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Οικονομικές πτυχές του COVID-19: Εκτιμήσεις, και συμπεράσματα οικονομικής πολιτικής

Λούης Ν. Χριστοφίδης*

Περίληψη

Ο ιός SARS-Cov-2 έχει αναπτυχθεί σε όλο τον πλανήτη και οι πλείστες κυβερνήσεις έχουν συγκλίνει στην αντιμετώπιση της ασθένειας COVID-19, την οποία προκαλεί, διαχωρίζοντας τις οικονομικές τους δραστηριότητες σε ζωτικής και μη-ζωτικής σημασίας και απαγορεύοντας προσωρινά συναθροίσεις στη δεύτερη κατηγορία. Η παραγωγή ΑΕΠ μη ζωτικής σημασίας έχει μειωθεί κατακόρυφα ή και μηδενιστεί σε κάποιες δραστηριότητές, όχι όμως σε όλες. Η μελέτη διαπραγματεύεται τις οικονομικές πτυχές της ασθένειας και των τρόπων αντιμετώπισης της, και προσπαθεί να δώσει εκτιμήσεις της συνεπαγόμενης μείωσης του ΑΕΠ, της αύξησης των δημοσιονομικών δαπανών, και των ενδεικνυόμενων τρόπων 'πληρωμής του κόστους' της ασθένειας από την κοινωνία.

Το αρχικό οικονομικό σοκ είναι η μείωση της παραγωγής που απορρέει από την αποστασιοποίηση στις μη-ζωτικής σημασίας παραγωγικές δραστηριότητες της οικονομίας. Η συνάρτηση παραγωγής, που προσδιορίζει πως ο συνδυασμός των συντελεστών παραγωγής εργασία και κεφάλαιο καταλήγει στην παραγωγή προϊόντων (δηλ. ΑΕΠ), προσφέρεται ως ένας τρόπος άτυπης εκτίμησης της μείωσης του ΑΕΠ που απορρέει από την χρήση μόνο ενός κλάσματος της εργασίας στις μη-ζωτικής σημασίας δραστηριότητες κατά τη διάρκεια της αποστασιοποίησης. Υποθέτοντας ότι: (α) το ΑΕΠ του 2020 θα ήταν €22 δ., (β) το μερίδιο της εργασίας είναι 0.65 και του κεφαλαίου 0.35, (γ) η αποστασιοποίηση της εργασίας επιτρέπει μόνο τα 3/5 της χρήσης του συντελεστή παραγωγής εργασία για τους 4 μήνες (Μάρτιο-Ιούνιο) που ο COVID-19 είναι σε έξαρση, και (δ) ότι κατά το δεύτερο μέρος του 2020 η ασθένεια COVID-19 θα συνεχίσει υποτονικά και ότι ο τουρισμός θα δεχτεί ένα μεγάλο πλήγμα, εκτιμώνται τα ακόλουθα. Το ΑΕΠ θα μειωθεί κατά €3.7 δ. ή 6.82% της υποτιθέμενης αξίας του το 2020. Η μείωση θα επιφέρει μείωση των φορολογικών εσόδων κατά €1.51 δ. στην οποία πρέπει να προστεθεί το κόστος των διαφόρων προγραμμάτων στήριξης της οικονομίας που συντηρητικά υπολογίζεται στο €1 δ, αυξάνοντας τις δημοσιονομικές ανάγκες κατά €2.51 δ. ή 11.41% του

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ΑΕΠ. Παρ' όλον ότι το πιο πάνω είναι το βασικό σενάριο, διάφορες άλλες περιπτώσεις εξετάζονται επίσης.

Από οικονομικής πλευράς, το κόστος αντιμετώπισης της ασθένειας συνιστά επένδυση στο μέγεθος και την υγεία του μελλοντικού εργατικού δυναμικού, πράγμα που θα βοηθήσει την κοινωνία στο μέλλον. Επομένως, επιβάρυνση των μελλοντικών γενεών μέσω δανεισμού είναι δίκαιη. Όμως η έκταση του δανεισμού που θα επέλθει παγκοσμίως θα ασκήσει μια ανοδική πίεση στα επιτόκια, καθιστώντας αύξηση του λόγου (χρέος/ΑΕΠ)100 κατά 11.41 περίπου μονάδες ακριβή και το χρέος ίσως μη βιώσιμο. Θα χρειαστεί να επιβαρυνθούν και οι σημερινοί φορολογούμενοι.

Ένας δεύτερος λόγος γιατί αυτό πρέπει να συμβεί είναι ότι οι εργαζόμενοι και οι επιχειρήσεις έχουν επηρεαστεί άνισα μέχρι στιγμής. Οι εργαζόμενοι και οι επιχειρήσεις στον τομέα ζωτικής σημασίας δεν έχουν χάσει εισοδήματα. Βεβαίως αυτοί που με κίνδυνο της ζωής τους έφεραν ένα δύσκολο έργο σε αίσιο πέρας πρέπει να τύχουν ενός τιμητικού επιδόματος. Οι άνεργοι, οι εργαζόμενοι στις επιχειρήσεις μη ζωτικής σημασίας, και οι ίδιες οι επιχειρήσεις έχουν υποστεί μείωση των εισοδημάτων τους, παρ' όλη τη στήριξη από το κράτος. Επομένως, η φορολογική επιβάρυνση πρέπει να αντικατοπτρίζει τα εισοδήματα των φορολογουμένων και των επιχειρήσεων. Ο καταμερισμός του κόστους της ασθένειας θα γίνει έτσι πιο δίκαιος. Η μελέτη περιέχει και σωρεία άλλων συμπερασμάτων.

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Economic aspects of COVID-19, numerical illustrations, and policy implications

Louis N. Christofides[*]

Abstract

The new virus SARS-Cov-2 has caught many governments unprepared. COVID-19 has typically given rise to 'lockdown' and isolation policies which aim to limit the spread of the virus and safeguard the capacity of medical systems to deal with this new illness. Relevant economic questions, including but not limited to the likely impact of these responses on GDP, arise. Because the initial confinement of labour and consequent loss of production in the 'non-essential' sectors constitute a supply shock, a reasonable first step to understand relevant economic implications and have a stab at 'forecasting' the impact on GDP is a production function approach. One such approach is fleshed out and illustrated using details from the Republic of Cyprus. The informational requirements are minimal, the approach flexible enough to help think about the circumstances in other countries, and pliable enough to take on board new information that may emerge about the virus and the treatment of the associated disease.

Key Words**:** COVID-19, lockdown, GDP, policy, fiscal needs, financing, generations.

JEL Classification**:** E23, E27, E60, E65, H51, H6.

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1. Introduction

The world has been hit by a serious pandemic and its damage will be felt for a long period of time. A substantial decline in GDP and a very deep recession appear certain at this point. How large will the flow of lost output be and for how long will this recession last? What will be the impact on public finances and the need by the state to tax and to borrow? Who should bear the cost of this disaster? Current economic agents, through tax increases and possibly wage reductions? Under what circumstances would the latter be advisable? Can burdening future taxpayers with further debt be justified and achieved? Can this disaster be moderated with appropriate policies and what form should these take?

An attempt is made here to address these questions with special reference to Cyprus. To do so clearly, it is necessary to define the characteristics of the medical emergency *and* the medical policies that have been adopted to deal with it. This clarity comes at the price of laying out an epidemiological and a medical policy scenario[1] which can be modelled in a transparent way. It is conceivable that the evolution of the disease may change, calling into question some of the assumptions made. Despite that, the approach taken here should be judged by its capacity to discuss relevant issues clearly and, importantly, its ability to analyse new scenarios which may become relevant as more medical information emerges.

The main vehicle used here is simple. In view of the fact that the pandemic was initially a supply shock because of the 'lockdown' measures adopted to deal with it, it is reasonable to rely on a production function perspective for the first round, approximate, effects that will be studied.[2] The discussion deals with the anticipated economic developments during 2020, but the model's horizon can easily be extended to encompass 2021 and beyond. This is an unusual forecasting method, but the more widely used mechanisms which rely on history face their own modelling challenges in unprecedented times.

[1] For example, in the context of severe shortages of testing and personal protective materials, and the unknown properties of the virus SARS-Cov-2, the disease COVID-19 can currently be contained most effectively through a 'lockdown' which is only possible in the 'non-essential' sectors of the economy; examples of these sectors include construction, education, restaurants, hotels and the tourist industry generally, retail trade, many personal services, and many aspects of public transportation. In the 'essential' sectors (these include food retailers of various kinds, medical services, pharmacies, some personal services, and most governmental and semi-governmental services) and all households generally, care must be taken to exercise the prescribed isolation and social distancing measures. This background conditions the framework adopted here.

[2] The loss of output and income in the non-essential sector will be the main initial shock considered. But further income-induced reductions could affect demands in all sectors. Tourism will almost certainly be affected by declines in international income and attitudes to travel abroad. Guerrieri et al (2020) explore how, in an economy with more than one sector, a supply shock in one sector can impact another sector.

2. The impact of COVID-19 and the measures taken on the economy; setting the stage

An initial reaction in several countries to COVID-19 banked on attaining an early 'herd immunity'. It was abandoned when the speed and severity of contagion threatened to overwhelm medical systems and to lead to a massive number of infections and deaths. The policy targets now in effect in most countries include: extensive RNA-based testing, the strict isolation of infected or suspected cases, the home confinement of individuals who work in non-essential services (resulting in the partial or complete 'lockdown' of their sectors), the adoption of strict precautions for those who work in essential services, and the imposition of isolation and social distancing measures for all households and their members. This multifaceted response is difficult to model and a lean basic scenario is needed at the outset.

It will be assumed that with the lockdown in the non-essential sectors, enough caution when venturing outdoors for work in essential sectors or for other reasons, and with a medical system that can cope with COVID-19 and all other medical problems, the dangerous phase of COVID-19 will last for only four months, or 1/3, of a year.[3] This fraction can be adjusted to reflect new information; perhaps a gradual return to normality would seem more realistic, but the calculations would be more cumbersome, the intuition less transparent, and the assumptions that will have to be made no more plausible ex ante.[4] During the four months of the lockdown, GDP generation will be severely affected: Unlike the services of capital which will be assumed constant,[5] the usual services of labour will not *all* be available in the sectors that are deemed non-essential. This is the fundamental essence of a lockdown. As a result, GDP will be lower in the non-essential sectors and normal or even higher in the essential sectors.

Even less is known about how this disease might end.[6] Until the discovery and mass application of a vaccine, returning economic activity and social discourse will probably rely on whatever herd immunity may have been achieved (reliable antibody tests remain elusive), on social

[3] China achieved zero new cases towards the end of the four months of the disease (December 2019 to March 2020), but a second wave of imported cases then occurred. Cyprus will adopt measures to loosen the lockdown effective May 4, 2020; the observance of the measures and possible increase in the COVID-19 cases are, at this point, unknown and so the time framework adopted in early April will be maintained as an approximation.

[4] Roula Khalaf (Financial Times, May 2, 2020) described the phase after strict isolation as '… an uneasy halfway house between lockdown and any semblance of normality'. For the sake of exposition, it is useful to begin the paper in this simple way, but a stylised version of an extended COVID-19 presence is considered in Model 3 below.

[5] Lockdowns do not prohibit the use of capital, as when teachers and university professors use the information technology infrastructure of their institutions to continue lecturing, or when restaurants use their kitchens for take-away. However, the utilisation of capital can also be modelled as partial – see section 4 for a discussion.

[6] On the assumption that all borders are securely closed, a situation of no new cases for fourteen days and closure of existing cases through cure or death, may define the domestic end of Covid-19. Whether this is attainable in reasonable time remains to be seen. Societies are now beginning to re-establish economic activity in the lockdown sectors and proceed as described in the next sentence.

distancing, and on the isolation and treatment of newly infected individuals by asymptomatic individuals and imports; widespread RNA-based testing will be needed. With luck, COVID-19 will then be like the flu, imposing individual but not mass debility and then for the length of the current 'sick days'. Clearly, a number of complex scenarios can be relevant and one of these is accommodated in the calculations below.

For simplicity of exposition, it will be supposed that, after four months, the disease will be eliminated completely and the economy will be back to 'business as usual' with employment (L) and capital stock services (K) intact and ready again to plug into the simple production function, Y=LK for the annual Gross Value Added Y. In this simple illustrative Model 1, output Y is equal to the product of labour and the capital services rendered during the year. This function provides a kind of 'accounting discipline' rather than a prelude to estimation.[7] Once the main intuition of the effects of COVID-19 is established and illustrated in the expository Model 1, the main estimates will be based on the standard Cobb-Douglas production function described in footnote 8. Much is known about the properties of this function; an accepted estimate of the exponent on employment L will be used and knowledge of the values of all other variables (except Y) and parameters will not be needed; constant returns to scale will be assumed.

This is an abstract setting, but it can be modified in a number of ways with results that are transparent. For instance, if only a fraction χ of L can be engaged in the productive process during a lockdown, the economy will only be able to produce χY. It is important to stress for what follows that, in this production function, the impact of being able to use only a fraction of L is to be able to only produce that *same* fraction of Y. This property will allow us to calculate the effects of the medical crisis on GDP simply and flexibly.

In addition to what we have assumed so far, we need to specify the *extent* to which the economy can function during the four-month lockdown. The essential and non-essential sectors will not be reckoned separately but in their blended whole. The essential sectors are clearly functioning at full tilt. In addition, many individuals in lockdown can still work effectively by replacing existing private capital services (e.g. a home office and a computer) for firm capital services. On the other hand, construction, international public transport and tourism have all but ceased functioning. The most important feature of a lockdown is the stoppage of personal contact and gatherings at the workplace, not the prohibition of using capital services. It may

[7] Econometric use of a traditional Cobb-Douglas specifications is widespread. Estimation and prediction was not the objective here and, as will be seen, will not be needed. An estimated stochastic production function with a multiplicative constant, unequal exponents for L and K, and uncertain returns to scale, could in some circumstances be useful and its use would be fully consistent with the approach adopted here.

then be possible to characterise the lockdown period as one where only a fraction of labour services can be used but capital services are still available in one form or another. The use of capital will be considered again below. What fraction of the flow of output is lost during the lockdown period? The size of this fraction will depend on the country, the usual distribution of output by sector, and the country's input-output matrix structure which describes the interconnection of sectors.

3. The expository Model 1

In the context of Cyprus, and based on the brief discussion above, it will for simplicity be assumed that *during lockdown* the economy can use only 3/5 of its labour services, all of its capital services K, and produce only 3/5 of the normal *monthly* flow of output (Y/12) for four months; the fraction 3/5 is analogous to the fraction χ above, where 1-χ=2/5. The economy will lose 2/5 of the normal monthly value of Y for the four months during which labour cannot be fully engaged in the productive process. The fraction 3/5 is an informed guess which can easily be changed.[8] If, as in Cyprus during 2019, the approximate 2020 annual output *without* COVID-19 would have been Y= €22 bn, annual output in a year that includes the four months (assumed to be March to June) of COVID-19 will be given by the expression[9] P|Covid=(2/3)Y+(1/3)[(3/5)Y]=14.67+4.4=€19.07 bn. During the active COVID-19 four-month period of the lockdown, the loss of output will be €2.93 bn or 13.32% of the €22 bn. The lockdown cost in Model 1 is substantial, larger than the total loss of GDP for Cyprus over the entire period 2011-2015 (approximately €2 bn). Moreover, a 13.32% drop in GDP can be expected to reduce tax revenues and increase the government's fiscal needs. As this is an expository first step, we do not discuss these – but see Table 1 below.

In the model, the output sacrificed during lockdown has, in effect, been invested in preserving the pre-COVID-19 effective level of the labour force L, making future GDP recovery to its pre-COVID-19 level possible (measures to encourage labour hoarding adopted in Cyprus and

[8] For the US, P. Krugman (2020) quotes a study by Miguel-Faria-e-Castro of the St. Louis Federal Reserve which provides estimates of that might be considered equivalent to the size of the non-essential sector here; the upper range of these estimates is close to the 0.4 fraction assumed in this paper. Dingel and Neiman (2020) provide estimates of the fraction of jobs that can be done at home. For Cyprus, the estimate in their diagram is about 0.38. These estimates are only indicative of the capacity of the economy to produce (say 3/5 of output) under the COVID-19 lockdown: The matrix of venues (home working, home inactive, and at the job) and lockdown status (essential and non-essential) is a 3x2 one; only 2 cells (home inactive/essential, and at the job/non-essential) can be presumed to have entries close to zero. And a variety of other values can be consistent with the 0.4 lockdown.

[9] The predicted annual output P, given Covid and the lockdown, is indicated by P|Covid. For eight months (or 2/3 of the year 2020) the normal annual rate of output Y will be produced but for four months (1/3 of the year) only 3/5 of Y will be possible and will be given by (1/3)[(3/5)LK]=(1/3)[(3/5)Y]=€4.4 bn, instead of (1/3)Y=€7.33 bn. The fraction 3/5 will reflect the sum total of output in the essential sector and the functioning part of the non-essential sector, while the loss of 2/5 will be borne primarily by the non-essential sector.

elsewhere (see section 7) complement the impact of the investment in the preservation of L). In the process, conventionally-measured GDP will be smaller because of the reduced activity in the non-essential sector. Without this investment during *an unavoidably adverse state of the world*, epidemiologists suggest that the health system could collapse, the well-being and productivity of many more individuals could be compromised, and many more lives would be lost. The effective labour force in the more distant and uncertain post-COVID-19 period would be smaller, producing less output for a while, both because of reduced labour productivity and the smaller surviving number of workers. The scientific basis of this position is not the subject of this paper. Eichenbaum et al (2020) explore the economic implications of the SIR epidemiological model and an updated infection environment.

4. Sensitivity to the production function assumed and main calculations

The production function used in Model 1, namely Y=LK, provides (i) an easy way to connect the inputs L and K to the output Y, (ii) a transparent intuition about the processes involved, and (iii) enables simple calculations such as those presented above. However, it entails some strong assumptions which, in the present context may lead to an overestimate of the effect of the lockdown on GDP. This possibility is explored in this section and its conclusions are adopted and carried forward to the rest of this paper.

A more usual form of the production function in much of economic analysis is known as the Cobb-Douglas production function $Y=AK^bL^a=BL^a$. In this context, the elements of B will be assumed constant; as already noted in footnote 6, however, the utilised value of K can be made less than full. The form used in Model 1 implicitly assumed that A=a=b=1. The assumption that a=1 leads to an overstatement of the effects of COVID-19 as modelled here. In the more general, standard, form just noted, the parameters a and b can have the interpretation of the share of labour and capital in GDP, respectively, and are thought to be in the region of 0.65 and 0.35 respectively.[10] These values will be taken on board in what follows.

In Model 2, we can conduct the analysis carried out above in much the same manner but using the production function $Y= BL^a$ instead. The value of B need not be separately known, as shown below, and it will be assumed that a=0.65. The expression P_{CB}|Covid denotes that we are predicting the 2020 level of output using the Cobb-Douglas specification of this section and that

[10]The estimations (using data for 1964-2017) behind the results in Karagiannakis and Mamuneas (2018) and Empora and Mamuneas (2020) suggest that the parameter a for Cyprus is equal to 0.64. The 'stylised fact' about the share of labour is 0.65 and this very similar number is used here in the calculations for 2020.

Covid-19 is present during the lockdown period March-June 2020. Then, using the analogy $\chi=3/5$ and noting that $(3/5)^{0.65}=0.72$,

$P_{CB}|Covid=(2/3)Y+(1/3)\{B[(3/5)L]^{0.65}\}=$

$=(2/3)Y+(1/3)\{B(3/5)^{0.65}L^{0.65}\}=(2/3)Y+(1/3)\{(3/5)^{0.65}\,BL^{0.65}\}=$

$=(2/3)Y+(1/3)\{0.72Y\}=14.67+5.28 = €19.95$ bn.

The output during four *no*-COVID-19 months would have been $(1/3)\{BL^{0.65}\}=€7.33$ bn but, in Model 2, it is now $(1/3)\{B[(3/5)L]^{0.65}\}=€5.28$ bn, the difference being €2.05 bn or 9.32% of GDP. By contrast, the impact of COVID-19 in Model 1, where Y=LK, was €2.93 bn; the difference between the two specifications is substantial (€0.88 bn), so, indeed, the simple production function led to an overstatement, given its larger exponent on L.[11] The new impact of COVID-19 is now comparable to the decline in GDP over the period 2011-2015. In view of the fact that this production function specification is less restrictive and has been used extensively in estimation, the calculations and effects of COVID-19 in this section are preferred.

The impact of COVID-19 on GDP during the lockdown is shaped like an inverted Greek Π or a U with sharp corners – see Figure 1. The solid line represents the predicted evolution of GDP under the assumed conditions of Model 2. The lower horizontal portion is the level of GDP possible during the four months of lockdown and is €1.32 bn monthly, while the top of the inverted Π extends left for two months and right for the last six months of 2020 at €1.83 bn per month.[12] A rough idea of the GDP sacrifice in dealing with COVID-19 has been obtained in a manner that highlights the source of the loss of output. It is the fact that 2/5 of the labour force is excluded from the productive process for four months. In Figure 1, this loss is given by the area of the well, generated by the drop in monthly output during the lockdown period. Note that the predicted inverted Greek Π, rather than a V-shaped recession, is purely the result of the length of the assumed COVID-19 period. This highlights the point that the course of COVID-19 and the policies taken to contain it determine how GDP will evolve. At the same time, any policy (see section 7 and point (a) in section 9) that shortens the life of the disease and, therefore, the

[11] Note that, if only 3/5 of K as well as L were available during lockdown, the prediction for $P_{CB}|Covid$ would have been the same as in Model 1: Output during lockdown would be given by the expression $(1/3)\{A[(3/5)K]^{0.35}[(3/5)L]^{0.65}\}=(1/3)(3/5)^{0.35+0.65}A\,K^{0.35}L^{0.65}=(1/5)Y=€4.4$bn. Added to $(2/3)Y=€14.67$ bn, the prediction for this case would be €19.07. The reason is that, under constant returns to scale, the exponents add up to unity, producing (1/3)(3/5)Y, as in Model 1. $P_{CB}|Covid$ is larger when both factors of production are reduced during lockdown. As already discussed, this assumption that the use of capital is also reduced by (2/5)ths during lockdown seems both institutionally wrong and stronger than appropriate.

[12] The model is set up in 'seasonally adjusted' terms, interpreted as a constant monthly value of GDP in each sub-period. Since annual Y=€22 bn, division by 12 months gives the monthly rate of flow of €1.83 bn. Similarly, division of the reduced output produced during the lockdown (€5.28 bn) by 4 gives the monthly height at the bottom of the well which is equal to €1.32 bn. Allowing for rounding, the Loss Area is 4(1.83-1.32)= €2.05 bn.

length of the lockdown, will reduce the size of GDP losses. However, a premature end to the lockdown, as is currently being attempted by some governments, may strengthen the number of COVID-19 cases and increase economic costs either through sick days lost (section 5) or a return to the lockdown.

A 9.32% decline in GDP would generate an equal percentage decline in government tax revenue from the €9 bn achieved when GDP=€22 bn, adding €0.84 bn or 3.82% of GDP to the government's fiscal needs. These amounts for Model 2 are shown in the last two columns of Table 1. The entries for Model 1 are derived in a similar way, both based on the elasticity of tax revenue with respect to GDP (unity) used by the government.[13]

5. COVID-19 lingering into the second half of 2020 (2020H2)

It is likely that, despite the four-month period of lockdown and severe isolation, this disease will not be wiped out and will continue to exact a GDP loss by incapacitating some of the labour force with unusually high 'sick days' during the last six months of the year. Returning economic agents will have to reckon on only a fraction ψ of L being available for production. In this Model 3, and with less information on the impact of this continuing sickness on capital utilisation, firms may plan on engaging a similarly reduced level of capital ψK. As shown in footnote 12, this will imply a lower GDP than in Model 2, i.e. P_{CB}|Covid+Linguering Sickness $=(2/12)Y+(4/12)\{B[(3/5)L]^{0.65}\}+(6/12)\psi Y$=€19.4 bn. The term (2/3)Y in section 3 was split into the GDP for the two months before March 2020, and the GDP for the six months after lockdown *times* the fraction ψ=0.95 of Y. Rather than GDP equaling €19.95 bn as in Model 2, the additional loss of GDP due to extending the impact of the disease in Model 3 is €0.55 bn. In Figure 1, the GDP profile under this scenario is the dotted, horizontal, line for July-December at €1.74 bn pm.

Of course, other scenarios could easily be investigated; for example, an enforced return to a lockdown as in the last-but-one paragraph of section 4, would imply extending the lockdown period in Model 2 from four months to something longer, breaking up the Model 2 period of six months during 2020H2. Then, the reduction of L and constancy of K might be more appropriate than the lingering sickness model in this section, which reduces both L and K by the same fraction. As Cyprus loosens the lockdown, there is too much uncertainty ahead, to spell out more specific examples of how this illness might linger and what government measures (e.g. a

[13] I am indebted to Dr. A. Charalambous for advice on the value of the elasticity of tax revenue with respect to GDP.

return to lockdown) might be adopted. Despite that, the model is flexible enough to take new information on board.

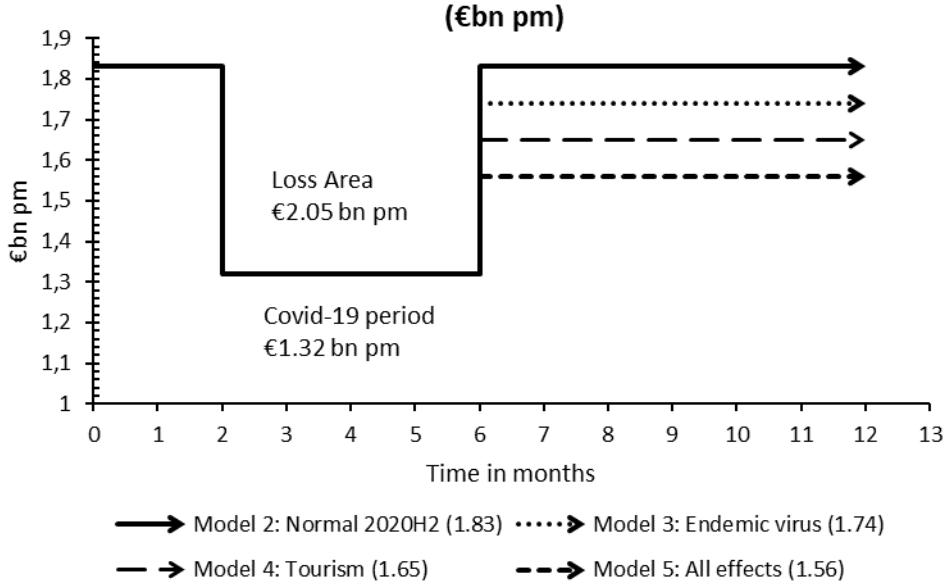
6. A possible impact on tourism during 2020H2

There is a good chance that, in Cyprus and other vacation destinations, tourism will be extremely slow during 2020H2. This, because of declines in incomes in other countries affected by the pandemic and because the disease may make people loathe to travel at all. With this expectation in mind, engaging only a fraction φ of labour and capital services would make sense and, as seen above, it will result in only a fraction φ of the 2020H2 level of expected output being produced; φ=0.90 is a reasonable value for Cyprus. Note that adverse tourism effects during the lockdown are already imbedded in the assumptions made for the economy during those four months.

Following the same procedure as in the case of the lingering COVID-19, the expression for output in Model 4 is given by P_{CB}|Covid+Tourism Reduction=(2/12)Y+(4/12){B[(3/5)L]$^{0.65}$}+(6/12)φY=€18.85 bn, rather than €19.95 bn, as in Model 2. A further GDP loss of €1.1 bn, will be incurred if tourism, which has the assumed weight of approximately (1-φ)=0.10, has this reduced contribution to GDP after COVID-19 and for the rest of 2020. In Figure 1, the dashed line for the period July to December (located at €1.65 bn per month) shows the evolution of GDP if tourism is so affected during this period.

If, in addition to the lockdown impact, both of the above effects occur, the appropriate profile during 2020H2 in Figure 1, based on (6/12)ωY, where *ω=1-(1-ψ)-(1-φ)*=0.85, would be the short-dashed horizontal line of Model 5, located at €1.56 bn pm. The sum of the Loss Area during Covid-19, the lingering COVID-19, and tourism effects is 2.05+0.55+1.1+=€3.7 bn or 16.82% of GDP. That would generate a 16.82% fall in government tax revenue from the €9 bn achieved when GDP=€22 bn, adding €1.51 bn to the government's fiscal needs. As the debt to GDP ratio for Cyprus is in the region of 100%, additional borrowing of this magnitude would increase the debt to GDP ratio by about 6.86 percentage points (pps)– given by 100(1.51/22). Table 1 summarises the predictions of the five models and their fiscal implications. To the combined cost of €1.51 bn must be added the unusual costs of the medical responses and the programmes undertaken and planned (see below) to help those in need and prepare for the return to normalcy.

Figure 1. Effects of COVID-19 on GDP during months of 2020 (€bn pm)



7. Measures taken, proposed, and further costs

How does the estimated, substantial, investment in staying healthy, the expected length of COVID-19, and the likely decline in tourism activity influence the type of economic measures that should be taken going forward? The obvious first comment is that the nature of the medical crisis is such that its costs can be moderated with smart and disciplined isolation policies, adequate supplies, medications, and equipment that can deal with COVID-19 more effectively, along with a general upgrading of the facilities and procedures of the National Health System. Maximum efforts to contain the virus should, therefore, be exerted and they will pay off economically. A V-shaped, rather than an inverted Greek Π, recession and recovery is more likely if the disease can be shortened.

To the extent that the lockdown generates an increased likelihood of layoffs and bankruptcies, unusual measures are called for, beyond the normal running of the social safety network (SSN) through unemployment insurance, the Guaranteed Minimum Income Programme, support for the disabled, and other initiatives. A number of related schemes are in operation under two broad classes. First, given the four-month nature of the emergency in Model 2 after which it will be 'business as usual', it would be very unwise for firms and wasteful for the economy generally to fire and then re-hire labour. This is also true in the remaining models considered. Policies which subsidise firms to maintain their labour force, while at the same time preserving labour income and basic consumption, are very appropriate. Some moral hazard and adverse selection

behaviour by firms (exerting inadequate effort to succeed and opting strategically into government programmes) may occur in light of the benefits offered; however, these behaviours, if present, may be difficult to detect under current circumstances.

Second, loan guarantees and loan re-payment freezes for viable firms which experienced difficulties only after the virus emerged and which maintain their work-force have also been considered. These help preserve the entrepreneurial infrastructure in preparation for the end of the emergency. If there is any concern here, it is that the government loan guarantees hark back to the older and failed practices and may bypass the rigorous screening of borrower business plans by the banks which will do the actual lending. The lender should have to make a substantial own-capital commitment and be induced to assess the business plan of the borrower carefully. Currently, only a 30% commitment on the part of the banks is planned. Moral hazard and adverse selection, if they occur, may, again, be difficult to detect.

These two broad classes of policies, favoured by many countries including Cyprus, which aim to maintain the productive web of the economy, will have costs over and above the normal running costs of the SSN that are difficult to estimate at this point. Even if the loan guarantee programme is not put into effect or it is not called upon to pay for any defaults, the cost of the first, labour market, policies may be in the region of €500 mn per month, planned for two months, and requiring €1 bn. This amount must be added to the Model 5 fiscal needs of the government of €1.51 bn, raising the total to €2.51 bn or 11.41% of a GDP of €22 bn. The increase in the debt to GDP ratio would be 11.41 pps, up from the 6.86 pps reported for Model 5 in Table 1; this would be difficult to sustain if interest rates rise. There will not be a fiscal cushion once the loss of government revenues and the cost of the measures taken is revealed.

Much has been heard from various lobbies in Cyprus about the need to stimulate aggregate demand by supporting consumption. To the extent that this means the subsistence support offered through the regular SSN channels and the schemes discussed above, these are sensible strategies. However, mitigation of the anticipated GDP reductions due to COVID-19 through pure consumption-oriented policies should not be encouraged. The argument is twofold: First, as a means of stimulating aggregate demand, it is dominated by alternative strategies which achieve an increase in demand but in a sustainable fashion. Substantial investments in infrastructure, health and the medical system, digitalisation, and in the research and innovation sectors are needed. The second argument against pure consumption policies is that the government and private sectors are over burdened with debt. Restraining consumption in order to save and invest is a recipe for sustained growth, not a contributor to recession.

TABLE 1

Impact of COVID-19 scenarios on GDP and public finances

N	Model of the scenario numbered N	Predicted GDP	GDP Impact		Fiscal Impact	
		€ bn	€ bn	% GDP	€ bn	% GDP
1	P=(2/3)Y+(1/3)[(3/5)L]K	19.07	-2.93	-13.32	-1.20	-5.45
2	P_{CD}=(2/3)Y+(1/3){B[(3/5)L]$^{0.65}$}	19.95	-2.05	-9.32	-0.84	-3.82
3	P_{CD}=(2/12)Y+(1/3){B[(3/5)L]$^{0.65}$}+(6/12)ψY	19.40	-2.60	-11.82	-1.06	-4.82
4	P_{CD}=(2/12)Y+(1/3){B[(3/5)L]$^{0.65}$}+(6/12)φY	18.85	-3.15	-14.32	-1.29	-5.86
5	P_{CD}=(2/12)Y+(1/3){B[(3/5)L]$^{0.65}$}+(6/12)ωY	18.30	-3.7	-16.82	-1.51	-6.86

Notes: All calculations involving GDP are based on its 2019 level of €22 bn and the 2019 government revenues of €9 bn. The elasticity of government revenues with respect to GDP is unity. All models assume that January and February will be months with a normal level of monthly output equal to €22/12=€1.83 bn pm. This is also the monthly rate of output during 2020H2 for models 1 and 2. The assumed lockdown period of March-June involves a partial (3/5) utilisation of L and a constant K. The constant parameter a=0.65 and b=0.35. The shock parameters ψ=0.95, φ=0.90 and ω=1-(1-ψ)-(1-φ)=0.85. Under the column 'Model of the scenario numbered N', the predicted level of output P is as specified in the text for the respective model (Model 1 for Y=LK and Models 2-5 for the standard Cobb-Douglas production function under constant returns to scale and the assumed parameter values). The obvious condition |Covid-19 is omitted for brevity. Note the rounding to two decimals.

8. How should these costs be borne?

A frequent 'way out' of these budgeting conundrums is to borrow. Cyprus has been prone to adopt this solution. A prior question arises. Is it appropriate to shift part, or all, of these costs onto future taxpayers? In the models used, but also in fact, the lockdown and supporting policies discussed above have preserved the post-COVID-19 level of the labour force healthy and entrepreneurship intact, making it possible to pick up the pieces from the point when COVID-19 began. However, this investment in human capital health and in entrepreneurship have been achieved through the substantial income losses incurred by some of those earning their living in the non-essential sector and by the superhuman and widely applauded efforts of many groups in the essential sector. So it is not unreasonable to feel that future taxpayers should also be burdened with much of this cost. However, as the SARS-Cov-2 virus has reached the whole planet, massive borrowing in all its corners will raise interest rates, making it more difficult to sustain new debts and shift costs into the future.

The split between temporary charges and borrowing to finance (i) the fiscal needs arising from the reduced tax revenue (€1.51 bn) and (ii) the extra-ordinary cost of government expenditures

and special programmes to deal with the effects of COVID-19 on employment and entrepreneurship (at least €1 bn) has not been discussed so far. The income loss of the individuals in the non-essential service sector is very substantial (though unevenly distributed), so the burden on future taxpayers could also be sizeable. The split should also depend on the prevailing interest rates. These are currently low, favouring a larger share from borrowing, but the expected international increase in borrowing and possibly interest rates may shift the share towards the COVID-19 charges and taxes.

However, a temporary, income-related, contribution from the current members of society will also be needed and is justified. All current members of society are benefitting from the health policies adopted. Because of the externalities involved[14], this investment had to be undertaken by the government and was not a matter for private choice, as argued by protesters in some countries. Such a COVID-19 charge should be levied on all earnings in a progressive way which may, or may not be part of the regular tax schedule. Some individuals in non-essential areas would have reduced or no employment income and would pay less or zero taxes/charges. Others in the non-essential areas and those in essential services will earn at least their usual income[15] and will have to pay more taxes/charges.

Wage reductions have also been advocated by some, but these would make better sense if COVID-19 had permanent effects, as for example if tourism suffers a secular blow and the SARS-Cov-2 virus becomes endemic. This is too early to judge, suggesting that temporary contributions should be planned for the time being.

The COVID-19 charge would not be a means of righting past wrongs, such as unreasonable pay differentials between the public and private sector. Where such differentials exist, they should be dealt with separately by a committee of international experts for a number of reasons, including the fact that the correction that may be required will not necessarily fall more heavily on the highly paid. For the public-private sector wage gap, this point holds for a number of European countries, including Cyprus. Michael and Christofides (2020) show that this pay gap is high for the low-paid, but low to non-existent for the highly paid employees of the two sectors.

[14] Garibaldi et al. (2020) introduce optimising decisions into the SIR model and explore the individual infection and health facility congestion externalities involved; these justify government-imposed social distancing, beyond what individuals would choose on their own.

[15] Individuals in essential services may have increased their incomes due to overtime and other payments. These, if present, will be reflected in their tax and special COVID-19 payments. Those in health services will, unfortunately, be also asked to pay more. They have been justly admired and applauded for their service; thought should be given to an ex post honorarium, as a gesture of appreciation, not unlike gestures towards war veterans.

It has been argued by some that a charge on current earnings will reduce consumption, aggravating the measured decline in GDP. Although consumption is the largest component of aggregate demand it is not the only one. Another component is investment; aggregate demand can increase if infrastructural projects are pursued, even when they are financed through saving. Such projects would moderate the recession and would increase future production in a manner that can continue into the indefinite future. Also, a progressive charge on those currently earning will affect low-income individuals but can only reduce their consumption by small amounts; high income individuals are likely to maintain their consumption through dissaving. Finally, any improvement in competitiveness, resulting from infrastructural investments and possible future wage restraint made necessary by long-lasting effects of COVID-19, should have a beneficial effect on the trade balance and aggregate demand. Thus, stimulating consumption as a means of increasing aggregate demand is dominated by policies that enhance the future capacity to produce sustainably, do not aggravate the trade balance, and do not increase indebtedness. The government and private households in Cyprus are sufficiently indebted already.

9. Implications for policy options

A catalogue of government policies to deal with COVID-19 suggests itself:

a) Deal with the medical emergency *as aggressively as possible*, securing all necessary supplies, anti-virus medications, ventilators, and imposing isolation. The economic costs will diminish or disappear if COVID-19 is contained, so this is where greatest energy must be expended. Safeguard the achievements of the lockdown, especially by monitoring new arrivals in Cyprus and, when possible, by further testing to locate asymptomatic carriers of the virus. Monitor the impending gradual relaxation of the lockdown in various sectors and geographical areas and be ready to re-activate it, perhaps selectively, if deemed necessary.

b) The argument that stimulating consumption per se will speed up recovery, even if true, does not dominate better policies. Saving and investing in health, digitalisation and other infrastructure projects are more sound methods to stimulate aggregate demand; they also enhance productive capacity and increase productivity and output sustainably.

c) Borrow to finance a substantial portion of the COVID-19 tax revenue lost and the outlays on new policies. While current and future economic agents will all benefit from investments in human health and the maintenance of the economy's human capital and productive capacity, current economic agents have already paid a heavy price to make

isolation successful and it is not unreasonable to shift some of the costs incurred into the future. However, current tax-payers will also have to be charged a temporary income-related share of these costs. The income cost of the lockdown was distributed very unevenly and this temporary charge will be one way to raise taxes and improve equity.

d) Encourage previously viable firms to avoid layoffs by subsidising the cost of labour hoarding. This policy maintains the ability of firms to resume operations once the medical emergency subsides, while also maintaining aggregate demand.
e) Strengthen and speed up the financial support of people who nevertheless become unemployed or who, in any case, need help, using the social safety network aggressively. Their consumption of basic goods and services will also help to maintain aggregate demand.
f) To avoid bankruptcies, increase the availability of bank liquidity to viable firms that only encounter difficulties due to COVID-19, if they maintain their workforce.
g) Policies under d, e, and f entail costs which add to the government's loss of revenue from the decline in GDP. Thus, substantial fiscal challenges lie ahead.
h) If, against hope, long-lasting adverse effects are experienced in particular sectors or the economy as a whole, wage reductions may become appropriate.
i) In cases where permanent declines in demand and firm bankruptcies are inevitable, the rationale for subsidising employment and supporting firm liquidity does not exist. Labour may have to retrain and programmes for retraining hospitality workers as carers may be very sensible.

10. Summary of findings

The assumptions made in this paper have produced a COVID-19 context which can be analysed with relative clarity and which permits evaluation of the loss of GDP due to the disease. Use of the standard Cobb-Douglas production function suggests that the GDP loss during 2020 could be as low as €2.05 bn. However, this is judged to overlook important extensions in the calculations. While the above number includes the loss of tourism-generated GDP during the lockdown period (March – June, 2020), it assumes that tourism will be fully recovered by July 2020. This is most unlikely. Extending the analysis to suppose that 10% of GDP during 2020H2 will be lost because of a reduction in tourism flows, suggests that a further cost of €1.1 bn should be expected. A further refinement, which allows for some COVID-19 costs into 2020H2, would add an additional €0.55 bn. It would appear that the sum of all three

effects would be an appropriate estimate for the 2020 losses in GDP, that is €3.7 bn, or 16.82% of the 2019 GDP of €22 bn.

A fall in GDP of 16.82% would generate a fall in tax revenues by roughly the same percentage, adding €1.51 bn to the government's fiscal requirements. To this must be added the cost of programmes recently introduced to aid affected workers and firms and those are minimally costed at €1 bn. Abstracting from any EU help that may be received, the sum of these needs is very substantial.

During the lockdown, it was assumed that capital of various forms and ownership would be available to combine in production with 3/5ths of the labour force, thereby justifying keeping capital services constant. If this second factor of production were also limited during the lockdown, the GDP cost would be the same as in Model 1 and higher by €0.88 bn. That modelling modification would bring the treatment of capital into conformity with what was used in the endemic COVID-19 and decline in tourism cases. However, rough calculations suggest that a reduction in K would not be as descriptively accurate as assuming constant K, even as the latter may understate the GDP losses from COVID-19 GDP. On the other hand, it appears that an extensive lockdown may not last as long as four months, reducing the GDP loss that has been claimed in Table 1. Taking these two forces together, the estimates based on a constant K during the lockdown may prove nearer the mark. It should be stressed, however, that these predictions are surrounded by a great deal of uncertainty.

A number of other points have emerged on the way: (i) The epidemiological strategy of a lockdown and isolation has been given a clear interpretation as an investment in the health, productivity, and level of future human capital. (ii) The cost of this investment has been borne by some, but not all, of the economic agents in the non-essential sector; as well, agents in the essential sector have not seen their income reduced substantially if at all. (iii) This justifies improving the government's difficult fiscal position by imposing some temporary income-related charge on current taxpayers. (iv) But, in view of the substantial income sacrifices in the non-essential sector, the life-risks and hours of work endured by individuals in the essential sector, and the benefit derived by future members of society from the preservation of its human capital, a large portion of the fiscal needs should be raised through borrowing, particularly while low interest rates last. (v) The argument that consumption should be stimulated for fear of a deeper recession is dominated by saving and investments in health and infrastructural projects which increase productive capacity sustainably. (vi) Finally, in a presumed short-lived emergency, it makes sense to avoid bankruptcies and maintain employment so that firms can be ready to

resume operations in the near future. Clearly, this strategy is not warranted when firm closures are inevitable due to secular and irreversible drops in demand.

The informational requirements of this approach are so limited that it can easily be adapted to the circumstances of other countries. The elements and parameters can be modified to reflect new information, or to analyse unexplored possibilities. Much will be learned in the weeks ahead and this information can be easily incorporated to enrich the implications and enhance the reliability of the conclusions flowing from this sort of analysis.

References

Dingel, J. I. and B. Neiman (2020). 'How many jobs can be done at home?' NBER Working Paper o W26948.

Eichenbaum, M.S., S, Rebello, and M. Trabandt (2020). 'The Macroeconomics of Epidemics', Unpublished manuscript, March 29.

Empora, N. and T. Mamuneas (2020). 'Sectoral Productivity Developments in Cyprus', Productivity Analysis Bulletin, Economics Research Centre, University of Cyprus, Issue 20/1, March.

Garibaldi, P., E. R. Moen, and C. A. Pissarides (2020). 'Modelling contacts and transitions in the SIR epidemics model', COVID Economics Vetted and Real-Time Papers, CEPR Press, Issue 5, 16 April, pp. 1-20.

Gurrieri, V., G. Lorenzoni, L. Straub, and I. Werning (2020). 'Macroeconomic Implications of Covid-19: Can Negative Supply Shocks Cause Demand Shortages?', Unpublished manuscript, April 2.

Karagiannakis, Ch. And T. Mamuneas (2018). 'Productivity Developments in Cyprus', Productivity Analysis Bulletin, Economics Research Centre, University of Cyprus, Issue 18/1, December.

Krugman, P. (2020). 'Notes on the Coronacoma', New York Times, April 1, 2020.

https://www.nytimes.com/2020/04/01/opinion/notes-on-the-coronacoma-wonkish.html

Michael, M. and L. N. Christofides (2020). 'The impact of austerity measures on the public-private sector wage gap in Europe', *Labour Economics*, Vol. 63, April, in press.

https://doi.org/10.1016/j.labeco.2020.101796