{p(\upsilon)}\right) = R\left(\frac{1}{2}\upsilon^2\right)\upsilon. \tag{8}$$

There is a positive supply relation between the number of places in day care and the (producer) price of day care. There will be no supply if $\upsilon = 0$. Hence, we

[13]Note that (7a) on its LHS has parental labor force participation, which is the same as parental demand for day care places and on its RHS has the total supply of day care places; i.e., every second spouse participating in the labor force demands one day care place for the child of this family, whereas every day care entrepreneur corresponds to υ_p day care places.

Figure 1: Non–intervention equilibrium in the day care market ($z_1 > z_0$).



have $\frac{\partial S}{\partial \upsilon} = R(\tilde{\gamma}) + r(\tilde{\gamma})\upsilon > 0$ with $S(0) = 0$. Also, there is a negative demand relationship between the number of children in day care and the price of day care, $\frac{\partial D}{\partial \upsilon} = -f(\tilde{y})\frac{\partial \tilde{y}}{\partial \upsilon} < 0$. If $\upsilon \to \infty$ there will be no demand for child care, that is $D(\upsilon, z) \to 0$. Also, when $\upsilon = 0$ it follows from (5) that $\tilde{y} = \upsilon + z > 0$. Hence, we will always have a unique, strictly positive and finite equilibrium price. The monetary measure of the utility of staying home with the child $z > 0$ has a negative impact on labor force participation. This means that an increase in this income reduces the demand for day care, $\frac{\partial D}{\partial z} < 0$.

It is instructive to draw a figure in the quantity–price space; see Figure 1. This figure is drawn under the assumption that the distributions F and R are uniform. Relaxing this assumption the demand (supply) function will still have a (negative) positive slope, but they need not be concave (convex) everywhere. The equilibrium price for day care is determined by the equilibrium condition $D(\upsilon_0, z_0) = S(\upsilon_0)$, where υ_0 denotes the equilibrium price. The only exogenous variable that will change the equilibrium is the home utility value z. If this value increases, the equilibrium price and quantity be reduced. Not participating in the labor force becomes more attractive. This decreases demand for day care. This is illustrated in Figure 1 where z_0 increases to z_1. This results in the dashed demand $D(\upsilon, z_1)$ and the lower equilibrium price υ_1.

Suppose instead that consumer and producer prices may differ. This may, for instance, be because there exists a tax or transfer which is specific or *ad valorem*. We can conceptually think of the producer price υ_p as an exogenous variable whereas the consumer price υ_c is endogenous. The model can be reduced to a two–variable system with υ_c and $\tilde{\gamma}$ as endogenous variables. It consists of the equilibrium condition (7a) and the first order condition for the marginal household (7b). Suppose that we differentiate the system with respect to the producer price υ_p. This means that we ask which labor force participation and consumer price are consistent with any given point on the day care supply curve. The equilibrium condition yields a negative trade–off between threshold income and the producer price. It is

$$\frac{d\tilde{y}}{d\upsilon_p} = -\frac{1}{f(\tilde{y})}\left(R(\tilde{\gamma}) + r\upsilon_p^2\right) < 0. \tag{9}$$

where we have suppressed any indices indicating that we are dealing with equilibrium prices and quantities. If the producer price increases more day care will be supplied. It is necessary for equilibrium that the threshold income decreases so that the demand keeps up with the supply.

The trade–off (9) can be used when solving the first order condition for the marginal household for the trade–off between consumer and producer prices. It is

$$\frac{d\upsilon_c}{d\upsilon_p} = -\frac{p}{f(\tilde{y})}\left(R(\tilde{\gamma}) + r\upsilon_p^2\right) + p'\tilde{y} < 0. \tag{10}$$

This trade–off is also negative. If the producer price increases it is necessary for equilibrium that the consumer price decreases. A lower consumer price will increase demand, matching the increased supply that the higher producer price will lead to.

3 Social optimum

We now study the social optimum of the model. This means that we assume that the policy maker can control all relevant quantities in the economy. Therefore, there are no decentralized decisions coordinated by (from the point of view of households and entrepreneurs) given equilibrium prices. We assume that the policy maker is utilitarian. Since utilities are linear in income an explicit introduction of prices, and as a consequence of pure profits, would only mean that households' payment of day care would net out the revenues of entrepreneurs and we would arrive at exactly the same welfare expression.

The utilitarian policy maker's measure of social welfare has three components. First, there is the utility of own child care. Second, there is the social value produced by second spouses who participate on the labor market. This value is assumed to correspond to their labor income. Third, there is the social cost of providing the day care that makes it possible for second spouses to work. Social welfare W is measured by

$$W(\tilde{y},\tilde{\gamma},g) := \int_0^{\tilde{y}} z dF(y) + \int_{\tilde{y}}^{\infty} p(g)\, y dF(y) - \int_0^{\tilde{\gamma}} \left(\frac{1}{2}g^2 + \gamma\right) dR(\gamma). \tag{11}$$

In a first best situation, the policy maker chooses three quantities to maximize social welfare. First, the policy maker chooses the number of households that participate on the labor market. This is done by choosing the threshold income $\tilde{y}$. The second quantity is the number of entrepreneurs (day care centers). This is chosen be deciding the cost threshold $\tilde{\gamma}$. Finally, the policy maker decides the group size g. This is done subject to the equilibrium condition $E(\tilde{y},\tilde{\gamma},g) := (1-F(\tilde{y})) - R(\tilde{\gamma})g = 0$. The Lagrangian function to this problem is

$$L(\tilde{y},\tilde{\gamma},g,\lambda) = W(\tilde{y},\tilde{\gamma},g) - \lambda E(\tilde{y},\tilde{\gamma},g), \tag{12}$$

where $\lambda > 0$ is the Lagrange multiplier. Both cumulative distribution functions R and F are continuous and strictly increasing. This means that an interior solution's first order conditions, after some simple manipulations, can be written

$$\frac{\partial L}{\partial \tilde{y}} = 0 \implies p(g^s)\tilde{y}^s - z - \lambda^s = 0, \tag{13a}$$

$$\frac{\partial L}{\partial \tilde{\gamma}} = 0 \implies \frac{1}{2}(g^s)^2 + \tilde{\gamma}^s - \lambda^s g^s = 0, \tag{13b}$$

$$\frac{\partial L}{\partial g} = 0 \implies \int_{\tilde{y}^s}^{\infty} p'(g^s)\, y dF(y) - R(\tilde{\gamma}^s)\, g^s + \lambda^s R(\tilde{\gamma}^s) = 0, \tag{13c}$$

$$\frac{\partial L}{\partial \lambda} = 0 \implies (1-F(\tilde{y})) - R(\tilde{\gamma})g = 0, \tag{13d}$$

where the Lagrange multiplier λ^s is interpreted as the shadow price of day care at the social optimum. From (13c) we get

$$\lambda^s = -\frac{\int_{\tilde{y}^s}^{\infty} p'(g^s)\, y dF(y)}{R(\tilde{\gamma}^s)} + g^s. \tag{14}$$

The first right hand side term measures the total income loss that the negative externality causes when the group size is increased marginally divided by the number of entrepreneurs. The second term, g^s, is the marginal private cost of production for day care. The shadow price of day care at the social optimum can be written as

$$\lambda^s := g^s(1+m), \tag{15}$$

where m is a monetary measure of the negative externality for the average household participating on the labor market. This is the average loss of income per child in day care when group size is increased. It may (using the market equilibrium condition) be defined by

$$m := -p'(g^s) \frac{\int_{\tilde{y}^s}^{\infty} y dF(y)}{1 - F(\tilde{y}^s)}, \tag{16}$$

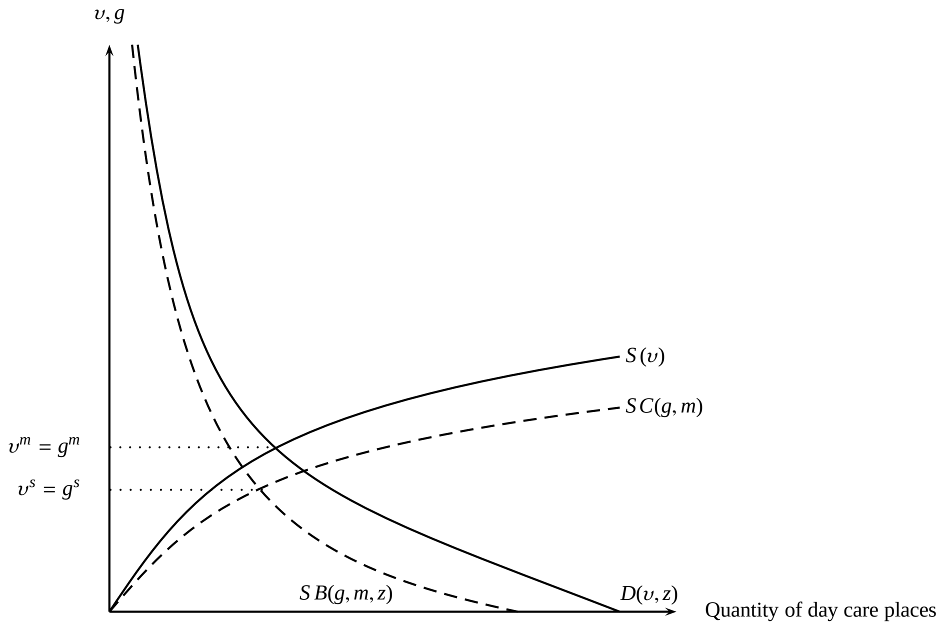
i.e., the increased probability of a sick child due to larger group size of an additional second spouse entering the labor market times the average income of households where the second spouse is in the labor force. The average monetary loss per child can be interpreted as a markup on the marginal private cost that gives the marginal social cost of day care.

The private marginal cost and benefits of the some given group size g are defined by the private supply $S(g) = R\left(\frac{1}{2}g^2\right)g$ and the private demand $D(g, g + z) = 1 - F\left(\frac{g+z}{p(g)}\right)$, where consumer and producer prices are replaced by group size. Given the first order condition for the social optimum and the definition of the monetary measure of the negative externality m we can now define the social marginal cost and benefits of some given group size g.

To do this we need, for some given group size g, the socially optimal cut–off cost for entrepreneurs and the socially optimal cut–off income for households. The first order conditions (13b) and (13c) related to the supply of day care can be manipulated to yield socially optimal cut–off cost $\tilde{\gamma} = \left(\frac{1}{2} + m\right)g^2$ for arbitrary group sizes. The first order conditions (13a), related to the demand for day care, and (13c) can be manipulated to yield the socially optimal cut–off income $\tilde{y} = \frac{(1+m)g+z}{p(g)}$ for arbitrary group size.

Inserted into the supply and demand functions we get the social marginal cost and benefits for arbitrary group sizes; i.e., the second and first terms of the left–hand side of (13d). Then the social marginal cost of supplying day care is $SC(g) := R\left((\frac{1}{2} + m)g^2\right)g$, which is increasing in g. Also, as long as there is an externality cost the social cost schedule will be below the supply schedule in the quantity–group size space because the social cost will, for some given group size, always be evaluated at cut–off income which is mg^2 units higher than the level at which private supply is evaluated given the same group size; see Figure 2. The marginal social benefit of providing day care can be defined as $SB(g, g + z) := 1 - F\left(\frac{(1+m)g+z}{p(g)}\right)$ for arbitrary group sizes. As long as there is an externality cost, the social benefit schedule will be below the demand schedule in the quantity–group size space because, for some given group size, the social benefit is evaluated at a cut–off income which is $\frac{mg}{p(g)}$ units higher than the level at which private demand is evaluated given the same group size; see Figure 2. Note

Figure 2: Social optimum and market equilibrium.



that the quantity of day care on the abscissa is total demand/supply of day care places and not the group size.

This means that marginal households and entrepreneurs should behave according to

$$p\,(g^s)\,\tilde{y}^s - z - g^s = mg^s, \tag{17a}$$

$$(1+m)\,(g^s)^2 = \frac{1}{2}\,(g^s)^2 + \tilde{\gamma}^s \tag{17b}$$

which should be compared to (7b) and (7c). The private net benefit of a marginal household participating in the labor force should equal the externality cost of participation in the social optimum. The social benefit of a marginal day care center should equal the marginal private cost. The reduction of externality costs should be included in the social benefits in addition to the revenues of the entrepreneurs.

Figure 2 shows that the social benefit schedule is below the demand schedule and that the social cost schedule is below the supply schedule. This means that the group size in the social optimum is lower than the group size in the non–intervention market equilibrium.

Proposition 1. *The social optimum implies a lower group size compared to the non–intervention market equilibrium.*

Proof. See the Appendix. □

The gain from participating in the labor force must be strictly positive in the social optimum for the marginal household. On contrary this gain is zero in the non–intervention market equilibrium. The marginal household should take the negative externality into account when deciding to participate in the labor force. For this reason, fewer households should participate. The price of day care will, on the other hand, be lower. This will work in opposite direction, more households will participate. The combined effect on labor force participation is, therefore, ambiguous. This is an important feature of the model since it implies that there is no one–to–one relation between the negative externality caused by parental labor force participation and the level of labor force participation.

The firm with the highest fixed cost that supplies on the day market must have costs exceeding market revenues in the social optimum. In the non–intervention market equilibrium profits for the marginal firm are zero. The marginal entrepreneur should take the positive externality that the group size decreases and, therefore, the probability that parents can work is increased. For this reason, more entrepreneurs should run day care centers. The price of day care will, on the other hand, be lower. This will work in opposite direction, fewer entrepreneurs will run day care centers. The combined effect on the number of entrepreneurs and day care centers is, therefore, ambiguous.

Suppose we apply a short term perspective such that the number of day care entrepreneurs is fixed. Then it follows that a reduced group size will reduce the aggregate number of day care places and limit the extent of second spouse labor force particpation which then has to be lower in the social optimum. The model is not dynamic, but when the general equilibrium effects of a flexible supply of day care places is taken into account, then even increased second spouse labor force participation in the social optimum is a possibility.

4 Tax instruments and policy implementation

The optimal solution calls for an increase in the opportunity cost of participating in the labor force for households. It also calls for a decrease in the opportunity cost of running day care centers for entrepreneurs. Increasing the cost for households can be done by introducing a tax on day care services. Another possibility is to introduce a home care allowance in the form of a fixed sum payment to parents who do not participate in the labor force. Decreasing the cost for entrepreneurs can be implemented through subsidy to entrepreneurs who run day care centers. Any such policy implementing the optimal solution is self–enforcing. Only the most productive households participate in the labor force and only the most efficient entrepreneurs run day care centers.

Suppose now that the policy maker chooses to use a tax on day care services τ, an allowance to households not participating in the labor force α, and a subsidy to entrepreneurs running day care centers κ. Equations (7b)–(7c) can now, for an optimal policy solution, be rewritten as

$$p\,(g^s)\,\tilde{y}^s - (1+\tau^s)\upsilon_p^s - z - \alpha^s = 0, \tag{18a}$$

$$\frac{1}{2}\left(\upsilon_p^s\right)^2 + \kappa^s - \tilde{\gamma}^s = 0, \tag{18b}$$

where the producer price satisfies $(1+\tau^s)\upsilon_p^s = \upsilon_c^s$. Combining with (13a)–(13d) and using the fact that $g^s = \upsilon_p^s$ gives us

$$\tau^s + \frac{\alpha^s}{g^s} = m, \tag{19a}$$

$$\kappa^s = m\,(g^s)^2\,. \tag{19b}$$

We can now formulate a result that follows directly from equations (19a) and (19b):

Proposition 2. *The policy $(\tau^s, \alpha^s, \kappa^s)$ that implements the social optimum implies that $\kappa^s > 0$ and that at least one of the pair (τ^s, α^s) is strictly positive.*

The most natural first best policy implementation is, therefore, a tax on marginal households and a subsidy to marginal entrepreneurs, but with no home care allowance. If the tax is reduced, however, introducing a home care allowance, so that (19a) holds, is also consistent with a first best allocation.

But what will be the outcome if all households pay a day care tax and all entrepreneurs receive a subsidy? The policy maker has to handle possible budget surpluses or deficits generated. However, in this model there are no income effects on the households' labor force participation decision. Non–labor income earned by a household does not affect the decision to participate in the labor force. Any tax revenues that a first best policy generates or requires can, therefore, be disposed of or generated through lump sum transactions with all households. This will not change the first order condition for the social optimum. A traditional second best tax problem does, therefore, not exist in this model. Since this policy is the same for all households and entrepreneurs it is reasonable to assume it is feasible.[14]

Let us, therefore, compute the consequences for the public budget of first best policies. Suppose that all households are treated in the same way and that all firms

[14]Below, however, we study how regulating the group size that can be done if such taxes are unfeasible.

also are treated in the same way. Using $g^s = v_p^s$, the budget balance, B, is

$$B := (1 - F(\tilde{y}^s))\, g^s \tau^s - \alpha^s F(\tilde{y}^s) - \kappa^s R(\tilde{\gamma}^s) = -\alpha^s, \tag{20}$$

where the last equality is derived from plugging in the expressions for τ^s and κ^s from (19a) and (19b).

Hence, any policy given by (19a) and (19b) such that $\alpha^s = 0$ implies a balanced budget, i.e., $B = 0$. The most reasonable policy is to tax day care with $\tau^s > 0$ and subsidize day care entrepreneurs with $\kappa^s > 0$. At the same time there is no home care allowance, $\alpha^s = 0$. This policy has the appeal that it also balances the budget. Suppose that a home care allowance $\alpha^s > 0$ is used in a first best policy. The resulting budget deficit can be financed by a lump sum tax on all households equal to α^s. Such a tax will neutralize the effect of the home care allowance for households not participating in the labour force. The tax on day care for participating households is lower compared to an optimal policy without a home care allowance. In addition, however, all households participating in the labor force will have to pay the lump sum tax α^s. Such a balanced budget policy is, however, equivalent to an optimal policy without a home care allowance.

5 Regulation

In our model it does not exist a traditional second best optimal tax problem. We have so far assumed that the public sector has a sufficient number of policy tools to reach the social optimum. But suppose that the taxes and subsidies required by first best are not feasible. It may still be possible for the public sector to improve social welfare by regulating the group size at day care centers. This is clearly a second best policy. The policy maker would prefer to affect households and entrepreneurs independently with two different policy instrument. Here it is assumed that there is only one policy instrument available to affect households and entrepreneurs.

Suppose that the policy maker regulates the group size. Day care entrepreneurs maximize profits. The producer price is, therefore, regulated to equal the group size. The total supply of day care will, in effect, be determined by the zero profit constraint on marginal entrepreneurs. Households are charged a price lower than in the non–intervention market equilibrium. Demand will, therefore, be higher. But there will be not be enough supply to meet this higher demand. Supply will be the limiting factor on the market. It is not possible for all households that want to participate in the labor market to do so. There will be excess demand at the regulation optimum. Day care will have to be rationed. This should be possible as it is very difficult to resell day care services obtained. We assume that day care is allocated to households with high willingness to pay for day care. That is, the same outcome as would be achieved if the policy maker controlled the consumer price. To sum up we assume that

- the policy maker regulates the group size (i.e. picks one point on the supply curve),
- the number of entrepreneurs is determined by the zero profit condition and
- to handle the excess demand for day care existing day care places are allocated to households with the highest willingness to pay.

The cost threshold of entrepreneurs decreases if the regulator decreases the group size, i.e., $-\frac{\partial \tilde{\gamma}}{\partial g} = -g < 0$. Effective demand for day care is determined by supply, technically via the equilibrium condition. Decreased group size, therefore, has to imply lower effective demand and lower labor force participation. This means that the income threshold will increase, i.e., $-\frac{\partial \tilde{y}}{\partial g} = \frac{r(\tilde{\gamma})g^2+R(\tilde{\gamma})}{f(\tilde{y})} > 0$.

Group size is chosen to maximize social welfare given by (11). This is done subject to the market equilibrium condition and the cost threshold condition $\tilde{\gamma} = \frac{1}{2}g^2$. The Lagrangian function to this problem is

$$M(\tilde{y}, \tilde{\gamma}, g, \lambda_1, \lambda_2) = W(\tilde{y}, \tilde{\gamma}, g) - \lambda_1 E(\tilde{y}, \tilde{\gamma}, g) - \lambda_2 \left(\frac{1}{2}g^2 - \tilde{\gamma}\right). \qquad (21)$$

and where the formal decision variables are $\tilde{y}$, $\tilde{\gamma}$, g and λ_i $i = 1, 2$. Note that formally choosing $\tilde{y}$ is equivalent with rationing day care to the highest willingness to pay. Similarly, choosing $\tilde{\gamma}$ subject to the zero profit constraint is equivalent to decentralized decision making among profit maximizing entrepreneurs. The advantage of this approach is that is provide us directly with expressions for the optimal regulatory consumer and producer shadow prices.

An interior solution's first order conditions can after some manipulations be written as

$$\frac{\partial M}{\partial \tilde{y}} = 0 \quad \Longrightarrow \quad p(g^r)\tilde{y}^r - z - \lambda_1^r = 0, \qquad (22a)$$

$$\frac{\partial M}{\partial \tilde{\gamma}} = 0 \quad \Longrightarrow \quad -\left(\frac{1}{2}(g^r)^2 + \tilde{\gamma}^r - \lambda_1^r g^r\right) r(\tilde{\gamma}^r) + \lambda_2^r = 0, \qquad (22b)$$

$$\frac{\partial M}{\partial g} = 0 \quad \Longrightarrow \quad \int_{\tilde{y}^r}^{\infty} p'(g^r) y dF(y) - (g^r - \lambda_1^r) R(\tilde{\gamma}^r) - \lambda_2^r g^r = 0 \qquad (22c)$$

in addition to $\partial M/\partial \lambda_i = 0$ $i = 1, 2$. Note, however, that for $i = 2$ we have that $\tilde{\gamma}^r = \frac{1}{2}(g^r)^2$. The solution is illustrated in Figure 3.

Solving for the shadow price of day care at the regulation optimum we get

$$\lambda_1^r = -\frac{\int_{\tilde{y}^r}^{\infty} p'(g^r)\, y dF(\tilde{y}^r)}{R(\tilde{y}^r) + (g^r)^2 r(\tilde{y}^r)} + g^r. \tag{23}$$

There is a difference from the first best optimum for the following reason: Any reduction in the group size of day care must take place along the supply curve. Total supply (and accordingly also effective demand) of day care will, therefore, be reduced. At the social optimum, the optimal group size can be determined independently of the optimal number of day care centers. This is not the case here. When there is only one policy instrument available, reducing the group size (and the producer price) will have two effects. The supply of day care will decrease, first, as the supply from day care centers that stay in business will go down. This is captured by the first term $R(\tilde{\gamma}^r)$ in the denominator. But there is a second effect that the policy maker has to take into account. The number of day care centers will be reduced. This is captured by the second term $(g^r)^2\, r(\tilde{\gamma}^r)$ in the denominator; i.e., the previous supply of day care of firms leaving the market.

The shadow price of day care at the regulation optimum can be written as

$$\lambda_1^r = g^r(1+n) \tag{24}$$

where n is a monetary measure of the negative externality. This is the total loss of income when group size is increased divided by the total change in supply of day care when the group size is increased. It is defined by

$$n := -\frac{\int_{\tilde{y}^r}^{\infty} p'(g^r)\, y dF(y)}{g^r\left(R(\tilde{\gamma}^r) + r(\tilde{\gamma}^r)(g^r)^2\right)}. \tag{25}$$

We can, therefore, define the markup on the marginal private cost that gives the marginal social cost of day care in a similar way as in the social optimum.

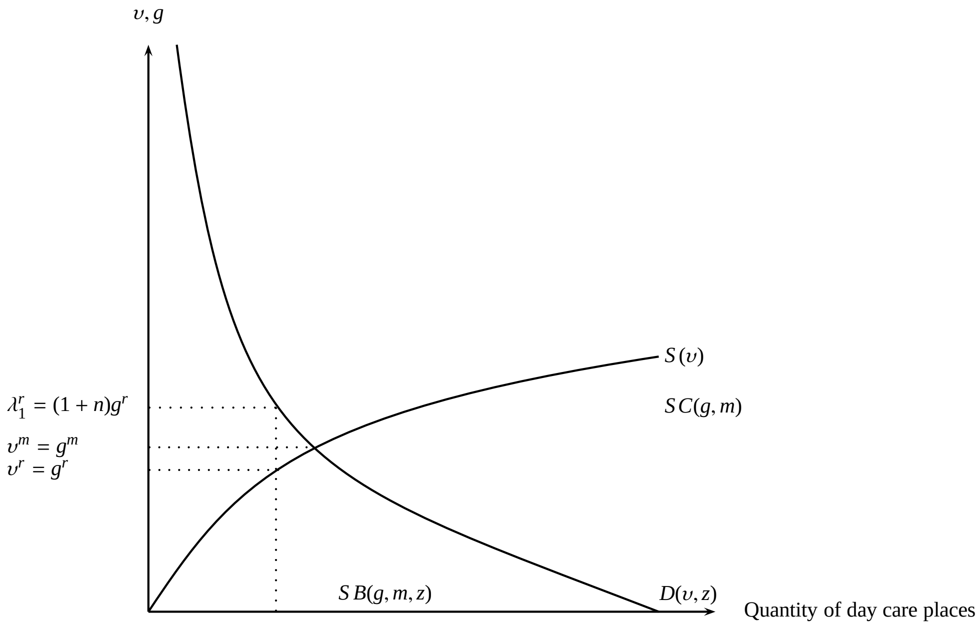
Combining the first order conditions, we can obtain the two equations corresponding to (17a)–(17b). In the regulation optimum, the marginal households and entrepreneurs should behave according to

$$p(g^r)\tilde{y}^r - z - g^r = ng^r, \tag{26a}$$

$$(g^r)^2 = \frac{1}{2}(g^r)^2 + \tilde{\gamma}^r. \tag{26b}$$

The private net benefit of a marginal household participating in the labor force should equal the externality cost of participation in the regulation optimum. This

Figure 3: Regulatory optimum and market equilibrium.



is similar to what we found for the social optimum, see (17a). The social benefit of a marginal day care center equals the private benefit. It should equal the marginal private cost at the regulation optimum. This reflects our assumed constraint that the supply is determined by the zero profit condition for entrepreneurs. As a consequence externality costs will not affect the number of day care centers.

Note also that λ_2^r measures the negative impact on social welfare of this constraint. It satisfies

$$\lambda_2^r = -nr\,(\tilde{\gamma}^r)\,(g^r)^2 < 0. \tag{27}$$

We can also show that the following results regarding the regulation optimum hold:

Proposition 3. *The regulation optimum implies (i) a lower group size, (ii) fewer day care centers, and (iii) lower labor force participation compared to the non–intervention market equilibrium.*

Proof. See the Appendix. □

6 Concluding remarks

Children at day care centers with large child groups are ill more frequently than children at day care centers with smaller groups. Sick children are usually cared for at home by parents. This creates a negative externality of parents' labor force participation. At the same time, entrepreneurs' decision to decrease group size has positive externalities. We show that the social optimum implies lower group size than the non–intervention market equilibrium.

We have studied the optimal Pigouvian policy, which implies reduced group size, increased cost of labor force participation and reduced cost for establish day care centers. Increased cost of labor force participation can be achieved by either or both a *tax* on day care services and a home care *allowance*. The cost of providing day care should be decreased by a *subsidy* to entrepreneurs running day care centers. In the optimum, therefore, both demand and supply curves are shifted compared, compared to the market outcome, such that group size is lower in the social optimum. This can be interpreted as long term effect when both demand and supply for day care is flexible. This is important since it implies that a negative externality caused by increased parental labor force participation, does not necessarily imply a lower parental labor force participation and more day care centers.

Some features of the real problem have been neglected in the present analysis: In this paper we focus on a negative externality. We ignore problems of social insurance and income redistribution. There are interesting and natural extension of the present analysis. One is to investigate how social insurance interacts with the optimal incentives to participate in the labor force studied here. We have also only addressed one type of externality in day care. There are, of course, other factors and other externalities that may lead to different conclusions. One example: Here day care is assumed just to care for children while parents are working. Day care can be important in contributing to human capital accumulation. Day care may also contribute to increase the tax base in the economy.

Appendix

A Proof of Proposition 1

We start by noting that the producer price is equal to the group size (i.e., $\upsilon_p^k = g^k$ $k = m, s$ and that $\lambda = g(1 + m)$. We now want to show that the group size in the social optimum is lower than in the non–intervention market equilibrium, which is equivalent to show that the social optimum implies a lower producer price, i.e., $\upsilon_p^s < \upsilon_p^m$ where super indices s and m indicate social optimum and unregulated market outcome. By equation (7c) and since equations (13b) – (13c) implies $\tilde{\gamma}^s = \left(\frac{1}{2} + m\right)\left(\upsilon_p^s\right)^2$ we know that

$$R(\tilde{\gamma}^m) = R\left(\frac{1}{2}\left(\upsilon_p^m\right)^2\right) \text{ and } R(\tilde{\gamma}^s) > R\left(\frac{1}{2}\left(\upsilon_p^s\right)^2\right). \tag{28}$$

Therefore, by equation (7a) and $E(\tilde{y}^s, \tilde{\gamma}^s, \upsilon^s) = 0$

$$\begin{aligned} 1 - F(\tilde{y}^s) - (1 - F(\tilde{y}^m)) = R(\tilde{\gamma}^s)\upsilon_p^s - R(\tilde{\gamma}^m)\upsilon_p^m > \\ > R\left(\frac{1}{2}\left(\upsilon_p^s\right)^2\right)\upsilon_p^s - R\left(\frac{1}{2}\left(\upsilon_p^m\right)^2\right)\upsilon_p^m. \end{aligned} \tag{29}$$

Suppose now that $\upsilon_p^s \geq \upsilon_p^m$. We note that both R and F are strictly increasing on their supports. Then the assumption that $\upsilon_p^s \geq \upsilon_p^m$ implies, by equation (29), that $\tilde{y}^s \leq \tilde{y}^m$. However, equations (7b) and (13a) – (13c) imply

$$p(\upsilon_p^s)\tilde{y}^s - p\left(\upsilon_p^m\right)\tilde{y}^m > \upsilon_p^s - \upsilon_p^m. \tag{30}$$

Note also that $\upsilon_p^s \geq \upsilon_p^m$ implies $p(\upsilon_p^s) \leq p(\upsilon_p^m)$ by Assumption 1. Equation (30), therefore, implies $\tilde{y}^s > \tilde{y}^m$. This is a contradiction and, therefore, the conclusion $\upsilon_p^s < \upsilon_p^m$ follows.

B Proof of Proposition 3

The proof of part (i) is analogous to the proof of Proposition 1. Hence $\upsilon_p^r < \upsilon_p^m$ and $\tilde{\gamma}^r < \tilde{\gamma}^m$ because of the cost threshold condition. There will be fewer day care centers at the regulation optimum and part (ii) follows. Also, with lower group size and fewer day care centers, supply will be lower. Market equilibrium requires that $\tilde{y}^r > \tilde{y}^m$. Labor force participation will be lower, which gives part (iii).

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