Covid-19: Lockdown Decision in Switzerland

Subjective Expected Utility

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Abstract

Far-reaching measures were decided by the Swiss federal council to counter the Covid-19 pandemic. This paper analyses this decision using separate models of the health and economic impact with the Subjective Expected Utility Theory (SEU). Based on different assumptions regarding the impact of the pandemic, a partial lockdown would have been suggested. In order to assess the uncertainty about the specifications, a shiny application has been set up. Despite considering different aspects, different types of uncertainty remain and therefore make it unpossible to give a clear suggestion.

1 Motivation

Due to the Covid-19 pandemic, the Swiss federal council made a decision on March 16th, 2020 with a massive impact on society, economy and healthcare. Shops, schools, theaters, museums, restaurants, bars, libraries and many more institutions were closed, large events with more than 100 people were forbidden and the Swiss armed forces were mobilized for the first time since world war two (cf press conference).

Within this project, this decision shall be analyzed and assessed using Subjective Expected Utility Theory (SEU).

2 Subjective Expected Utility

SEU was introduced by Leonard Savage in 1954[1] and gives the possibility to assess decisions under uncertainty in the absence of physical probabilities.

Following components must be defined to apply SEU for our purpose:

- Acts $a \in A$: decision opportunities;
- States i: mutually exclusive and exhaustive events;
- Consequences x_{ia}: the outcome for every act $a \in A$ and state i (i.e. the outcome if a is decided and i occurs);
- Subjective Prior $\tilde{p}_i$: the subjective belief on the likelihood of i occuring;
- Utility function $u(x_{ia})$: the utility function for every consequence, complying with the SEU-postulates.

Based on the SEU, a decision maker should choose the act a, which has the highest expected utility of all acts $a \in A$. In mathematical notation, the decision criteria can be represented as:

$$\max_a \sum_{\forall i} x_{ia} * \tilde{p}_i$$

3 Our modelling Approach

Following the suggestion of Berger et al. (2020, p.5)[2], this assessment will be made based on separate modellings of the health and disease impact and the economic impact. Subsequently these inputs will be used in the formal decision rule, the SEU.

There are countless possibilities regarding measures that the federal council could have decided. Assuming that it would have been unfeasible to take minor measures than the ones already implemented earlier, we only consider the following two acts:

- Partial Lockdown: Minor restrictions, e.g. on large events, restaurants, bars;
- Full Lockdown: Major restritions, e.g. closure of shops, schools, universities and the granting of loans and subventions for the economy.

Furthermore, only the 33 days following the date of decision will be considered.

[1] Savage, L.J. (1954) “The Foundations of Statistics” *New York, Wiley.*

[2] Berger, L. et al. (2020) “Uncertainty and decision-making during a crisis: How to make policy decisions in the COVID-19 context?” *Chicago, Macro Finance Research Program.*

3.1 Economic Model

3.1.1 General Approach & Basic Assumptions

We defined economic costs as the second cost driver in our model. The term *economic costs* is rather vague, and there are different aspects one could take into account. We decided to define economic costs in our model as lockdown-related government spending, consisting of five different cost categories. The economic cost function and the corresponding cost categories are illustrated below.

$$G_i^a = PUB_i^a + DC_i^a + TaxP_i^a + TaxVA_i^a + OEE_i^a$$

- $a \in \{\text{Partial Lockdown} = \text{PL}, \text{Full Lockdown} = \text{FL}\}$
- $i \in \{\text{optimistic} = \text{o}, \text{neutral} = \text{n}, \text{pessimistic} = \text{p}\}$
- G_i^a = Additional government spending in act a and state i
- PUB_i^a = Partial unemployment benefits
- DC_i^a = Defaults of granted credits
- $TaxP_i^a$ = Corporate profit tax shortfalls
- $TaxVA_i^a$ = Value added tax shortfalls
- OEE_i^a = Other extraordinary expenses

Our economic cost function is inspired by similar analysis from NZZ and Avenir Suisse. We argue that the focus on government spending captures essential economic costs the Swiss people care about because they have to finance it through taxes. Furthermore, we argue that it is a good measurement of economic damage caused by the lockdown decision because it directly and indirectly takes into account some of the decision's effects on the labor market and the domestic economy. Consequently, we believe that our model, at least to some extent, factors in the economic costs the Federal council considered for its lockdown decision. Besides that, this approach appeared reasonable in terms of data availability. Firstly, it allowed us to respect the particularity of the Swiss case since we could rely on data about the Swiss economy. Secondly, it enabled us to reasonably and transparently differ between the costs in a full and a partial lockdown which was another difficult challenge to tackle. Nevertheless, it is important to state that our approach represents a strong simplification of the actual economic costs since it ignores many other important cost categories such as long-term unemployment.

3.1.2 Economic Shock Exposure Variable

As already mentioned above, one of the main challenges in our approach was the differentiation between the costs in the two acts. This was a particular problem for cost categories which differed across the sectors in the economy, namely the partial unemployment benefits and the two tax categories. We decided to tackle this problem by introducing a so-called *Economic Shock Exposure Variable* $X_{s,i}^a$. This variable measures two things at the same time. Firstly, it indicates how much percent of sector s' current wage bill will be subject to partial unemployment benefits in act a and state i and secondly it indicates by how much percent a sector's usual tax payments will be reduced in act a and state i. As a further simplification, we assumed that the act exercised by the Federal Council would only affect the economic shock exposure of six particular sectors. This enabled us to ignore all other sectors of the Swiss economy in our model since the lockdown-decision would not cause any additional government spending related to these sectors. We then assumed that the Federal Council knew the precise shock exposure of these six sectors in case of a full lockdown whereas it was unsure about the shock exposure in case of a partial lockdown. As a consequence, the Federal Council faced uncertainty about the difference of lockdown-related government spending in the two acts.

The introduction of the economic shock exposure variable was inspired by an analysis of Avenir Suisse which followed a similar approach. The overview below shows the shock exposure of the six considered sectors. For the *full lockdown* act we adopted the economic shock exposure suggested in the paper of Avenir Suisse. In case of the retail trade sector the paper did not mention the concrete value it used but indicated that it assumed a full shock exposure of 100% except for the food retail trade which was presumed to be unaffected by the lockdown decision. We did not find any data concerning the composition of the retail trade's earnings, but we found that the Unia assumed in 2012 that the food retail trade accounted for 37% of all employment in the retail trade sectors. We used this information and consequently assumed that the retail sector would experience a shock exposure of only 63%. This represents a strong simplification, but it allowed us to at least estimate the ambivalent effects in the retail trade sectors.

Table 1: Economic Shock Exposure per Sector, State and Act

	Sector	a=PL i=o	a=PL i=n	a=PL i=p	a=FL i={o,n,p}
1	Handel, Inst. u. Rep. v. Mfz	0.200	0.600	1	1
2	Detailhandel	0.200	0.415	0.630	0.630
3	Schifffahrt und Luftfahrt	0.200	0.600	1	1
4	Beherbergung	0.200	0.475	0.750	0.750
5	Gastronomie	0.200	0.600	1	1
6	Erbringung sonstiger DL	0.200	0.600	1	1

Due to the uncertainty assumption, the shock exposure variable required more than one value as input for the act of a partial lockdown. The paper of Avenir Suisse did not suggest any values for the economic shock exposure in case of a partial lockdown but it assumed that the other sectors in the economy (i.e. the sectors we ignored in our model) would all be subject to a shock exposure of 20% in case of a full lockdown. We decided to take this 20% shock exposure and define it as the minimum shock exposure of the six considered sectors in case of a partial lockdown in order to remain consistent within our model. We already assumed that the shock exposure of the ignored sectors would be the same in both acts. Since the partial lockdown measures discriminated considerably less across the sectors in the economy, it seemed consistent to assume that the shock exposure of our six considered sectors would also equal 20% in a partial lockdown. As a next step we had to define a maximum value of the shock exposure, representing a pessimistic state of the economic shock in the event of a partial lockdown. We assumed that the values of the shock exposure in this state would equal the values in case of a full lockdown. As a final and neutral scenario, we then decided to take the average of the shock exposure in the optimistic and pessimistic state of each sector. The uncertainty about the economic shock exposure in a partial lockdown required us to assign a prior to each value. Due to the lack of further information we decided to rely on the principle of insufficient reason from De Finetti (1981)[3] and assumed equal prior probabilities for each economic state.

[3]Bruno De Finetti (1981) "Wahrscheinlichkeitstheorie" *München, Oldenburg Verlag GmbH.*

Overall, the introduction of the economic shock exposure variable allowed us to differentiate between the economic costs in the two acts in a consistent way. However, it also required us to establish several assumptions which are debatable and base on a relatively thin academic proof since we mainly rely on the analysis of a domestic think-thank. It is an important point of criticism in our model and should be subject to improvements in further research.

3.1.3 Cost Categories

This subchapter gives an overview of the calculations of the five cost categories and indicates the data sources we relied on.

Partial Unemployment Benefits

$$PUB = \sum_{s=1}^{n} L_s * \emptyset w_s * X_{s,i}^{a} * 0.8$$

- n = Number of sectors whoose economic shock depends on the act
- L_s = Number of workers in sector s (indicated as full-time equivalents)
- $\emptyset w_s$ = Average monthly wage in sector s
- t = Duration of lockdown = 33 days = 1.1 months
- $X_{s,i}^{a}$ = Economic shock exposure of sector s in state i in the event of act a

The calculation of the partial unemployment benefits is largely self-explanatory. In case of a partial lockdown, there are three different possible cost outcomes due to the uncertainty represented by the economic shock exposure variable. The data about the wage level and the full-time equivalents per sector are both provided by the Federal Statistical Office of Switzerland.

Defaulted Credits

$$DC = \begin{cases} d * CV^{SME} + d * c * CV^{LE}, & \text{if } a = FL \\ 0, & \text{if } a = PL \end{cases}$$

- $d = 0.05$ = default rate of the credit facilities
- $c = 0.85$ = Share of the credit facility for large enterprises which is covered by a guarantee of the Swiss Government
- CV^{SME}= Credit volume for small and medium enterprises
- CV^{LE} = Credit volume for large enterprises

This cost category refers to the two credit facilities the Swiss government decided to guarantee after the lockdown-decision. The key points of the credit facilities can be found in the associated media release of the Swiss government. We assumed that the Federal Council already knew that it would take this measure when it announced the full lockdown on March 16. We then estimated that 5% of these credits would default in case of a full lockdown which is in line with estimations of financial experts according to a report from the NZZ. As one can see in the equation below, we assumed that the costs resulting from defaulted credits would equal to zero in case of a partial lockdown. This reflects our assumption that either the default rate of these credits would be zero or that the Federal Council would not have had to guarantee loans in the first place in case of a partial lockdown. It is also important to state that we ignored potential interest rate incomes of the credit facility for large enterprises.

Corporate Profit Tax Shortfalls

$$TaxP = \frac{\sum_{s=1}^{n} \Pi_s^{2018} * * q^P * X_{s,i}^a *}{12} * t$$

- π_s^{2018} = Profits exposed to taxes in sector s in 2018
- q^P = 8.5% = Federal tax ratio in Switzerland for corporate profits
- $X_{s,i}^a$ = Economic Shock Exposure of sector s in the event of act a

The calculation of the corporate profit tax shortfalls is largely self-explanatory. In the event of a partial lockdown, there are again three different possible cost outcomes due to the uncertainty represented by the economic shock exposure variable. Furthermore, it is important to state that we assumed that the profits exposed to taxes in the six sectors would be at the same level as in 2018 which was the latest year with available data. We also assumed that these profits would be equally distributed over all the days of a year. Both of these assumptions are debatable since profits vary with the season and also over the years, but they helped to simplify our model. The data about the earnings and the costs per sector are both provided by the Federal Statistical Office of Switzerland.

Value Added Tax Shortfalls

$$Tax = \frac{\sum_{s=1}^{n} VA_s^{2018} * q_s^{VA} * X_{s,i}^a *}{12} * t$$

- VA_s^{2018} = Value added exposed to taxes in sector s in 2018
- q_s^{VA} = Tax ratio in Switzerland on value added in sector s
- $X_{s,i}^a$ = Economic Shock Exposure of sector s in the event of act a

The calculation of the value added tax shortfalls is conceptionally identical to the one of corporate profit tax shortfalls and does therefore not require further explanations. The data used to calculate the value added per sector is also the same as the one used to calculate the profit taxes.

Other Extraordinary Expenses

$$OEE = \begin{cases} 4'000'000'000, & \text{if } a = FL \\ 0, & \text{if } a = PL \end{cases}$$

This cost category incorporates two different types of lockdown-related government spending. First, it includes compensations for self-employed people whose business has been closed in the course of a full lockdown or who could not work due to quarantine. Secondly, it refers to compensations for parents who could not work due the closing of the schools. The estimations for both cost types base on an article from NZZ. This cost category does not include subsidies for cultural or sport organization because we assumed that they would have been closed in both acts. Moreover, the equation displayed below indicates that we supposed the other extraordinary expenses to be zero in case of a partial lockdown. This seems reasonable since both types of lockdown-related government spending explained above are directly linked with the measures of a full lockdown.

3.1.4 Results

The graph below indicates the economic costs for all three economic states. Every economic state has two different outcomes since our model has two different acts. We see that the lockdown-related government spending equals approximately 9 billions in the event of a full lockdown whereas these spendings vary between 1.0-3.2 billions in the event of a partial lockdown, depending on the value of the economic shock exposure. We recognize that the additional spending in a full lockdown is mainly caused by other extraordinary expenses and defaulted credits. The other three cost categories, which were subject to stronger assumptions, account for a considerably smaller proportion, especially the tax-related cost categories which almost seem negligible in comparison to the others. The main variance of the payoffs in a partial lockdown comes from the partial unemployment benefits.

Table 2: Composition of Economic Costs per State and Act (in Mio)

	State	Prior	Act	PUB	DC	TaxP	TaxVA	OEE	AddGovSpend
1	Optimistic	0.333	FL	2′684	1′850	106	410	4′000	9′050
2			PL	891	0	44	149	0	1′084
3	Neutral	0.333	FL	2′684	1′850	106	410	4′000	9′050
4			PL	1′788	0	75	279	0	2′142
5	Pessimistic	0.333	FL	2′684	1′850	106	410	4′000	9′050
6			PL	2′684	0	106	410	0	3′200

3.2 Health Model

The health costs are the first cost driver in our model. We chose to consider only the costs incurred due to the years of life lost because of corona deaths. For example, one could have also considered the costs of mental illness because of the consequences of a full lockdown. Still, the data situation was scarce when the decision had to be made to declare a full lockdown or keep a partial lockdown. We took six factors into account to calculate the health costs.

$$L^a_{tij} = (Infected_{t-TrmT} \times R^a_{0_i}) \times FatR_j \times LYrs \times CpLYL$$

with $a \in$ {Partial Lockdown = PL, Full Lockdown = FL}
and $i \in$ {low, medium, high}, $j \in$ {low, medium, high}

$TrmT$: Transmitting Time
$CpLYL$: Cost per Year of Life
R_0: Reproduction Rate
$\downarrow R_0$: Lockdown Discount on R_0
$FatR$: Fatality Rate
$LYrs$: Lost Years

3.2.1 Transmitting Time

The coronavirus's incubation period showed a large variance across many of the studies available at that time. We assumed that an infected person infects R_0 people as soon as symptoms occur, namely after the incubation period. As some people probably do not spread the disease immediately on the first day of the appearance of symptoms, we used in our calculations the transmitting time instead of the incubation period. According to a study of Eurosurveillance the 50th percentile of the incubation period is 6.4 days, and the 97.5th percentile is 11.1 days. To get the transmitting time, we calculated the mean of the percentiles and rounded the result. We arrived at a transmitting time of nine days.

$$TrmT = \frac{IncP_{50th\ PCTL} + IncP_{97.5th\ PCTL}}{2} \approx 9 \text{ days}$$

3.2.2 Cost per Year of Life

The cost per year of life represents the monetary loss of one year of life lost due to a corona death. We implicitly assumed that the value of life is not infinite. Another assumption we made is that each year of life has the same value regardless of the dead person's age. We came across a case from the Federal Court where the maximum amount of CHF 100,000 was considered appropriate for a year of life saved.

$$CpLYL = 100'000 \text{ CHF}$$

3.2.3 Reproduction Rate and Lockdown Discount

The reproduction rate indicates how many people an infected person passes on the virus after the transmitting time. Since the data on the reproduction rate was very scarce at the time of the decision on a lockdown, we distinguished between three different scenarios (low, medium, high) in our calculations. We then subtracted the lockdown discount (in per cent) from each scenario in the full lockdown scenario. To obtain the values for the different scenarios, we used a study from the Journal of Travel Medicine, which analysed twelve individual studies from China and took the smallest value, the arithmetic mean and the largest value. For the lockdown discount, we used a study by the World Health Organization. We assumed that all three scenarios have the same probability and the World Health Organization was communicating with the government of Switzerland before publishing the results.

	low	medium	high
Partial Lockdown	1.4	2.79	3.3
Full Lockdown (−55%)	0.63	1.26	1.49

3.2.4 Fatality Rate

The fatality rate indicates the proportion of infected persons who die from the coronavirus. Here, too, the data was very scarce at the time in question. We again distinguished between three scenarios (low, medium, high) for which we assumed the same probability. Since a lockdown does not change the virus's lethality, we have not distinguished between a partial lockdown and full lockdown. We obtained the data for the average mortality rate from China CDC Weekly and Annals of Translational Medicine.

	low	medium	high
Partial Lockdown	0.15%	2.3%	5.25%
Full Lockdown	0.15%	2.3%	5.25%

We then extrapolated the average mortality rates above down to age groups based on an age distribution from China CDC Weekly. We have implicitly assumed that the fatality rates of the individual age groups in Switzerland are the same as in China.

3.2.5 Lost Years

To calculate the number of years of life lost by a covid deceased, we used data from Switzerland's Federal Statistical Office. For each year of life up to 99, the number of years of life still expected was listed. Since life expectancy differs between males and females, and the distribution of sexes was almost identical before the lockdown decision regarding to another page of the Federal Statistical Office, we used the average life expectancy per age group in our calculations.

	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
Life Expectancy	77.4	67.4	57	47.1	37.4	28.1	19.4	11.8	5.9

3.3 Utility Function

Regarding the utility function it is assumend, that the decision maker's utility only depends on health cost and economic cost. Furthermore it is assumed, that the utility decreases in both. It is also assumed, that the decision maker is risk neutral.

A straightforward representation of these preferences is the following:

$$u_{neutral}(EconCost, HealthCost) = -\frac{EconCost + HealthCost}{10^9}$$

Beside its simplicity, its interpretability is also an advantage. The resulting value can be perceived as monetary loss equivalent of health and economic cost (in Bn CHF). Note: its values are likely to be negative.

4 Results and Discussion

The economic and the health model are combined as such that every state consists of a certain reproduction rate R_0, fatatality rate $FatR$ and an economic expectation. This leads to $3^3 = 27$ states, which, based on de Finetti's principle of insufficient reason, are all assigned with a probability of 1/27. Based on all mentioned assumptions, following subjective expected utilities are obtained for the two acts:

partial lockdown	full lockdown
-8.587	-9.648

When following Savage's approach with the SEU, based on the mentioned assumptions, the Swiss federal council should have decided a partial lockdown. But as the values already suggest, the assumptions made lead to a very close decision.

In order to assess the model's sensitivity to critical input parameters easily, our results are deployed in this shiny application. As can be seen in the following table, different ceteris paribus changes in the assumptions, which might also have been plausible in March 2020, change the suggested decision:

Variable	assumed value	changed value	partial lockdown	full lockdown
Risk-profile	neutral	averse[4]	-135.122	**-93.537**
Cost LYOL	100'000	120'000	-9.876	**-9.768**
Ld duration	33	35	-11.032	**-9.937**
Credit default	5%	1.8%	-8.587	**-8.390**
Transmission Time	9	8	-12.164	**-9.775**
R_0 pessimistic	3.3	3.6	-9.943	**-9.739**

Berger et al. (2020)[5] describe three types of uncertainty, which are relevant for models in the context of the Covid-19 crisis.

First, uncertainty within the model, referring to the standard notion of risk, meaning the uncertainty of outcomes with prespecified probabilities. In our case, this uncertainty goes even beyond this, since the probabilities of the occurence of the states is unknown and, based on de Finetti's principle of unsufficient reason, is assumed to be equal for all states.

Second, uncertainty across models, which reflects the uncertainty about parameters for the models. This issue can be seen in the table above, showing that slight changes in the assumptions can lead to a different optimal decision.

Third, uncertainty about models, referring to the property of a model, that it is a simplification of a more complex phenomenon and therefore is misspecified to some extent. Although our models reflect many aspects of the impact of the Covid-19 crisis, there are certainly some issues missing. Neither the impact on mental health, nor the capacities of the health care system were explicitly specified in the models, leading to a bias.

Due to many remaining uncertainties regarding the models, it is not possible to come to very clear result based on these models.

[4] For the risk-averse profile, following utility function was assumed: $u_{averse}(EC, HC) = -(\frac{EconCost+HealthCost}{10^9})^2$

[5] Berger, L. et al. (2020) "Uncertainty and decision-making during a crisis: How to make policy decisions in the COVID-19 context?" *Chicago, Macro Finance Research Program.*