The Macroeconomic Effects of Overworking in China*

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in partial fulfillment of the requirements for the degree of

Master of Science

in

Economics

Tufts University

May 2021

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*I wish to thank Alan Finkelstein Shapiro for his time and invaluable guidence on this paper. Also, I really appreciate the helpful comments and discussions with Marcelo Bianconi. I am responsible for remaining errors, if any.

Abstract

I build a macroeconomic framework with searching and matching model that incorporates overworking with an endogenous health channel to analyze the labor market and macroeconomic consequences of overwork. With the existence of productivity heterogeneity in the labor force, the weight of high productivity workers is determined endogenously so that firms are indifferent between worker categories, leading to overworking. At the same time, working not only causes disutility directly but also creates disutility through the health channel by accelerating the depreciation in health. Under a right-to-manage setting, as the weight shift towards low productivity workers, workers experience an increase in overtime and health depreciation, a decrease in the level of health and in consumption, leading to lower overall welfare with negligible changes in labor market variables.

1 Introduction

Working overtime has always been prevalent in China. In 2019, the average hours worked in China was 46.7 hours per week, which might even be an understatement given the size of so-called 'voluntary overtime' and the possibility of under-reporting, but it is still much higher than many other countries (China Labor Statistics Yearbook 2020; see Table 1). For example, in 2019 average hours worked in the U.S. were 34.4 hours per week (Bureau of Labor Statistics). As shown in Table 1, about 52.5% of the population in China have to work overtime (41 hours or more). According to a more informal labor survey on Boss zhipin (one of the major job search applications in China), for workers aged between 25 and 30, over 90% of them need to work overtime at least one day a week, and about 26% of them need to work overtime every day in a week. Such a phenomenon is not new in China but it only started to gain wide public attention when a thread titled "996 ICU" was posted on GitHub. Under the thread, thousands of Chinese software developers have gathered to support the campaign against the 996-working schedule. 996 refers to a working schedule where the working hour last from 9 a.m. to 9 p.m., six days a week. Astonishing as it might be, 996 is now a common practice in many technology firms, where a lack of government regulation on the labor market makes it possible for firms to force their workers to work overtime "voluntarily"

This thread brings up an intriguing fact about the effect of working overtime that has been missing in the economics literature: health. Several studies suggest that less labor market regulation could be beneficial for improving the performance of the economy (Bernal-Verdugo et al.(2012), Botero et al.(2004), Elmeskov et al.(1998), and Nickell (1997)), without considering the fact that this labor market deregulation is often at the cost of workers' welfare. In the case of China, despite the existence of laws regarding labor protection, the government has not been enforcing these regulations faithfully, which is effectively a form of deregulation that favors firms, with the aim of reducing the cost of keeping workers and hence increase the competitiveness of firms. However, there has been an abundance of

Table 1: Working Hours of Urban Employed Persons by Household Registration and Sex in China

Househod Registration		1-8 hrs	9-19 hrs	20-39 hrs	40 hrs	41-48 hrs	48 hrs above
Total		0.9	1.0	5.3	40.4	20.7	31.8
	Agricultural	1.1	1.7	8.3	28.3	20.3	40.3
	Non agricultural	0.7	0.5	3.3	48.7	20.9	25.8
Male		0.8	0.8	4.5	38.4	20.7	34.9
	Agricultural	0.8	1.3	6.8	26.6	20.4	44.1
	Non agricultural	0.7	0.4	2.9	47	20.9	28.2
Female		1.1	1.3	6.4	43.1	20.7	27.5
	Agricultural	1.5	2.3	10.5	30.8	20.2	34.6
	Non agricultural	0.8	0.6	3.8	51	20.9	22.8

Source: China Labor Statistics Yearbook 2020

evidence in the medical literature on how working overtime might negatively affect health. For example, working 3-4 hours overtime increases the hazard ratio of coronary heart disease (CHD) by 1.9 times compared to workers who do not work overtime, and psychological distress, like depression and anxiety, is often reported among those workers working overtime. (Virtanen, et al., 2010) Overtime workers also tend to adopt less healthy practices, such as less physical exercise and worse diets, which is also one of the main contributing factors to their deteriorating health condition. (Taris et al. 2010) There is even a significant correlation between overtime and untreated tooth decay in financial workers. (Yoshino1 et al., 2017)
Thus, the goal of this paper is to explore the consequences of working overtime on macroeconomic performance, in a model where the health component of working overtime is taken explicitly into consideration and firms can induce 'voluntary' overtime. The existence of overtime is probably the best testimony of the lack of market power of workers in the labor market and the absence of protections of workers' rights. In the case of China, rising housing prices have increased the debt burden of millions of Chinese citizens, making it nearly impossible for them to afford unemployment, hence reducing the bargaining power they possess. On the other hand, due to the lack of labor protections, firms could exploit workers without having to worry about being punished by government authorities.

Thus, instead of setting up the model focusing on the monopsony power of the firm over employment, we focus on workers' lack of power to manage their own hours worked. For each worker, the firm has a presumed value of the output that a worker would produce, which makes the firm indifferent to different types of workers as long as the worker could meet the presumed value, which implies the same total wage payment for any type of workers. At the same time, firm possesses enough market power to manage the hours workers need to work. Thus, low productivity workers would be forced to work longer hours to meet firms' presumed value of the output of a typical worker, which implies a lower wage for low productivity workers under the same total wage payment. To capture the firm's right to manage on the hour's margin, the model in this paper follows Trigari (2006) by introducing hours worked in the presence of search frictions. This allows the firm to determine the wage rate by setting hours worked.

At the same time, intuitively, constantly working overtime would lead to the deterioration of health. In principle, deterioration in health would decrease the welfare of households by lowering the utility gained from the staying health and also lowering the level of consumption due to the need for investment in health. Thus, introducing a channel that links the hours worked and the depreciation in health would allow us to explore how overworking would negatively affect the welfare of households and, more broadly, macroeconomic performance. One of the main outcomes of the model is that, through introducing the mechanism that allows the firm to be indifferent between different types of workers, we confirmed the hypothesis that total wage payments stay the same and low productivity workers have to work overtime and receive a lower wage. Also, we find that, through the health channel, households working overtime need to face a higher health cost, and consequently they have to sacrifice additional consumption to cover the additional health deficits caused by working. This negative impact on consumption is expected to be larger when health depreciation is more sensitive to the change in hours worked.

The remainder of the paper is organized as follows: Section 2 describes the model, Section 3 describes the calibration targets, Section 4 presents the main quantitative results and, finally, Section 5 concludes this paper.

2 Model: Workers with differentiated productivities

The model proposed in this paper is a general equilibrium model with search and matching frictions, with intensive margin of labor and heterogeneity in employment. I follow Trigari's paper (Trigari, 2006) to introduce the mechanism where firm has the right to manage the hours worked by workers. In addition, I follow Huang, He, Hung (2016)'s paper to introduce the health channel where hours worked affects the health deficits. Households could also choose to allocate resources to invest in health where the level of health affects the welfare. On the basis of these mechanism, I hereby introduce the mechanism that allows the firm to choose the weight of different types of workers so that the firm would be indifferent between the different types of workers, which leads to the issue of overtime. This enables us to study the effect of overtime and the role health channel plays.

2.1 Households

A representative agent derives utility from consumption and health, and disutility from labor.

$$u\left(c_t, h_t^h, h_t^l, a_t\right) = \frac{c_t^{1-\sigma}}{1-\sigma} - \psi\left(\omega_t \frac{h_t^{h1+\sigma_h}}{1+\sigma_h} + \left(1-\omega_t\right)\frac{h_t^{l1+\sigma_h}}{1+\sigma_h}\right) n_t + ln(a_t) \tag{1}$$

The contemporaneous utility function used is the standard CRRA utility function, with σ as the risk adversion parameter. Employment is associated with two different types of technologies: one with high productivity z_t^h with hours worked h_t^h and the other with low productivity z_t^l with hours worked h_t^l . The weight of high productivity worker is ω_t, which is endogenously determined by the firm and taken as given by the household. Thus, the disutility from working h_t^h, h_t^l hours for individual workers are $g\left(h_t^h\right) = -\psi\omega_t \frac{h_t^{h1+\sigma_h}}{1+\sigma_h}$ and $g\left(h_t^l\right) = -\psi\left(1-\omega_t\right)\frac{h_t^{l1+\sigma_h}}{1+\sigma_h}$ respectively, adding up to a weighted average of the disutility from hours worked h_t^h, h_t^l by each type of workers. Note that both the wage and hours worked are determined in the Nash bargaining process rather than being decided by either firms or households.

The stock of health follows the law of motion of health:

$$a_{t+1} = \left(1 - \phi\left(h_t^h, h_t^l, \omega_t\right)\right) a_t + I_t^h \tag{2}$$

where the a_t is the level of health stock at time t, I_t^h is the level of investment into health. For the health depreciation rate, I followed the function form used in Huang, He, Hung (2016)'s paper, modified with heterogeneity in workers:

$$\phi\left(h_t^h, h_t^l, \omega_t\right) = \delta + \frac{h_t^{h\varpi}}{\varpi}\omega_t + \frac{h_t^{l\varpi}}{\varpi}\left(1 - \omega_t\right) \tag{3}$$

where δ is the natural rate of depreciation of health and the depreciation in health from working is the weighted average of the negative impact on health from working: $\frac{h_t^{h\varpi}}{\varpi}$ and $\frac{h_t^{l\varpi}}{\varpi}$, with ϖ as the curvature parameter. With more hours worked, the faster the stock of health depreciates, thus $\phi'\left(h_t^{h/l}\right) > 0$ and $\phi''\left(h_t^{h/l}\right) > 0$

Thus, the maximization problem for the representative agent is simply choosing sequences of consumption c_t and health a_{t+1} to maximize:

$$\sum_{t=0}^{\infty} \beta^t u(c_t, h_t^h, h_t^l, a_t) \tag{4}$$

subject to the resource constraint:

$$c_t + a_{t+1} - \left(1 - \phi\left(h_t^h, h_t^l, \omega_t\right)\right) a_t + T_t = \left(w_t^h h_t^h \omega_t + w_t^l h_t^l \left(1 - \omega_t\right)\right) n_t + b\left(1 - n_t\right) + \pi_t \tag{5}$$

where the number of employed workers is n_t and each worker receives the total wage payment as a weighted average between the total wage payment of $w_t^h h_t^h$ and $w_t^l h_t^l$, where w_t^h and w_t^l are the real wage associated with high and low productivity workers, respectively. The unemployed workers receive the unemployment benefit b, and the firms are also owned by the households.

Through setting up the Lagrange, we would be able to obtain the first order conditions for consumption c_t and health a_{t+1} :

$$u_{c_t}(c_t, h_t^h, h_t^l, n_t, a_t) = \lambda_t \tag{6}$$

$$u_{c_t} = E_t \beta \left[u_{a_{t+1}} + u_{c_{t+1}} \left(1 - \phi \left(h_t^h, h_t^l, \omega_t\right)\right)\right] \tag{7}$$

Where u_{c_t} and $u_{a_{t+1}}$ are taking the derivative of the utility function with respect to c_t and a_{t+1}, respectively. Equation 7 suggests that the marginal benefit of investing in an additional unit of health equals to the marginal cost of investing in an additional unit of health, with the left hand side being the loss from the consuming less at time t and the right hand side being the sum of the discounted marginal utility gained from an additional unit of health and leftover health after 'depreciation' in time $t + 1$.

Also, using the Lagrange multiplier λ_t, we define the intertemporal discounting factor $\Xi_{t,t+n} = \beta^n \frac{\lambda_{t+n}}{\lambda_t}$.

2.2 Firm's problem:

For the firm, each job position could be either filled or vacant and the matching process is simply matching the unemployed workers u_t with the vacancies v_t, which follows the constant returns to scale matching function:

$$m\left(u_t, v_t\right) = M u_t^{\xi} v_t^{1-\xi} \tag{8}$$

where M is just the parameter of matching efficiency. From the matching function, we can obtain that the probability of filling a vacancy is $q\left(\theta_t\right) = \frac{m_t}{v_t}$ and the probatility of an unemployed worker finding a job is $p\left(\theta_t\right) = \frac{m_t}{u_t}$, with $0 < \xi < 1$ as the matching elasticity parameter.

Firms hire workers for production and use the following technology for production:

$$y_t = z_{h,t} \left(h_t^h\right)^{\alpha} n_{h,t} + z_{l,t} \left(h_t^l\right)^{\alpha} n_{l,t} \tag{9}$$

where $z_{h,t}$ and $z_{l,t}$ are the productivity for each type of workers respectively, $h_t^h$and h_t^l are the hours workers spent at time t with $\alpha \in (0,1)$. ω_t is the labor share, and $n_{h,t} = \omega_t n_t$, $n_{l,t} = (1-\omega_t) n_t$ are the the measures of the two types of employment, where n_t represents total employment.

The labor hired follows the law of motion of labor:

$$n_{t+1} = (1-\rho) n_t + v_t q(\theta_t) \tag{10}$$

which simply states that the number of workers hired at time $t+1$ would be the number of workers employed n_t that survived the separation with the probability of $(1-\rho)$ plus the new workers matched from the labor market which is the number of vacancies opened v_t times the probability of filling a vacancy $q(\theta_t)$. The size of the labor force is normalized to 1 and thus the number of unemployed u_t is simply $u_t = 1 - n_t$.

Thus, the optimization problem for the firm is now that the firms choose workers employed next period n_{t+1} and number of vacancies v_t, and the weight ω_t to maximize the presented discounted value of profits:

$$\sum_{t=0}^{\infty} \Xi_{t,0} \left(z_{h,t} \left(h_t^h\right)^{\alpha} \omega_t n_t + z_{l,t} \left(h_t^l\right)^{\alpha} (1-\omega_t) n_t - w_t^h h_t^h \omega_t n_t - w_t^l h_t^l (1-\omega_t) n_t - \gamma v_t \right)$$

subject to:

$$n_{t+1} = (1-\rho) n_t + v_t q(\theta_t) \tag{11}$$

where γ is the cost of opening a vacancy.

Through setting up the Lagrange, we would be able to obtain the first order condition for workers employed n_{t+1} and number of vacancies v_t to have the Job Creation Condition:

$$\begin{aligned} \frac{\gamma}{q(\theta_t)} = \Xi_{t+1,t} \{ & z_{h,t+1} \left(h_{t+1}^h\right)^{\alpha} \omega_{t+1} + z_{l,t+1} \left(h_{t+1}^l\right)^{\alpha} (1-\omega_{t+1}) \\ & - w_{t+1}^h h_{t+1}^h \omega_{t+1} - w_{t+1}^l h_{t+1}^l (1-\omega_{t+1}) + (1-\rho) \frac{\gamma}{q(\theta_{t+1})} \} \end{aligned} \tag{12}$$

Where the left hand side represents the cost of hiring a worker as in the expected number of vacanies needed for hiring a worker $\frac{1}{q(\theta_t)}$ times the cost of opening vacancies γ and the right hand side represents the expected benefit of hiring a worker in the form of weighted average between the profit generated from hiring each type of workers at time $t+1$, and the expected saving in opening vacancies from keeping this worker in time $t+1$, all discounted back to time t.

The optimality condition with respect to the weight ω_t is:

$$z_{h,t}\left(h_t^h\right)^{\alpha} - w_t^h h_t^h = z_{l,t}\left(h_t^l\right)^{\alpha} - w_t^l h_t^l \tag{13}$$

Through choosing the weight of both types of workers, the net marginal return to having a high-productivity worker equals to the net marginal return to having a low-productivity worker, making the firm indifferent between the two types of workers.

2.3 Value functions:

To firms, J_t^h and J_t^l each represents the value of hiring a high and low productivity worker at time t, which is given by:

$$J_t^h = z_{h,t}\left(h_t^h\right)^{\alpha} - w_t^h h_t^h + \Xi_{t,t+1}\left[\left(1-\rho\right)J_{t+1}^h + \rho V_{t+1}^h\right] \tag{14}$$

$$J_t^l = z_{l,t}\left(h_t^l\right)^{\alpha} - w_t^l h_t^l + E_t\left[\left(1-\rho\right)J_{t+1}^l + \rho V_{t+1}^l\right] \tag{15}$$

where the value of the job to firm is the sum of the profits from hiring the worker and the continuation value, which is the expected value of having a job plus the expected value of having a vacancy at time t+1, both discounted back to time t by $\Xi_{t,t+1}$.

V_t^h and V_t^l each represents the value of a vacancy for high and low productivity worker at time t, which is given by:

$$V_t^h = -\gamma + \Xi_{t,t+1}\left[q_t\left(1-\rho\right)J_{t+1}^h + \left(1-q_t\right)V_{t+1}^h\right] \tag{16}$$

$$V_t^l = -\gamma + \Xi_{t,t+1}\left[q_t\left(1-\rho\right)J_{t+1}^l + \left(1-q_t\right)V_{t+1}^l\right] \tag{17}$$

where the value of a vacancy to firm is the sum of the flow cost of opening a vacancy and the continuation value, which is the expected value of filling a vacancy and the worker survived the separation plus the expected value of not filling a vacancy and keep the vacancy open at time $t+1$, both discounted back to time t.

For workers, W_t^h and W_t^l each represents the value of having a job for each type of worker, which is given by:

$$W_t^h = w_t^h h_t^h + \frac{g\left(h_t^h\right)}{\lambda_t} + \Xi_{t,t+1}\left[\left(1-\rho\right)\left(W_{t+1}^h - U_{t+1}^h\right) + U_{t+1}^h\right] \tag{18}$$

$$W_t^l = w_t^l h_t^l + \frac{g\left(h_t^l\right)}{\lambda_t} + \Xi_{t,t+1}\left[\left(1-\rho\right)\left(W_{t+1}^l - U_{t+1}^l\right) + U_{t+1}^l\right] \tag{19}$$

where the value of the job to worker is the sum of the wage payment: wage w_t times hours worked h_t, $\frac{g\left(h_t^h\right)}{\lambda_t}$ and $\frac{g\left(h_t^l\right)}{\lambda_t}$ each stands for the disutility from work in the real term for high and low productivity workers respectively, and the continuation value.

U_t^h and U_t^l each represents the value of being unemployed for a worker, which is given by:

$$U_t^h = b + \Xi_{t,t+1}\left[p_t\left(1-\rho\right)\left(W_{t+1}^h - U_{t+1}^h\right) + U_{t+1}^h\right] \tag{20}$$

$$U_t^l = b + \Xi_{t,t+1}\left[p_t\left(1-\rho\right)\left(W_{t+1}^l - U_{t+1}^l\right) + U_{t+1}^l\right] \tag{21}$$

where the value of being unemployed is simply the sum of unemployment benefit plus the continuation value.

2.4 Nash Bargaining:

In this model, following Trigari (2006)'s paper, firms are assumed to have the power of managing the hours worked by the workers. Thus, firms maximize the value of J_t^h and J_t^l by choosing h_t^h h_t^l respectively:

$$\max_{h_t^h} J_t^h = \max_{h_t^h} \left\{ z_{h,t} \left(h_t^h\right)^{\alpha} - w_t^h h_t^h + \Xi_{t,t+1} \left[(1-\rho) J_{t+1}^h + \rho V_{t+1}^h \right] \right\}$$

$$w_t^h = MPL_t^h = \alpha z_{h,t} \left(h_t^h\right)^{\alpha-1} \tag{22}$$

$$\max_{h_t^l} J_t^l = \max \left\{ z_{l,t} \left(h_t^l\right)^{\alpha} - w_t^l h_t^l + \Xi_{t,t+1} \left[(1-\rho) J_{t+1}^l + \rho V_{t+1}^l \right] \right\}$$

$$w_t^l = MPL_t^l = \alpha z_{l,t} \left(h_t^l\right)^{\alpha-1} \tag{23}$$

Under this setting, since wage is determined through the Nash bargaining, firms take wages as given and hire labor up until the marginal product of labor equals to the wage. Thus, hours worked is a function of the wage for both types of workers: $h_t^h = h\left(w_t^h\right)$ and $h_t^l = h\left(w_t^l\right)$. Through the Nash bargaining process, the Nash product is maximized by choosing the wage w_t^h and w_t^l for each type of worker:

$$\max_{w_t^h} \left(W_t^h - U_t^h\right)^{\eta} \left(J_t^h\right)^{1-\eta}$$

which would give us the optimal condition:

$$\eta \left(W_t^h - U_t^h\right)^{-1} \Psi_{h,t}^W J_t^h + (1-\eta) \Psi_{h,t}^F = 0 \tag{24}$$

where

$$\Psi_{h,t}^W = \frac{h_t^h}{\alpha - 1} \left(\alpha + \frac{-\psi \omega_t \left(h_t^h\right)^{\sigma_h}}{\lambda_t w_t^h} \right) = \frac{h_t^h}{\alpha - 1} \left(\alpha + \omega_t \frac{MRS_t^h}{w_t^h} \right) \tag{25}$$

$$\Psi_{h,t}^F = \alpha z_{h,t} \left(h_t^h\right)^{\alpha-1} \frac{\partial h\left(z_{h,t}, w_t^h\right)}{\partial w_t^h} - h\left(z_{h,t}, w_t^h\right) - w_t^h \frac{\partial h\left(z_{h,t}, w_t^h\right)}{\partial w_t^h} = h_t^h \tag{26}$$

$\Psi_{h,t}^W$ measures how increase in the wage would affect the value of working for high productivity workers and $\Psi^F_{h,t}$ measures how increase in the wage would affect the value of working for firms, which is simply the hours worked. These expressions are identical to the ones obtained in Trigari (2006), with the only difference being that my model contains heterogeneity in employment.

After substitution, we would obtain:

$$w^h_t h^h_t = \left(\frac{\eta \Psi^W_{h,t}}{(1-\eta)\Psi^F_{h,t} + \eta \Psi^W_{h,t}}\right)\left(z_{h,t}\left(h^h_t\right)^{\alpha} + \gamma \theta_t\right) + \left(\frac{(1-\eta)\Psi^F_{h,t}}{(1-\eta)\Psi^F_{h,t} + \eta \Psi^W_{h,t}}\right)\left(b - \frac{g\left(h^h_t\right)}{\lambda_t}\right) \tag{27}$$

where the total wage payment is still the weighted average between the value created by the worker plus the future saving from the hiring to firm, and the cost for worker to work, which is the sum of the unemployment benefit and the disutility from working in real term. Unlike standard Nash bargaining outcomes, the weight in this setting is $\frac{\eta \Psi^W_{h,t}}{(1-\eta)\Psi^F_{h,t} + \eta \Psi^W_{h,t}}$, which depends the relative bargaining power and also the relative marginal benefit of wage to both workers $\Psi^W_{h,t}$ and firms $\Psi^F_{h,t}$.

We could also rewrite equation (27) to give us the wage equation:

$$w^h_t = \left(\frac{\eta \Psi^W_{h,t}}{(1-\eta)\Psi^F_{h,t} + \eta \Psi^W_{h,t}}\right)\left(z_{h,t}\left(h^h_t\right)^{\alpha-1} + \frac{\gamma}{h^h_t}\theta_t\right) + \left(\frac{(1-\eta)\Psi^F_{h,t}}{(1-\eta)\Psi^F_{h,t} + \eta \Psi^W_{h,t}}\right)\left(\frac{b}{h^h_t} - \frac{g\left(h^h_t\right)}{\lambda_t h^h_t}\right) \tag{28}$$

And similarly, the Nash product is maximized by choosing w^l_t for low productivity workers:

$$\max_{w^l_t} \left(W^l_t - U^l_t\right)^{\eta} \left(J^l_t\right)^{1-\eta}$$

which gives us:

$$\eta \left(W^l_t - U^l_t\right)^{-1} \Psi^W_{l,t} J^l_t + (1-\eta)\Psi^F_{l,t} = 0 \tag{29}$$

$$\Psi^W_{l,t} = h\left(z_{l,t}, w^l_t\right) + w^l_t \frac{\partial h\left(z_{l,t}, w^l_t\right)}{\partial w^l_t} + \frac{g_{h^l_t}\left(h^l_t\right)}{\lambda_t}\frac{\partial h\left(z_{l,t}, w^l_t\right)}{\partial w^l_t} = \frac{h^l_t}{\alpha - 1}\left(\alpha + \frac{(1-\omega_t) MRS^h_t}{w^l_t}\right) \tag{30}$$

$$\Psi_{l,t}^F = \alpha z_{l,t} \left(h_t^l\right)^{\alpha-1} \frac{\partial h\left(z_{l,t}, w_t^l\right)}{\partial w_t^l} - h\left(z_{l,t}, w_t^l\right) - w_t^l \frac{\partial h\left(z_{l,t}, w_t^l\right)}{\partial w_t^l} = h_t^h \tag{31}$$

$\Psi_{l,t}^W$ measures how increase in the wage would affect the value of working for low productivity workers and $\Psi_{l,t}^F$ measures how increase in the wage would affect the value of working for firms, which is simply the hours worked.

After substitution, we would have:

$$w_t^l h_t^l = \left(\frac{\eta \Psi_{l,t}^W}{(1-\eta)\Psi_{l,t}^F + \eta \Psi_{l,t}^W}\right)\left(z_{l,t}\left(h_t^l\right)^{\alpha} + s_t \frac{\gamma}{q_t}\right) + \left(\frac{(1-\eta)\Psi_{l,t}^F}{(1-\eta)\Psi_{l,t}^F + \eta \Psi_{l,t}^W}\right)\left(b - \frac{g\left(h_t^l\right)}{\lambda_t}\right) \tag{32}$$

Which could also be rearranged to obtain the wage equation:

$$w_t^l = \left(\frac{\eta \Psi_{l,t}^W}{(1-\eta)\Psi_{l,t}^F + \eta \Psi_{l,t}^W}\right)\left(z_{l,t}\left(h_t^l\right)^{\alpha-1} + \frac{\gamma}{h_t^l}\theta_t\right) + \left(\frac{(1-\eta)\Psi_{l,t}^F}{(1-\eta)\Psi_{l,t}^F + \eta \Psi_{l,t}^W}\right)\left(\frac{b}{h_t^l} - \frac{g\left(h_t^l\right)}{\lambda_t h_t^l}\right) \tag{33}$$

From equation (14) and together with equation (26) and (27), we could obtain:

$$\left(\frac{h_t^h}{h_t^l}\right)^{\alpha} = \frac{z_{l,t}}{z_{h,t}} \tag{34}$$

And plug (36) back into (14) we could also show that:

$$w_t^h h_t^h = w_t^l h_t^l \tag{35}$$

Since $z_{l,t} < z_{h,t}$, the ratio $\left(\frac{h_t^h}{h_t^l}\right)^{\alpha}$ is smaller than 1, suggesting that low productivity workers would be working more hours than high productivity workers but they end up receiving the same wage payment as the high productivity workers.

3 Parameterization and Calibration

I set the value of $\sigma = 1$, which turns the utility function into the log form, and $\beta = 0.99$, which is commonly used in the literatures. The value of the elasticity of intertemporal substitution for hours worked is $1/\sigma_h$ where I set the value of σ_h to be 7, which gives the elasticity value around 0.14, which is close to the estimates of average elasticity of intertemporal substitution to be 0.1 from (Best, et al 2020). The ψ is merely a scaling paramater with an assigned value of 1.

For the motion of health, the natual rate of depreciation of health stock is set to be around 4%, which is based on the estimates from various medical paper under the common assumption that health deficits accumulate exponentially, with an annual rate of 3%-5% and stay relatively stable over the adulthood. (Mitnitski, A., Rockwood, K., 2016) As for the curvature parameter, there is not much empirical evidence that helps to set the target. In Huang, He, Hung (2016)'s paper, they set the curvature parameter to be 4 to estimate 0.26% depreciation in health stock from working. I set the curvature parameter to be 1.5 to increase the impact of hours worked on health since the steady state values of hours worked both tend to be small and close to 0.1.

As for the unemployment rate, the official data in China has always been fixed around 4% for the past two decades, which is highly unlikely even given the slight possibility that the labor market in China is simply more efficient. During the 08 financial crisis, the unemployment rate only varied between the range of 4% to 4.3%, which clearly indicates an underestimation of the actual unemployment rate. According to the estimation of Feng, Hu, Moffitt's paper (2017), the unemployment rate has been steadily around 8% to 10% over the period of 2002 to 2009, which coincides with the timeline of privatization starting around 2000. Therefore, I set the steady state unemployment u to be 0.1. Then, the probability at which a firm could fill the vacancy $q(\theta)$ set to 0.7, which is commonly assumed in the literature. (Cooley and Quadrini (1999) den Haan, Ramey and Watson (2000)). The bargaining power η is set to be 0.5 and the matching elasticity parameter ξ is also set to 0.5, values that are commonly used in existing literatures.

For the technology firm used, α is set to be 0.8, which suggests that at the steady states, the profit share of firm is 20%. According to the model, the ratio between the high and low producitvity should reflect $\frac{h_t^h}{h_t^l} = \left(\frac{z_{l,t}}{z_{h,t}}\right)^{\frac{1}{\alpha}}$. To mimic the working schedule of 996 or equivalently working 72 hours per week, the productivity ratio should be set at around 1.8. The productivity for low productivity technology is then normalized to one $z^l = 1$ and the high productivity technology is then $z^h = 1.8$. The rate of separation ρ is set to be 0.05. The vacancy cost γ is obtained through calculating the steady state values. The unemployment benefit in China has been between the range of 70% to 95% of the minimum wage , whereas the minimum wage has been roughly around half of the average income for each region, according to the the announcements from the municipal human resources and social security bureau of various regions in China. Thus, it is reasonable to assume that the output generated from non work activity should be much less than marginal product. The unemployment benefit b is then set to be 47% of the weighted average of the wage for each type of worker since wage for each type of worker is equal to the marginal product created by each worker.

4 Main Results

In this section, I discuss and compare the steady state results of the model together with the model without health channel, and the steady state results from changing the parameters of interest. The model without health channel is obtained through setting the $\phi_t^{'} = \delta$, where $0 < \delta < 1$, making the health deficits not affected by the hours worked. The different values of ω_t are set directly, which would be discussed in more detail in the following.

Table 2 reports the steady state values of the baseline model where $\omega = 0.45$ for both models with and without the health channel, and the percentage change from the baseline model by setting the value of omega to 0.75 and 1. For the model with health channel, in steady state, the total wage payment received by both types of workers are the same but high productivity workers enjoy higher wage rate (208%) and works less hours (47%). The ratio of the wage rate between two types of workers reflects the productivity differentials (1.8:1 as stated in calibration targets). As the weight of high productivity labor ω decreases,

Table 2: Steady State Values for models with and without Health Channel

Baseline values and percent changes relative to baseline values

	Model with Health Channel			Model without Health Channel		
	ω=0.45	ω=0.75	ω=1	ω=0.45	ω=0.75	ω=1
GDP y	0.11	0%	0%	0.11	0%	0%
Consumption c	0.0509	0.39%	0.79%	0.0518	0%	0%
Employment n	0.9	0%	0%	0.9	0%	0%
Depreciation of Health ϕ	0.049	-4.08%	-10.20%	0.04	0%	0%
Health Stock	0.86	4.65%	9.30%	1.034	0%	0%
Investment in Health $\phi * health$	0.0423	-0.71%	-1.18%	0.0414	0%	0%
Lifetime Utility	-312.87	-1.58%[1]	-3.09%[1]	-292.69	0%	0%
Vacancies v	0.064	0%	0%	0.064	0%	0%
Labor Market Tightness θ	0.64	0%	0%	0.64	0%	0%
Hours (High)h^h	0.035	0%	0%	0.035	0%	0%
Wage (High) w^h	2.81	0%	0%	2.81	0%	0%
Hours (Low)h^l	0.074	0%	0%	0.074	0%	0%
Wage (Low)w^l	1.35	0%	0%	1.35	0%	0%

1. the negative sign here means that the lifetime utility is less negative, suggesting an increase in the lifetime utility.

more workers are allocated with low productivity technology and have to work longer hours. Households respond to the change in the hours worked by changing the the level of consumption and health stock. According to the optimal condition for a_{t+1} (equation (7)) and applying the implicit function theorem, we could obtain $\frac{\partial a_{t+1}}{\partial h_t^h} < 0$ and $\frac{\partial a_{t+1}}{\partial h_t^l} < 0$ (since the optimal function is decreasing in health depreciation and health depreciation is increasing in hours worked), suggesting that longer hours lead to lower level of health. Also, we would be obtain $\frac{\partial c_t}{\partial h_t^h} < 0$, which suggests that a higher level of hours worked would actually lead to a lower level of consumption, meaning households are shifting their consumption towards investment in health. It is important to note that as the value of ω changes, the steady state value for output, employment, labor market outcome, hours and wages are not affected. Originally, the steady state value for ω is set by adjusting the productivity ratio but we found that omega could be assigned any value directly without changing the steady state results. Since the two types of workers are perfectly substitutable under the current setting where capital is not involved and also given the fact that through choosing the weight, the net return generated from both types of the workers to the firm are the same, firm becomes indifferent between the two types of workers and the labor market outcome would be exactly

Table 3: Steady state value for alternative parameters

Baseline values and percent changes relative to baseline values

	ϖ=1.5 η=0.5	ϖ=2	η=0.6
GDP y	0.112	0%	-20.54%
Consumption c	0.0509	1.38%	-21.41%
Employment n	0.9	0%	-2.22%
Depreciation of Health ϕ	0.049	-14.29%	-6.12%
Health Stock	0.86	15.12%	-16.28%
Investment in Health $\phi * health$	0.0422	-1.42%	-21.80%
Lifetime Utility	-312.87	1.62%[2]	13.38%[2]
Vacancies v	0.064	0%	-20.31%
Labor Market Tightness θ	0.64	0%	-32.81%
Wage (High) w^h	2.81	0%	4.98%
Hours (High)h^h	0.035	0%	-22.86%
Wage (Low)w^l	1.35	0%	4.44%
Hours (Low)h^l	0.074	0%	-22.97%
Weight ω	0.45	0%	0%

2. the positive sign here means that the lifetime utility is more negative, suggesting a decrease in the lifetime utility.

the same on the aggregate level when the value of ω changes, which is confirmed by the baseline result. It also shows that, at the steady state, the level of health stock is higher compared with the model with the health channel, since hours worked does not take a toll on the health stock anymore. This is also supported by the optimal condition for a_{t+1} (equation 7) since $\frac{\partial a_{t+1}}{\partial \phi_t} < 0$ suggesting that lower health depreciation rate would lead to a higher level of health stock. This result is particularly interesting since under the setting of current model, firms do not have face any cost concerning changing the working schedule of workers. Households alone are bearing the all the cost rise from the health channel when shifting towards overtime. It is important to note that in the current model, there is no physical capital. With the inclusion of physical capital in the production, this result might change slightly as households' decision on the investment in health might be different and firms have to face the cost of adjusting the value of omega. At the same time, the involvement of physical capital would increase the wage since under the right to manage setting, the wage would equal to the marginal product of hours worked by a worker.

Table 3 reports the steady state values for the full model with certain parameter values adjusted. In the third column, the health curvature parameter ϖ is adjusted to test the elasticity. Within the range of hours worked, the larger the ϖ is, the less sensitive the depreciation in health is to the change in the hours worked. As ϖ increase from 1.5 to 2, it is clear that the labor market outcome is not affected by the change in ϖ but the depreciation in health ϕ is lowered by 14.29% and the health stock is consequently increased by 15.12%. This results in a lower level of investment in Health by 1.42%.

In the forth column, we adjusted the value of η to test how the labor market and health outcome changes when bargaining power of workers change. As workers gain more bargaining power (η=0.6), workers now can bargain for higher wages (increase by 4.98% and 4.44% for high and low productivity workers, respectively) and they are also now working lower hours (reduce by 22.86% and 22.97% for high and low productivity workers, respectively), but their total wage payments are lowered by 18%. As shown in equation 28 and 33, as η increases, the weight shift more towards the value created by the worker, increasing the wage received by workers. According to equations 22 and 23, we know that wage is a function of hours worked, and at the same time $\frac{\partial h^h}{\partial w^h} < 0$ and $\frac{\partial h_t^l}{\partial w^l} < 0$. Thus, an increase in the wage is achieved through a decrease in the hours worked, which in turn reduces the wage payment received by both types of workers since we could simply rewrite the total wage payment as a function of hours worked. As a result, the output produced by workers are lowered by 20.54%, which means that less resources are available for the purpose of consumption (decrease by 21.41%) and investment in health (decrease by 21.80%) as suggested by the resource constraint. Since workers are now working less hours, the depreciation in health is lowered ($\frac{\partial \phi_t}{\partial h_t^h} < 0$ and $\frac{\partial \phi_t}{\partial h_t^l} < 0$) but the level of health stock is still lowered by 16.28% since the investment in health is lowered. Even though both consumption and level of health decreased, the life time utility still increased (13.38%) because households are now working less and avoids the disutility from working.

5 Conclusion

The model proposed in this paper is an attempt to study the mechanism of overtime and the health channel through which hours worked would affect the level of health, which is especially relevant for developing countries where workers have to work overtime without proper compensation. The weight ω introduced in this model allows firm to be indifferent between different types of worker, which created an interesting mechanism where the value of the weight itself does not affect the labor market outcome but the presence of the weight itself matters. This mechanism reflects how firm makes hiring decisions in real life, allowing us to understand more about how such practice would affect the labor market. Also, given firm's right to manage worker's working schedule, the indifference towards the heterogeneity of workers leads to overtime which creates the additional health burden on households. The model showed that, households adjust their consumption and investment in health in response to the change in the working schedule and as hours worked increase, the households have to reallocate more output towards the investment in health to maintain the level of health. Another finding of the paper is that as households gain more market power, their wage increases but their hours worked decrease so that households have less resources available for both consumption and health investments, leading to a lower level of health stock.

This research could help shed some light on the issue of overtime, for many developing countries like China, and the model could be expanded to include policies like monetary policies to study the cyclical behavior and response to policies. We could also explore the model with uncertainty of the worker type to see how the introduction of weight ω affects the labor market outcome. Another area that could be expanded is the combination of the health channel, retirement and pensions. Many developed countries are facing the issue of aging population right now and China is about to experience the same issue. Our model might help understand how overworking in a younger age might affect the social welfare system on a macroeconomic level. Last but not the least, this paper might inspire further empirical studies in the same field, like estimating the actual health cost and health investment.

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