RATIONAL ADDICTION, OCCUPATIONAL CHOICE AND HUMAN CAPITAL ACCUMULATION

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Abstract

Addiction to a substance like alcohol can be viewed from many perspectives: as a psychiatric medical condition; as a public health and safety problem; as a problem threatening worker productivity; and as an extreme form of consumer behavior. Most economic research on addictions takes one of the last two perspectives. The primary objective of the paper is to begin to integrate economic research on alcohol and worker productivity with research on rational addiction as a consumer behavior. We generalize the rational addiction model by considering the labor market as an integrated part of the dynamic environment. In so doing, we can examine theoretically the relationship between alcohol abuse and post-schooling human capital investment, including effects on wage growth, occupational choice and on-the-job human capital accumulation. We also allow for endogenous time discounting and human capital depreciation, depending on individual addictive behavior. The forward-looking behavior of the rational addict implies that the labor market consequences of alcohol abuse will be anticipated, thereby providing an active role for alcohol policies to encourage productivity growth. Moreover, the examination of how workers' alcohol consumption choices interact with their human capital decisions can shed new light on interesting phenomena in the labor market, including the dynamics of the wage earning profile.

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1. Introduction

Addiction to a substance like alcohol can be viewed from many perspectives: as a psychiatric medical condition; as a public health and safety problem; as a problem threatening worker productivity; and as an extreme form of consumer behavior. Most economic research on addictions takes one of the last two perspectives. The most recent comprehensive study suggests that alcohol problems in the U.S. in 1995 led to productivity losses of $77.1 billion [see Harwood, Fountain, and Livermore (1998)]. Moreover, there is good evidence that drinking reduces individuals' investment in schooling, limiting their lifetime earnings potential [see, for example, Cook and Moore (1993)]. Kenkel and Wang (1999) establish some benchmark empirical patterns describing relationships between alcoholism, job choice, and post-schooling human capital investment. Another line of economic research extends the rational model of the consumer to explain addictive behavior (Becker and Murphy 1988, Orphanides and Zervos 1995). The primary objective of the paper is to explore theoretically the relationships between alcohol abuse and post-schooling human capital investment to integrate research on rational addiction with research on alcohol and worker productivity.

This paper makes a first step towards establishing a theory by developing a generalized rational addiction model in which occupation and post-schooling human capital accumulation are endogenously determined. The framework is also general enough to allow for time discounting and human capital depreciation to depend on individual addictive behavior. The forward-looking behavior of the rational addict implies that the labor market consequences of alcohol abuse will be anticipated. This allows us to examine the dynamic effect of rational addiction on labor market decisions, including occupational choice and on-the-job accumulation of human capital. In addition, we can explore the short and long-run consequences of some relevant public policies, such as an alcohol tax, a wage income tax, and an education subsidy.

Our model builds on the rational addiction model of Becker and Murphy (1988). Although not the only economic model of addiction, the rational addiction model has been very influential because it both explains well-known features of addictions (such as abrupt or cold-turkey quitting behavior) and generates testable predictions about addictive behavior [for more discussion see Grossman (1993)]. In particular, Becker and Murphy show that by holding the marginal utility of wealth (λ) constant, the λ-constant demand for the addictive good depends on not only the current price but also the past and future prices. By reducing past consumption, higher past prices lead to a lower consumption stock and thus lower marginal utility of current consumption, reducing current demand (which can be called the conventional addiction effect). By decreasing future consumption, higher future prices result in a higher shadow price of current consumption, also reducing current demand (the rational addiction effect). The long-run price elasticity of addictive demand consequently exceeds the short-run elasticity in absolute value. The main hypotheses on addictive consumption demand can be tested empirically when the utility function is quadratic [e.g., see Chaloupka (1991), Keeler, Hu, Barnett and Manning (1993), Becker, Grossman and Murphy (1994), Moore and Cook (1994), Waters and Sloan (1995) and Grossman, Chaloupka and Sirtalan (1998)]. All these studies find evidence supporting the rational addiction approach to cigarette and/or alcohol consumption. However, it is notable that these empirical tests of the rational addiction model focus almost exclusively on the impact of future prices on current demand and on the relationship between short-run and long-run price elasticities.

A major shortcoming is that in the previous rational addiction studies, the rational addict is not allowed to take into account future consequences of current consumption through productivity effects. [1] Beyond our focus on the productivity effects, we also try to fully incorporate the implications of multiple equilibria as well as many features of addiction, including cold-turkey quitting, vintage-distribution of

[1] In the original model Becker and Murphy (1988) include productivity effects by assuming earnings are a concave function of the stock of addictive consumption capital. To derive an empirical rational addiction demand function, Becker, Grossman and Murphy (1994) make several simplifying assumptions, including the assumption that earnings are independent of addictive consumption. Other empirical studies using the rational addiction framework maintain that assumption.

new addictions, and regret. One approach to explaining addiction is to move away from the concept of rationality (Schelling 1984, Akerlof 1991). Alternatively, Orphanides and Zervos (1995) build a rational addiction model that incorporates learning and regret. However, introducing departures from rationality or perfect foresight also tends to remove empirical content. While this paper retains the assumptions of rational, forward-looking addicts, it will try to shed new light on interesting and important phenomena in the labor market by undertaking further study of the dynamic productivity effects of alcohol abuse.

The main contributions of our paper to the existing literature are fivefold. First, rational addicts' consumption behavior interacts with occupational choice and post-school human capital accumulation. Second, the shape of the dynamic wage profile depends on the alcohol status: alcohol-dependents have a flatter profile compared to the non-dependents. Third, addictive stock-dependent time preference and human capital depreciation together cause the job package of fringe benefits to be less generous for alcoholics. As a consequence, the wage loss from alcoholism may significantly understate the true productivity loss. Fourth, due to the interplays between consumption and labor market decisions, an education subsidy may be as effective as an alcohol tax for discouraging excessive drinking. Finally, information may play a crucial role when self-fulfilling expectations-driven multiplicity is present. Minimizing informational frictions can enhance the effectiveness of public policy.

The organization of the remainder of the paper is as follows. Section 2 reviews research on alcohol and the labor market, including some simple but we hope convincing empirical evidence documenting the relationship between alcohol consumption and post-school human capital accumulation. These benchmark empirical patterns motivate our construction of a dynamic general equilibrium model of rational addiction in Section 3, where the labor market is an integrated part of the basic environment. Section 4 presents the optimization of the model, which lead to a dynamical system of 7 x 7 with two contemporaneous price variables solved recursively after deriving the quantity and intertemporal price variables. Section 5 characterizes the asymptotically balanced growth equilibrium and illustrates the underlying dynamic properties. In particular, we examine how workers' consumption choices interact with their labor market decisions, including occupational choice, on-the-job human capital accumulation, and the resulting wage dynamics. We illustrate the possibility of multiple equilibria in the sense that a continuum of transition paths converges to a finite number of asymptotically balanced growth paths (i.e., both local and global indeterminacy). Finally, we conclude the paper in Section 6 by offering some interesting avenues for future research.

2. Addiction and Labor Market Outcomes: Evidence from the NLSY Data

Most studies of the effect of alcohol abuse in the labor market have been conducted within the static human capital framework using cross-sectional data. Since critical reviews of these studies exist elsewhere [e.g., see Cook (1991) and Mullahy (1993)], it is only necessary to highlight here some of the main results and shortcomings. These studies estimate models in which current earnings or income are specified to be a function of exogenous current drinking. They generally conclude that problem drinking causes earnings losses in the range from 10 to over 20 percent [cf. Harwood, et al. (1984) and Rice, et al. (1990)]. In contrast, moderate drinking appears to be associated with higher earnings. For example French and Zarkin (1995) find an inverse U-shaped relationship where wages peak at 1.5 to 2.5 drinks per day while Zarkin et al (1998) find that male drinkers earn 7 percent more than nondrinkers (but somewhat surprisingly do not find evidence that this earnings differential disappears or becomes negative for heavier drinkers). A series of studies by Mullahy and Sindelar (1991, 1993, 1995) go beyond the conventional research line by addressing more subtle effects of alcohol abuse on productivity through indirect channels such as labor market participation, schooling, and marital status. Kenkel and Ribar (1994) argue that methodological shortcomings of many of these studies tend to yield estimates that are biased away from finding any negative effect of drinking on earnings. Kenkel and Ribar use a variety of approaches to address these shortcomings, including instrumental variables (IV) analysis. Their IV results provide the strongest indication that alcohol problems reduce earnings, yielding point estimates that alcohol problems cause about a 30 percent drop in earnings. A remaining shortcoming is that existing work fails to carefully address labor market dynamics related to the productivity effects of alcohol abuse despite some good evidence that supports for the detrimental effect of alcohol abuse on schooling [e.g., see Benham and Benham (1982), Mullahy and Sindelar (1989), and Cook and Moore (1993)].

To address this last shortcoming, we now present some simple empirical exercises to establish a plausible relationship between alcohol addiction and labor market outcomes. The primary data used herein comes from the panels of the NLSY, which contains detailed economic and demographic information for 12,686 individuals who were fourteen to twenty-one years old in 1979. Annual data on work behavior and incomes are available for each individual in the survey; retention is roughly 90 percent. The NLSY has become a standard data source for empirical labor economics. Questions allowing measurements of alcohol consumption and problem drinking were added to various waves of the NLSY. The exact wording and types of questions varies, but the set of questions asked in 1989 can be used to construct measures of alcohol abuse and alcohol dependence that correspond to the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders, third edition, revised (DSM-IIIR)* definitions. Another advantage of the NLSY is that it allows us to focus on young adults. The NLSY sample provides a look at individuals at the age when they simultaneously are at high risk of alcohol problems and are making key decisions about their occupation and future career.

We restrict our attention to the examination of the NLSY data of the 1989 wave for male workers. Non-working individuals are excluded because they do not face directly a choice between alcohol consumption and labor market decisions (although they do enjoy some fringe benefits through spouse coverages and/or government subsidies). In Table 1, we provide a partial listing of sample means for relevant labor market outcomes and alcohol measures available in the 1989 wave. The "alcohol dependency"status is defined by the DSM-IIIR criteria. Tables 2-6 summarize some relevant empirical findings concerning alcohol addiction and post-school labor market outcomes.

In Table 2, we provide a descriptive analysis of 1989 NLSY data for men, which indicates some of the questions to be explored. The results suggest that statistically significant group differences between alcohol-dependent and non-dependent workers (at the 1 percent confidence level). Relatively speaking, alcohol-dependent workers have on average received lower pensions, health/life/dental insurance, paid sick leave/vacation, and training opportunities. Such reduction in non-wage fringe benefits ranges from 6 to 13 percentage points. On the other hand, alcohol-dependent workers have suffered more (by 4 percentage points) on-the-job injury. Thus, we may conclude that alcoholics seem to be in "bad jobs."

To further explore this issue, we perform an econometric analysis, based on a companion paper, Kenkel and Wang (1999, see especially Tables 2, 3 and 9 therein). The estimates in Table 3 are from 14 probit models, where the dependent variable in each model indicates that the respondent reported receiving the fringe benefit in question. In addition to alcohol dependency status the models also include as explanatory variables measures of individual and family background, including year of birth, ethnicity, the individual's standardized score on the Armed Forces Qualifying Test (AFQT), and whether at age 14 the individual lived in a nonintact family, attended religious services regularly, read magazines, or had a library card. In this way, the models attempt to control for many background variables that are potentially correlated with alcohol abuse. The models do not include current human capital variables such as schooling, job tenure, and marital status. Even though these are also potentially correlated with alcohol abuse, they are also potentially endogenous. With these variables excluded from the models, we estimate the total impact of alcohol abuse on the receipt of fringe benefits, noting that part of the total impact may be through the channels of reduced schooling and marital status.

The probit coefficients have been transformed to show the effect on the probability of a discrete change of the alcohol dependency dummy variable from zero to one; the proportion of the sample receiving each fringe benefit is also reported for a point of reference. Alcohol dependency is associated with a 5 to 10 percentage point reduction in the probability of receiving most major fringe benefits including health insurance, paid sick leave, paid vacations, and retirement plans. The estimates in Table 4 suggest that relative to their non-dependent peers, alcohol dependent workers were almost 40 percent (or 3.3 percentage points) more likely to suffer an on-the-job injury. This together with results in Table 3 reinforces previous findings in Table 2, indicating that alcohol-dependent workers are indeed in jobs with worse non-wage attributes.

We next turn to examining the distribution of earnings by occupation and by alcohol dependency status, seeking to address whether alcoholics are also facing a disadvantage in wages. We obtain simple OLS regression results in Table 5, reporting the effect of alcohol dependency on earnings, after controlling for schooling, tenure, marriage and other job characteristics. The total earnings loss associated with alcohol dependency is of 9.8 percent, or about $2100 at the average earnings in the sample. Only 4.6 percent ($1000) is the direct effect of alcohol dependency while the remaining 5.2 percent ($1100) is the indirect effect of alcoholism through the measured human capital variables.

Finally, we can use these data to begin to explore the relationships between alcohol dependency and occupation and earnings. Since occupational requirements concerning workers' drinking habits are not directly observable, we can only study general occupational differences, comparing the proportions of alcohol non-dependents and dependents in different occupational categories. Table 6A indicates that about 37.5 percent of non-dependents are in white collar occupations, compared to only 30.9 percent of dependents. In contrast, only 48.1 percent of non-dependents are in blue collar occupations, compared to 57.9 percent of dependents. There is also a smaller difference showing that alcohol dependents are less likely to be service occupations. Table 6B presents mean and median earnings by occupation and alcohol dependency status. Among those workers in white collar occupations, alcohol dependents appear to earn nearly as much as non-dependents. There are virtually no differences in median earnings between the two groups, while mean earnings are somewhat higher for non-dependent workers. In contrast, in terms of either median or mean earnings, alcohol dependent workers in blue collar occupations earn less than non-dependent workers. Alcohol dependent service workers earn somewhat less than non-dependents. There appears to be a large difference in the earnings of non-dependent and alcohol dependent farm workers, but this should be interpreted cautiously due to the small cell sizes.

Of course, these findings are preliminary as they are based only on the 1989 wave of the NLSY data for men only. Nevertheless, they in general suggest that there are inter-relationships between alcohol abuse and labor market outcomes: while alcoholics are likely in bad jobs in both wage and non-wage compensations, alcohol-dependents are likely to be sorted into blue collar jobs rather than white collar or service occupations. Such empirical links between alcohol consumption, occupational choice and human capital reflected by wage and non-wage attributes remain open to be explored in a dynamic general-equilibrium framework.

3. The Model

By developing a generalized general-equilibrium framework for additive behavior, we extend the existing rational addition literature in two significant ways. First, it integrates the labor market into the intertemporal choice environment to study the dynamic interactions between alcohol addiction, occupation choice, labor supply and human capital investment. Second, it considers two additional channels of the detrimental effects of alcohol consumption -- by raising the time discount rate and by reducing human capital accumulation. In general equilibrium, this structure allow us to characterize the dynamic paths of alcohol consumption and price as well as the lifetime wage earning profile. The model builds on an infinite-horizon, perfect-foresight framework in continuous time with inelastic leisure and constant population normalized to unity. The adoption of the continuous-time framework is not only for technical convenience but also provides a sharp distinction between stocks and flows, which is particularly relevant to the considerations of addictive behavior.

Before proposing the theoretical framework formally, it would be useful to summarize the importance of these considerations in comparing potential productivity loss and wage loss due to alcohol abuse. In the empirical literature on alcohol abuse, estimating the impact of alcoholism on earnings has proven to be a difficult methodological challenge. Kenkel and Wang (1999) point out a methodological shortcoming that has received little attention to date: wage differences are unreliable estimates of the productivity losses from alcoholism if there are important differences in the non-wage attributes of the jobs of problem drinkers. To see the possible biases, consider a simple model of job choice depicted graphically in Figure 1A. The indifference curves drawn are based on the assumption that the worker has homothetic preferences over after-tax wage earnings (W) and the level of a fringe benefit (F) (or other non-wage job attribute). The worker's opportunity set is described by the negatively sloped schedule W(F) showing possible combinations of wages and fringes employers can offer, given the worker's level of productivity. For simplicity, it will be assumed that W(F) is linear. The worker's optimizing job choice is thus given by the tangency of an indifference curve and the w(F) schedule. In the absence of endogenous human capital depreciation, alcohol abuse causes a parallel shift of the opportunity line W(F) downward to W'(F), thus resulting in a proportional changes in productivity and wage losses. In principle, the absolute value of productivity loss may be greater or less than that of wage loss, depending on the slope of the opportunity line.

However, it may be more natural to consider non-homothetic preferences as a direct consequence of endogenous time discounting. As one can see from Figure 1B, changes in productivity and wage losses due to alcohol abuse are no longer proportional. The left panel of Figure 1B shows the possibility that the observed wage loss overestimates the productivity loss in the case when the alcoholic has stronger preferences for the fringe benefit than does a non-alcoholic. For example, the alcoholic might be more willing to accept lower wages in return for more generous health insurance, flexible hours, and sick leave. This is in part due to the possibility that the benefits of a health insurance fringe may accrue more timeproximately for addicts than non-addicts. In this case, part of the observed difference in the wages earned by alcoholics and non-alcoholics is actually the compensating differential for the higher level of fringe benefits. Put differently, even if there were no productivity loss from alcoholism, alcoholics would choose to earn less but receive more generous fringes.

More plausibly and interestingly, the alcoholic has weaker preferences for the non-wage job attribute than does a non-alcoholic, as shown in the right panel of Figure 1B. In this case the observed earnings losses underestimate the true productivity loss. The preference effect reinforces the income effect shown in Figure 1A. This particular case can be motivated several ways. First, Becker, Grossman and Murphy (1991) argue that people with relatively high rates of time preference are more likely to become addicts. If the typical alcoholic has an exogenously higher rate of time preference than the typical non-alcoholic, he will discount more heavily pensions and other benefits that accrue in the future. By the same token, the alcoholic will be less willing to give up current wages for future wage growth, and so could be expected to sort into jobs with relatively flat age-earnings profiles. Second, when alcohol consumption endogenously raises the time discount rate, the rational alcoholic will place a lower value on fringe benefits like pensions and will sort into jobs with relatively flat age-earnings profiles. Obviously, when human capital depreciation is allowed to depend on the alcohol consumption stock and job specification, the shift of the effective budget line becomes non-parallel, implying more sophisticated changes in the responses of productivity and wages to alcohol consumption.

The above discussion compels us to think more carefully about adding alcohol-dependent endogenous discounting and endogenous human capital depreciation. These considerations suggest that measuring differences in wage earnings may very possibly lead to a severe under-estimation of productivity losses from alcohol addiction. To incorporate these features into a rational addiction model that permits perpetual human capital accumulation is by no means an easy task. As a consequence, we will simplify the preference and technology structure whenever it is inessential to our main conclusions.

Formally, consider a representative individual consumer/worker who seeks to maximize lifetime utility (Ω) subject to the evolution equations for the addictive consumption stock (S), human capital (H) and physical capital or non-human wealth (K). Instantaneous utility or felicity (U) at any point in time depends positively on current consumption of the composite non-addictive good (C) and current consumption of the (detrimental) additive good or alcohol (A), but negatively on the addictive consumption stock. Specifically, we postulate:

$$U(C,A,S) = V(S)(C^{\alpha}A^{1-\alpha})^{1-\sigma}/(1-\sigma),\ 0<\alpha<1, \sigma>1, V'>0, V''<0. \tag{1}$$

Under these restrictions (noting that σ, the inverse of the intertemporal elasticity of substitution, exceeds unity), S has not only a conventional direct negative effect on U reflecting the utility cost of addictive behavior, but also a positive effect on the marginal utility of alcohol consumption (U_A) . The latter is necessary for the presence of addictive effect (i.e., Pareto complementarity between current and future consumption) and is a natural force for dynamic instability due to the non-convergence of the accumulation process.

Let the evolution process of alcohol consumption stock be:

$$\dot{S} = A - \pi S,\ 0<\pi<1; \tag{2}$$

that is, the current alcohol consumption flow net of depreciation of the past consumption stock adds to the accumulation of the current stock. As in Grossman (1972) and Ehrlich and Chuma (1990), consumption decisions have health and longevity implications. Due to its effects on human health, the stock of alcohol consumption is allowed to affect the length of lifetime (which has been ignored in the existing literature). Rather than using an uncertain lifetime model, this effect is simply captured in the present research by an increase in the cumulated subjective discount rate (Δ):

$$\dot{\Delta} = \delta(A-\pi S),\ \delta'>0,\ \delta''<0,\ \Delta(0)=0,\ -\frac{(A-\pi S)\delta''}{\delta'} \leq D \in R_{+}. \tag{3}$$

That is, an increase in current and past alcohol consumption is allowed to result in a higher subjective discount rate, implying that the individual may become more impatient given an increased probability of alcohol-related death. Since the discount rate depends on the consumer's choice variable, our model follows in the spirit of the existing endogenous preference literature [cf. Epstein (1987), Becker, Boyd and Sung (1989) and Becker and Mulligan (1997)].

The lifetime utility can thus be written as:

$$\Omega = \int_0^\infty V(S)(C^\alpha A^{1-\alpha})^{1-\sigma}/(1-\sigma)\exp[-\int_0^t \delta(A(i)-\pi S(i))di]\,dt. \tag{4}$$

Due to path-dependent discounting, it is necessary to define the marginal utility of alcohol consumption in the Volterra derivative sense as the increment in Ω caused by a small increase in A along the addictive consumption path at time near a particular date T:

$$\partial_V \Omega_T(\{A\}) = \partial U(\cdot(T))/\partial A - \delta'(A(T))\{\int_T^\infty U(\cdot)\exp[-\int_T^t \delta(A(i)-\pi S(i))di]dt\}\exp[-\int_0^T \delta(A(t)-\pi S(t))dt].$$

Should the discounting rate be constant over time, the Volterra defined above is equivalent to the standard concept of marginal utility $\partial U(\cdot)/\partial A$. To ensure the marginal utility of alcohol be positive, we assume the direct marginal utility of alcohol consumption exceeds its adverse effect via increased impatience (i.e., the second term in the Volterra derivative).

Moreover, we also need to modify the concept of the rate of time preference. Specifically, we define it as:

$$\rho_T = -\frac{d}{dT}\log\partial_V\Omega_T(\{A\})\,|_{\dot{A}=0} = \delta\,\frac{\partial U(\cdot(T))/\partial A - \delta' U(\cdot(T))/\delta}{\partial U(\cdot(T))/\partial A - \delta'\{\int_T^\infty U(\cdot)\exp[-\int_T^t \delta(A(i)-\pi S(i))di]dt\}},$$

which measures the rate at which the marginal utility of alcohol consumption falls along a locally constant path. This time preference rate measure reduces to the conventional one when discounting is constant over time (under which the fraction on the right hand side becomes unity). Under the assumption of positive marginal utility, the denominator of that fraction is positive. Thus, as long as the numerator is positive, we ensure the positiveness of the time preference rate. To guarantee the strict concavity of the Hamiltonian we assume: $U_{AA} - U_A \frac{\delta''}{\delta'} < 0 \;\forall A > 0$. In order for the optimization to be sensible, we need to ensure the boundedness of the lifetime utility: $U/\delta \leq \Omega_0 e^{\delta_0 \Delta}$ *for* $\Omega_0 > 0$ *and* $\delta_0 \in (0,1)$. Under this condition, the lifetime utility is bounded above by a positive constant $\Omega_0/(1-\delta_0)$. These regularity conditions will be imposed throughout the whole paper.

The non-addictive consumption good is produced with the use of physical capital Z=μK (0<μ<1) and human-capital augmented effective labor L=vH (0<v<1) via a constant-returns-to-scale technology F(μK,vH)=vHf(z), where μ and v represent the fraction of physical capital and time, respectively, devoted to the non-addictive good production and z denote factor proportion (μK/vH). The production of alcohol is simply assumed to depend on physical capital alone via a linear technology (with a constant scaling factor M>0). This assumption together with the human capital evolution equation specified below allows us to restrict our factor allocation choice to two dimensional (μ and ν only). Denote w as the (before-tax) real wage rate in effective unit (thus, W=wH is the standard wage rate measure). The evolution of non-human wealth is governed by:

$$\dot{K} = \Lambda(n)F(\mu K, vH) + pM(1-\mu)K - \tau_W wvH - C - (1+\tau_A)pA, \tag{5}$$

where p denotes the (before-tax) mill price of alcohol in units of the non-addictive consumption goods; τ_W and τ_A are the wage income tax and the alcohol consumption tax rates; and Λ is a productivity measure, depending on the occupation specification n (Λ'>0 and Λ"<0). In contrast to the existing literature, job selection is endogenous and consumption and labor decisions are interactive. Let n ∈ [0,1], where n=0 indicates a job most suitable for problem drinkers and n=1 is for non-drinker. In reality, a higher n is associated with a job requiring better human capital/health maintenance or more intensive on-the-job training. Equation (5) specifies that the net-of-tax output, Y=ΛF+PM(1-μ)K, can be allocated to consumption of both non-addictive and addictive goods and savings which enhance non-human wealth.

The increment of human capital, on the other hand, relies on the current production of human capital net of depreciation:

$$\dot{H} = B(1-v)H - \eta(n)G(S/K)H, \ G' > 0, \ G'' > 0, \tag{6}$$

where ηG measures the endogenous rate of human capital depreciation ($\eta' > 0$ and $\eta'' > 0$). Due to its detrimental effect on health, the alcohol consumption stock increases the rate of depreciation of human capital. By improving nutrition and medical-care, an increase in non-human wealth retards human capital depreciation. Notably, the size of the former effect is assumed to be job-specific: for a job most suitable for problem drinkers (n=0), human capital depreciation is insensitive to alcohol additions (i.e., the correspondent value of η is low). For simplicity, assume G to exhibit constant elasticity: $G=(S/K)^{\zeta}/\zeta$, $\zeta>1$. Comparing (5) and (6), selecting a higher n increases productivity (and hence the rate of return on human capital), but at the expense of higher human capital maintenance cost (as reflected by the endogenous human capital depreciation). This tension will provide an endogenous determination of occupation choice.

To close the model, we consider a government that balances its budget at any point in time. It collects wage income and alcohol consumption tax to finance an infrastructural or environmental spending required to maintain the non-economic status of the society (which is assumed to be a fixed proportion to output:

$$\beta Y = \tau_W wvH + \tau_A pA, \quad 0<\beta<1. \tag{7}$$

Denote the co-state variables associated with the evolution equations of S, K and H as λ_S , λ_K and λ_H respectively. Thus the ratio $q = \lambda_H/\lambda_K$ measures the relative price of human capital investment. In equilibrium, perfect competition in the factor market implies that factor returns must equal marginal products:

$$w(z,n) = \Lambda(n)(f - zf_z) \;\; \text{and} \;\; r(z,n) = \Lambda(n)f_z. \tag{8}$$

By full employment in the factor market, we have:

$$vz + (1-\mu)(K/H) = (K/H). \tag{9}$$

Finally, material balances in the goods market require that the supply of and the demand for each consumption good be equal:

$$C = \Lambda F \;\; and \;\; A = M(1\text{-}\mu)K. \tag{10}$$

4. Dynamic Optimization

This environment can be thought of as a dynamic two-sector (goods and human capital investment), general-equilibrium model with two types of consumption goods (non-addictive and addictive) and with a general recursive utility in the sense that both past and current consumption (of the addictive good) can affect the instantaneous utility and the cumulated subjective discount rate.

The first step toward solving this model is to conduct the Uzawa transformation by converting the calendar time (t) into the psychological time (Δ) using the identity: $dt = d\Delta/\delta(A\text{-}\pi S)$. The transformed optimization problem can then be solved using standard optimal control techniques. It contains five control variables concerning consumption, factor allocation and occupation choice (C, A, μ, v and n) and three state variables consisting the reproducible stocks (S, K and H). After deriving the necessary and sufficient conditions for optimization, one can then transform the whole system back to conventional calendar time.

Applying Palivos, Wang and Zhang (1997), we can show that this class of constant-returns, recursive utility model can yield non-degenerate asymptotically balanced growth equilibrium at which the common rate of growth of C, A, S, K and H is positive and asymptotically constant. This growth rate is strictly positive provided that the scaling factor B dominates the sum of the maximum rates of time discounting and human-capital depreciation. Recall from the previous section that the elasticity of marginal discounting $[(A\text{-}\pi S)\delta''/\delta']$ is bounded above, our model will accept an asymptotically balanced growth path as long as the elasticity of marginal felicity with respect to the alcohol consumption stock (SV"/V) and the subjective discount rate (δ) are asymptotically constant.

Define $\gamma = \lambda_S/\lambda_K$. To characterize the dynamical system, we apply the technique developed by Bond, Wang and Yip (1996) by transforming the non-stationary variables into ratios to human capital: c = C/H, a = A/H, s = S/H and k = K/H. We then use eight first-order conditions, three evolution equations, one full employment condition, two material balance conditions, and the government budget constraint (where one is redundant by Walras's law) to obtain the following relationships.

First, optimal occupation choice implies

$$\Lambda'(n)/\eta'(n) = q \ , \tag{11}$$

implying that n can be written as a decreasing function of q alone. Intuitively, when the relative price of human capital investment is higher, it discourages labor sorting toward that requiring higher skills and human capital maintenance. This general-equilibrium relationship between job selection and intertemporal pricing has been completely ignored in the existing literature.

Second, cross-sector (after-tax) factor return equalization yields:

$$r(z,n) = Mp \ \text{ and } \ (1-\tau_W)w(z,n) = q \ . \tag{12}$$

Combining these relationships with the factor market equilibrium condition, we have:

$$z = z(q),\ n = n(q),\ p = p(q) \ \text{ and } \ w = w(q) \ . \tag{13}$$

When human capital accumulation is labor intensive, one obtains: z' > 0, p' < 0 and w' > 0.

Third, the intertemporal no-arbitrage condition, by equating the capital gain of human capital from changes in q with the difference in the rates of returns on K and H, gives:

$$\dot{q}/q \ = \ Mp(q)+q\eta(n)G(s/k)(1+\zeta/k)-B. \tag{14}$$

Note that there is another no-arbitrage condition pinning down the evolution of γ. However, due to the complexity of the model, we ignore any possible general-equilibrium effects thru changes in γ and thus proceed to solve for the equilibrium consistent with any given path of γ. By utilizing (13) and (14), the alcohol price and the (effective) wage dynamics can be derived as:

$$\dot{p}/p \ = \ (qp'/p)[Mp(q)+q\eta(n)G(s/k)(1+\zeta/k)-B] \tag{15}$$

$$\dot{w}/w \ = \ (qw'/w)[Mp(q)+q\eta(n)G(s/k)(1+\zeta/k)-B], \tag{16}$$

which indicate that the dynamics of the alcohol price and the effective wage rate must depend on q, s and k. Equations (14)-(16) together with the optimal job selection schedules from (11), n(q), clearly illustrate the dynamic interactions between alcohol pricing, occupation choice and wage earnings.

Fourth, full employment (for K) and material balance (for A) provide the validity of expressing μ and v as functions of (q,k,a):

$$\mu(a,k) = 1 - \frac{a}{Mk} \quad and \quad v(q,a,k) = \frac{k}{z(q)}\left(1 - \frac{a}{Mk}\right). \tag{17}$$

Thus, as the capital-labor ratio is higher more physical and human capital inputs will be devoted to goods production, whereas the effects of alcohol consumption are opposite. While the relative price of human capital investment has no direct influence on the allocation of physical capital, it encourages human capital to be devoted to the education sector.

Fifth, the Keynes-Ramsey equations, governing intertemporal consumption efficiency, generate:

$$[1+\alpha(\sigma-1)]\frac{\dot{c}}{c}+(1-\alpha)(\sigma-1)\frac{\dot{a}}{a}-\frac{SV'}{V}\frac{\dot{s}}{s} = Mp+\eta G[\frac{\zeta}{k}+\sigma-\frac{SV'}{V}]-B(1-v)[\sigma-\frac{SV'}{V}]-\delta, \tag{18}$$

$$\frac{s\gamma}{p}\frac{\dot{s}}{s}+\frac{k}{p}\frac{\dot{k}}{k} = (1+\frac{s\gamma+k}{p})[\eta G-B(1-v)]+(a-\pi s)[\frac{\gamma}{p}+\frac{1-\alpha}{\alpha}\frac{c}{ap}-(1+\tau_A)][\frac{\delta}{(A-\pi S)\delta'}]. \tag{19}$$

Finally, manipulation of (2), (5), (6) and (17) yields two transformed equations for the dynamics of (s, k):

$$\dot{s}/s = a/s+\eta(n)G(s/k)-B(1-v)-\pi. \tag{20}$$

$$\dot{k}/k = \Lambda(n)vf(z)/k+pa/k+\eta(n)G(s/k)-\tau_W wv/k-c/k-(1+\tau_A)ap/k-B(1-v), \tag{21}$$

The dynamic system is captured by five differential equations, (14), (18)-(21), governing the rates of change of q, c, a, s and k, respectively. Two additional conditions are required to ensure the existence of the relative price path and non-degenerate growth: $sup_q\,[r(q)-w(q)/p(q)] > \delta-\eta > inf_q\,[r(q)-w(q)/p(q)]$

and

$\beta(1-v(q,k,a)) > \eta(n(q))G(s/k)$, where the first equation permits a well-defined price path governed by (14) and the second guarantees positive rate of growth of the underlying economy. Once these above transformed quantity and intertemporal price variables are solved, the dynamics of p and w can then be determined recursively with the use of (15) and (16).

5. Characterization of the Asymptotically Balanced Growth and the Dynamics

Under the specifications of the preference structure and production technologies and the regularity conditions presented in Sections 2 and 3, there exists a non-degenerate *asymptotically balanced growth path* (ABGP) on which all the transformed variables {q, c, a, s, k, p, w} are asymptotically constant with an asymptotic growth rate $\theta > 0$ [see Proposition 4 of Palivos, Wang and Zheng (1997)].

Utilizing Propositions 2, 3, 5 and 6 of Bond, Wang and Yip (1996), we can examine the stability properties of the model and provide the necessary theoretical structure toward understanding the dynamics of both price variables the wage rate as well as quantity variables (especially in our interest, addictive consumption, labor effort and human capital investment). In particular, one can combine (6) and (16) to obtain the dynamic wage profile W=wH:

$$\dot{W}/W = (qw'/w)Mp(q)+B[1-v-qw'/w)]-\eta(n)G(s/k)[1-q(1+\zeta/k)], \tag{22}$$

Though we are able to study analytically the asymptotically balanced growth rates and stability properties, it is clear that the dynamics cannot be fully characterized, since the individual decision rule and the dynamic system are highly non-linear.[2] This is due to the joint considerations of habit formation/endogenous time preferences and labor market decisions (v, H and n). Nevertheless, we may still draw some useful conclusions by imposing further simplifying assumptions (which will be employed in the discussion below).

What are the model implications for rational addiction behavior? Conventional rational addiction models focus on the effects of future and past prices on current alcohol consumption. Our framework further suggests that a forward-looking individual's alcohol consumption *and* labor decisions depend on the current state variables as well as the entire (past and future) path of exogenous variables. In

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[2] This is true even when V exhibits constant-relative-risk-aversion, δ is an inverse exponential function and F takes the Cobb-Douglas form.

particular, when deciding about current alcohol consumption, work effort, and occupation the rational addict will anticipate the effects of alcohol abuse on human capital accumulation and the induced wage effects. Labor decisions can thus offer additional tests for rational versus myopic addiction.

Equation (22) illustrate the wage dynamics. Due to the consideration of endogenous time preferences and occupation choice, the corresponding wage profile for a drinker is expected to be flatter than a non-drinker - a rational drinker will accumulate less human capital and work more at earlier ages and face a slow increase in wage earnings onwards. Specifically, a drinker in our model is associated with a lower n, which by reducing the productivity results in a lower rate of wage growth (direct productivity effect).

Even by omitting the relative price effect (which is valid if $\eta \ll B$), there are still two additional channels for n to influence the wage earning profile. First, a lower n leads to a lower rate of return (r) in the non-addictive good sector and, by factor price equalization, results in a lower rate of return in the alcohol sector. The latter requires the alcohol price to fall, which through intertemporal no-arbitrage decreases the rate of wage growth (alcohol price effect). Second, given the same rate of return, a lower n creates a downward pressure on the rate of return in the non-addictive good sector and hence demands an offset force from a reduction in the factor proportion (z). As a consequence, the s/k ratio decreases, resulting in a lower rate of wage growth (alcohol stock effect).

All these effects imply that a rational drinker faces a flatter wage profile, which is again empirically testable. Mullahy and Sindelar (1993) find differences in the labor market consequences of alcoholism over the life cycle that are suggestive of the predicted pattern. Young adults with alcohol problems appear to earn slightly more than their nonalcoholic peers, but large negative impacts of alcohol abuse appear in the prime working ages (approximately 30 - 59 years old). Of course, this cross-sectional evidence, that compares different individuals of different ages at a point in time, may be misleading on the pattern of wages over the life cycle for a given individual.

An immediate problem is a possible observational equivalence between rational addictions and the ability of the employers to screen for alcohol abuse -- both result in similar work and occupational choice outcomes. We do not explicitly model the demand side of the labor market, but a natural assumption would be that employers try to sort alcoholic workers into low n jobs. As a result, observing alcoholic workers in jobs with flat wage profiles could be due to rational addicts or due to effective employer screening. Additional tests are required to disentangle these two alternative hypotheses. Suppose job selection is a consequence of employment screening. Then future policy such as an alcohol tax or an education subsidy (i.e., a negative wage tax) would not affect current occupation choice and work effort. In contrast, a rational addict will react to these policy changes. For example, our model indicates that an anticipated future alcohol tax raises the alcohol price. Thus, it discourages alcohol consumption and encourages human capital accumulation, which by increasing real wage earnings makes job selection of a higher n more attractive.

On the other hand, an anticipated education subsidy will enhance human capital accumulation and by encouraging a choice of a higher n, reduce the demand for alcohol. A large number of empirical studies document that people with more schooling human capital make healthier lifestyle choices, such as avoiding cigarette and alcohol addiction. Previous studies explore whether schooling causes the healthier behaviors by improving people's knowledge of the health consequences of the addictions (Kenkel 1991). Our model suggests a more subtle way schooling can "cause" healthier lifestyles: more schooling places the individual on optimal trajectories of choice variables that are inconsistent with alcohol addictions. Moreover, a rational addict will also take into account the job package of fringe benefits related to future health, including pensions and insurance. In particular, these benefits are expected to be less generous for an alcohol-dependent. This is mainly due to endogenous time preference (so an alcohol-dependent cares less about pensions) and endogenous human capital depreciation (so an alcohol-dependent picks a package with less human capital maintenance required). Thus alcohol policy can affect labor market outcomes whereas education policy can influence addictive behavior. Any policy evaluation without a full account for such inter-plays may be biased.

Finally, we note that this class of model may lead to multiple balanced growth equilibrium paths. Differently from the threshold multiplicity as in Becker and Murphy (1988), our model may have a continuum of equilibrium paths leading to a unique asymptotically balanced growth path. As a consequence, the selection of a specific equilibrium path does not depend on history (initial conditions) but rely solely on expectations (self-fulfilling prophecies). An individual who believes in a strong future labor market is more likely to avoid being addicted to alcohol and thus to choose an occupation that has a relatively higher elasticity of human capital depreciation in response to alcoholism. Therefore, he or she accumulates more capital and receives a higher wage, fulfilling the original expectations. In the presence of self-fulfilling expectations-driven multiplicity, dynamic indeterminacy emerges. An immediate consequence is that it is difficult to evaluate the effect of any public policy in transition to the asymptotically balanced growth path. Thus, to enhance the effectiveness of public policy, one must minimize informational frictions, hoping to reduce expectations-caused volatility.

6. Concluding Remarks

This paper only begins to explore alcohol addiction and the labor market, leaving many interesting avenues for future research. First, it would be interesting to study the effect of alcoholism on job duration and unemployment spells. This can be done by introducing the addictive behavior into the dynamic search model. Intuitively, heavy drinkers would face limited choice of occupations in order to prevent severe human capital depreciation and possible job loss. On the one hand, this increases search duration and unemployment spells. On the other hand, this makes drinking workers more willing to stay at a given job, until a critical point when job loss occurs.

Second, the employment effects of alcoholism cannot be completely analyzed without separating the intensity of work effort from labor hours. In particular, work effort depends crucially on the worker's health. The rational addiction model described above can be readily modified (at expenses of simplifying the basic structure) to disentangle work effort from hours. While alcoholism may reduce employment measured by hours, it also reduces labor productivity due to lower work effort intensity. Since in certain types of jobs, wages are not sensitive to work effort, it is expected to see that more frequent drinkers would be likely to select such occupation. Both of these extensions have empirical implications. Specifically, in addition to the alcohol consumption and labor market data described above, we can construct measures of job duration and occupation classifications in the NLSY data. Thus it is possible to investigate the possible relationships between alcohol abuse and job duration, as well as between the degree of alcoholism and the productivity elasticity of wage earnings. These will have positive value-added to the empirical labor search literature summarized in Devine and Kiefer (1991).

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Table 1. NLSY Variable Means—Full Sample 1989

Variable	Men Mean	Men Standard Deviation	Women Mean	Women Standard Deviation
1989 Outcomes				
Log(earnings)	9.48	(0.88)	8.99	(1.07)
Log(hours / 100)	7.57	(0.55)	7.25	(0.79)
Marriage	0.46	(0.50)	0.54	(0.50)
Alcohol dependence	0.20	(0.40)	0.08	(0.28)
Alcohol abuse	0.15	(0.36)	0.05	(0.23)
Heavy drinking	2.01	(3.09)	0.63	(1.75)
Days drinking per month	6.44	(7.92)	2.81	(4.99)
Personal characteristics				
African origin	0.27	(0.44)	0.26	(0.44)
Latino origin	0.16	(0.37)	0.16	(0.37)
Year of birth	60.65	(2.22)	60.51	(2.22)
Religious	0.41	(0.49)	0.49	(0.50)
Interview status	0.12	(0.32)	0.06	(0.24)
Health Status	0.04	(0.19)	0.05	(0.21)
Completed high school	0.80	(0.40)	0.84	(0.37)
Completed college	0.16	(0.37)	0.17	(0.37)
AFQT score	183.45	(39.87)	184.44	(36.38)
Children	1.04	(1.18)	1.47	(1.29)
Family background				
Mother's education	9.99	(4.17)	10.17	(3.84)
Mother's education missing	0.07	(0.26)	0.05	(0.22)
Father's education	9.25	(5.29)	9.19	(5.23)
Father's education missing	0.15	(0.35)	0.15	(0.35)
Non-intact family at age 14	0.32	(0.47)	0.33	(0.47)
Siblings	3.88	(2.65)	3.96	(2.68)
Magazines at age 14	0.55	(0.50)	0.54	(0.50)
Alcoholic mother/stepmother	0.04	(0.19)	0.05	(0.23)
Alcoholic father/stepfather	0.18	(0.38)	0.23	(0.42)
Other alcoholic relative	0.23	(0.42)	0.25	(0.44)

Table 2: Job Characteristics by Problem Drinking Status (1989 NLSY Data)

Job characteristic	Alcohol dependent workers	Alcohol non-dependent workers	T-test for hypothesis of no group differences
Pensions	0.46	0.55	4.85***
Training opportunities	0.38	0.44	2.90***
Health insurance	0.71	0.77	3.93***
Life insurance	0.58	0.65	3.86***
Paid sick leave	0.47	0.60	6.59***
Dental insurance	0.47	0.52	2.80***
Paid vacation	0.71	0.78	4.06***
Attended OTJ training	0.16	0.16	0.19
On-the-job injury	0.12	0.08	3.45***

Note: The definition of alcohol-dependence is based on DSM-IIIR criteria. Statistical significance is denoted by *, ** and *** at .10, .05 and .01 level, respectively.

Table 3: Alcohol Dependency Status and Fringe Benefits (1989 NLSY Data for Men)

	Sample Proportion	Effect of alcohol dependency on probability
health insurance	0.764	-0.064*** (0.018)
life insurance	0.643	-0.055*** (0.021)
paid sick leave	0.575	-0.105*** (0.022)
dental insurance	0.509	-0.046** (0.022)
paid vacation	0.774	-0.059*** (0.018)
m(p)aternity leave	0.485	-0.047** (0.023)
retirement plan	0.534	-0.090*** (0.022)
employee discounts	0.453	0.006 (0.022)
flexible work schedule	0.437	0.018 (0.022)
profit-sharing	0.288	-0.012 (0.020)
training opportunities	0.423	-0.037* (0.022)
child care	0.042	0.001 (0.008)
paid/ subsidized meals	0.160	0.001 (0.016)
parking	0.540	-0.007 (0.021)

Notes: Probit coefficient has been transformed to show the effect on the probability of a discrete change of the alcohol dependency dummy variable from zero to one. Standard errors in parenthesis. Models also include measures for year of birth, ethnicity, non-intact family/ religious attendance/ magazines/ library card at age 14, mother's and father's education, siblings, and AFQT score.

Table 4: Alcohol Dependency Status and Job Characteristics (1989 NLSY Data for Men)

	Sample Proportion (or mean of continuous variable)	Effect of alcohol dependency on probability (or OLS coefficient for continuous variable)
occupation	0.159	-0.025* (0.013)
like job very much	0.328	0.029 (0.018)
injury/illness occurred at job	0.088	0.033*** (0.011)
ln (number of employees)		-0.235*** (0.090)

Note: See also notes to Table 3.

Table 5: Alcohol Dependency and Earnings (1989 NLSY Data for Men)

	(1)	(2)
alcohol dependent	-0.098** (0.035)	-0.046* (0.030)
schooling		0.054*** (0.007)
tenure		0.003*** (0.0003)
married		0.244*** (0.025)
white collar occupation		0.317 (7.994)
blue collar occupation		0.225 (0.036)
log (number of employees at job)		0.055 (0.005)
attended training		0.151*** (0.033)

Notes: In the OLS regressions, the dependent variable is ln(earnings). See also notes to Table 3.

Table 6A: Occupation by Alcohol Dependency Status (1989 NLSY Data for Men)

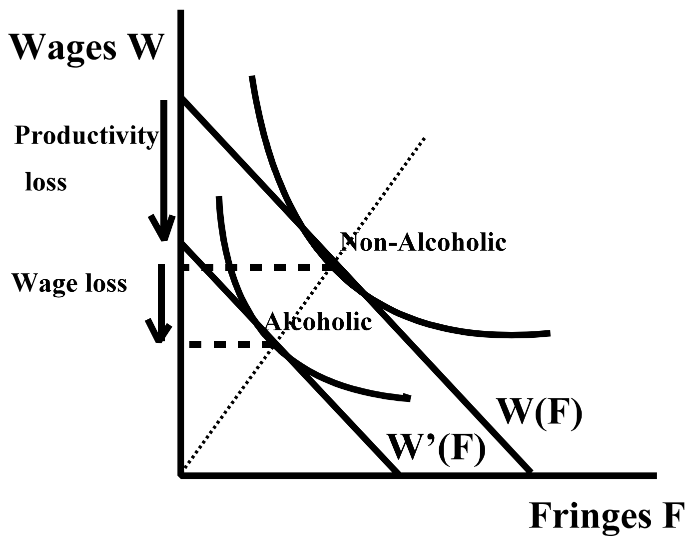
Occupational Status	Alcohol Non-dependent	Alcohol dependent
White Collar	**37.5**	**30.9**
Professional and technical	13.9	10.1
Managers and administrators	11.4	10.5
Sales workers	4.3	3.2
Clerical workers	7.9	7.1
Blue Collar	**48.1**	**57.9**
Craftspeople	19.2	25.0
Operatives	19.1	20.1
Non-farm laborers	9.9	12.8
Service workers	**12.0**	**9.6**
Farmers/ farm workers	**2.2**	**1.5**

Table 6B: Earnings, by Occupation and Alcohol Dependency Status (1989 NLSY Data for Men)

Occupational Status	Median Earnings ($)		Mean Earnings ($)	
	Non-dependent	Dependent	Non-dependent	Dependent
White Collar (n=1619)	**25,000**	**25,000**	**28,398**	**27,252**
Professional and technical (n=584)	29,000	29,300	31,186	31,325
Managers and administrators (n=505)	26,000	25,000	30,087	29,505
Sales workers (n=181)	25,750	27,000	30,412	25,467
Clerical workers (n=349)	18,950	18,500	20,056	18,994
Blue Collar (n=2,202)	**18,000**	**15,000**	**18,941**	**16,807**
Craftspeople (n=898)	20,400	16,500	21,224	18,378
Operatives (n=853)	18,000	15,000	18,758	16,718
Non-farm laborers (n=451)	12,000	14,000	14,763	13,805
Service workers (n=513)	**15,000**	**13,000**	**16,032**	**15,433**
Farmers/ farm workers (n=94)	**10,000**	**5,000**	**13,012**	**6,257**

Figure 1: Productivity Vs. Wage Losses

Case A - Homothetic Preferences



Case B - Non-homothetic Preferences