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Abstract

An important role of normative economics is to provide an analytical framework to evaluate social states. Such an evaluation is based on value judgments derived from moral views of the members of the society. There exist three major approaches in normative ethics, which formalize many people's moral views. These are consequentialism that focuses on consequences of actions such as utilitarianism; deontology that focuses on moral duties, and virtue ethics that focuses on the cultivation of virtues and the moral character of people. Among these, important aspects of consequentialism and deontology have been incorporated into social welfare functions. However, normative economics does not have a formal analytical framework for virtue ethics. The purpose of this paper is to develop such a framework for models with endogenous preferences. We apply this framework to a rational addiction model and an intergenerational altruism model. We find that introduction of virtue ethics can lead to very different policy recommendations than those based solely on social welfare functions. Importantly, in contrast to the commonly held view, we find that incorporating virtue ethics into normative economic analysis may not always lead to greater government interventions in the market.

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1. Introduction

An important role of normative economics is to provide an analytical framework to evaluate social states. Such an evaluation is based on value judgments derived from moral views of the members of the society. There exist three major approaches in normative ethics, which formalize many people's moral views.[1] One approach is consequentialism, which emphasizes consequences of actions of individuals and is the underlying moral principle for utilitarianism and other forms of welfarism.[2] The other approach is *deontology*, which emphasizes moral duties. Immanuel Kant is widely regarded as one of the most prominent contributors to deontological ethics.[3] The third major approach is virtue ethics, which is concerned with the moral character of people and cultivation of virtues.[4] An important aspect of virtue ethics for our purpose is that virtue is cultivated when a person learns to feel pleased with what he can do for a community. One reason why virtue ethics is considered an important ethical theory is that many people use it in their everyday lives to think about ethical issues. For example, consider a child who after carefully weighing future costs and benefits of addiction wants to engage in the smoking or consumption of a highly addictive drug. The parent of that child may not want the child to form such preferences. Behind this value judgment, there is an element of virtue ethics that one should cultivate preferences that are

[1] `http://stanford.library.usyd.edu.au/entries/ethics-virtue`

[2] Sen (1979) defines *welfarism* as "the judgment of the relative goodness of alternative states of affairs must be based exclusively on, and taken as an increasing function of, the respective collections of individual utilities in these states."

[3] See http://plato.stanford.edu/entries/ethics-deontological/. One version of moral duty by Kant (translation in Kant (1964)) is:@"I say that man, and in general every rational being, exists as an end in himself, not merely as means for arbitrary use by this or that will."

[4] Plato, and more especially Aristotle, are often regarded as the founding fathers of virtue ethics.

ethically better.

Even though the other two approaches have been extensively used in economics, virtue ethics has largely been ignored in normative economic analysis (Bruni and Sugden, 2013). Given the importance of virtue ethics in philosophical traditions and normative ethics, it is imperative to address its omission from normative economic analysis. We believe that such an omission is due to the fact that normative economics has not developed an analytical framework that incorporates virtue ethics. The two other major approaches in normative ethics have been integrated into normative economic analysis through the Bergson-Samuelson social welfare functions (SWF, henceforth). For example, utilitarianism can be captured by defining a SWF as the sum of individual utilities. Similarly, as argued by Sandel (Sandel (2009), Ch 5), Rawls' (1971) theory of justice develops a form of a social contract for Kant's deontology (translation in Kant (1964)). At least some of the important aspects of Rawls' theory of justice are incorporated in the maximin SWF. However, no such framework exists for incorporating virtue ethics into normative economic analysis. In this paper, we provide a framework that can be used to explicitly embody virtue ethics in evaluating alternative social states in the class of economic models with endogenous preferences. Our framework is most closely related to the meta-preference approach that offers a normative guide when our manifest choice comes into conflict with our moral values (see, e.g., Sen (1974, 1977), Hirschman (1984), and George (1984)). In this paper, we propose a social-state evaluation framework that balances virtue ethics and the other approach (e.g., welfarism) incorporated in a SWF. For this purpose, we first define a *moral evaluation function* (MEF, henceforth)

that expresses evaluations based on virtue ethics. We then define a *social objective function* (SOF, henceforth) that weighs both the MEF and the SWF in evaluating alternative social states. Kaplow and Shavell (2001) prove that any social evaluation function that is not pure welfarist will violate the weak Pareto criterion.[5] As a result, our proposed SOF will violate the weak Pareto criterion. However, in models with endogenously determined preferences, such a violation may be natural and we illustrate that with the help of two examples from the literature on endogenous preferences.

For the purpose of illustrating our approach, we use two examples of endogenous preferences models. Our first example is the rational addiction model proposed by Becker and Murphy (1988), which is one of the standard approaches to modeling the consumption of addictive goods such as alcohol, cigarettes, binge eating, etc. In this framework, an individual chooses the level of addictive good consumption by maximizing his lifetime utility. The non-zero level of addictive good consumption will result from such maximization as long as the benefit from consumption exceeds any cost of future addiction. An important policy implication of this framework is that the welfare maximizing tax rate is zero as long as there is no externality. By contrast, using the framework developed in this paper we show that any positive weight placed on virtue ethics makes the optimum tax rate positive even in the absence of an externality.

As our second example, we use the tough love altruism model in Bhatt and Ogaki (2012) from the literature on intergenerational cultural preference transmission and for-

[5]Sen (1970) makes similar arguments about the weak Pareto criterion and his analysis can be considered a special case of the framework used in Kaplow and Shavell (2001).

mation. Given that virtue is often taught by parents, this type of model is important for our purpose. In the model, greater childhood consumption leads to a smaller discount factor for the child during adulthood. Hence, a parent can use childhood transfers, an important determinant of a child's consumption, to influence the child's discount factor. We extend the tough love altruism model by adding a bequest motive for the parent. This induces a trade-off for the parent between childhood transfers and adulthood bequest. For example, the amount saved by lowering childhood transfers can be used to increase parental bequest during the child's adulthood. In this setting, the government has a policy tool, the bequest tax rate, that can be used to influence the optimizing behaviors of the parent and the child. The optimum tax rate depends on functional forms and parameters, but in our numerical example, the optimum tax rate is positive if the government maximizes the SWF by placing zero weight on virtue ethics. However, if the weight is increased, then the optimum tax rate becomes smaller and becomes zero at a certain weight on virtue considerations.

Thus, introducing virtue ethics into normative economics may imply a greater role for the government through optimum policies as in our addiction model example, but it can also lead to a smaller role for the government as in our tough love altruism model example. One conclusion we draw from these two examples is that incorporating virtue ethics considerations into normative economic analysis does not necessarily lead to greater intervention in the market by the government. Consequently, it is important to distinguish between utilizing virtue ethics in normative economic analysis and discussion of the role of the government in the economy.

The rest of the paper is organized as follows. Section 2 provides a brief review of the related literature. Section 3 presents our theoretical framework and defines the MEF and SOF. Sections 4 and 5 first highlight the limitation of Pareto Efficiency in policy evaluation and then illustrates the application of our framework to the rational addiction model and the tough love altruism model, respectively. Section 6 concludes.

2. Related Literature

In this paper, our proposal to develop an MEF represents an effort to provide a mathematical framework for the evaluation of social states using virtue ethics. The concept of the MEF can, therefore, be viewed as a response to a call by Sandel (2013) to bring more value judgments into economics. Instead of relying solely on virtue ethics for the evaluation of social states, we seek to combine value judgment based on welfarism (or deontology) incorporated into SWF and virtue ethics using the SOF. In the same issue of the *Journal of Economic Perspectives*, Bruni and Sugden (2013) argue that classical and neoclassical economics already incorporate many elements of virtue ethics when "market virtues" are considered. The virtue of patience, on which we focus in our second example in this paper, can be considered a market virtue. Thus, we emphasize the need for developing a new analytical framework that adds virtue ethics considerations when evaluating social states in economic models, and argue that economics can benefit from formalizing the notion of "market virtues" in such a framework. For this purpose, we combine these two literatures in economics: that on endogenous preferences and that on introducing moral considerations other than welfarism into normative economics.

In the literature of endogenous preferences, many theoretical and empirical studies have emphasized and identified various channels through which preferences might be endogenously determined in the economy. Addiction models have been used in microeconomics (e.g., Becker and Murphy (1988)). In the literature of behavioral economics, reference points are often endogenously determined (see, e.g., Kőszegi and Rabin (2006)). Habit formation models that are closely related to addiction models have been widely used in macroeconomics (see, e.g., Lawrence et al. (2005)), and finance (see, e.g., Constantinides (1990)). In the models studied in the literature of intergenerational cultural preference transmission and formation (see Bisin and Verdier (2011) for a survey), children's preferences are affected by parents' decisions.

There are two main issues in exclusively using standard SWF-based normative analysis when preferences are endogenous. First, preference ordering conditional on endogenous economic variables cannot be used as a yardstick for the evaluation of social states. To compare two social states, we need an exogenous basis for such an evaluation. Second, given that preferences may be numerous, some preferences may be considered "better" in terms of virtue.

Regarding the first issue,Schoeffler (1952) provides an early critique of the standard welfare analysis based on the constancy of preferences. He argues that preference orderings of individuals are very sensitive to changes in their environments. As a result, a policy action that affects the economic environment faced by an individual may also affect his/her preferences. Consequently, the standard welfare analysis, which is based on welfare comparisons

for a given fixed preference, has little appeal in situations of changes in preferences. One solution he offered is that if there exists an absolute ordering of alternative social states for an individual, then it can be used to evaluate alternatives even with changing preferences.

Pollak (1978) introduces the concept of "unconditional preference ordering" and suggests the use of such an ordering for normative analysis when preferences change endogenously. Pollak's proposal resolves the first issue because, by definition, the unconditional preference ordering is exogenous. However, it does not address the second issue. Even though the unconditional preference ordering is exogenous, such a criterion is based on purely welfarist considerations and hence cannot rank alternatives in terms of virtues. If a society values virtue, we may not want to rely exclusively on unconditional preference ordering in policy evaluation; we may require an evaluative framework that explicitly accounts for virtue ethics considerations.[6]

Guttman et al. (1992) argue that the relative lack of formal analysis of the role of moral values in economics is due to the importance of fixed preferences in the standard welfare analysis. They extend the theory of rent seeking by allowing for preferences to change through explicit investment in educating individuals about socially desirable preferences such as altruism. They show that under certain conditions altruistic preferences may be superior to egoist preferences if the cost of education needed to generate altruistic preferences is less

[6]Dixit and Norman (1978) focus on estimating the welfare effect of advertising. An excellent discussion on this issue is provided by Galbraith (1958). Because advertising typically induces changes in tastes, standard welfare analysis based on a fixed yardstick cannot be applied in this case. They argue that the existence of multiple possible standards with changing tastes should be tackled by examining the consequences of using each possible standard and comparing the outcomes under each yardstick. They use pre and post-advertising tastes as two separate standards and evaluate the welfare effects of advertising under different assumptions about market power.

than that of rent seeking. Importantly, using Schoeffler (1952), they conduct the welfare analysis based on different standards identified by egoist and altruistic preferences, and show that it is possible that individuals experience higher welfare regardless of which set of preferences are used for evaluation.

A review of the relatively sparse literature on introducing moral considerations other than welfarism identifies three approaches to bring moral considerations into economics (see, e.g., Hausman and McPherson (1993) and Goldfrab and Griffith (1991) for surveys). These are 1) moral values as norms, 2) moral values as constraints on behavior, and 3) moral values as preferences. Our approach is most closely related to the meta-preference framework (see, e.g., Sen (1974, 1977), Hirschman (1984), and George (1984)). Meta-preferences are preferences one may have about one's own preferences or about the preferences of others. For example, imagine a voter who wants to vote in order to be a good citizen or a smoker who does not want to smoke. In both cases, there is a meta-preference about the preference itself. Although such meta-preferences most commonly derive from moral values (e.g. the duty of a good citizen to vote, in the above example), it is possible to have a non-moral basis as well (the desire not to smoke for health reasons). Such a view is pertinent to our research question because meta-preferences can provide a normative guide to cope with the conflict between the manifest choice and what our moral values dictate. In this sense, the meta-preference framework is a natural way to incorporate moral value considerations in economic models. Our proposed MEF applies this framework to rank conditional preference orderings in models with endogenous preferences, for the purpose of introducing virtue ethics

into this class of models. Our application of this framework is more related to the "sense of duty" emphasized by Sen (1974, 1977) than to the free choice emphasized by George (1984).

This paper is also related to other literatures in economics. Our framework introduces virtues in evaluating alternative social states. One implication of our proposed framework is that policy interventions may be aimed at enhancing character and foster virtues. Cunha and Heckman (2007) identify non-cognitive skills to include values such as perseverance, time preference, and self-control. Heckman and Mosso (2014) survey the literature on interventions aimed at enhancing cognitive and non-cognitive skills during childhood. They suggest that early childhood interventions have lasting effects, are more effective than programs aimed at helping disadvantaged adolescents, and are an important channel through which they improve adult outcomes in the enhancement of non-cognitive skills.[7] More importantly, the findings from this literature suggest that most promising interventions involve active mentoring. They define mentoring as involving teaching values such as perseverance and cooperation among other character values.

Our paper is also related to the literature of normative behavioral economics, in which many models explicitly or implicitly have endogenous preferences. For example, the reference point of prospect theory is often simply assumed to be the level of the initial endowment. Because the initial endowment has been determined endogenously within the economic system (represented more generally by a dynamic model), prospect theory implies a model with endogenous preferences. In a companion paper, Bhatt et al. (2015), we provide a review of

[7]For example, Heckman et al. (2013) used a dynamic factor approach to evaluate the effect of the Perry Preschool Program on later life outcomes such as health, wages, and education. They attribute the effects of this program mainly through the improvement of non-cognitive skills.

the literature on normative behavioral economics, and highlight the dominance of welfarism as a basis for policy evaluation in this field of inquiry. The main purpose of this paper is to develop a framework to introduce virtue ethics, whereas in Bhatt et al. (2015) we apply this framework to models of endogenous altruism with the objective of integrating the three major approaches in normative ethics into a *principle of learning to unconditionally love* in the context of behavioral economics. For this purpose, in Bhatt et al. (2015) we develop a model of endogenous altruism a lá Mulligan (1997), in which a worker can devote resources to become more altruistic toward his own child and a disabled stranger.[8]

This paper is also related to positive psychology which emphasizes universality of virtues. Dahlsgaard et al. (2005) conduct an extensive survey of philosophical and religious traditions in the East and the West using written texts from Confucianism, Taoism, Buddhism, Hinduism, Athenian Philosophy, Judaism, Christianity, and Islam. They found that the following six virtues appeared in these writings: courage, justice, humanity, temperance, wisdom, and transcendence. For the examples of virtue we use in this paper (patience and self-control) the relevant core virtue identified by Dahlsgaard et al. (2005) is that of temperance. They find that in seven out of eight traditions temperance is explicitly stated as a virtue whereas in Confucianism it is thematically implied (see Table 2 on pg 211, Dahlsgaard et al. (2005)). They argue that such strong convergence across varied traditions is indicative of universality of these core virtues and hence allows a non-arbitrary basis for classifying virtuous behavior across traditions.

[8]In this model we consider the virtue of altruism, which is not a market virtue. Hence, the virtue ethics framework can also incorporate non-market virtues into economic models.

Finally, this paper is also related to the recent literature on the economics of happiness. (Frey, 2008, p. 5) lists eudaimonia as one of the three concepts of happiness. Eudaimonia is Aristotle's concept of happiness in virtue ethics as a "good life," defined by the acquisition and use of virtue. Hence our MEF can be viewed as an expression of an aspect of eudaimonia. Benjamin et al. (2014) used surveys with personal and policy scenarios to estimate relative marginal utilities. They estimated high relative marginal utilities not only for happiness and life satisfaction but also for aspects related to values (morality and meaning), among other things. Thus, they show that eudaimonic aspects are important for policy considerations. Sachs (2013) argues that promoting virtue ethics should form an important part of policy to increase happiness in a society. In his discussion, he provides arguments for incorporating virtue ethics in public education and promoting virtuous behavior through public policy. Crespo and Mesurado (2015) propose an approach to base economics of happiness on eudaimonia and positive psychology.

3. Reformulating Normative Economics to Introduce Virtue Ethics

In this section, we propose a framework that explicitly incorporates virtue ethics considerations in normative economic analysis. Our approach is based on three evaluation functions. The first is the social welfare function (SWF), which captures welfarist (or deontological) considerations. The second is the moral evaluation function (MEF), which is based on virtue ethics. Finally, we have the social objective function (SOF), which weighs both welfarism and virtue ethics. In this section, we formalize these concepts and then illustrate their ap-

plication in the context of the rational addiction model and the tough love altruism model in Sections 4 and 5, respectively.

Consider an economy with N agents. Let x denote a social state and $U_i(x)$ be the utility function of agent i, and $\psi_i(x)$ be a function that expresses properties of the endogenous utility function of agent i.[9] Let $SWF(U_1(x), ..., U_N(x))$ be the social welfare function. The moral evaluation function (MEF) is a function $MEF(\psi_1(x), ..., \psi_i(x); \psi^*)$ that evaluates $(\psi_1(x), ..., \psi_i(x))$ in terms of moral judgments such as deviations of these properties from perfect virtue, ψ^*, in the context of the model economy such as zero addiction stock in a rational addiction model. The social objective function $SOF(MEF(x), SWF(x))$ is a function that evaluates social states by considering both virtue and welfarism.

Just as the SWF is required to satisfy the Weak Pareto Criterion for pure welfarism, we need formal criteria that add ethical considerations of virtue for MEF and SOF. In order to achieve this, we first need a modification of the Weak Pareto Criterion that allows for ethical factors in comparing social states. This is because any social evaluation that is not pure welfarist, such as those based on our proposed SOF, will violate the weak Pareto criterion (Kaplow and Shavell, 2001). To address this issue, a companion paper Bhatt et al. (2015) adapts Temkin's modification of the Pareto criterion (Temkin, 2011, p. 408), and proposes the *Modified Weak Pareto Criterion: Given two social states x and y, if everyone strictly prefers x to y, then x should be evaluated to be better than y for society as long*

[9]The utility function for individual i, $U_i(x)$, must be exogenous in our framework. One such candidate proposed by Pollak (1978) is a utility function that represents the unconditional preference ordering. However, there are alternative formulations possible depending on the particulars of the economic model under consideration. For example, the commitment utility function in models such as Krusell et al. (2010) is a candidate if endogenous temptation utility functions are introduced.

as x is not evaluated to be worse than y in terms of other ethically relevant factors. The conditional statement implied by "as long as" in the aforementioned modified criterion allows for the possibility that ethical considerations such as virtue may outweigh purely welfarist considerations.

Second, we need a criterion that can rank conditional preference orderings in terms of purely virtue ethics considerations in order to implement the MEF based evaluation proposed by us in this paper. We adapt the Bhatt et al. (2015) criterion of Virtue of Altruism to a more general *Criterion of Virtue Ethics: Given two social states x and y, if at least one person's conditional preference ordering is strictly better in terms of virtue ethics and everyone else's conditional preference ordering is at least as good in terms of virtue ethics in x than in y, then x should be evaluated to be better.*

Finally, for SOF, we need to modify the above criterion to allow for the possibility that other ethically relevant factors such as welfarism may outweigh the considerations of virtue ethics. Hence we define the *Modified Criterion of Virtue Ethics: Given two social states x and y, if at least one person's conditional preference ordering is strictly better in terms of virtue ethics and everyone else's conditional preference ordering is at least as good in terms of virtue ethics in x than in y, then x should be evaluated to be better as long as x is not evaluated to be worse than y in terms of other ethically relevant factors.*

In our proposed mathematical framework, SWF needs to satisfy the Weak Pareto Criterion, MEF needs to satisfy the Criterion of Virtue Ethics, and SOF needs to satisfy both the Modified Weak Pareto Criterion and the Modified Criterion of Virtue Ethics.

4. Rational Addiction and Virtue Ethics

Consider an economy with infinitely many identical consumers who derives utility from the consumption of an addictive good (a_t) and a non-addictive good (c_t). The representative consumer also derives utility from the stock of past consumption of the addictive good denoted by S_t. The period t instantaneous utility is assumed to take the following form:

$$u_t = u(c_t, a_t, S_t) \quad t = 0, 1 \tag{1}$$

In the above formulation, we assume that the utility function is twice continuously differentiable. The positive cross-partial derivative, $\frac{\partial^2 u(c_t, a_t, S_t)}{\partial a_t \partial S_t} > 0$, indicates the addictive nature of the good as its consumption will increase future marginal utility. We assume that the stock of past consumption of the addictive good evolves as follows:

$$S_{t+1} = (1 - d)S_t + a_t \quad t = 0, 1 \tag{2}$$

where d is the rate of depreciation of the stock.

In the economy in period 0, y_0 units per capita of endowment of the non-addictive good falls from a tree. One unit of the endowment in period 0 can be transformed by an intertemporal linear technology into R units of the non-addictive good in period 1. In each period, one unit of the non-addictive good in period t can be transformed into p_t units of the addictive good with intra-temporal linear technologies.

In this economy, an allocation is determined by competitive markets in which relative prices and the interest rate are determined by linear technologies. Let p_t denote the price of the addictive good and the price of the non-addictive good is normalized to 1. Let y_0 denote the exogenously given income in period 0 and b_0 denote the first period savings. For simplicity, we assume that there is no second period income and the individual simply consumes his first period savings that earn a gross interest rate of R. We also assume that the consumption of the addictive good is taxed at a time-invariant rate denoted by τ and the individual receives a subsidy every period denoted by z_t. The budget constraints faced by the individual in each period are given as follows:

$$(3) \qquad \begin{aligned} Period\ 0: \ p_0 a_0 + c_0 + b_0 &= y_0 - \tau a_0 + z_0 \\ Period\ 1: \ p_1 a_1 + c_1 &= R b_0 - \tau a_1 + z_1 \end{aligned}$$

We can combine the above two constraints and write the intertemporal budget constraint as follows:

$$(4) \qquad p_0 a_0 + \frac{p_1 a_1}{R} + c_0 + \frac{c_1}{R} = y_0 - \tau(a_0 + \frac{a_1}{R}) + z_0 + \frac{z_1}{R}$$

In our framework, the optimization problem of the individual can be expressed as follows:

(5) $$\max_{c_0,c_1,a_0,a_1} u_0 + \beta_1 u_1$$

$$\textit{subject to } (4)$$

We assume that the government budget is balanced in each period giving us the following government budget constraint:

(6) $$z_t = \tau a_t \; ; \quad t = 0, 1$$

4.1. Introducing Virtue Ethics into Policy Evaluation

We now illustrate the application of our theoretical framework that balances welfarism and virtues within the rational addiction framework. For this purpose, we define the SWF to be the same as the unconditional utility function:[10]

(7) $$SWF = u(c_0, a_0, S_0) + \beta(u(c_1, a_1, S_1))$$

The moral evaluation function (MEF) is given by:

(8) $$MEF = MEF(S_1) \qquad where \quad MEF'(S_1) < 0$$

[10]Given a particular value Q for the state variable of the stock of the addictive good, S_1, the conditional utility function, which represents the *conditional preference ordering*, for an allocation $x = (c_0, a_0, c_1, a_1)$ is given by the following expression:

$$U(x|S_1 = Q) = u(c_0, a_0, 0) + \beta(u(c_1, a_1, Q))$$

The above formulation of the MEF implies that a larger future stock of the addictive good is evaluated to be morally undesirable.

Finally, the SOF is given by the following expression:

$$(9) \qquad SOF = F(MEF, SWF) \quad where \quad F_1 = \frac{\partial SOF}{\partial MEF} \geq 0 \quad and \quad F_2 = \frac{\partial SOF}{\partial SWF} \geq 0$$

In the above formulation, $F_i \geq 0$ ensures that the two modified criteria proposed in Section 3, namely the modified Weak Pareto Criterion and the modified Criterion of Virtue Ethics, are satisfied by the SOF. The above social objective function combines the concepts of welfarism and virtue. Hence, maximizing the SOF is an expression of a balanced approach that combines welfarism and virtue ethics considerations.

Using the above framework we state our main result in the following proposition:

Proposition 1 *The optimum tax rate on addictive good consumption is not zero as long as where* $\tau = 0$ *and* $F_1 > 0$, $\left[\frac{\partial a_0^*}{\partial \tau} + a_0^* \frac{\partial a_0^*}{\partial z_0^*} + a_1^* \frac{\partial a_0^*}{\partial z_1^*}\right] \neq 0$, *and the consumer's optimization is obtained with interior solution. Furthermore,*

1.1. If $\left[\frac{\partial a_0^*}{\partial \tau} + a_0^* \frac{\partial a_0^*}{\partial z_0^*} + a_1^* \frac{\partial a_0^*}{\partial z_1^*}\right] < 0$ *then the optimal tax rate is positive.*

1.2. If $\left[\frac{\partial a_0^*}{\partial \tau} + a_0^* \frac{\partial a_0^*}{\partial z_0^*} + a_1^* \frac{\partial a_0^*}{\partial z_1^*}\right] > 0$ *then the optimum tax rate is negative.*

Proof: See A.1 in the appendix for a proof. ∎

In the above proposition, the assumption of $F_1 > 0$ implies that there is a positive weight attached to virtue ethics considerations in the evaluation of alternative social states. Unless $\left[\frac{\partial a_0^*}{\partial \tau} + a_0^* \frac{\partial a_0^*}{\partial z_0^*} + a_1^* \frac{\partial a_0^*}{\partial z_1^*}\right] = 0$ (this equality only holds by chance), introducing virtue ethics

considerations implies more government intervention in that the optimum tax rate deviates from 0 and the equilibrium addictive good consumption decreases.[11]

5. Tough Love Altruism with Bequest

Introducing virtue ethics meant more government intervention in the addiction model in the last section, but it can mean less government intervention in other models. The main purpose of this section is to give such an example.

Imagine a three-period model economy with three agents; the representative parent, the representative child, and the government. For simplicity, we consider the case of a single parent and a single child. The three periods considered are childhood, work, and retirement for the child. Just as in the previous section, we consider this economy with linear technologies so that the interest rate is not affected by the government policy. We will evaluate how the policy affects the allocation determined by a competitive equilibrium of markets among identical families where a game is played between the parent and the child in each family.

We make the following seven assumptions. First, the timing of the model is assumed to be such that the life of the parent and the child overlap in the first two periods of the child's life. Hence, the parent has the child in the second period of his own life, which in turn corresponds to the first period of the child's life. Second, the parent not only cares

[11] In the context of our discussion of undesirable addiction, it is strange to subsidize the addictive good by imposing a negative tax rate. The most important condition for obtaining a positive optimal tax rate is that $\left[\frac{\partial a_0^*}{\partial \tau} + a_0^* \frac{\partial a_0^*}{\partial z_0^*} + a_1^* \frac{\partial a_0^*}{\partial z_1^*}\right] < 0$. Even though this condition can be violated in general, it should hold for most reasonable specifications of the economy.

about his own consumption but is also altruistic toward the child. He assigns a weight of θ to the child's lifetime utility, where $0 \leq \theta \leq 1$.[12] Third, in period 2 of his life the parent receives an exogenous income, denoted by y^P. For simplicity, we assume that the parent receives no income in the last period of his life, but simply divides savings from the previous period into his own consumption and bequest. The bequest is taxed at the rate of τ by the government. Fourth, the parent maximizes utility over the last two periods of his life by choosing consumption, inter-vivo transfers, and bequest, denoted by C^P, T, and B, respectively. Fifth, the child is assumed to be a non-altruist, and derives utility only from her own consumption stream $\{C_t^K\}_{t=1}^3$.[13] y_2^K denotes the child's second period exogenous income, and we assume that she receives no income in the first and last period of her life. Sixth, the child's childhood consumption is assumed to be equal to the parent's inter-vivo transfers, because of social convention (alternatively, the child is assumed to be borrowing constrained in period 1 with a binding constraint). Lastly, there is no uncertainty in the economy.

In the tough love model, the parent thinks that his child should grow to be patient, but is tempted to spoil her. This interpretation is captured by the following two important features of the model. First, the child's discount factor is endogenously determined as a decreasing function of period 1 consumption:

[12] When compared to the framework of Bhatt and Ogaki (2012), we have the following relationship:

$$\theta = \widetilde{\beta}\left(\frac{1-\eta}{\eta}\right)$$

[13] In this simple consumption good economy, we view consumption as a composite good that may include leisure activities such as TV time, video game time, etc.

$$\beta_K(C_1^K) \quad ; \quad \frac{d\beta_K}{dC_1^K} < 0.$$

We assume that the child's childhood consumption equals transfers from the parent ($C_1^K = T$). Therefore, the child's period t discount factor is given by $\beta_K(T)$. The idea is that if the child is spoiled by too much consumption during her childhood, then she will grow to be impatient.

Second, the parent does not use the child's endogenous discount factor, but uses a constant discount factor, $\beta_{t,P}$ to evaluate the child's lifetime utility. The parent's objective function is given by,

$$U_P(x) = u(C_2^P) + \widetilde{\beta}u(C_3^P) + \theta\Big(u(C_1^K) + \beta_P u(C_2^K) + \beta_P^2 u(C_3^K)\Big). \tag{10}$$

where $\widetilde{\beta}$ is the parent's own consumption discount factor and β_P is the discount factor used to evaluate the child's future utility, and θ denotes the altruism parameter.

The child's unconditional utility function that represents an *unconditional preference ordering* is assumed to be given by:[14]

$$U_K(x) = u(C_1^K) + \beta_K(C_1^K)u(C_2^K) + \beta_k(C_1^K)^2 u(C_3^K). \tag{11}$$

[14]Given the state variable of the parent's transfer, T, the child's conditional utility function that is represented by a *conditional preference ordering* is

$$U_K(x|T) = u(C_1^K) + \beta_K(T)u(C_2^K) + \beta_k(T)^2 u(C_3^K).$$

The government collects the bequest tax from the parent, and distributes s as a lump sum subsidy. We assume that $s = \tau B$. An allocation in this economy consists of $x = (C_2^P, C_3^P, C_1^K, C_2^K, C_3^K)'$. The parent solves the following optimization problem:

$$\max_{C_2^P, T, B} \Big[u(C_2^P) + \widetilde{\beta} v(R(y_2^P - C_2^P - T) - B)\Big]$$

$$+\theta\Big[u(T) + \beta_P u(C_2^{K*}) + \beta_P^2 u(R(y_2^K + (1-\tau)B + s - C_2^{K*}))\Big], \tag{12}$$

subject to:

$$\big\{C_2^{K*}\big\} \equiv \arg\max_{C_2^K} \Big[u(C_2^K) + \beta_K(T) u(R(y_2^K + (1-\tau)B + s - C_2^K))\Big]. \tag{13}$$

where R is the gross interest rate, which is assumed to be exogenously fixed by a linear technology. In the above framework, the government can influence the child's patience by changing the bequest tax rate. If the bequest tax rate is reduced, then the parent has a greater incentive to leave bequests than to make transfers to the child. Lower transfers, in turn, would imply a higher discount factor for the child.[15]

A recent study by Doepke and Zilibotti (2014) is related to the tough love altruism example we use in this paper. They develop a theoretical framework for transmission of preferences between generations where alternative parenting styles (authoritarian, authoritative and permissive) may emerge in equilibrium depending on parental preferences and socioeconomic environment. A paternalistic parent in their framework cares about his child's

[15]It should be noted that the government's objective when setting the bequest tax rate may not have anything to do with affecting the child's preferences, but any nonzero tax rate does, in fact, affect her preferences.

welfare and attempts to affect his child's choice either by influencing preferences directly or by imposing restrictions on choice sets. Although the framework proposed by (Doepke and Zilibotti, 2014) is general, their analysis focuses on patience. They argue that a key area of disagreement between parents and children is about delayed rewards due to children innately having a lower level of patience than what is considered desirable by their parents. They use their model of patience to highlight how socio-economic factors affect parenting styles.

We numerically solve the parent's optimization as a non-linear root finding problem. For the purpose of simulations, we assume the following functional forms for the period utility and the child's discount function:

$$u(C) = \frac{C^{1-\sigma}}{1-\sigma}. \tag{14}$$

The discount factor is given by:

$$\beta_K(T) = \beta_0 + \frac{1}{1+aT} \quad where \quad a > 0 \; and \; \beta_0 \leq 0. \tag{15}$$

In our solution algorithm we impose the government's budget constraint: $s = \tau B$.[16]

5.1. Introducing Virtue Ethics in Policy Evaluation

We now introduce virtues in the tough love altruism model and derive policy implications of such an extension. For this purpose, we need to define the three evaluation functions, namely, SWF, MEF, and SOF. The SWF is defined as follows:

[16]The details of our solution algorithm are provided in appendix B.

$$SWF = U_p + U_k \tag{16}$$

where U_P and U_K are given by equations (10) and (11), respectively. The MEF is given by:

$$MEF = -(\beta_K(T) - 1)^2 \tag{17}$$

so that larger deviations from the virtue of patience are morally undesirable.

An important component of the above formulation of the MEF is the definition of the virtue of patience. We define perfect patience as the time discount factor being exactly one.[17]

In the context of intertemporal choice models, Bhatt (2014) discusses the arguments for and against the view that zero discounting is a virtue. He argues that the common arguments against zero discounting conflate the normative with the positive aspects of the debate. Bhatt (2014) identifies two common criticisms of the view that zero discounting is a virtue. First, is a lack of empirical evidence for such discounting behavior, and second, is the undesirable implications of zero discounting for the optimum consumption path in certain economic environments (Koopmans (1967), Olson and Bailey (1981)). He argues

[17] An important point here is to distinguish between intragenerational discounting and intergenerational discounting. Our definition of the virtue of patience concerns intragenerational discounting where we seek the normative value of the discount factor for future utilities over one's own lifetime. On the other hand, intergenerational discounting concerns the discounting of the well-being of future generations. The issue of intergenerational discounting and the implied social discount rate is a key parameter in public policy debates. For example, see the climate change debate surrounding the Stern Review (Stern, 2007). Some economists have criticized the social discount rate value used by the report as being too low (Nordhaus (2007), Weitzman (2007), Dasgupta (2007)). However, even among these critics most are sympathetic to the view that from a normative perspective, the pure time preference rate should be zero (Cowen and Parfit (1992), Broome (1994), and Dasgupta (2007))

that although both are important elements in understanding individual choice, they do not serve as a normative basis for discounting. He finds that the ethical foundation for zero discounting as a virtue is fairly robust. Such a view is also supported by others in the field of economics and philosophy (Brink (2010), Broome (1994), Ramsey (1928)). In this paper, we employ the MEF to express a moral judgment that one has a duty to value one's future self exactly as much as one's present self. It is important to note that the dictate of our MEF formulation is normative and not prescriptive. When a child cultivates preferences such that she is *pleased* with this duty, she is said to have the virtue of patience. Observe that this sense of duty is expressed in terms of preferences in our model, rather than in terms of *actions*; the choice of how much to save depends on the interest rate even when one has the virtue of patience.[18]

For the purpose of defining the SOF we have to account for the fact that MEF and SWF are in different units and hence not directly comparable. Following the approach of section 4.2, we first define the two functions for the worst case scenario:

$$\overline{SWF} \;=\; U_p(x_0) + U_K(x_0) \tag{18}$$

$$\overline{MEF} = -\left(\beta_K(T_0) - 1\right)^2 \tag{19}$$

In the above definition of the $\overline{SWF}$, we utilize the worst possible allocation (x_0) in terms of the SWF for the parent and the child.[19] We assume that the worst possible value for

[18] In order to model the free choice that George (1984) emphasizes, we need to model the decision-making process when the sense of duty expressed by the MEF affects individual behaviors. For example, one can model the voting behavior of the child in the model when she feels that the MEF expresses her sense of duty and when she is tempted to vote for more spoiling. That type of modeling is beyond the scope of this paper.

[19] In our simulations we assume that the minimum level of each agent's consumption is 0.001, and use this level for each agent's consumption in x_0.

the moral evaluation function is obtained when the child receives the maximum possible transfers, because in that case his discount factor will be the lowest possible. In our model, $T_0 = y^P$ and hence we use $\overline{MEF} = -(\beta_K(y^P) - 1)^2$ in our simulations. The SOF is then given by the following expression:

$$SOF = (MEF - \overline{MEF})^{\alpha} \times (SWF - \overline{SWF})^{1-\alpha} \tag{20}$$

where $0 \leq \alpha \leq 1$ is the parameter of the SOF that sets the relative weights given to the virtue and welfare considerations.

5.1.1. Simulation Results

We solve the parent's optimization problem numerically and use the same parametric specification and parameter values as in Section 5.1, for a menu of bequest tax rates. We assume that the tax rates available to the government range from -0.5 to 0.5, with an increment of 0.05. Table 1 presents the resulting optimal (i.e., SOF-maximizing) bequest tax policies. The optimized values for the SOF are presented in bold in the table.

We discuss simulations for four policy scenarios, each of which is consistent with one of four alternative principles guiding government policy. The first is based on laissez-faire, wherein the government avoids affecting preferences through policy action. In this case the government would set the tax rate to zero. The second is based on welfarism, which involves maximizing social welfare (i.e, maximizing $SOF(\alpha = 0)$). The third is based on our proposed framework that weighs both welfarism and virtue ethics considerations in policy evaluation.

This can be achieved by setting $\alpha \in (0,1)$ and then by maximizing the social objective function (SOF). Finally, the fourth is based solely on virtue ethics and aims to maximize only the moral evaluation function (MEF). This obtained by setting $\alpha = 1$ in our model.

There are several findings of interest from the simulation results presented in Table 1. First, a policy based on laissez-faire may lead to a social cost in terms of lower welfare. This can be observed from the simulations corresponding to $\alpha = 0$ in Table 1. We observe that based on laissez-faire, the tax policy of $\tau = 0$ does not maximize the $SOF(\alpha = 0)$ and hence is not a welfare maximizing policy.[20]

Second, if we follow the principle of welfarism, which seeks to only maximize social welfare ($SOF(\alpha = 0)$), the optimal tax policy is $\tau = 0.2$. Hence, the government can achieve a higher level of welfare in our model economy by abandoning laissez-faire and following welfarism. An important point to note is that in this case government policy is impacting the preferences of the child leading to a lower level of patience.

Third, given that the government policy is affecting preferences when it follows welfarism, it seems irresponsible for the government to completely ignore the virtue consideration by setting $\alpha = 0$. A more balanced approach would be to assign positive weights to both the SWF and the MEF. As we observe from Table 4, for small values of $\alpha = 0.01$ the optimum bequest tax based on maximizing the SOF leads to a smaller but still positive tax rate. On the other hand, if the government chooses to put a larger weight on virtue ethics then the optimum tax rate becomes negative. For example, with $\alpha = 0.1$ the optimal bequest tax

[20] A similar argument is developed in Pavoni and Yazici (2016) who argue that when parents and children disagree about intertemporal allocation of resources the optimal taxation may differ from the laissez-faire policy. An important difference between our framework and the one proposed by Pavoni and Yazici (2016) is that their model does not have endogenous discounting for the child.

rate is -0.35. An interesting policy scenario is that of setting $\alpha = 0.05$. In this case the SOF is maximized at $\tau = 0$. Thus in our model economy, a balanced consideration of both virtue ethics and welfarism can lead to a zero tax rate; this is superficially similar to laissez-faire, but the motivations for the policy recommendation are very different.

Fourth, an extreme case is when the government only pursues virtue ethics and sets $\alpha = 1$. We observe that even in this case, the optimum tax policy of $\tau = -0.5$ fails to fully attain the virtue of patience because the corresponding level of $\beta_K < 1$.

Table 1: SOF vs SWF: Tough Love Altruism

Global Parameters

$\theta = 0.51$; $R = 0.4$; $\sigma = 1.2$; $\beta_0 = -0.5$; $\widetilde{\beta} = \beta_p = 0.99$
$y_2^K = 1$; $y^P = 10$; $a = 0.18$

τ	-0.5	-0.35	-0.15	0	0.15	0.2
β_K	0.3195	0.3158	0.3107	0.3066	0.3024	0.3010
$SOF(\alpha = 0)$	80.7976	80.8560	80.9228	80.9597	80.9785	**80.9790**
$SOF(\alpha = 0.01)$	77.1939	77.2446	77.3012	77.3309	**77.3431**	77.3417
$SOF(\alpha = 0.05)$	64.3164	64.3413	64.3645	**64.3706**	64.3620	64.3546
$SOF(\alpha = 0.075)$	57.3831	57.3956	**57.4029**	57.3980	57.3799	57.3698
$SOF(\alpha = 0.1)$	51.1971	**51.1998**	51.1943	51.1807	51.1552	51.1430
$SOF(\alpha = 1)$	**0.8431**	0.8380	0.8310	0.8254	0.8195	0.8176

6. Conclusion

In this paper, we proposed a new framework to introduce virtue ethics into the evaluation of social states for models with endogenous preferences. In our approach, virtue ethics is used in combination with welfarism (or deontology). Using two models of endogenous preferences as examples, we illustrated that compared with the policy based purely on welfarism,

introduction of virtue ethics may imply greater or lesser government intervention.

For our evaluation framework, we proposed the introduction of virtue ethics captured by the MEF and defined the SOF that combines the MEF and SWF. The MEF must satisfy the *Criterion of Virtue Ethics* and the SOF must satisfy both the *Modified Weak Pareto Criterion* and the *Modified Criterion of Virtue Ethics*. The idea of modifications of these criteria is that we allow these two criteria to fail in our SOF evaluation, but only when a benefit in terms of one approach in normative ethics (say, welfarism), is dominated by the cost in terms of another approach (say, virtue ethics).[21]

An important step here was to define *virtue* for each example. In our rational addiction model example, we regarded having zero stock of addiction as a virtue. In our tough love altruism example, we focused on the virtue of patience. We view the time discount factor as determining the altruism of the present self toward her future self. If the time discount factor is less than one, then the present self is considered too selfish, while if it exceeds one, then the present self is considered to be excessively altruistic. Hence, we define the virtue of patience as when the child's discount factor is one. Such a formulation of the virtue of patience is espoused by many economists and philosophers. In our proposed framework virtue ethics considerations are captured by an MEF, and for both examples of endogenous preferences considered in this paper we formulate the MEF such that large deviations from virtue yield lower values.

In the rational addiction example, we showed that even with a small weight given to the

[21]It should be noted that the new criteria can be used to evaluate social states without relying on the MEF and SOF just as the Pareto criterion can be used without relying on the SWF.

virtue ethics considerations in the policy evaluation process, the optimal tax on the addictive good is positive even there is no externality. This is in stark contrast to the existing literature that focuses either on externalities or hyperbolic discounting to rationalize such a tax. Many people are in favor of taxing tobacco even when externalities are becoming minimal because of separating smoking areas. This may reflect virtue ethics elements in their judgments.

In the tough love altruism model, we showed that introducing virtue ethics may mean less government intervention for the optimal policy in a numerical example. We first show that the laissez-faire policy of setting the tax rate to zero does not maximize social welfare (i.e., the SWF). Second, the SWF is maximized at a positive tax rate, which in our model economy implies that the child's patience is being influenced by the government policy. Given that the policy is already affecting the child's preferences, we argue that it is irresponsible for the government to completely ignore virtue ethics considerations. Finally, for a given weight on the MEF, we show that the optimum policy may actually be to set the tax rate to zero.

Based on informal discussions, we believe that many economists object to the use of virtue ethics considerations in public policy evaluation because they believe that such an approach involves the government influencing people's preferences. The second example in our paper is constructed to show that this argument is conflating the government's motivation and its action. If a government is motivated to increase the SOF, then its action will often deviate from the laissez-faire policy. If endogenous preferences are a reality, then this deviation means that the government is influencing people's preferences. Introducing virtue considerations may necessitate greater or lesser government intervention depending on the particulars of

the economic environment under study. Given these findings, one important implication of our theoretical analysis is that whether or not a certain government policy *does* influence people's preferences is an empirical issue that is independent of whether or not we think that the government *should* influence preferences.

These findings suggest that an important direction for future research along the line of research in this paper is to gather empirical evidence for (or against) models with endogenous preferences. For rational addiction models, there is already a large empirical literature testing the key predictions of this framework, and many studies have found strong empirical support for this model (e.g. see Gruber and Kőszegi (2001)). The next step toward applying our framework is to empirically investigate people's meta-preferences for preferences for addiction. For the tough love altruism model used in this paper, there already exists some empirical evidence for the model. A starting point of any model with endogenous time discounting is that genetic factors do not completely determine time discounting. Using a unique data set of twins in Japan, Hirata et al. (2010) found empirical evidence for this. Kubota et al. (2013a,b) found empirical evidence consistent with the tough love altruism model, using unique survey data for the U.S. and Japan. Similarly, Akkemik et al. (2013) found evidence that empirically supports the main predictions of the tough love altruism model using survey data from Turkey and from Turkish migrants in Germany. Similarly, Akabayashi et al. (2014) found evidence for the tough love altruism model using an experiment on parent–child pairs in Japan. We believe that more studies aimed at empirically validating endogeneity of different types of economic preferences are needed to provide better

understanding of preference formation and how they can be influenced by public policy.

Another direction of future research is to empirically investigate the effect of public policies on preferences. There is some empirical evidence on this effect. Ito et al. (2015) find that people who experienced participatory/cooperative learning process in their elementary schools in Japan tend to form more altruistic preferences. Another way for a public policy to affect preferences is by affecting social norms. Thaler and Sunstein (2009) provide several examples of such policies implemented in different states in the U.S. For example, Montana used data on teenage smoking and ran a successful advertisement campaign called "Most (71 percent) Montana teens are tobacco free" with the objective of influencing the social norms regarding smoking by correcting the social perceptions about such consumption. These policies based on libertarian paternalism can change social norms, affect some people's behaviors and their conditional preference orderings, for example, by changing the stock of the addictive good.

Bhatt: James Madison University

Ogaki: Keio University

Yaguchi: Chuo University

A.1 Proof of Proposition 1

In this appendix we provide a proof for *Proposition 1.* We begin by first deriving a general expression for the derivative of the SOF with respect to τ. By definition:

$$SOF = F(MEF, SWF) \tag{A.1}$$

Taking the derivative with respect to τ, we get:

$$\frac{dSOF}{d\tau} = F_1 \frac{\partial MEF}{\partial \tau} + F_2 \frac{\partial SWF}{\partial \tau} \tag{A.2}$$

where $F_1 = \dfrac{\partial SOF}{\partial MEF}$ and $F_2 = \dfrac{\partial SOF}{\partial SWF}$.

Using the definitions of MEF and SWF, the first order conditions for the optimization problem of the decision-maker, the resulting optimal choices given by $(a_0*, a_1^*, c_0^*, c_1^*)$, and applying the first welfare theorem, we get:

$$\left.\frac{\partial MEF}{\partial \tau}\right|_{\tau=0} = MEF'(a_0^*)\left[\frac{\partial a_0^*}{\partial \tau} + a_0^* \frac{\partial a_0^*}{\partial z_0^*} + a_1^* \frac{\partial a_0^*}{\partial z_1^*}\right] \tag{A.3}$$

and

$$\left.\frac{\partial SWF}{\partial \tau}\right|_{\tau=0} = 0 \quad \text{by the First Welfare Theorem} \tag{A.4}$$

Hence, for $\tau = 0$, we can rewrite equation (A.2) as follows:

$$\left.\frac{SOF}{d\tau}\right|_{\tau=0} = F_1 MEF'(a_0^*)\left[\frac{\partial a_0^*}{\partial \tau} + a_0^*\frac{\partial a_0^*}{\partial z_0^*} + a_1^*\frac{\partial a_0^*}{\partial z_1^*}\right] \tag{A.5}$$

Given that by assumption $F_1 > 0,$ and $MEF'(a_0^*) < 0$, we get $\left.\frac{dSOF}{d\tau}\right|_{\tau=0} \neq 0$ if $\left[\frac{\partial a_0^*}{\partial \tau} + a_0^*\frac{\partial a_0^*}{\partial z_0^*} + a_1^*\frac{\partial a_0^*}{\partial z_1^*}\right] \neq 0$. Further,

(i) $\left.\frac{dSOF}{d\tau}\right|_{\tau=0} > 0$ if $\left[\frac{\partial a_0^*}{\partial \tau} + a_0^*\frac{\partial a_0^*}{\partial z_0^*} + a_1^*\frac{\partial a_0^*}{\partial z_1^*}\right] < 0.$

(ii) $\left.\frac{dSOF}{d\tau}\right|_{\tau=0} < 0$ if $\left[\frac{\partial a_0^*}{\partial \tau} + a_0^*\frac{\partial a_0^*}{\partial z_0^*} + a_1^*\frac{\partial a_0^*}{\partial z_1^*}\right] > 0.$

B. Solution Algorithm

In this appendix we explain the numerical optimization method we used to solve the decision-maker's problem outlined in Section 3.2.

Step 1: Given T and B, the child solves the following optimization problem:

$$\max_{C_2} \frac{C_2^{1-\sigma}}{1-\sigma} + \beta_k \frac{[R(y_2 + (1-\tau)B + z - C_2)]^{1-\sigma}}{1-\sigma} \tag{B.1}$$

where

$$\beta_k = \beta_0 + \frac{1}{1 + a(y_1 + T)}$$

The above optimization problem gives us a closed form solution for optimal values of

C_2 and C_3:

$$C_2^* = \frac{R(y_2 + (1-\tau)B + z)}{R + (\beta_k R)^{\frac{-1}{\sigma}}} \tag{B.2}$$

$$C_3^* = R(y_2 + (1-\tau)B + z - C_2^*) \tag{B.3}$$

Step 2: We substitute for optimal C_2 and C_3 in the objective function and solve the parent's optimization problem:

$$\max_{T,B} W \frac{[R(y_p - T) - B]^{1-\sigma}}{1-\sigma} + \theta\left(\frac{T^{1-\sigma}}{1-\sigma} + \beta_k \frac{C_2^{*1-\sigma}}{1-\sigma} + \beta_k^2 \frac{C_3^{*1-\sigma}}{1-\sigma}\right) \tag{B.4}$$

where

$$W = \frac{1 + \tilde{\beta}(\tilde{\beta}R)^{\frac{1-\sigma}{\sigma}}}{[R + (\tilde{\beta}R)^{\frac{1}{\sigma}}]^{1-\sigma}}$$

The step 2 optimization problem has no closed form solution for T and B. Hence, we use numerical methods to find the solution to the above function. For this purpose, we define a grid for T and B and choose a baseline for model parameters. Given these we search for the values of T and B that yield the maximum value for the objective function defined in Equation (A-4). To implement this, we need to initialize values of three key variables: T, B and the level of subsidy, i.e., z. For a given tax level set by policy, τ, we adopt the following algorithm to choose initial values:

1. For a given τ_i, we set:

$$T_{0i} = T^*(z_{i-1}^*; \tau_{i-1})$$

$$B_{0i} = B^*(z_{i-1}^*; \tau_{i-1})$$

2. To choose the initial level of the subsidy we use:

$$z_{0i} = \tau_i B^*(z^*_{i-1}; \tau_{i-1})$$

We initialize the above process by first solving for the laissez-faire policy, $\tau = z = 0$.

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