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The economic impact of Covid-19 pandemic in Sardinia

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ABSTRACT

The spread of the Covid-19 pandemic forced Central and Local Governments to introduce a set of policy measures aimed at restraining the contagion among people. These interventions resulted in actions that put a brake on the production system and at the same time on the growth of aggregate demand. The economic impact is far-reaching, with direct, indirect and induced effects mainly related to the interconnection between production sectors and institutional sectors. In particular, the economic impact of Covid-19 crisis exacerbated in the territories where the economy mostly depends on tourism activities, which continues to suffer a decrease despite the interruption of containment measures. The crucial point in the current economic debate is the estimation of the impact these measures will have on economic systems, with the aim of assessing the regulatory mechanisms necessary for the restart of the economic system. In this work we propose an estimate analysis of the effect of the Prime Minister Decree (DPCM) of 22 March 2020 on the economic system of the Sardinia Region. The analysis is developed through the application of a SAM based CGE and the results are provided in terms of change in production, final demand and disposable income.

1. Introduction

The pandemic caused by Covid-19 has led to the adoption of regulatory interventions aimed at limiting infections and protecting public and individual health. The legislative interventions have concerned restrictions on personal freedom and the interruption of non-essential production. While lockdown was imposed on the entire national territory, different responses emerged at local level demonstrating the need of a specific territorial analysis concerning economic consequences. As a matter of fact, the decrease of production and the resulting weakening in the final demand could be more located into those regional systems specialized in non-essential productions. The stop of production for those goods and services whose demand cannot be postponed implies a cut of total output that will affect the economic system according to which magnitude is contingent on the underlying structure of income creation and distribution. Moreover, the inability of people facing the lockdown to move outside and inside regions, leads to a further reduction in final demand.

The analysis of the economic structure of Sardinia region in the pre-pandemic period (from 2017 to 2018) reveals the increase of GDP around 2.35%, while in the first part of 2019 there is an economic stagnation, with a deceleration compared to the previous year. The increase in GDP is supported primarily by the increase in final consumption, to which is added a growing prudence in gross investment. The industry of construction, together with the real estate services, is one of the key activities in the Sardinia regional economy, and it has continued to show positive contribution to the growth of production, supported by both household demand for housing and increased investment in public works and private non-residential construction. For the services activity, on the other hand, in recent years, there has been a slowdown, with tourist activity showing a contraction linked to the national component of final demand. Furthermore, the mining and oil activities, also key activities of regional production, should not be overlooked; the latter in particular represents the 80% of regional sales abroad and drove the decline in total exports in the first half of 2019; on the import side, there is a decrease resulting from lower purchases of fossil fuels and oil products, which represent the 90% of purchases from abroad. Given that the Sardinian economy is characterised by a productive structure driven by few key activities it is evident that a lockdown which impacts those very activities can be highly disruptive for
the regional economy.

The recent economic literature is focusing more and more on the estimation of pandemic effects on the economy via the application of different classes of models. From the applied statistical perspective, there has been an extensive use of SIR models (Atkinson, 2020; Stock, 2020), which are models through which the potential economic costs are estimated on the basis of different assumptions regarding the evolution of the virus. The SIR model has been extended to macroeconomic aspects (Eichenbaum et al., 2020) by including the decline in consumption and in working hours in order to reduce the probability of being infected; this model therefore highlights the trade-off between containment policies and the economic crisis. Further elaborations relating to the economic analysis were carried out through the use of cost-benefit models (Scherbina, 2020; Drake et al., 2012; Hadeti et al., 2014) in which pandemic containment policies are assessed through the analysis of the costs and benefits attributable to them. A further contribution has been proposed through the use of DSGE models (McKibbin & Fernando, 2020), which reproduce the general economic equilibrium with stochastic methodology, and therefore top-down, where the parameters of the model are usually estimated or chosen in such a way that the dynamics of the model similarly report macroeconomic benchmark data.

However, the aforementioned models are aggregated and do not consider intersectoral interdependencies, and fail to link such linkages with the income generation and income distribution processes that exists amongst productive and institutional sectors. From this particular point of view, in order to assess the consequences of the lockdown by type of product on the Sardinian economy, it is important to proceed with a methodology that allows for the capture and description of the entire circular flow of income (Severini et al., 2020; Socci et al., 2015) disaggregated for the different industries, in the sphere of production, distribution and use of income. In general terms, a Computable General Equilibrium (CGE) model calibrated on a Social Accounting Matrix (SAM) is certainly functional to evaluate the economic impact of the COVID-19 (Smith et al., 2011), having the advantage of proceeding with a selective grafting of the block on the supply side, to which is associated a contraction of the final demand, also in spatial terms, inside and outside the Sardinia region.

The model proposed in this paper provides a comprehensive macroeconomic framework for assessing the economic and social impact of policies with direct and indirect effects (Claschini et al., 2010); in particular, multisectoral analysis offers the possibility to identify the contribution of each activity to income generation and how it is distributed among the primary factors. Moreover, it allows to detect how income is allocated to institutional sectors and therefore to final demand (Soverini et al., 2019). The effects will therefore be distributed inside and outside the regional territory, highlighting the formation of the circular flow of income.

CGE models are widely used to analyse the effects of economic policy in the areas of trade, taxation, public spending, labour market, but also natural and man-made disasters, the environment and financial crises, etc. (Dixon and Jorgenson, 2013). In addition, they have been widely used both to assess the economic impact of policies focused on transport activities (Hamed and Bachmann, 2019) and to evaluate the economic impacts of the investments regarding infrastructure projects compared to their financing options (Euijune et al., 2017).

This paper focuses on the Sardinia regional economy with the aim to assess the resulting effects on regional GDP when a lockdown on regional production processes is implemented. We also highlight the strong impact of internal demand, mainly linked to local products, which is associated with a significant slowdown in final external demand both from the rest of Italy and the rest of the World.

2. The regional SAM for Sardinia

The SAM represents the most innovating tool among the accounting schemes used to recreate and simulate the entire economic system (Socci, 2004). Indeed, it enables one to integrate the production account with the income accounts in a way that the entire economic system is described at the macrolevel but even with a deep disaggregation of the typology of activities, commodities and institutional sectors (Miyazawa, 1976). The SAM consists of many blocks (Miller and Blair, 1985), they represent the phases of the circular flow of income. The first block reveals the generation of income by means of the intermediate transactions between activities, including the use of production factors and it represents the intermediate consumption flows and the value added by each industry that are considered in the production system. The SAM contains the block of the primary distribution of income because it describes quantitatively the value added attributed to its components, mainly labour and capital factors. A very important aspect of the SAM is the possibility to link flows of production between activities to the income accounts between institutional sectors through the phases of the attribution of income to primary factors and then whist the secondary distribution of income (taxes and transfers between Institutional Sectors). Essentially, the SAM is the most suitable accounting scheme to represent the complex framework of interindustry and inter institutional flows characterising a macroeconomic system.

The importance of the SAM is crucial as it acts as the database upon which the respective model is calibrated, as well as serves as a key input for the estimation of parameters, such as elasticities and the coefficients of propensity, furthermore it crucially also represents a benchmark equilibrium of the economy through which the simulation exercise can be later compared against. A framework of the SAM for the Sardinia developed in this paper can been seen in Fig. 1. This Sardinia SAM was developed according a regional scheme and for this reason each phases of the regional income can be represented both by intra-regional flows and inter-regional flows with respect to the national economy (Italy) and the foreign economy (resto of the World). The SAM for Sardinia includes 54 commodities and 37 industries (activities) while the value added is distinguished into two primary factors (capital and labour) by each industry. It represents also three main institutional sectors at regional level (households, corporations, regional government) and two non-residential sectors that are presented as an aggregate economy such as the rest of Italy and the rest of the World. The flows of transfer between sectors comprehend the quantification of three different typologies of regional and national taxation: output taxes, activity taxes and income taxes. The framework can be closed by the flows regarding the foreign sectors, rest of the Italy and rest of the World.

The usefulness of the SAM lies in its huge flexibility to adapt its structure according the aim of the analysis and the possibility to look at how a single production performs whist respect to all the other, both at supply and demand side (Ahmed et al., 2018a). In the case of this study, since the effort is made to assess the different responses emerging at regional economy when a lockdown is imposed by central government, we want to highlight the size of the production process of the regional “transport” into the SAM and how this type of service could impact more into a regional income decrease.

Transport represents a key activity for the island region such as Sardinia, and it is commonly linked to that goods which were mostly affected by the stop of movement of people and non-essential goods such as tourism goods and services, accommodation, restaurant, and so. From the stand point of production and income creation, the regional SAM represents transport industry as three types of production process: i) land transport and pipeline transport services, ii) maritime and water transport services, iii) air transport services (see Fig. 2).

Basically, it is possible to quantify, for each of these services, the value of internal consumption by household and the value of non-residential consumption which are exported to the rest of the Italy and the rest of the World. The domestic consumption of transport goods represents the 4.2% of total consumption by Households and they are included into the top ten rank as we expect due to the insularity of Sardinia: the major part of the domestic demand for transports services is explained by land transport services, air and sea transport follow.
Transport goods account for a notable proportion of the overall exports of goods and services to the Rest of Italy (see Fig. 3). Export for transport goods, the part of the final demand expressed by foreign sectors, is worth around 6.6% for the Rest of the Italy and 3.1% for the rest of the World, so thus the transport services is included into the top five most exported goods (see Fig. 4).

### 3. The CGE model

The representation of the Sardinia economy through the regional SAM enables to develop a CGE model which considers all the phases of the circular flow of income (Ahmed et al., 2019; Pretaroli et al., 2018) recreating the benchmark equilibrium of the SAM (Taylor, 1990). In this paper regional CGE model will be use to analyse the economic impact caused by the stop on production as a consequence of national lockdown. This model is structured through a system of non-linear simultaneous equations but since it recreates the framework of the regional SAM, we can shock any of the variables like as it represents an exogenous modification and we can assess how it impacts on the regional macrovariables (Scrieciu, 2007). Consequently, shock results will be determined on a basis of a comparative analysis between the initial equilibrium situation (the benchmark equilibrium) and the counterfactual equilibrium resulting from the simulation (Shoven and Whalley, 1984). In particular, each single block in the SAM represents one of the macro variables modelled by the CGE so that the whole process of income creation and distribution can be recreated by means of the simulation of the initial equilibrium (Ahmed et al., 2018b). A detailed representation of how the model is calibrated on the SAM is shown in Fig. 5.

The production process, which takes place at industry level, generates total output and value added. This latter characterises the primary factors used in each production process. The value added components are then allocated to each institutional sector according the property of primary factors. The primary income is further redistributed among the institutional sectors through the taxation and through the transfers that take place between the sectors themselves, generating the secondary income distribution, through which disposable income by institutional sectors is formed. Finally, the disposable income sets the final demand by institutional sectors for each commodity in the economy. Therefore, the structure of the equilibrium allows to include exogenous shocks on both the demand and the supply side of the economy, as well as on the primary and secondary distribution of income, recalculating the new equilibrium, and thus allowing the comparison between the benchmark values and the values obtained with the simulation.

The total production is achieved through a multi-stage combination of inputs, referred to as a nested production function in which the elasticity of substitution is differentiated by stage (see Fig. 6). In each nesting level, the aggregates combinations are carried out through the use of the CES (Constant Elasticity Substitution) function, which allows to easily switch to a Leontief function by setting to zero the elasticity of substitution.

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**Fig. 1. Regional SAM for Sardinia.**

Source: our elaboration.

| Commodities ($i, \ldots, i$) | Activities ($j, \ldots, j$) | Primary Factors ($L, K$) | Taxes on Output | Taxes on Activity and Value Added | Private Institutional Sectors ($h, \ldots, h$) | Government | Income Taxes | Investments | Exports | Rest of Italy | Rest of the world |
|-------------------------------|-----------------------------|-------------------------|----------------|----------------------------------|---------------------------------|-----------|-------------|-------------|--------|-------------|-----------------|
| Intermediate Consumption      | Output                      | Value added at factor cost | Transfers among Private Institutions | Public transfers to private institutions | Transfers from rest of Italy to private institution | Transfers from rest of the world to private institution | Income Tax | Private savings | Public savings | (+/-) Savings | (+/-) Savings |
| Private Institutional Sectors ($h, \ldots, h$) | Primary Incomes | Net Indirect Taxes on output | Net Indirect Taxes on activities | Private transfers to public institutions | Transfers among Public Institutions | Income Tax Revenues | Transfers from rest of Italy to public institution | Transfers from rest of the world to public institution |
| Government                    | Primary Incomes             |                          |                          |                                  |                                |                              |
| Income Taxes                  |                             |                          |                          |                                  |                                |                              |
| Saving                        |                             |                          |                          |                                  |                                |                              |
| Rest of Italy                 | Imports                     | Primary Incomes          | Private transfers to rest of Italy | Public transfers to rest of Italy |
| Rest of the world             | Imports                     | Primary Incomes          | Private transfers to rest of the world | Public transfers to rest of the world |

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Construction and solution of the CGE consists in a method of several steps: the identification of the equations and functional forms, as well as the specification of parameters and variables.
In the first nesting stage, the total production formation and the generation of the relative prices is defined by the type of product. Total production is obtained by combining domestic production with imports from the rest of the world, according to the Armington condition (Armington, 1969), based on imperfect substitutability between domestic and imported goods.

The corresponding cost function is given by equation (1):

$$ P_i = \left( \delta_{i}^{dom} P_{q_{i}^{dom}} \right)^{1-\sigma} \left( 1 - \delta_{i}^{dom} \right) P_{m_{i}^{dom}} \left( 1 - \sigma_{m} \right)^{\frac{1}{1-\sigma_{m}}} $$  \hspace{1cm} (1)
where $P_i$ represents the price of goods by type of product, $P_{dom,i}$ are the prices of domestic goods, $P_m$ are the prices of imports from the rest of the World, $\delta^{dom}_i$ represents the share of domestic goods in the total production by type of product and $\sigma^{Q}_{dom}$ represents the elasticity of substitution between domestic and imported goods.

In the second nesting stage, the domestic production is generated through the combination of internal production and imports from the rest of Italy. This is modelled in equation (2):

$$P_{dom,i} = (\delta^{dom}_i P_{int,i}^{(1-\sigma^{Q}_{dom})} + (1-\delta^{dom}_i) P_{it}^{(1-\sigma^{Q}_{dom})})^{1/1-\sigma^{Q}_{dom}}$$

where $P_{int,i}$ represents prices of internal goods, $P_{it}$ are prices of imports from the rest of Italy, $\delta^{int}_i$ represents the share of internal production on total domestic production and $\sigma^{Q}_{int}$ represents the elasticity of substitution between internal production and imports.

Internal production, that is generated in the third nesting stage, is obtained through the combination of intermediate goods and the value

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### Table 1: CGE macrovariables in the SAM framework.

| Commodity (1, ..., l) | Activities (1, ..., l) | Primary Factors (K, L) | Taxe on Activity and Value Added | Private Institutional Sectors (1, ..., b) | Government | InCOME Taxes | Investments | Rest of Italy | Rest of the world |
|-----------------------|-----------------------|------------------------|----------------------------------|-----------------------------------------|------------|--------------|-------------|--------------|------------------|
| $X^i_P$                | $X^i_P$                | $X^i_P$                | $X^i_P$                          | $X^i_P$                                 | $X^i_P$    | $X^i_P$      | $X^i_P$     | $X^i_P$      | $X^i_P$            |
| $X^i_P$                | $X^i_P$                | $X^i_P$                | $X^i_P$                          | $X^i_P$                                 | $X^i_P$    | $X^i_P$      | $X^i_P$     | $X^i_P$      | $X^i_P$            |
| $X^i_P$                | $X^i_P$                | $X^i_P$                | $X^i_P$                          | $X^i_P$                                 | $X^i_P$    | $X^i_P$      | $X^i_P$     | $X^i_P$      | $X^i_P$            |
| $X^i_P$                | $X^i_P$                | $X^i_P$                | $X^i_P$                          | $X^i_P$                                 | $X^i_P$    | $X^i_P$      | $X^i_P$     | $X^i_P$      | $X^i_P$            |

Source: our elaboration.
Fig. 6. The structure of the production function in the regional CGE model.

added as showed in equation (3):

$$P_{mj} = \left( \sum_{i} \delta_{ij} P_{ij}^{(1-s_{ij})} + \sum_{i} (1 - \delta_{ij}) P_{vi}^{(1-s_{ij})} \right)^{\frac{1}{\sigma_{ij}}}$$

where $P_{ij}$ represents prices of intermediate goods, $P_{vi}$ represents prices of value added, $\delta_{ij}$ represents share of intermediate goods in total production and $s_{ij}$ is the elasticity of substitution between intermediate goods and value added.

Intermediate goods and value added are obtained in the fourth nesting stage; the first is calculated through the combination of the applications for the individual types of intermediate goods as in equation (4):

$$P_{bi} = \left( \delta_{ij} P_{ij}^{(1-s_{ij})} \right)^{\frac{1}{\sigma_{ij}}}$$

where $P_{ij}$ represents the average price on goods market from the market clearing condition, $\delta_{ij}$ represents share of the cost by intermediate goods in the total cost and $s_{ij}$ is the elasticity of substitution between intermediate goods; the second is obtained through the combination of the productive factors labour as modelled in equation (5):

$$P_{vi} = \left( \delta_{ij} P_{ij}^{(1-s_{ij})} + (1 - \delta_{ij}) P_{K}^{(1-s_{ij})} \right)^{\frac{1}{\sigma_{ij}}}$$

where $P_{ij}$ and $P_{K}$ are the prices of labour and capital, $\delta_{ij}$ represents the share of the labour in the total of primary factors and $s_{ij}$ is the elasticity of substitution between labour and capital (Van der Werf, 2008).

The allocation of primary income within institutional sectors is explained by equation (6):

$$Y^{disp} = L^{end} P_{L} + K^{end} P_{K}$$

where $L^{end}$ and $K^{end}$ represent the labour and capital supply, while $P_{L}$ and $P_{K}$ represent the price of labour and capital.

From the formation of primary income, it is possible to move on to the formation of disposable income, obtained by adding to the primary income of each institutional sector the income items arising from taxes and transfers between institutional sectors, both calculated on the basis of primary income. The formation of disposable income is diversified according to the institutional sector equations (7, 8, 9, 10 and 11). Transfers from the Public Administration and the rest of the World are considered exogenous.

$$Y^{disp} = Y^{prov} - \sum_{i} \delta_{i} Y_{i} P_{prov} + \sum_{i} (1 - \delta_{i}) Y_{i} P_{prov} + \sum_{i} Y_{i} tr_{i} + TR_{pub}$$

where $Y_{i}$ represents the price of labour and capital.

$$Y^{disp} = Y^{prov} - \sum_{i} \delta_{i} Y_{i} P_{prov} + \sum_{i} (1 - \delta_{i}) Y_{i} P_{prov} + \sum_{i} Y_{i} tr_{i} + TR_{pub}$$

$$Y^{disp} = Y^{prov} - \sum_{i} \delta_{i} Y_{i} P_{prov} + \sum_{i} (1 - \delta_{i}) Y_{i} P_{prov} + \sum_{i} Y_{i} tr_{i} + TR_{pub}$$

where $Y^{disp}$ represents the implicit rates of income tax, $tr_{i}$ are the implicit rates of transfers paid to other institutional sectors, $TR_{pub}$ represents implicit rates of transfers collected from other institutional sectors, $tq_{i}$ are the implicit tax rates on output and $tq_{i}$ implicit tax rates on activities.

For the institutional sectors, households, corporations and rest of Italy, disposable income represents the budget constraint on which they allocate consumption and savings, according to their utility function, thus generating demand for consumption, investment and exports to the rest of Italy. The utility function is represented by equation (12):

$$U_{ind} = \left( C_{ind}^{\alpha_{ind}} + S_{ind}^{\beta_{ind}} \right)^{\frac{1}{\alpha_{ind}}}$$

where $C_{ind}$ and $S_{ind}$ are respectively the level of consumption and the level of savings, and $\sigma_{ind}$ is the elasticity of substitution between consumption and savings.

As far as the institutional sector of the government is concerned, disposable income is obtained through the sum of taxes collected, transfers received and net transfers paid. This institutional sector does not maximise the utility function, this allows for the possibility of making public expenditure choices using the deficit; for this reason, it is considered that public expenditure is not influenced by policy measures, and is therefore considered constant. The utility function is given by equation (13):

$$U_{pub} = G_{pub} + S_{pub} + def_{pub}$$

where $G_{pub}$ and $S_{pub}$ are respectively the level of public expenditure and the level of savings, and $def_{pub}$ the level of deficit.

For the rest of the World, institutional sector is considered the hypothesis of not maximizing the utility function; in addition, the export price is a function of the world price, fixed exogenously, and the exchange rate.

The closure rules of the model are generated by market balances, both of goods and inputs, through the adjustments of prices as modelled in equation (14):

$$Q_{i} = \sum_{j} b_{ij} Y_{i}^{tov} + \sum_{j} C_{ij}^{tov} + \sum_{j} C_{ij}^{tov} + I_{i} + E_{i}^{ext} + E_{i}^{tov}$$

where $Q_{i}$ is the total production by product, $b_{ij}$ are the intermediate goods, $C_{ij}$ are household consumption, $Q_{ext}$ is the public expenditure, $I_{i}$ are the investments, $E_{i}$ are the export to the Rest of Italy and $E_{i}^{tov}$ are the export to the Rest of the world, and it is also considered that gross investment equals gross savings, as modelled in equation (15):
Finally, the equality between supply and demand of production factors is guaranteed by equations (16) and (17):

\[ L_s = L_d \]  
\[ K_s = K_d \]

4. Simulation results

The application of the CGE SAM based model for the Sardinia region to assess economic effects caused by COVID-19 is based on the application of a selective block of certain production activities for the time set by the Prime Ministerial Decree dated 22 March 2020. This lockdown has led to a clear interruption of some production processes with a consequent reduction in the capacity to meet final domestic and external demand (the rest of Italy and the rest of the World).

The lockdown corresponds to a policy shock that can be simulated through a supply-side intervention diversified by production type, using a percentage reduction in the output of each activity. This reduction implies a lower use of primary factors employed in the production process, including imports, which is transferred into a reduction of the primary income of the institutional sectors. As a result, the secondary distribution is affected by the change in transfers between institutional sectors and by the lower tax revenues paid by them, which is equivalent to a reduction in revenue for the Government. The reduction in disposable income of the institutional sectors affects the levels of demand components. In particular, consumption decreases in relation to the change in disposable income and the value of the parameter of propensity to consume, while investments change in relation to the active saving. Government expenditure, being considered exogenous as mentioned above, does not change, and therefore the reduction in government revenue is transferred into an increase in the deficit. Exports to the Rest of Italy and to the Rest of the world, linked to their respective disposable income, also decrease. In this flow, a particular role is played by sectoral multipliers, which can increase certain effects, thus adding the indirect effect to the direct effect.

In this simulation, a lockdown of 3 months is assumed for all activities affected by the Decree, and the period is extended to 5 months for the transport activity and all activities related to tourism. The output change compared to the benchmark is 13.4% and the reduction composition is shown in Fig. 7:

The three activities most affected by the lockdown are the activities linked to mining, accommodation and catering services, and real estate, which together account for 32% of the drop in production; it should be pointed out that for services related to the tourism activities, the production block is extended to a time span of 5 months, so that the economic impact is suffered by the mining and the real estate, which are both linked to the construction activity. From Fig. 7 is possible to observe that land transport and maritime and water transport activities are amongst the activities which have been impacted mostly on the basis of the selected scenario. It should however be noted that air transport service is not included in this specific category. The effects on the main macroeconomic aggregates are shown in Table 1.

Furthermore, Table 2 shows that changes in GDP, compared with the benchmark, are in line with the analysis of transport in relation to consumption and exports mentioned. In fact, the services most affected by the lockdown are those linked to tourism, i.e. maritime and water transport services, while there is an indirect effect of air transport which leads to a slight growth in GDP.

This is due to the fact that air transport is the service most used by foreign people traveling to the region for work reasons, and vice versa, such as regional political activity linked to Italian central government. This phenomenon therefore guarantees a continuous economic flow because the region cannot isolate itself totally from the rest of Italy. However, the growth of GDP in this activity has a residual influence on the variation of GDP in the transport activity; in fact, the structure of the variation of the GDP shows that the greatest contribution in terms of the relative decline is consistently attributed to the maritime and water transport service activities.

It also interesting to note that the use of capital and labour

| Table 1 | The lockdown impact on macroeconomics variables (percentage change from the benchmark). |
|---------|--------------------------------------------------------------------------------------------|
| Real Variables | % |
| GDP | −13.2 |
| Households consumption | −23.4 |
| Gross Investment | −12.7 |
| Exports - rest of Italy | −43.2 |
| Exports - rest of the world | −5.8 |
| Imports - rest of Italy | −35.1 |
| Imports - rest of the world | −26.7 |

![Fig. 7. Output changes: commodities output decrease.](image-url)
production factors falls about 34.01% and in transport activities falls by 56.05% compared to the benchmark. However, it should be emphasised that this decrease is to be considered gross of government intervention, particularly with regard to the labour factor; social shock absorbers to support employment tend to mitigate this phenomenon.

An important feature of the current pandemic crisis is that it has caused a shock both on the supply side, following the forced interruption of non-essential production activities, and on the demand side, with the sudden and widespread reduction in the population’s consumption capacity. The latter can be traced back to two substantial cases: on the one hand, consumption capacity suffers the effect of forced quarantine, which physically prevents the possibility of being able to consume, and on the other hand it suffers the effect of reduced income. The effect on consumptions should be added to the effect on investment, which also depends on spending capacity. As can be seen, the economic impact on regional GDP of the pandemic event, based on the current duration and assuming that the health problem is solved, it should stop at a contraction of about 13.2%. The percentage reduction in real GDP is significant, and for a significant part is linked to the strong reduction in final domestic demand for household goods and services (23.4%).

Despite the operation of the ordinary automatic stabilisers activated by the Central and Regional Government to deal with the emergency, the contraction in demand from households remains significant. Even real investments, albeit with less intensity, reach a considerable reduction of 12.7%. An important effect is the reduction of the region’s exports to Italy and the Rest of the World. In particular, the commercial balance towards the rest of Italy is linked to the strong tourist vocation of the region.

Shifting the focus to the impact that healthcare limitations can have on the generation of value added, Table 3 shows its composition by showing a sharp decline in compensation of employees and income from gross operating results:

| Table 2 | Lockdown impact on transport activities (percentage change from the benchmark). |
|---------|--------------------------------------------------------------------------------|
| Service                                        | %       |
| Land transport and pipeline transport services  | −31.4   |
| Maritime and water transport services           | −57.4   |
| Air transport services                          | 4.3     |

This effect justifies the drop-in household’s consumption highlighted in Table 1, and also justifies the introduction at national level of the “layoff” extension, a measure aimed at containing the contraction, which is not considered in this work, in order to provide an analysis net of the urgent measures implemented by central and local government to mitigate the economic impact. At industry level (see Fig. 8), the biggest impact on labour primary factor is suffered by the accommodation and catering services i.e. the tourism-related industries, followed by the commercial and transport services:

Looking instead at the change in gross operating surplus (see Fig. 9) it should be noted that the most affected activity is the real estate activity, with a 27.1% decrease, followed by the commercial activity and the accommodation and catering services activity:

Consequently, it is clear that the tourism are the activities that most of all suffers the effect of the economic contraction resulting from the lockdown, both in terms of production and value added, thus characterizing the Sardinia region as a territory with a strongly tourism-oriented economic structure. The contraction in production also translates into a reduction in activity taxes, thus generating a reduction in tax revenue collected by the regional government. A further aspect important finding relates to the contraction of disposable income and its impact on related taxes, which account for about 40% of the regional government’s disposable income. Table 4 shows the respective estimated reduction in tax revenue by type:

Based on this, the disposable income of the institutional sectors is also suffering a far-reaching setback as a result of transfers between sectors, considering that the primary income contraction in fact reduces the transfers tax base. Results are shown in Table 5:

There is a general contraction in income for all institutional sectors, with the exception of financial corporations; for the latter, in fact, the component of incoming transfers from the Government and Rest of the World institutional sectors, considered fixed, represents the largest component, and therefore disposable income tends to grow. Moreover, considering fixed transfers from the Public Administration, which can operate in deficit, implies a strong reduction in its disposable income generated by the contraction of tax revenues. This implies that all actions aimed at maintaining Public Expenditure and transfers to other institutional sectors, in order to support their spending capacity to meet demand, can be carried out only via the generation of a budget deficit. The variation in disposable income of households and non-financial corporations are of considerable interest; the first is affected by the contraction in primary income deriving above all from compensation of employees, as a result of the contraction in production, as well as the drop-in income deriving from the gross operating result; the second, also suffers the drop-in income from gross operating result as a result of the lockdown. However, Fig. 10 shows the distribution of institutional sectors according to the income contraction, showing that for non-financial corporations it represents the 2.5% of the total income reduction, while households are the institutional sector most affected by the income contraction. It can also be seen that the increase in the disposable income of financial corporations represents only the 0.8% of the total change.

From this point of view, through the simulation of the lockdown measure enabled in order to contain contagions, its impact on the economic system is highlighted through a strong contraction in the production of key activities, which is followed by a contraction in household spending capacity resulting from the incomes drop, which translates into a demand drop. The regional government also suffers the income contraction resulting from lower tax revenues, both on the production side and on the income institutional sectors side, while guaranteeing the level of public spending and transfers to households and corporations through recourse of a budget deficit.

5. Conclusions

In this work the impact of the measures provided for by the DPCM of 22 March 2020, concerning “Urgent measures for the containment of coronavirus infection throughout the national territory” is analysed with application to the Sardinia region. The decree refers to the production lockdown for specific economic activities due to the Covid-19 pandemic. Through a CGE SAM based model the impact on production, final demand and disposable income of the institutional sectors that characterize the regional economy is analysed. The pandemic effect has led to a significant production lockdown to various economic processes in a selective manner, however affecting the entire economic system through direct, indirect and induced effects. The results obtained suggest a significant decrease in real GDP, and in general in all its components; a sharp decrease in the disposable income of the institutional sectors and the related tax revenue for the Government from income taxes and taxes on productive activities is also estimated. The policy strategy which will be activated by the local government for the future restart of the economic system, cannot fail to consider the possibility of operating in

| Table 3 | Lockdown impact on Value Added (percentage change from the benchmark). |
|---------|---------------------------------------------------------------------|
| Value added components                                      | %       |
| Compensation of employees                                   | −29.1   |
| Gross and mixed operating result                            | −38.9   |
| Taxes less subsidies on products                            | −33.4   |
| Other taxes less subsidies on production                     | −35.1   |
Moreover, given that the impact of the lockdown is diversified at disaggregated level, economic policy measures can be geared towards safeguarding the output production of the most affected activities, as well as the protection of labour income and related gross operating deficit.  

### Table 4
Lockdown impact on income tax revenue (percentage change from the benchmark).

| Variables                  | %    |
|----------------------------|------|
| Households income taxes    | -33.1|
| Corporate income taxes     | -38.9|

### Table 5
Lockdown impact on disposable income (percentage change from the benchmark).

| Disposable income          | %    |
|----------------------------|------|
| Non financial corporations | -32.9|
| Financial corporations     | -26.7|
| Public administration      | -82.1|
| Households                 | -23.4|
| ISP                        | -17.5|

![Fig. 8. Change in Compensation of employees.](image1)

![Fig. 9. Change in gross operating surplus.](image2)

![Fig. 10. Change in Disposable income.](image3)
surplus, through the reduction of the tax wedge or through transfer-related instruments. The interconnection between productive activities will therefore generate and support the mechanism for transmitting and propagating economic recovery to all other activities through the multiplier mechanism. This does not exclude that the actions implemented cannot be oriented to the entire production system, through a structure of interventions of a proportional or progressive type.

Declarations

- The manuscript has not been submitted to more than one journal for simultaneous consideration.
- The submitted work is original and has not been published elsewhere in any form or language (partially or in full).
- The authors declare that they have no conflict of interest.

CRediT authorship contribution statement

S. Deriu: Conceptualization, Data curation, Methodology, Validation, Writing – original draft. I.P. Cassar: Conceptualization, Data curation, Methodology, Validation, Writing – original draft. R. Pretaroli: Conceptualization, Data curation, Methodology, Validation, Writing – original draft. C. Socci: Supervision, Conceptualization, Data curation, Methodology, Validation, Writing – original draft.

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