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COVID-19, lockdown and labor uncertainty *

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Abstract

In this paper, we investigate the impact of containment and closure policies amid the COVID-19 pandemic on the labor market. We show that these effects depend on the presence of labor uncertainty. In the absence of labor uncertainty, the containment and closure policy resulted in people applying fewer self-protection measures, facing lower income and saving more. We predict that workers will lose their job as a consequence of this policy if and only if the containment elasticity of labor demand is sufficiently large. By contrast, when labor uncertainty is introduced, our model predicts more self-protection, more job loss and fewer savings as a result of a lockdown. In addition, income loss occurs if and only if the elasticity of labor demand is large enough. We test our predictions by employing new survey data collected on representative samples across 6 countries: China, Japan, South Korea, Italy, the UK, and the U.S. The survey collected information from households about their work and living situations and their income and socio-demographic characteristics. We find that young, low-income workers and urban dwellers are more vulnerable to containment and closure policies as they are more likely to lose their jobs and income. More importantly, our data provides supporting evidence to all of the predictions of our model.

Keywords: Lockdown; labor uncertainty; job loss; self-protection measures; savings

JEL Codes: I12, I15, I18, J18, J21, J23

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1 Introduction

From January 2020, the COVID-19 pandemic has had significant impacts on nearly every aspect of society. As of August 2020, more than 20 million cases of COVID-19 have been recorded, in addition to three-quarters of a million deaths (Worldometer, 2020). In order to stop the spread of this disease, a wide range of containment and closure policies were, and continue to be, imposed by governments across the world to various degrees. While these policies aim to limit movements of people to reduce the virus infection rate, they can result in significant economic costs. In this paper, we consider several important effects of the pandemic and the containment policies on the labor market. In particular, we ask the following questions: *Who are likely to lose their jobs? How do containment policies affect people's jobs? How do people react to the pandemic and the containment policies?*

In this paper we propose a simple extension of standard precautionary savings framework to quantify the impact of the pandemic and containment policies on the labor market. Our model has two important building blocks: one for the dynamics of contagion, and one for consumption and production, including containment strategies such as the decision to work from home. The dynamics of contagion are based on the classic epidemiology model, namely the SIR model proposed by Kermack and McKendrick (1927). The population is divided into groups of Susceptible (S), Infected (I), and Recovered (R) people. Infected people transmit the virus to susceptible people at a rate that depends on the nature of the virus and the frequency of social interactions. The economic side of the model focuses on two key decisions: consumption and labor supply. We use a standard model where members of large households jointly make these decisions.

Our model enables us to study the reactions of households in response to the outbreak and containment policies of the government. In particular, the household maximizes its utility over two periods. In the first period, it decides on its level of consumption and of protective measures that the household will take against the virus. These measures will reduce the virus infection rate, which then determines the supply of labor in the next period. In addition, the demand for labor in the second period depends on the containment policies of the government and some demand shocks.

Our model makes a clear distinction of the outcomes with and without labor uncertainty. In the benchmark model, we assume that containment policies are the only factor in the labor demand function. Under this set-up, we show that people apply fewer protective measures in the presence of more stringent containment policies. We also show that there will be higher levels of unemployment if the containment elasticity of labor is large enough. This is because, in addition to the direct effect of containment policies on labor demand, there is an indirect effect of containment policies on the labor market. Indeed, the lower self-protection measures as a result of the containment policies reduces the number of people actively seeking jobs. This reduces unemployment. We call this the indirect effect of containment policies. When the containment elasticity of labor demand is large, the direct effect dominates the indirect one. We also show that people lose income and save more to compensate for this loss of income in response to containment policies.

Very interesting results arise when we introduce labor uncertainty into the model. Indeed, people might have to work from home to avoid the risk of disease transmission. However, the extent to which people work from home is not known. This is an example of a demand shock that can be introduced. We also assume that people are prudent, i.e. they make an effort to reduce the probability of the risks that they face. Under this setting, we find that most of our initial results reverse. In particular, we now find that containment policies induce *more* self-protection measures. This is because containment policies reduce future income, which consequently increases the marginal value of wealth among risk-averse people. As a result, prudent people seem to want to protect themselves more in this scenario. Containment policies also have various impacts on the labor market: the unemployment rate is *always* higher, while household savings are *lower* than without the policies.

We then tested our predictions using data collected during the initial months of the pandemic. We employ two main datasets. The first is a survey conducted in April 2020. In the survey, people were asked a number of questions regarding their socio-demographic characteristics and the outcomes of their jobs, income and savings during the pandemic. The second dataset is a collection of government policy responses during the pandemic. To capture the policy heterogeneity across countries, we construct a number of indices based on criteria such as how early and swiftly the government reacted to the pandemic. By merging these two datasets we are able to quantify the effects of the pandemic and the containment policies imposed by the governments.

Our data reveals that young workers were more likely to experience job loss than others. In addition, low earners were more vulnerable than high earners. As a result, both their income and expected income decreased. These results are consistent with what has been found in other studies (Beland, Brodeur and Wright 2020; Joyce and Xu 2020).

More importantly, our data provides evidence to support our predictions. By using the variation in the households' expectations of future income losses, we are able to separate the regions according to their level of labor uncertainty. In the regions in which the variation is low (i.e. labor uncertainty is absent), the effect of containment measures on job loss is insignificant. According to our model, this effect depends on whether the direct effect of containment measures (i.e. containment leading to lower labor demand) dominates the indirect effect (i.e. containment reduces the number of healthy people who are active job seekers). This prediction is supported when we separate our sample into two categories: people who were waiting to be tested for the virus and those who were not. In the first sample, the indirect effect is strong and hence containment results in fewer job losses. In the second sample, the indirect effect of containment policies are weak. As a result, containment policies result in more job losses. Our model also predicts that in the absence of uncertainty, people's income would be lower, savings would be higher and self-protection measures would be less utilised. All of these predictions are supported by our data.

Interestingly, we have different results when labor uncertainty is present. In regions where the variation of the household's expectation of future income loss is high, we find that the rate of job loss is higher with stricter containment policies. Higher levels of income loss occur with the sample of people not waiting to be tested because the indirect effect of containment policies are weak. People save less but apply more self-protection measures. All these results support our initial predictions.

Our paper is organized as follows. In the next section, we discuss the related literature. We then present out model in Section 3. Our data and empirical strategy are introduced in Sections 4 and 5. We discuss our results in Section 6 and conclude in Section 7.

2 Related literature

There is a fast-growing body of literature that applies an epidemiology model to analyse the impact of the crisis. Eichenbaum, Rebelo and Trabandt (2020) applied the SIR model to investigate the macroeconomic impacts of the pandemic. They showed that in response to the disastrous effects of the pandemic, people reduced their consumption and economic activity. These demand and supply forces, while helping to stop the spread of the virus, brought the economy into a major recession. Atkeson (2020) also used this framework to simulate the spread of the virus under various scenarios. Toxvaerd (2020) applied this model to pin down social distancing in equilibrium while Acemoglu et al. (2020) looked for the optimal containment policy when different groups of people had various levels of risk when exposed to the virus.

Our paper joins the growing body of literature on the impacts of the pandemic on the labor market. Coibion, Gorodnichenko and Weber (2020) warned that the impact was larger than shown in the unemployment claims. Job vacancies collapsed at a magnitude similar to the Great Depression (Kahn, Lange and Wiczer 2020). These effects were larger for occupations that required more inter-personal contact (Montenovo et al. 2020). The pandemic has also disproportionately affected other vulnerable groups. Platt and Warwick (2020) show that, in the UK, ethnic minorities are more economically vulnerable to the current crisis than the white British majority. Beland, Brodeur and Wright (2020) show that men and young workers are more likely to be affected by the pandemic. Joyce and Xu (2020) add that low-earners and women were more likely to work in the sectors most negatively impacted by the pandemic. Andrew et al. (2020) show that workers with children face immense pressure from the crisis, due to the lack of childcare available. Borjas and Cassidy (2020) suggest that the shock was more severe for immigrant workers in the early stages of the pandemic.

Additionally, we contribute to the emerging literature that investigates the impacts of containment policies. Brodeur et al. (2020) use Google Trends data and found that containment policies have resulted in higher levels of mental health issues as more people face boredom, loneliness, anxiety and sadness. Glover et al. (2020) look at the distributional effects of containment policies while Rampini (2020) proposes lifting containment policies sequentially to allow the less vulnerable share of the population, who have a higher labour force participation rate, to resume their economic activity.

We build on existing literature that looks at optimal prevention policies in the presence of prudence. In addition to risk aversion, which is well-known in the economic-finance literature, Kimball (1990) introduce the notion of "prudence" to measure the sensitivity of a decision variable (effort) to risk. Eeckhoudt and Gollier (2005) then analyse the link between prevention and prudence. They show that prudence reduces prevention. Courbage and Rey (2006) extend this research further by showing that people who have a fear of sickness (i.e. their loss of sickness is large enough) only pursue more prevention if they are less prudent (Courbage and Rey 2006). Contrary to these one-period models where prevention and its effects occur simultaneously, our setting is a two-period model in which the effect of prevention is only realized in the future. In this setting, however, prudence *increases* prevention efforts (Menegatti 2009; Courbage and Rey 2012). In these papers, the marginal value of wealth, a key variable that dictates the level of prevention effort, does not change. A novel feature in our model is that this variable varies with the stringency of a containment policy.

Finally, we relate our paper to the literature that studies the "new normal" in the labour market, namely working from home. Indeed, the COVID-19 pandemic has led to more people working remotely (Brynjolfsson et al. 2020). However, the ability to work from home varies with occupation and socio-demographic characteristics. Only 37% of jobs in the U.S. can be done from home (Dingel and Neiman 2020). People in the US who work from home are likely to be white with a college degree and a stable well-paid job (Mongey and Weinberg 2020). Finally, according to Jones, Philippon and Venkateswaran (2020), people make the decision to work from home based on their fear of infection and expected level of hospital congestion. On the one hand, working from home helps reduce one's risk of getting infected. On the other hand, by getting infected early and developing immunity to the virus, they can avoid hospital congestion at the peak of the pandemic.

3 Model

This section provides a theoretical framework to help interpret results from empirical models discussed in Section 4.

3.1 Representative consumer

We consider a model in which a representative household faces a risk of being infected with the virus. The dynamics of an epidemic are much faster than the population dynamics of a household, assuming a constant household size. We will assume that disease dynamics between period t and $t+1$ follow the standard SIR model:

$$
\begin{aligned}
S_{t+1} &= S_t - \Gamma S_t I_t / N_t \\
I_{t+1} &= I_t + \Gamma S_t I_t / N_t - \Psi I_t \\
R_{t+1} &= R_t + \Psi I_t \\
&S_0, I_0, N_0 > 0 \text{ with } N_0 = S_0 + I_0
\end{aligned}
$$

where S_t is the number of susceptible individuals, I_t is the number of infectious individuals, and R_t is the number of recovered or deceased individuals in period t. The epidemiology parameters are the contact rate Γ and the recovery rate Ψ from the disease. As we have sampled representative households, the proportion of the household in each disease status mirrors that of the population. In other words, we have $s_t = \frac{S_t}{N}$, $i_t = \frac{I_t}{N}$ and $r_t = \frac{R_t}{N}$.

From the laws of motion in the SIR model we get:

$$s_1 = s_0 - \Gamma i_0 s_0 \tag{1}$$

$$i_1 = i_0 + \Gamma i_0 s_0 - \Psi i_0 \tag{2}$$

$$r_1 = \Psi i_0. \tag{3}$$

and thus the fraction of healthy individuals is

$$s_1 + r_1 = s_0 - \Gamma i_0 s_0 + \Psi i_0.$$

After presenting the epidemic modeling SIR model, we then incorporate it into a standard precautionary savings framework (Eaton and Rosen 1980; Eeckhoudt, Gollier and Schlesinger 2005). Our main emphasis is to analyze how the pandemic and containment policies affect labor market outcomes. For this purpose, we consider a containment policy that mitigates the effects of the pandemic by limiting social interaction. This policy has an indirect effect of having to shutdown some non-essential sectors, which results in a lower demand for labor.

In our model a representative household lives for two periods. In period 0, the household anticipates an outbreak that could occur in period 1. They know the fraction of healthy and infected individuals in their household, which are s_0 and i_0, respectively. Given an income level y_0, they choose consumption in each period C_0, C_1, the self-protection measures Q, savings S and labor supply for the next period.

3.2 Lockdown policy and self-protection

In response to the pandemic, the government applies a containment policy with a level of stringency z in period 1. This containment policy indirectly affects the labor supply of the household. We assume that infected people are unable to work. The labor supplied by healthy people is given by:

$$L(z,\epsilon) = B(z,\epsilon)(s_1 + r_1), 0 \leq B(z,\epsilon) \leq 1. \tag{4}$$

In the above equation, $s_1 + r_1$ is the total supply of labor in the household. $B(z,\epsilon)$ is the demand for labor. This depends on the containment policy z, as mentioned above. There is also an unknown demand factor ϵ that we will elaborate on in the subsequent section.

When people take more measures for self-protection, they are less likely to get infected with the disease. To capture this effect, we endogenize the contact rate as a function of protective measures Q. Following Goenka, Liu and Nguyen (2014), we assume that $\Gamma' = \frac{d\Gamma}{dQ} \leq 0, \Gamma'' = \frac{d^2\Gamma}{dQ^2} \geq 0$. Admittedly, when more self-protection is applied people are less likely to get infected and more likely to recover from the diseases. Furthermore, the marginal effect diminishes with these measures.

We will take the consumption good as the numeraire and denote p the price of protection. Then, the budget constraint in period 0 is given by:

$$y_0 = C_0 + pQ + S.$$

And the budget constraint in period 1 is:

$$C_1 = (1+r)S + y_1 \tag{5}$$

where r is the interest rate. Similar to the interest rate, wage w is fixed in this partial equilibrium. In period 1, the household receives their income from labor, which is given by:

$$y_1 = wL(z, \epsilon).$$

From Equations (1), (4) and (5) we have:

$$\begin{aligned} C_1 &= (1+r)S + wB(z,\epsilon)(s_0 - \Gamma(Q)i_0 s_0 + \Psi i_0) \\ &= (1+r)(y_0 - C_0 - pQ) + wB(z,\epsilon)(s_0 - \Gamma(Q)i_0 s_0 + \Psi i_0). \end{aligned}$$

The household maximizes its utility, given all relevant constraints. Assuming the utility function is additively separable over time, the household solves the following maximisation problem:

$$\max_{C_0,Q,S,L} U(C_0) + \mathbb{E}V(C_1). \tag{6}$$

The utility functions U and V are assumed to be strictly concave, i.e., ($U' > 0, V' > 0, U'' < 0, V'' < 0$). This implies that the household is a risk-averse agent. If interior solutions exist, the first-order conditions read:

$$\begin{aligned} &U'(C_0) - (1+r)\mathbb{E}V'(C_1) = 0, \\ &\mathbb{E}\{V'(C_1)(p(1+r) + wB(z,\epsilon)s_0 i_0 \Gamma'(Q))\} = 0. \end{aligned}$$

Denoting x by $x = 1 + r$ the gross return on savings, at the optimum we have:

$$U'(y_0 - S - pQ) = x\mathbb{E}\{V'(xS + wB(z,\epsilon)(s_0 - \Gamma(Q)i_0 s_0 + \Psi i_0))\}. \tag{7}$$

$$\mathbb{E}\{V'(C_1)(px + wB(z,\epsilon)s_0 i_0 \Gamma'(Q))\} = 0. \tag{8}$$

The FOC (7) shows the trade-off between consumption in periods 0 and 1. The FOC (8) illustrates the cost and benefit of self-protection measures. In particular, taking more measures reduces consumption expenditure. However, it also reduces the household's contact rate, which then increases labor income.

3.3 Risk-averse agent

We first consider a simple case where there is no labor uncertainty, i.e., $B(z, \epsilon) = B(z)$. The impact of containment policies is one of the main concerns of our analysis. It is, therefore, important to explain how we incorporate containment policies into our model. In particular, because of the restrictions imposed by these policies, certain sectors have to close down or reduce their operations. As a result, a large fraction $\theta(z)$ of healthy individuals will be laid-off. Therefore, we have:

$$B(z) = 1 - \theta(z) \tag{9}$$

From now on, if there is no confusion, we will denote f_x as the partial derivative of the function f with respect to the variable x. We can now rewrite the amount of labor supplied by the household as:

$$L(z) = (1 - \theta(z))(s_1 + r_1) = (1 - \theta(z))(s_0 - \Gamma i_0 s_0 + \Psi i_0), \tag{10}$$

We can then make the following proposition:

Proposition 1 *In the absence of labor uncertainty, more stringent policies result in:*

(i) fewer protective measures. (ii) more (less) loss of jobs if the containment policy elasticity of labor demand is high (low),

(iii) more loss of income,

(iv) more savings,

(v) ambiguous effect on consumption,

Proof

(i) To simplify notation, we denote

$$G(z) = px + w(1 - \theta(z))s_0 i_0 \Gamma'(Q).$$

Thus,

$$G_z = -w\theta_z s_0 i_0 \Gamma'(Q) + w(1-\theta)s_0 i_0 \Gamma''(Q)Q_z \tag{11}$$

where G_z and Q_z the partial derivatives of G and Q with respect to z. The FOCs (7) and (8) become

$$U'(y_0 - pQ - S) = xV'(xS + y_1(z)) \tag{12}$$

$$G(z)V'(xS + y_1(z)) = 0 \tag{13}$$

It follows from (13) that $G(z) = 0$ for all levels of stringency z, since $V'(.) > 0$ by assumption. Taking the derivative of G with respect to z we get:

$$Q_z = \frac{\theta_z \Gamma'(Q)}{(1-\theta(z))\Gamma''(Q)} \tag{14}$$

$Q_z < 0$ follows from $\theta_z > 0, \Gamma' < 0$ and $\Gamma'' > 0$.

(ii) The amount of job loss is defined as:

$$J(z) = \theta(z)(s_1 + r_1) = \theta(z)(1 - i_0 - s_0 i_0 \Gamma(Q(z)) + \Psi i_0)$$

If we take the derivative of the job loss function with respect to the stringency level, we have:

$$J_z = \theta_z(1 - i_1) - \theta(z)s_0 i_0 \Gamma' Q_z.$$

In the above formula, we can see two effects of a containment policy. On one hand, it results in more people being laid-off. On the other hand, it induces people to apply fewer protective measures (Result i), which reduces the number of healthy people in the population. As a result, there are fewer people actively seeking jobs. In other words, unemployment drops by definition.

The overall effect of a containment policy, therefore, depends on which effect is the dominant one. In particular, if labor demand is very elastic to the containment policy ($\frac{\theta_z}{\theta} > \frac{s_0 i_0 \Gamma' Q_z}{1-i_1}$) then a more stringent policy results in more job losses.

(iii) Denote Δ the loss of labor income. There are two reasons the household experiences income loss. First, infected people are unable to work, and hence lose their income. Second, healthy people are laid-off because of the containment policy. We can, therefore, write the income loss as:

$$\begin{aligned}\Delta &= w(i_1 + \theta(s_1 + r_1)) = w(i_1 + \theta(1 - i_1)) \\ &= w(\theta + i_1(1-\theta)) = w[\theta + (i_0 + s_0 i_0 \Gamma - \Psi i_0)(1-\theta)].\end{aligned}$$

In the formula above, we apply the SIR model (1). Taking the derivative of this income loss with respect to the stringency level, we have:

$$\begin{aligned}\Delta_z &= w[(\theta_z + s_0 i_0 Q_z \Gamma'(1-\theta) - (i_0 + s_0 i_0 \Gamma - \Psi i_0)\theta_z] \\ &= w[(\theta_z(1-i_1) + s_0 i_0 Q_z \Gamma'(1-\theta)].\end{aligned}$$

Given that $\theta_z > 0, Q_z < 0, \Gamma' < 0$, we have:

$$\Delta_z \geq 0.$$

From $y_1 = wL(z)$ we can derive the effect of containment policy on labor income in period 1 as:

$$\frac{\partial y_1}{\partial z} = -w\left((1-i_1)\theta_z + (1-\theta) i_0 s_0 \Gamma' Q_z\right) < 0$$

(iv) If we take the derivative of both sides of Equation (12) with respect to

z, we have:

$$-(S_z + pQ_z)U'' = x(xS_z + \frac{\partial y_1}{\partial z})V''$$

which implies that:

$$\frac{\partial S}{\partial z} = -\frac{pQ_zU'' + xV''\frac{\partial y_1}{\partial z}}{U'' + x^2V''} > 0$$

because $Q_z < 0, \frac{\partial y_1}{\partial z} < 0$.

We find that people save more because they expect a loss of income in period 1.

(v) We have:

$$\begin{aligned}\frac{\partial C_0}{\partial z} &= -pQ_z - S_z \\ &= -pQ_z + \frac{pQ_zU'' + xV''\frac{\partial y_1}{\partial z}}{U'' + x^2V''} \\ &= \frac{(\frac{\partial y_1}{\partial z} - xQ_z)xV''}{U'' + x^2V''}\end{aligned}$$

The effect of a containment policy on current consumption C_0 comes from two sources. On the one hand, people faced with such restrictions tend to apply fewer protective measures. On the other hand, they are also likely to save more to protect themselves against the loss of income in the next period. Therefore, whether or not current consumption increases (decreases) in response to containment policy depends on whether the former or the latter effect dominates.

Furthermore,

$$\begin{aligned}\frac{\partial C_1}{\partial z} &= xS_z + \frac{\partial y_1}{\partial z} \\ &= \frac{(\frac{\partial y_1}{\partial z} - pxQ_z)U''}{U'' + x^2V''}\end{aligned}$$

As a result, the effect of a containment policy on consumption in period 1 is also ambiguous.

3.4 Prudent agent with labor uncertainty

In the previous section, we assume labor demand is only affected by containment policies. However, the pandemic can also bring shocks to the structure of the labor market. For instance, people may decide to work remotely to avoid the risk of being infected. The extent to which people work from home can be considered a labor demand shock.

Formally, we reconsider the demand for labor $B(z, \epsilon)$. In the previous model, $\frac{\partial B}{\partial \epsilon} = 0$. Here, we extend the model by allowing $\frac{\partial B}{\partial \epsilon}$ to be different from 0. More precisely, let us consider a particular form of $B(z, \epsilon)$, where $B(z, \epsilon), = 1 - \theta(z) + \epsilon$. This assumption implies the random demand shock ϵ changes the labor supply rate but leaves marginal demand for labor intact. Thus, B_z is independent from ϵ. Recall that in the benchmark case we have $B_z < 0$.

In the previous set-up, the utility function is concave. This implies that our agent is risk-averse. Here, we assume further that the utility in period 1, V, is a decreasing absolute risk aversion (DARA) model. A DARA model implies a positive third derivative. It means that $\frac{-V''(C)}{V'(C)} = R(C)$ is decreasing in C. A positive third derivative of a utility function leads to precautionary savings (Kimball 1990; Gollier 2001). This implies that the agent is prudent (Eeckhoudt and Gollier 2005). In other words, not only does the agent not like uncertainty (risk-aversion), they also prepare themselves against such risk.

Denote the number of healthy people in the household in period 1 by

$$H(Q) = s_0 - \Gamma(Q) i_0 s_0 + \Psi i_0, = s_1 + r_1$$

We then rewrite the labor income in period 1 as well as the function G as below:

$$y_1(z, \epsilon) = w(1 - \theta(z, \epsilon) + \beta(z))(s - \Gamma(Q) is + \Psi i) = wB(z, \epsilon)H(Q),$$

The FOC (7) becomes:

$$U'(y_0 - S - pQ) = x\mathbb{E}\{V'(xS + y_1)\}. \tag{15}$$

Note that from budget constraint in period 0, $C_z = -pQ_z - S_z$. Differentiating the FOCs (15)-(8) with respect to z yields:

$$\begin{aligned}(pQ_z + S_z)U'' + x\mathbb{E}\{(wB_zH + wBH'Q_z + xS_z)V''\} = 0\\ \mathbb{E}\{(px + wBs_0i_0\Gamma')V^{''}\frac{\partial C_1}{\partial z} + (wB_zs_0i_0\Gamma' + wBs_0i_0\Gamma''Q_z)V'\} = 0\end{aligned}$$

Replacing $G = px + wBs_0i_0\Gamma'$ and $\frac{\partial C_1}{\partial z} = xS_z + \frac{\partial y_1}{\partial z} = xS_z + wB_zH + wBH'Q_z$ yields:

$$\begin{aligned}(pQ_z + S_z)U'' + x\mathbb{E}\{(wB_zH + wBH'Q_z + xS_z)V''\} = 0\\ \mathbb{E}\{(xS_z + wB_zH + wBH'Q_z)GV^{''} + (wB_zs_0i_0\Gamma' + wBs_0i_0\Gamma''Q_z)V'\} = 0\end{aligned}$$

We rearrange the terms and have that:

$$\begin{aligned}&(U'' + x^2\mathbb{E}\mathbb{V}'')S_z + (U''p + xw\mathbb{E}\{BH'V''\})Q_z = -xw\mathbb{E}\{B_zHV''\}\\ &x\mathbb{E}\{GV^{''}\}S_z + (w\mathbb{E}\{BGH'V'' + Bs_0i_0\Gamma''V'\})Q_z = -w\mathbb{E}\{B_zHGV^{''} + B_zs_0i_0\Gamma'V'\}\end{aligned}$$

This is can be rewritten as

$$\begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix}\begin{pmatrix} S_z \\ Q_z \end{pmatrix} = \begin{pmatrix} d_1 \\ d_2 \end{pmatrix}$$

where

$$
\begin{aligned}
b_{11} &= U'' + x^2\mathbb{E}V'' \\
b_{12} &= U''p + xw\mathbb{E}\{BH'V''\} \\
b_{21} &= x\mathbb{E}\{GV^{''}\} \\
b_{22} &= w\mathbb{E}\{GBH'V^{''} + Bs_0 i_0 \Gamma'' V'\} \\
d_1 &= -xw\mathbb{E}\{B_z H V''\} \\
d_2 &= -w\mathbb{E}\{B_z HGV^{''} + B_z s_0 i_0 \Gamma' V'\}.
\end{aligned}
$$

By Cramer's rule

$$
\begin{aligned}
Q_z &= \frac{b_{11}d_2 - b_{21}d_1}{b_{11}b_{22} - b_{12}b_{21}} \\
S_z &= \frac{b_{22}d_1 - b_{12}d_2}{b_{11}b_{22} - b_{12}b_{21}}
\end{aligned}
$$

where $b_{11}b_{22} - (b_{12})b_{21}$ is the determinant of the Hessian matrix of problem (6), and by the concavity assumption it is positive.

The following proposition shows that the presence of labor uncertainty plays a key role in labor market outcomes as well as the behavior of individuals.

Proposition 2 *In the presence of uncertainty, containment policies lead to:*

(i) more self-protection measures.

(ii) more unemployment,

(iii) more(less) income loss if θ_z is large(small),

(iv) fewer savings,

(v) ambiguous effects on consumption.

Proof.

(i) Since the determinant of the Hessian matrix is positive, the sign of Q_z is that of $b_{11}d_2 - b_{21}d_1$ which can be expanded as:

$$\begin{aligned} b_{11}d_2 - b_{21}d_1 =& -(U'' + x^2\mathbb{E}V'')(w\mathbb{E}\{B_zHGV^{''} + B_zs_0i_0\Gamma'V'\}) + x\mathbb{E}\{GV^{''}\}xw\mathbb{E}\{B_zHV''\} \\ =& -U''w(\mathbb{E}\{B_zHGV^{''} + B_zs_0i_0\Gamma'V'\}) - x^2w\mathbb{E}V''\mathbb{E}\{B_zs_0i_0\Gamma'V'\} \\ =& -U''w\mathbb{E}\{B_zs_0i_0\Gamma'V'\} - x^2w\mathbb{E}V''\mathbb{E}\{B_zs_0i_0\Gamma'V'\} - U''w\mathbb{E}\{B_zHGV^{''}\} \end{aligned}$$

Note that $B_z < 0, \Gamma' < 0, V' > 0, U' > 0, V'' < 0, U'' < 0$ by assumption, therefore:

$$-U''w\mathbb{E}\{B_zsi\Gamma'V'\} - x^2w^2\mathbb{E}V''\mathbb{E}\{B_zsi\Gamma'V'\} > 0. \tag{16}$$

If $U''w\mathbb{E}\{B_zHGV^{''}\}$ is negative, then we can conclude that Q_z is also positive.

Let us denote ϵ^* such that $G(\epsilon^*) = px + wB(z,\epsilon^*)s_0i_0\Gamma'(Q) = 0$. Note that $G_\epsilon(\epsilon) = ws_0i_0\Gamma'(Q) < 0.$, i.e. G is a decreasing function of the labor demand shock ϵ. Therefore $G(\epsilon) > 0$ if $\epsilon < \epsilon^*$ and $G(\epsilon) \leq 0$ if $\epsilon \geq \epsilon^*$.

As the agent's utility function in this case has DARA, $\frac{-V''(C_1)}{V'(C_1)} = R(C_1)$ is decreasing in C_1. Furthermore, we have $\frac{\partial C_1(\epsilon)}{\partial \epsilon} = w(s - \Gamma(Q)s_0i_0 + \Psi i_0) > 0$. Therefore,

$$\frac{\partial R(C_1(\epsilon))}{\partial \epsilon} = R'(C_1)\frac{\partial C_1(\epsilon)}{\partial \epsilon} < 0.$$

Hence $R(C_1(\epsilon))$ is decreasing in ϵ. If $\epsilon \leq \epsilon^*$ we have $R(C_1(\epsilon)) \geq R(C_1(\epsilon^*)$ and if $\epsilon > \epsilon^*$ we have $R(C_1(\epsilon)) < R(C_1(\epsilon^*)$.

This, in addition to the fact that $G(\epsilon)$ is positive (negative) if ϵ is smaller (larger) than ϵ^*, we have:

$$[R(C_1(\epsilon)) - R(C_1(\epsilon^*))]G(\epsilon) \geq 0.$$

Using the definition of $R(C_1)$ we get

$$\frac{-V''(C_1)}{V'(C_1)}G(\epsilon) \geq R(C_1(\epsilon^*))G(\epsilon)$$
$$\Rightarrow -G(\epsilon)V''(C_1) \geq R(C_1(\epsilon^*))G(\epsilon)V'(C_1)$$

Multiplying both sides by the negative term $B_z H$ we have:

$$-B_z H G(\epsilon)V''(C_1) \leq B_z H R(C_1(\epsilon^*))G(\epsilon)V'(C_1)$$

Taking expectations:

$$-\mathbb{E}B_z H G(\epsilon)V''(C_1) \leq R(C_1(\epsilon^*))B_z H \mathbb{E}G(\epsilon)V'(C_1).$$

Recall that $\mathbb{E}G(\epsilon)V'(C_1) = 0$ from Equation(8), hence:

$$\mathbb{E}B_z H G(\epsilon)V''(C_1) \geq 0 \tag{17}$$

This together with (16) implies that:

$$Q_z \geq 0.$$

Recall that in the previous set-up without labor uncertainty and risk-averse agent, containment policies induce fewer self-protection measures. Here, when we introduce labor uncertainty with a prudent agent, we have a completely opposite prediction: containment policies tend to induces *more* self-protection measures. Eeckhoudt and Gollier (2005) shows that prudence tends to reduce self-protection in a one-period model. However, in the case of a two-period model, the opposite result is found (Menegatti 2009). The key difference between the two models is that while in a one-period model self-protection measures and its effects occur *simultaneously*, in a two-period model the agents only witness the effects of their self-protection measures in the subsequent period. Our model is more similar to

Menegatti (2009) in this regard than to Eeckhoudt and Gollier (2005).

To understand the intuition of these results, note that the prudent agent makes more of an effort to increase his wealth in the period where he bears the risk. In a one-period model, prudence increases the marginal value of wealth. As self-protection and gaining wealth take place simultaneously, the agent is less willing to spend more on self-protection to preserve his wealth. However, in a two-period model, self-protection takes place in the first period and therefore only its effects, not the actual amount spent on it, impact the agent's wealth in period 1, the period in which they bear the risk.

In our model, containment policies reduce the labor income in period 1, which in turn increases the marginal value of wealth since the utility in this period is concave. Therefore when containment is imposed, the prudent agent will apply more self-protection measures.

(ii) The above proof shows that Q_z is positive. It implies directly that:

$$J_z = \theta_z(1 - i_1) - \theta(z)s_0 i_0 \Gamma' Q_z > 0.$$

Recall that in the absence of a labor demand shock, containment policies result in job loss if the containment elasticity of labor demand is large enough. Here, when we introduce a labor demand shock, we have a more clear-cut result: containment policies always result in job loss. This is because

(iii) The marginal change in income loss with respect to the stringency level is given by:

$$\Delta_z = w[(\theta_z(1 - i_1) + s_0 i_0(1 - \theta)Q_z\Gamma'].$$

As opposed to the previous case without a labor demand shock, we now have $Q_z > 0$. As a result, the sign of Δ_z depends on the containment elasticity of labor demand. In particular $\Delta_z > 0$ if and only if $\frac{\theta_z}{\theta} > \frac{s_0 i_0 \Gamma' Q_z}{1-i_1}$.

(iv) The sign of S_z is the same as the sign of the difference between $b_{22}d_1$ and $b_{12}d_2$, which can be rewritten as:

$$= -w\mathbb{E}\{GBH'V'' + Bs_0i_0\Gamma''V'\}xw\mathbb{E}\{B_zHV''\}$$
$$+ (U''p + xw\mathbb{E}\{BH'V''\})w\mathbb{E}\{B_zHGV'' + B_zs_0i_0\Gamma'V'\}$$
$$= -xw^2\mathbb{E}\{Bs_0i_0\Gamma''V'\}\mathbb{E}\{B_zHV''\} + U''pw\mathbb{E}\{B_zHGV'' + B_zs_0i_0\Gamma'V'\}$$
$$+ xw^2\mathbb{E}\{BH'V''\}\mathbb{E}\{Bs_0i_0\Gamma'V'\}$$
$$= -xw^2\mathbb{E}\{Bs_0i_0\Gamma''V'\}\mathbb{E}\{B_zHV''\} + w\mathbb{E}\{B_zs_0i_0\Gamma'V'\}(U''p + xw\mathbb{E}\{BH'V''\}) + wpU''\mathbb{E}\{B_zHGV^{''}\}$$

Note that $\mathbb{E}\{Bs_0i_0\Gamma''V'\} > 0, \mathbb{E}\{B_zHV''\} > 0, \mathbb{E}\{B_zs_0i_0\Gamma'V'\} > 0, \mathbb{E}\{BH'V''\} < 0$ and $\mathbb{E}\{B_zHGV^{''}\} > 0$ because $B_z < 0, \Gamma' < 0, \Gamma'' > 0, V' > 0, V'' < 0, H' = -\Gamma's_0i_0 > 0$ by assumptions. As a result, $-xw^2\mathbb{E}\{Bs_0i_0\Gamma''V'\}\mathbb{E}\{B_zHV''\} < 0, w\mathbb{E}\{B_zs_0i_0\Gamma'V'\}(U''p + xw\mathbb{E}\{BH'V''\}) < 0$ and $wpU''\mathbb{E}\{B_zHGV^{''}\} < 0$. In other words, as all the components of $b_{22}d_1 - b_{12}d_2$ are negative, S_z is also negative.

(v) As $C_z = -pQ_z - S_z$, the effect of containment policies on consumption is ambiguous in the case with uncertainty.

4 Data

4.1 Survey data

To understand the behaviors and the outcomes of individuals during the pandemic, we employed the survey data from Belot et al. (2020). Data was collected between April 15 and April 23 with the support of market research companies: Lucid for Western countries (Italy, UK and US), and dataSpring for Asian countries (China, Japan and Korea). This survey contains information about basic demographic characteristics and the impact of the pandemic on the respondents' jobs and incomes.

Table 1 summarizes the socio-demographic characteristics of our respondents. We can see that all age categories and income quantiles are well represented in this survey. There could be, however, an over-representation of self-employed workers in the sample, representing more than 44% of the total sample, with part-time and full-time employees representing 13% and 11% of the sample, respectively.

The survey measured the impacts of the pandemic on the labor market using a number of measures. First, it asked if respondents had lost their jobs as a consequence of the pandemic. The respondents could respond with three options: lost their job permanently (1), temporarily (2) or not at all (3). In other words, the higher the answer, the more secure the job. The loss of employment indicator was accompanied by a question about loss of income. Respondents were asked how much their typical household income was reduced as a result of the pandemic. The survey also asked respondents if they expected a loss of income in the future. All of this information was used to calculate a measure of workers' vulnerability during the crisis.

Table 1. Socio-demographic characteristics

			Age Distribution			
18-25	26-35	36-45	46-55	56-65	66-75	Above 75
12%	18%	19%	19%	16%	13%	4%
			Income Distribution			
	1st quantile	2nd quantile	3rd quantile	4th quantile	5th quantile	
	19%	18%	21%	22%	18%	
			Labor status			
		Self-employed	Part time	Full time		
		44%	13%	11%		

4.2 Lockdown policy

We used the index provided by Hale et al. (2020) for our government policy response data. To create this index, they used the Oxford COVID-19 Government Response Tracker (OxCGRT), which is a systematic cross-national, cross-temporal measure to understand how government responses have evolved with the spread of the virus. They tracked a number of government policies, from containment and closure, to economic responses and healthcare systems. Using the Principle Component Analysis, they created a single index that aims to quantify the stringency of government policies.

Figure 1 shows the stringency index overtime in the six countries in our analysis: China, Italy, Japan, South Korea, United Kingdom and United States. The first dashed line indicates when the country had 100 confirmed cases, often regarded as the beginning of the spread of the virus in the country. The second dashed line indicates the time the survey took place. We can see that the policy trajectory was different across countries and that there is a variation of approaches across countries. The containment level taken is the level of stringency from the start of the spread of the virus.

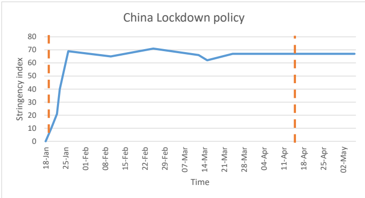
5 Empirical identification

5.1 Demand labor shock

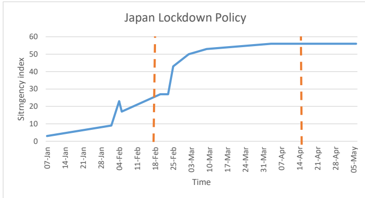
Our theory makes a clear distinction between the case with a labor demand shock and the case without it. Indeed, our predictions of protective measures, job losses, income and savings all depend on the presence of labor demand shock.

To match our empirical exercise with our theoretical model, we need a measure of labor demand shock. In our survey, respondents were asked whether they expected a loss in household income. The standard deviation of their answers is used as a measure of the extent of the labor demand shock. The labor demand shock for each region is provided in the Appendix (Table A1).

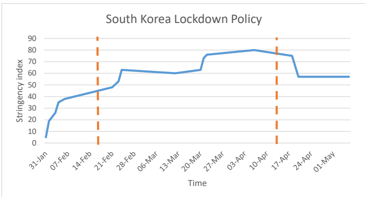
Figure 2 shows the shocks across different regions in our survey. We can see there is a variation of shocks, which helps us empirically investigate the impact of containment policies on key variables. In particular, we will classify that the region had (did not have) a labor demand shock if the standard deviation is higher (lower) than 0.49, which is the mean of the standard deviation in this sample. Following this classification, 30 percent of the respondents lived in areas that did not experience a labor demand shock.



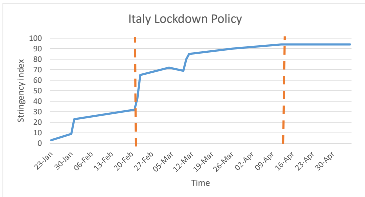
(a) China



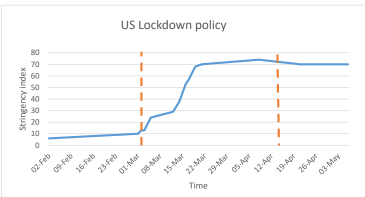
(b) Japan



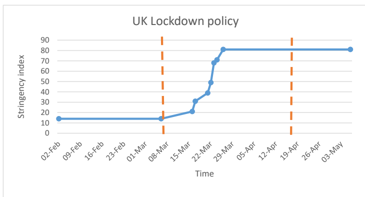
(c) South Korea



(d) Italy



(e) U.S.



(f) UK

Figure 1. The stringency of the lockdown policy across countries. The first dashed line on each graph shows the date of the hundredth confirmed case in the country. The second dashed line indicates when the survey took place.

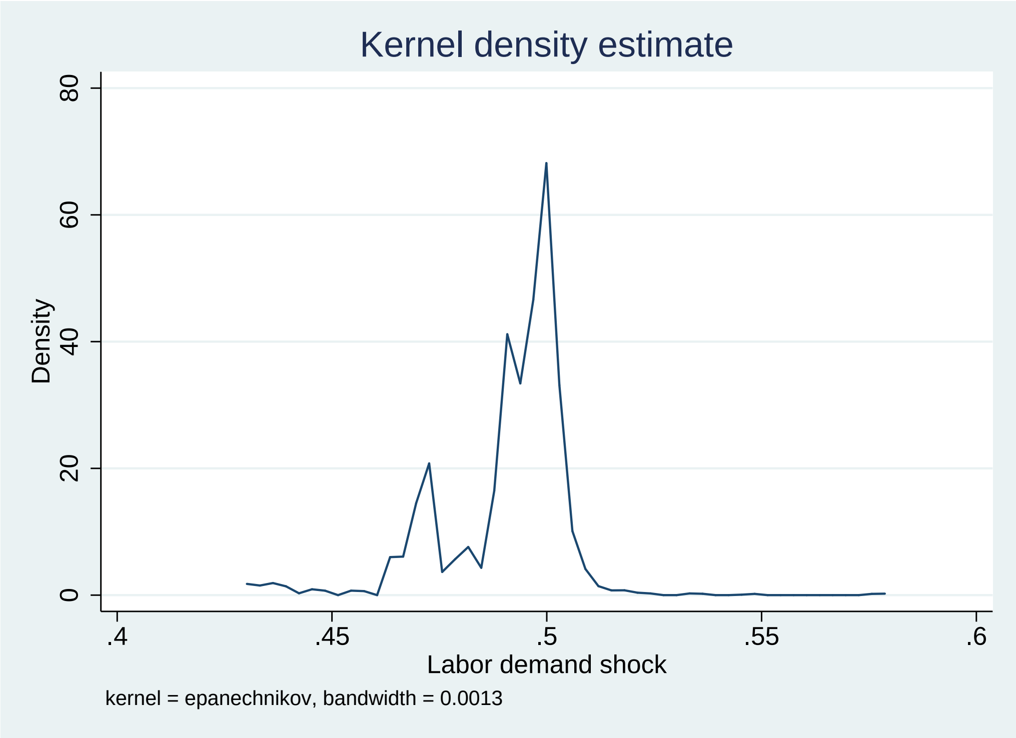


Figure 2. Kernel density of the regional labor demand shock. The labor demand shock is measured as the standard deviation of the respondents' expectation that they would face a loss in income in the next six months.

5.2 The impact of containment on the job outcomes

Our theory predicts that job loss $J(z)$ is a function of the level of stringency of a containment policy. In addition to this policy, we assume that $J(.)$ is also a function of the characteristics (e.g. age, gender, race, income level, etc.) of the workers. In particular, we will have $J(z, X)$, where X is a vector of the characteristics.

To match our theory with the survey data, we further assume that a household member will not be classified as having lost their job if the job loss J is lower than a certain threshold j_1. If $J(.)$ is in between j_1 and j_2, then the job loss is classified as only temporary. Finally, if $J(.)$ is above the threshold j_2 then the job is loss is classified as permanent. In particular, we have:

$$
\begin{aligned}
e &= 3(\text{no job loss}) \text{ if } J < j_1 \\
&= 2(\text{job loss temporarily}) \text{ if } j_1 \leq J < j_2 \\
&= 1(\text{job loss permanently}) \text{ if } j_2 \leq J
\end{aligned}
$$

where e_i is the observed employment status of the household. Together with the fact that $J(.)$ is a function of the containment policy z and household characteristics X we can write our regression as:

$$
f(e_{ci}) = \alpha + \Gamma * X_{ci} + \beta P_c + u_{ci} \tag{18}
$$

where X_{ci} is a vector of the respondent's demographic characteristics and P_c is a vector of the containment policies in country c, where that respondent lives. According to this model we have:

$$
\begin{aligned}
Pr(e_i = 3|X_{ci}, P_c) &= Pr(J_i < j_1|X_{ci}, P_c) = F(j_1) \\
Pr(e_i = 2|X_{ci}, P_c) &= Pr(j_1 \leq J_i < j_2|X_{ci}, P_c) = F(j_2) - F(j_1) \\
Pr(e_i = 1|X_{ci}, P_c) &= Pr(j_2 \leq J_i|X_{ci}, P_c) = 1 - F(j_2)
\end{aligned} \tag{19}
$$

where $F(.)$ is the cumulative distribution function of u_{ci}. If we assume u_{ci} follows a standard normal distribution then we have a ordinal probit regression. If we assume u_{ci} follows a logistic distribution then we have a ordinal logit regression. As a result, the function f(.) of Equation 18 represents the logit and probit functions.

5.3 The impact of containment on income, savings and protective measures

In the previous section, we laid out the identification strategy to empirically analyse the impact of containment policies on job outcomes. This identification strategy can be applied to other outcomes such as income, savings and self-protection measures. More precisely, if we denote y^* as the respondent's answers to the changes in their income, savings and self-protection measures we have:

$$f(y^*_{ci}) = \alpha + \Gamma * X_{ci} + \beta P_c + u_{ci} \tag{20}$$

6 Empirical evidence

6.1 Vulnerable workers

Table 2 highlights the characteristics of vulnerable workers during the pandemic. In particular, young workers were more vulnerable than senior ones. Relative to people aged between 18 and 25 years old, senior workers (aged above 56) had a higher chance of keeping their jobs. More precisely, our probit model predicts that senior workers aged between 56 and 65 years old were 6 percent more likely to keep their jobs than young people (aged 18 to 25 years old)[1].

Self-employed workers seem to fare better than part-timers and full-time workers. The probit model predicts that 84 percent of self-employed workers will keep their jobs, as opposed to only 65 percent of full-time workers. The lowest-income workers (the first quintile of the income group) only have an estimated 75 percent chance of keeping their jobs, which is 10 percent lower than the highest-income workers (the fifth income quintile). Finally, the job security of urban dwellers are more vulnerable to the effects of the pandemic than rural residents. 79 percent of the former groups are predicted to keep their jobs, compared to 84 percent of the latter group.

When people lose their job, they also experience a loss of income. In this regard, the results reported in Table 3 are consistent with those in Table 2. Young, employed, low-income and urban workers' incomes are more vulnerable to the effects of the pandemic. In particular, our probit model predicts that 67 percent of workers aged between 18 and 25 years old experience a loss of income, compared to 59 percent of workers aged between 56 and 65 years old. 59 percent

[1] The probability of those between the ages of 56 and 65 keeping their jobs is 86 percent, while it is 80 percent for young workers.

of self-employed workers are predicted to experience income loss, compared to 81 percent of full-time workers. The proportion of the lowest and highest income workers expected to lose their income are 71 and 63 percent, respectively. Finally, 68 percent of urban dwellers are expected to lose their income, as opposed to 62 percent of rural residents.

6.2 Impacts of containment

Our theory highlights the role of labor demand uncertainty in terms of the impact of containment policies. Indeed, in the absence of labor uncertainty, containment policies can result in job loss if the containment elasticity of labor demand is sufficiently large. This leads to income loss, an increase in savings and fewer self-protection measures being taken. In the presence of labor uncertainty, containment policies also result in job and income loss. However, in this scenario savings decrease and more self-protection measures are applied.

In Section 5.1 we explained our labor demand shock measure. Our prediction, in particular whether or not household members will lose their jobs during the containment period, depends on whether the direct effect of containment on labor demand dominates the indirect effect of containment on the availability of the workers. To measure this, we distinguish between the respondents who were waiting to be tested for the virus and those who were not. Admittedly, the latter group are likely to be healthier than the former. Therefore, the direct effect of containment is more likely to dominate the indirect effect of containment for the latter group than for the former.

Table 4 reports the impacts of containment on our key variables, namely job loss, income, savings and protective measures. In the first two columns, we present the impacts of containment in the absence of a labor demand shock. In the last two columns, we present the impacts of containment in the presence of a labor demand shock. As our answers are in the form of rating scales, we apply the ordinal logit and probit regressions to our data. Ordinal logit regressions are employed in Columns 1 and 3 while ordinal probit regressions are employed in Columns 2 and 4.

Table 2. Impact of demographic characteristics on the labor market

	(1)	(2)
Between 26 and 35	-0.084	-0.069
	(0.144)	(0.083)
Between 36 and 45	-0.066	-0.048
	(0.142)	(0.082)
Between 46 and 55	0.133	0.082
	(0.146)	(0.085)
Between 56 and 65	0.378**	0.229**
	(0.160)	(0.093)
Between 66 and 75	0.400*	0.238*
	(0.217)	(0.126)
Above 75	-0.023	-0.018
	(0.389)	(0.230)
Prefer not to answer my age	17.879	5.415
	(5503.343)	(875.827)
Female	0.072	0.029
	(0.084)	(0.049)
Prefer not to answer my gender	0.591	0.398
	(1.587)	(0.953)
Native American	-0.872	-0.433
	(0.827)	(0.510)
Asian	0.932*	0.563*
	(0.541)	(0.307)
Black	0.129	-0.010
	(0.400)	(0.223)
Hawaiian	0.419	0.252
	(0.819)	(0.450)
White	-0.470	-0.322*
	(0.317)	(0.181)
Prefer not to answer my race	-0.140	-0.051
	(0.533)	(0.317)
Employed part-time	-0.396***	-0.217***
	(0.112)	(0.065)
Employed full-time	-1.089***	-0.620***
	(0.114)	(0.066)
Second quantile	0.008	0.004
	(0.141)	(0.082)
Third quantile	0.271*	0.165**
	(0.139)	(0.081)
Fourth quantile	0.438***	0.258***
	(0.140)	(0.081)
Fifth quantile	0.625***	0.359***
	(0.151)	(0.087)
Prefer not to answer my income	1.025**	0.551**
	(0.427)	(0.235)
Semi-urban / residential	0.267***	0.154***
	(0.090)	(0.052)
Country side	0.370***	0.208***
	(0.136)	(0.079)
Observations	4103	4103

Standard errors in parentheses. The dependent variable is whether the respondent experienced a loss of job. 1 - job lost permanently, 2 - job lost temporarily, 3 - no job lost. * p<0.1, ** p<0.05, *** p<0.01

Table 3. Impact of demographic characteristics on household income

	(1)	(2)
Between 26 and 35	0.026	0.018
	(0.149)	(0.090)
Between 36 and 45	0.046	0.026
	(0.149)	(0.090)
Between 46 and 55	-0.089	-0.055
	(0.151)	(0.091)
Between 56 and 65	-0.346**	-0.209**
	(0.164)	(0.098)
Between 66 and 75	-0.687***	-0.414***
	(0.223)	(0.135)
Above 75	0.218	0.146
	(0.457)	(0.274)
Prefer not to answer my age	0.224	0.142
	(1.081)	(0.690)
Female	-0.027	-0.016
	(0.085)	(0.052)
Prefer not to answer my gender	-19.872	-6.365
	(7838.131)	(920.517)
Native American	1.811	1.017
	(1.213)	(0.655)
Asian	-0.586	-0.349
	(0.551)	(0.322)
Black	-0.437	-0.258
	(0.430)	(0.251)
Hawaiian	-0.543	-0.306
	(0.843)	(0.499)
White	0.205	0.143
	(0.363)	(0.211)
Prefer not to answer my race	-0.449	-0.249
	(0.592)	(0.356)
Employed part-time	0.506***	0.298***
	(0.115)	(0.069)
Employed full-time	1.064***	0.639***
	(0.131)	(0.077)
Second quantile	-0.111	-0.069
	(0.155)	(0.093)
Third quantile	-0.282*	-0.178*
	(0.152)	(0.091)
Fourth quantile	-0.305**	-0.191**
	(0.151)	(0.091)
Fifth quantile	-0.341**	-0.214**
	(0.158)	(0.096)
Prefer not to answer my income	-0.848**	-0.521**
	(0.383)	(0.230)
Semi-urban / residential	-0.256***	-0.157***
	(0.090)	(0.055)
Country side	-0.160	-0.090
	(0.135)	(0.082)
Observations	4103	4103

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

Panel A of Table 4 shows the impacts of containment on job loss. Respondents were asked if they experienced any job loss as a consequence of the pandemic. The answers were 1 (permanent job loss), 2 (temporary job loss) or 3 (no job loss). We can see that in the absence of labor uncertainty (Columns 1 and 2), the effects are insignificant. By contrast, in the presence of labor uncertainty (Columns 3 and 4), the effects are significantly negative. Table 5 provides the predicted job outcomes based on the ordinal logit and probit models. Both models predict that the stringency level of a containment policy increases the proportion of people who lose their jobs.

Note that the impacts of containment on job outcomes are insignificant in the absence of labor uncertainty (Columns 1 and 2 in Table 4). Indeed, the impacts of containment in such case depend on whether the direct effect of containment dominates the indirect effect. Panel A of Table A1 provides evidence to support this prediction. Indeed, the impact of containment among the people who were waiting to be tested are insignificant. This is because the indirect effect of containment (i.e. improvements in the health outcomes of households) in this case cancel out the direct effect. By contrast, among the people who did not need a test, and hence the indirect effect of containment, is insignificant. In addition, the effect of containment, which is mainly the direct effect, is significantly negative.

Panel B of Table 4 reports the impacts of containment on income. In the absence of labor uncertainty, the impacts of containment are negative (Columns 1 and 2). This is consistent with prediction (ii) of Proposition 1. By contrast, in the presence of labor uncertainty, the impacts of containment are positive (Columns 3 and 4). In fact, the biggest impacts occur among people who were not waiting to be tested because the indirect effects of containment are not pronounced.

Panel C reports the impacts of containment on savings. We can see that in the absence of labor uncertainty (Columns 1 and 2), the overall effect of containment on savings is positive. Hence, people save more in response to the decrease in their income. By contrast, in the presence of labor uncertainty (Columns 3 and 4) the overall effect of containment on savings is negative. All of these results support our initial predictions.

Finally, Panel D reports the impacts of containment on protective measures. In our survey, the respondents were asked if they wash their hands with water and soap, or regularly use hand sanitizer, normally (i.e. in the absence of a pandemic), right after the initial outbreak of the virus, and at the time of the survey. We interpreted their answers at the time of the survey to be their response to the containment policy imposed by their government. Our model predicts that in the absence of labor uncertainty, people apply fewer measures when containment is stringent. These results are shown in Columns 1 and 2 of Panel D. By contrast, in the presence of labor uncertainty, people apply more measures, which is shown in Columns 3 and 4.

7 Conclusion

We examined the impacts of containment policies on labor market outcomes and the behaviors of people. We show that the role of labor uncertainty is crucial. In the absence of this uncertainty, containment policies result in fewer self-protection measures, more savings, and less income. They also imply more job losses if, and only if, the containment elasticity of labor demand is large. Certain predictions reverse when we introduce labor uncertainty. In this case, containment policies lead to more self-protection, lower savings and higher rates of job loss. Income loss occurs when the containment elasticity of labor demand is sufficiently large.

We then provide supporting evidence that underpin our predictions. Using data from a recent survey taken during the pandemic, along with a constructed index measuring the stringency of government containment policies, we find that young, low income and urban dwellers are the most vulnerable workers during the pandemic. We find that they are more likely than other groups to lose their jobs and incomes when governments enact containment measures. We also test our predictions and receive supporting evidence for all of them.

Table 4. Impacts of lockdown policy

	No shock		Labor demand shock	
	(1)	(2)	(3)	(4)
	Ordinal logit	Ordinal Probit	Ordinal Logit	Ordinal Probit
Panel A: Impacts of lockdown on job loss				
Lockdown	-0.037	-0.015	-0.089***	-0.043***
	(0.040)	(0.023)	(0.026)	(0.015
Lockdown (waiting to be tested)	0.096	0.079		
	(0.214)	(0.122)		
Lockdown (no test necessary)	-0.040**	-0.019*		
	(0.019)	(0.011)		
Panel B: Impacts of lockdown on income loss				
Lockdown	-0.044	-0.026	0.138***	0.083***
	(0.043)	(0.026)	(0.027)	(0.016)
Lockdown (waiting to be tested)			0.031	0.028
			(0.094)	(0.052)
Lockdown (no test necessary)			0.039***	0.023***
			(0.008)	(0.005)
Panel C: Impacts of lockdown on savings				
Lockdown	0.021	0.006	-0.073***	-0.038***
	(0.033)	(0.019)	(0.022)	(0.012)
Panel D: Impacts of lockdown on protective measures				
Lockdown	-0.029	-0.015	0.011	0.008*
	(0.018)	(0.011)	(0.007)	(0.004)

Note: In all specifications, the household's characteristics included are: age group, gender, labor status and income group.
Other characteristics (race, living area, industry and profession) are also controlled for in all specifications, except when we divide the sample into those who were waiting for the tests and those who were not. Standard errors are in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$

Table 5. Predicted job outcomes across countries

	Ordinal logit		Ordinal probit	
	Temporary job loss	No job loss	Temporary job loss	No job loss
Italy - Japan (Lockdown = 3)	2.5%	97.4%	8%	91.8%
Korea (Lockdown = 5)	2.7%	97.1%	9.3%	90.5%
United States (Lockdown = 6)	2.8 %	97%	10.1%	89.7%
China (Lockdown = 10)	3.3%	96.6%	13.4%	86.3%
United Kingdom (Lockdown = 14)	3.8%	96.1%	17.4%	82%

Note: all values are predicted using the ordinal logit and probit models, at the corresponding lockdown levels and means of the other variables. The predicted proportion of permanent job loss are close to 0 and not reported here.

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8 Appendix

Table A1. Labor Demand Shock across surveyed regions

Anhui	0.43154767	Texas	0.49626908
Liaoning	0.43723732	North West	0.49634725
Trentino-Alto Adige	0.44095856	Puglia	0.49659333
Jiangxi	0.44657609	Kansai	0.49865815
Calabria	0.45584232	Seoul	0.49879956
Chugoku	0.46396092	Guangdong	0.4988659
East of England	0.46481112	West Midlands	0.49942595
Shandong	0.46598476	Zhejiang	0.49954608
Sicilia	0.46933967	Toscana	0.49986777
Marche	0.47016233	California	0.49993849
East Midlands	0.47131726	Qinghai	0.5
Chubu	0.47138551	New York	0.50060618
Lombardia	0.47139022	Gyeonggi-do	0.50107157
Veneto	0.47278896	Incheon Metropolitan City	0.50156987
Wales	0.47395957	South East	0.501652
Sardegna	0.47395957	Busan	0.50212598
Jilin	0.4767313	Sichuan	0.50239807
Hebei	0.47889027	Gyeongsangbuk-do	0.50248551
Hubei	0.4807829	Abruzzo	0.50262469
Yorkshire and the Humber	0.48139685	Tohoku	0.50296736
Hunan	0.4825587	Shikoku	0.50361013
Jeju Island	0.48304591	Chung-cheong bukdo	0.50361013
Guizhou	0.48304591	Gyeongsangnam-do	0.50423378
Hokkaido	0.48409033	Fujian	0.50485235
Daegu Metropolitan City	0.48666427	Heilongjiang	0.5061202
North East	0.48829436	Gangwon-do	0.50636971
Piemonte	0.48842493	Shaanxi	0.50636971
Campania	0.4887197	Jeollabuk do	0.50636971
Greater London	0.48927677	Chungcheongnam-do	0.50686979
Emilia-Romagna	0.49026561	Liguria	0.50787449
Scotland	0.49131879	Daejeon	0.5085476
Henan	0.49136862	Northern Ireland	0.51075393
Shanxi	0.49136862	Basilicata	0.51234752
Kanto	0.49149734	Hainan	0.51639777
Kyushu	0.49219257	Yunnan	0.51639777
Friuli-Venezia Giulia	0.49236596	Gansu	0.51754916
Lazio	0.49292517	Ulsan Metropolitan City	0.52223295
Jeollanam-do	0.49327022	Umbria	0.53452247
South West	0.4950785	Molise	0.54772258
Jiangsu	0.49534553	Sejong Special Self-governing City	0.57735026
Florida	0.49607426	Valle d'Aosta	0.57735026