A Methodology to Study Price-Quantity Interactions in input-output Modeling: an Application to NextGenerationEU Funds

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Abstract:

The input-output (I-O) model is a widely used tool to study the linkage structure of an economy and assess the effects of policies. The model is made up of two modules that describe the underlying forces that govern quantities and prices, but there is no connection between these modules as they reside in unconnected spheres: prices do not interact with quantities, and quantities, in turn, do not interact with prices. Because of this, the I-O model has been questioned for its limited descriptive capacity when a more comprehensive assessment exercise is required.

This work tries to contribute an improvement to the explanatory capacity of the I-O model. We develop an extension of the classic I-O price and quantity models to an integrated "price-quantity" model that connects the two modules and makes them interdependent. This new version of the model could be useful to advance the explanatory capacity of I-O analysis without having to resort to the use of computational general equilibrium (CGE) models. As we know, CGE models are more complex in their structure and costlier to implement in terms of required data than I-O models. We use this integrated I-O model to evaluate the impact of *NextGenerationEU* funds on the Spanish economy using data from a Social Accounting Matrix (SAM) for 2016, the last year with official I-O data.

Keywords: Price-quantity feedback, Social Accounting data, Impact evaluation

JEL Classification: C67, D57, E37

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1. Introduction

Standard input-output (I-O) analysis is composed of two modules that live independently and do not interact with each other (Miller and Blair, 2022, Chapter 2). The quantity module is the best known and most widely used model in quantitative I-O analysis. It represents the sectorial equilibrium between demand—intermediate and final—and supply. Dual to the quantity module, the I-O price model is the second module of I-O analysis. Prices are determined under constant returns to scale through an average cost rule with no market power presence. The pricing rule ensures profit maximization and zero pure profits. Average cost includes the unitary cost for primary factors—labor and capital—and intermediate unitary costs.

The independence between the quantity and price modules in I-O analysis means that prices and quantities are determined in isolation without quantities affecting prices or prices affecting quantities. This independence is an operational advantage, but also a conceptual drawback. Because of the independence property, the solutions of the quantity and price modules are certainly easier to obtain. All we actually need is the ability to invert matrices. However, it is difficult to accept, and goes against the overwhelming empirical evidence, that quantity and price determination are unrelated to each other in the actual functioning of markets. It goes without saying that the operational capacity of a model, although technically relevant, must nevertheless be secondary to the importance of its conceptual coherence and explanatory capacity. How can we deal with this difficulty?

Extensions to linear SAM modes do not work even if these models include additional levels of interdependence that are built from additional endogenous accounts on top of the ones considered in I-O. Neither the SAM quantity models (Pyatt and Round, 1979) nor the SAM price models (Roland-Holst and Sancho, 1995) contain price-quantity feedback. They still live isolated from each other.

Another option is the direct use of a computational general equilibrium (CGE) model, since in this type of model prices and quantities are determined simultaneously (Arrow and Debreu, 1954). However, CGE models have high implementation costs as well as considerable data requirements, and the needed data are not always readily available (Dervis et al, 1982; Shoven and Whalley, 1992). The nonlinearities in these models result, for example, in factor and input substitution, but the degree of substitution depends to a large extent on elasticity values that we often do not know. This introduces uncertainties in the results that require the systematic use of sensitivity analysis to try to reasonably bound their variability. The difficulty lies in the fact that the necessary parameter estimates either do not exist or, when they do, are markedly different (Harrison and Vinod, 1992; Harrison et al, 1993).

We will try to avoid these technical difficulties by keeping the simple and well-known structure of the I-O model to which we will add a communication channel between the quantity and price modules. This connection attempts to capture the essence of the interactions between prices and quantities that characterize typical market behavior. Recall that prices are market signals that integrate both the desirability of goods and services (demand) and their marginal costs of production (supply). In short, thanks to this open communication channel, we endow the linear model with greater descriptive power without at the same time incurring excessive modeling costs.

This set of methodological considerations is relevant when we consider evaluating an economic policy using input-output models. Let us take as an example the European Union (EU) policy known as NextGenerationEU (NGEU) funds, which pursues the dual objective of recovering the losses associated with the COVID pandemic and, at the same time, promoting a modernizing transformation of the economic structure. During the period 2021-26, each EU member country will receive a sum of funds to be injected into their economies and their governments will be required to implement programs that meet the objectives set by the EU.

Since the NGEU funds will eventually intervene as additional external stimuli in final demand, the I-O model is especially appropriate, through its quantity module, to estimate the multiplier effects on the levels of activity generated by the funds. In turn, these changes will also affect the state of supply and demand in the different sectors and, consequently, exert pressure on prices. These price effects, however, are not captured by the quantity module of the I-O model, which is blind to any impact on commodity and factor prices. Hence the need to have a mechanism that takes into account the price effects and the I-O price module can fulfill this function as long as a feedback channel from quantities to prices is adequately defined. But the changes in prices, in turn, will also generate feedback on quantities due to changes in disposable income levels (demand) and marginal costs (supply). And so on. Therefore, the evaluation of the NGEU effects must consider the accumulated feedback effects between prices and quantities in both directions.

In the case of the Spanish economy, the available official data show a substantial fall in real GDP in 2020 —the year in which the pandemic emerged—of close to 10 percent. The gradual recovery observed in 2021 and 2022 still fails to compensate for the initial losses. Table 1 summarizes the evolution of GDP in nominal and real terms.

Table 1. GDP evolution in the Spanish economy 2019-22

	2019	2020	2021	2022
GDP at current prices	1,245.51	1,117.99	1,206.84	1,327.11
GDP at 2019 prices	1,245.51	1,121.61	1,174.44	1,191.49
GDP volume index	100	90.05	94.29	95.66
% real change	--	-9.95%	+4.71%	+1.45%

Source: National Institute of Statistics data and our presentation.
Thousands of millions of Euros when applicable.

The total budgeted NGEU funds allocated to the Spanish economy amount to some 168 thousand of millions[1] of Euros base 2021 to be distributed between 2021 and 2026. The sectoral distribution of this figure is made on the basis of the criteria defined by the policymaker and will eventually result in a set of injections materialized as new final demand. The I-O quantity module can therefore estimate its impact on gross production and other interest magnitudes by using the Leontief inverse. However, as mentioned, this module would not be able to discern the possible effects on the price structure nor how changes in prices would affect quantities in a second round of feedback from prices to quantities.

To overcome this difficulty, we develop an enhanced I-O model that incorporates the novelty of accounting for mutual price and quantity interactions, and we use it to evaluate in a more comprehensive way the possible impact of the application of the NGEU funds on the Spanish economy during the six years of the program.

We structure the paper as follows. In Section 2 we present the methodological details of our enhanced version of the I-O model. In Section 3 we present the data that allow the model to be implemented and we discuss the criteria for assigning the budgeted funds, both in their effective distribution and in alternative distributions. The comparison between effective and alternative distributions allows us to approximate the implicit efficiency losses of the implementation. In Section 4 we present and discuss the most relevant empirical results. Finally, Section 5 highlights the main results.

[1] Billions in US units, or milliards in UK terminology. In the calculations that we present later on, we need to deflate this figure to 2016 prices to ensure compatibility with the model database. The deflated level of funds amount to 143 thousand of millions of Euros.

2. Methodology

In its simplest expression the quantity I-O module is fully described by:

Supply:	x
Demand:	$\mathbf{A}\cdot x + f$
Balance:	$x = \mathbf{A}\cdot x + f$

Output x and final demand f are $n\times 1$ vectors and matrix **A** is square ($n\times n$). Matrix **A** describes the technology and reflects fixed technical coefficients and constant returns to scale. Therefore $\mathbf{A}\cdot x$ is the ($n\times 1$) vector of intermediate demand that is required to fulfil the delivery of output vector x.

Under some regularity conditions on the matrix **A** (Nikaido, Chapter 3), the equilibrium solution in output x can be obtained from matrix inversion:

$$x = \mathbf{A}\cdot x + f \quad \Rightarrow \quad x - \mathbf{A}\cdot x = f \quad \Rightarrow \quad x = (\mathbf{I}-\mathbf{A})^{-1}\cdot f \qquad (1)$$

Notice that in the determination of the equilibrium output, prices do not play any role.

In turn, the price I-O module follows the cost accounting structure:

Prices:	p'
Average costs:	$p'\cdot\mathbf{A} + w\cdot\ell' + r\cdot\kappa'$
Zero profits:	$p' = p'\cdot\mathbf{A} + w\cdot\ell' + r\cdot\kappa'$

Prices p' and the labor ℓ' and capital κ' coefficients are ($1\times n$) vectors. Remunerations per unit of labor and capital services are w and r respectively. Under the same regularity conditions on **A**, we can solve for equilibrium prices as follows:

$$\begin{aligned} &p' = p'\cdot\mathbf{A} + w\cdot\ell' + r\cdot\kappa' \quad \Rightarrow \quad p' - p'\cdot\mathbf{A} = w\cdot\ell' + r\cdot\kappa' \quad \Rightarrow \\ &p' = (w\cdot\ell' + r\cdot\kappa')\cdot(\mathbf{I}-\mathbf{A})^{-1} \end{aligned} \qquad (2)$$

We notice, once again, that in the determination of equilibrium prices quantities do not intervene. We now discuss possible ways to introduce feedback between prices and quantities.

2.1 Feedback from prices to quantities

One way to study the communication channel from prices to quantities is to ask ourselves what possible changes in the economic environment would induce changes in prices. A possible example is the presence of taxes. Let us therefore consider as an explanatory vehicle the introduction of an indirect *ad-valorem* tax at rate τ_j that falls on price formation in sector *j*. Profit maximization leads, in the presence of such an indirect tax, to the expression:

$$p_j = (1+\tau_j)\cdot\left(\sum_{i=1}^{n} p_i \cdot a_{ij} + w\cdot \ell_j + r\cdot \kappa_j\right) \quad (3)$$

In matrix terms it becomes:

$$p' = \left(p'\cdot A + w\cdot \ell' + r\cdot \kappa'\right)\cdot \Phi_\tau \quad (4)$$

where Φ_τ is a diagonal matrix with terms $(1+\tau_j)$. Solving equation (4) gives:

$$p' = (w\cdot \ell' + r\cdot \kappa')\cdot \Phi_\tau \cdot (I - A\cdot \Phi_\tau)^{-1} \quad (5)$$

We observe that any change in the indirect tax rates will modify the vector of prices conditional on the prices of labor and capital services, *w* and r respectively. We also observe from expression (5) that taxes directly affect the cost of the use of primary factors and indirectly, by intervening in the formation of the inverse matrix, in its repercussion on the cost of using the material inputs. Any change $\Delta\tau$ in the indirect tax vector will impact the price vector through the adjustment governed by expression (5).

Changes in prices will obviously alter the welfare status quo of private agents. An increase in prices translates into a loss of purchasing power (i.e., less welfare, in microeconomic terminology) which frequently leads to arduous negotiations to achieve wage rate adjustments that mitigate the losses in purchasing power.

A commonly used rule is to adjust the wage rate *w* to a consumer price index (*CPI*) built according to the shares α_j of the baseline expenditure on the consumption of different goods over disposable income:

$$CPI = \sum_{j=1}^{n} \alpha_j \cdot p_j = p'\cdot \alpha \quad \text{with weights} \quad \sum_{j=1}^{n} \alpha_j = 1 \quad (6)$$

With a full wage adjustment, we would have:

$$w = CPI$$

However, the adjustment is never perfect so that the wage rate *w* only partially recovers the losses in purchasing power when prices rise. On the other hand, the rate *w* is usually downward rigid when prices fall (at least for those workers who maintain their employment). If we define by $0 < \rho \leq 1$ the negotiated recovery percentage, the dynamics of the wage rate is described by the rule:

$$w = w_0 \cdot Max(1 + \rho \cdot (CPI - 1), 1) \quad (7)$$

where w_0 is the wage rate before the change induced in prices (Sancho, 2021). Expression (7) implies that the wage rate is not constant and depends on the socioeconomic environment synthetically represented by the evolution of the *CPI* and the bargaining power of the employee representatives implicit in ρ. Consequently, wage income depends on the state of the current economic environment and from this it follows that consumer demand *c*, an integral part of the final demand of the economy, is also variable and dependent on current prices *p'* and consumers disposable income *m* a part of which is wage income. We can write consumption demand as:

$$c = c(p', m) \quad (8)$$

The specific form of the demand function *c* will depend on the structure of preferences. In our case, since we are working within the I-O model, we will use a Leontief consumption demand function that uses the above-mentioned shares α_j:

$$c_i = \frac{\alpha_i \cdot m}{\sum_{j=1}^{n} \alpha_j \cdot p_j} \quad (9)$$

If we retake expression (1) and distinguish consumption demand *c*, which is now endogenous, and the rest of final demand *d* we will have:

$$x = \mathbf{A} \cdot x + c + d \quad \Rightarrow \quad x = \left(\mathbf{I} - \mathbf{A}\right)^{-1} \cdot \left(c + d\right) \quad (10)$$

In short, a change in the economic environment—indirect tax rates in our leading example—causes a cascade of reactions in prices (through expression (5)) and in the *CPI* (through expression (6)), in the wage rate (through expression (7)) and finally in the economy's production levels *x* by the changes induced in consumer demand (through expression (9)) and from the equilibrium equation of the quantity module (10). We can visualize the cascade of effects of the adjustment process like this:

$$\Delta\tau \Rightarrow \Delta p', \Delta CPI \text{ via (5) and (6)} \Rightarrow \Delta w \text{ via (7)} \Rightarrow \Delta c \text{ via (9)} \Rightarrow \Delta x \text{ via (10)}$$

Apart from labor, capital is also a primary factor, and its price *r* will also be conditioned by the economic environment, although with different rules to those applying to labor. In a static model, such as the I-O model, one option is to determine the price of capital based on the marginal cost cm_k of providing a new unit of capital, or investment:

$$r = r_0 \cdot cm_k = r_0 \cdot \sum_{j=1}^{n} p_j \cdot \delta_j = r_0 \cdot p' \cdot \delta \text{ with weights } \sum_{j=1}^{n} \delta_j = 1 \quad (11)$$

where r_0 is the baseline price of capital.

This type of factor price formation rule was initially suggested by Steenge and Serrano (2012) in a neo-Ricardian context. Their original proposal connects each item of value added (i.e., labor, capital) with its corresponding item of final demand (i.e., consumption, investment). In expression (11) the coefficients δ_j represent the proportion of good *j* necessary to generate a new unit of a composite investment good that feeds the capital stock. For a given configuration of the price vector p', the marginal cost is constant, but it will change when changes in the environment modify the prices of the goods, such as in the tax example.

Since consumers also earn part of their income from capital, their level of disposable income will depend on the capital assets in their hands and again we will have a feedback effect from the price module to the quantity module:

$$\Delta\tau \Rightarrow \Delta p', \Delta mc_k, \Delta r \text{ via (5) y (11)} \Rightarrow \Delta c \text{ via (9)} \Rightarrow \Delta x \text{ via (10)}$$

In what follows we will adapt the proposal of Steenge and Serrano (2012), as regards investment, to a standard Leontief context with a certain macroeconomic touch. We will define σ_i as the coefficient that measures the amount of investment good of type *i* per unit of the initial capital stock K_0 and will assume that this coefficient is constant in scale. Thus, the sectorial investment in *i* per used level K_u of capital stock is governed by the rule:

$$v_i = \sigma_i \cdot K_u \tag{12}$$

or in terms of changing levels:

$$\Delta v_i = \sigma_i \cdot \Delta K_u = \sigma_i \cdot (K_u - K_0) \tag{13}$$

With two primary factors, total disposable income amounts to:

$$m = w \cdot L_u + r \cdot K_u \tag{14}$$

with L_u and K_u indicating the effective use of both factors in production activities:

$$\begin{aligned} L_u &= \ell' \cdot x \\ K_u &= \kappa' \cdot x \end{aligned} \tag{15}$$

Disposable income *m* depends on factors prices according to expressions (7) and (11) whereas their levels depend on (15) which in turn become determined from expression (10).

Since investment demand constitutes an integral part of the final demand that is not consumption demand, the previous expression (10) captures, once again, a feedback effect in this case through the changes induced in the investment levels that facilitate the availability of new capital as follows from expression (13). This, in turn, is conditioned by output activity levels x according to (15). Once investment demand is made endogenous and active in expression (10), the rest of final demand d includes just government demand and demand for exports. These two components of final demand will be left as exogenous since government decisions are discretionary and politically oriented and exports are decided elsewhere. The previous equation (10) with endogenous consumption c and endogenous investment v becomes now:

$$x = \mathbf{A} \cdot x + c + v + d \quad \Rightarrow \quad x = \left(\mathbf{I} - \mathbf{A}\right)^{-1} \cdot \left(c + v + d\right) \tag{10'}$$

With these connections, we close the communication channel from the sphere of prices p' to the sphere of quantities x through the evolution of prices and the use of primary factors in production. However, at the moment there is no feedback effect from the sphere of quantities to that of prices.

2.2 Feedback from quantities to prices

Thinking in terms of partial equilibrium is always a good starting point to establish possible links between economic magnitudes. The needs for primary factors established in (15), which responds to changes in productive activity, will lead to positive (or negative) excess demands with respect to their initial levels. These positive (negative) differences will exert an upward (downward) pressure on factor prices. If, for example, a change in the economic environment increases the needs for the labor force L_u over the initial level L_0, this shift in labor demand will generate an upward pressure on the wage rate w. Similarly, the effects induced by shifts in the demand for capital through (15) will also have an impact on the price of capital. In symbols:

$$\left(\frac{L_u}{L_0}\right)\uparrow \quad \Rightarrow \quad w\uparrow$$

$$\left(\frac{K_u}{K_0}\right)\uparrow \quad \Rightarrow \quad r\uparrow$$

One way of modeling these demand-induced effects on factor prices is to use a compound multiplicative rule applied over the marginal costs of labor and capital. As a result, the joint effect on factor prices would include both a supply effect that depends on the evolution of commodity prices that determine the marginal costs of labor and capital, and a demand effect that depends on the degree of deviation of factor demands from their initial levels:

$$
\begin{aligned}
w &= w_0 \cdot \left(\frac{L_u}{L_0} \right)^{\beta_L} \cdot Max(1+\rho \cdot (CPI-1), 1) \\
r &= r_0 \cdot \left(\frac{K_u}{K_0} \right)^{\beta_K} \cdot p' \cdot \delta
\end{aligned}
\tag{16}
$$

The coefficients β_L and β_K represent the responsiveness of the prices of factors to the changes in their use. We approximate them using the value-added shares of labor and capital.

Thanks to expression (16), and despite its simplicity, factor prices would now respond to supply and demand influences. To illustrate this, let us examine again a possible increase in indirect taxes. From the supply perspective, such a rise would lead to higher commodity prices due to the increase in the costs associated with indirect taxes within the cost structure. This effect on marginal costs would exert upward pressure on factor prices through relationships (7) and (11). On the demand side, higher commodity prices would cause a reduction in purchasing power and a contraction in consumption demand, thereby reducing productive activity and the need for factors, with the consequent downward pressure on factor prices. The combined effects through supply and demand shifts eventually fall back on factor prices, so that the linkage loop from the quantity module to the price module is closed. The sign of the effects exerted on factor prices can be positive or negative depending on the relative strength of demand and supply shifts.

The two modules are no longer independent of each other and prices and quantities, in this improved version of the I-O model, influence each other, which offers a higher degree of plausibility to the analysis. Thus, this extension of the model overcomes the conceptually difficult to accept dichotomy of independence in the determination of prices and quantities implicit in the standard I-O model.

3. Data

3.1 The database

The baseline data used in this study is a Social Accounting Matrix (SAM) for Spain in 2016. This SAM offers an updated and complete framework that, for a given aggregation rule, includes all economic transactions that take place between the different agents in the said period. The advantage of a SAM is that incorporates the mutual interrelationships between production activities, final demand structures (consumption, investment, etc.), and income distribution, allowing for the closure of the circular flow of income. For its construction, we have used the guidelines of the European System of Integrated Accounts (ESA2010).

The methodological development presented below is based on Cardenete (1998), Cardenete and Moniche (2001), Rodríguez et al. (2005), and Cardenete and Sancho (2006). For the construction of the SAM, the available Input-Output framework for 2016 is adjusted and complemented by the information in the Spanish National and Product Accounts and other official resources for 2016 (INE, 2021). The main statistical source is the I-O table of 2016 compiled by the Instituto Nacional de Estadística[2] (INE) at basic prices in millions of Euros.

The SAM follows the structure of the I-O table which includes 63 productive activities, 2 factors of production (labor and capital), 2 institutional sectors (households and public administration), 1 account for savings/investment, and 1 account representing the foreign sector. In addition, an important tax disaggregation is included, differentiating between employer and employee social contributions, net taxes on products, other net taxes on production and a personal income tax. A novel property of this SAM is the presence of the value-added tax imputed in turn to consumption, investment, and government demand according to their tax rates. The presence of the VAT in the database allows us to calculate purchase prices which is necessary to model, for instance, consumption demand by households since this demand takes place at purchase prices and not at basic prices. The 63 sectors were then aggregated, by related productive affinity, to a simpler subset of 30 sectors. It is worth remarking that this SAM 2016 is the first SAM of the Spanish economy that complements basic prices with purchase prices thus expanding the range of potential applications.

[2] INE is the Spanish National Institute of Statistics. It depends on the Ministry of Economic Affairs.

The SAM follows the schematic representation showed in Table 2. The first three submatrices summarize the transactions between agents of the economy and must comply with the accounting identity in which total gross production is equal to total demand.

Table 2. SAM for Spain. Base year 2016.

	Homogeneous Branches (1…30)	Factors of Production (31) Labour (32) Capital	Institutional Sectors (33) Households (34) Employers' social contributions (35) Net taxes on products (36) VAT (37) Income Tax (IRPF) (38) Social Contributions to employees (39) Public Administration	(40) Savings / Investment	(41) Rest of the World
Homogeneous Branches (1…30)	Intermediate consumption matrix (I)	Final use matrix (III)			
Factors of Production (31) Labour (32) Capital Institutional Sectors (33) Households (34) Employers' social contributions (35) Net taxes on products (36) VAT (37) Income Tax (IRPF) (38) Social Contributions to employees (39) Public Administration (40) Savings / Investment (41) Rest of the World	Primary factors matrix (II)	Closure matrix (IV)			

The composition of each submatrix is described below:

1. **Intermediate consumption matrix**: it records the transactions of intermediate goods and services between the homogeneous economic branches (1-30). It includes all intersectoral relationships included in the I-O table (63 sectors), aggregated to 30 productive sectors, and the total amount corresponds to aggregate intermediate consumption in Spain.
2. **Primary factors matrix**: it is composed by resources used by the productive activities taken from the I-O table, but rearranged according to the structure of a SAM. The labor account (31) is obtained by wages, gross salaries, while capital (32) includes the operating surplus and mixed income. The tax burden is made up of employers' social contributions (34), net taxes on products (35), VAT (36) and the personal income tax (37).

3. **Final use matrix**: the savings/investment account (40) represents the financing capacity or need of the productive sectors; the other accounts include final consumption expenditure by households (33) and by the public administration (39), which includes the purchasing activity of the public sector, and demand by the rest of the world (41) which includes exports to the EU. All taken from the IOT.
4. **Closure matrix**: with this matrix the circular flow of income is closed. For its construction, information related to household income is incorporated from gross wages and salaries, operating surplus, and mixed income minus employers' social contributions. Thus, this information corresponds to the allocation of income received by the productive factors—labor, capital, and government transfers—taken from current accounts by institutional sectors of the annual National Accounts of Spain. Finally, household income is also supplemented with net transfers from the rest of the world, obtained from purchases by non-residents in the economic territory and from purchases by residents outside the economic territory of the destination table. The closing accounts of the SAM will be the deficit (or surplus) of the government and the deficit (or surplus) of the foreign sector. Table 3 shows the SAM in aggregate terms. In this case, as can be seen, the aggregation describes a square matrix with 7 accounts. In all of them, incomes are equal to outlays. The SAM is specified in million Euros.

Table 3. Macro SAM of Spain. Base year 2016.

	Productive activities (1-63)	Labor (64)	Capital (65)	Households (66)	Savings/ Investment (67)	Public Administration (68-73)	Rest of the World (74)	Total
Productive activities (1-63)	922,715	0	0	614,216	197,045	221,587	331,192	2,286,755
Labor (64)	393,890	0	0	0	0	0	0	393,890
Capital (65)	495,819	0	0	0	0	0	0	495,819
Households (66)	0	393,890	495,819	0	13,466	190,720	0	1,093,895
Savings/Investment (67)	261	0	0	297,217	0	0	52,769	350,247
Public Administration (68-73)	151,784	0	0	120,787	262,530	139,736	0	674,837
Rest of the World (74)	322,286	0	0	61,675	0	0	0	383,961
Total	2,286,755	393,890	495,819	1,093,895	350,247	674,837	383,961	

3.2 The allocation of NGEU funds

As stated in a previous section, the volume of resources from NextGenerationEU funds committed to the country of Spain has been approved through the Spanish Recovery and Resilience Plan (Plan de Recuperación, Transformación y Resiliencia, Gobierno de

España, 2021). As we mentioned before, the non-deflated level amounts to more than 168 billion Euros for the period 2021-26 and is projected to go through different phases from budgeted to finally implemented. At the moment of writing this paper, the available information is based on budgeted figures. In broad terms, 40% of the total amount is targeted at green transition, 30% at digital transformation, 10% at R&D and 7% at education and training, fulfilling the European Commission requirements. A major priority of this financing is the investment in human, technological, natural, and scientific capital. The plan comprises a strong social component as well, to the aim of reducing gaps and inequalities and achieving fairer and more sustainable growth. The final, and ideal, aim is to initiate a complete structural change of the economic basis of the country, adapting it to the coming and challenging years.

The distribution of the funds, under the supervision of the European Commission, has been designed in two phases: a first one comprising nearly half of the total budget which is made up of non-refundable aid and a second phase, for which an Addendum has recently been published, which is slightly higher and based on granting loans to EU countries to finance their recovery. For the first time in history, the EU seems to have learnt from the previous financial crisis and is opting for expansionary public spending to boost growth instead of tough austerity measures that proved to be so devastating in the close past.

The Spanish plan defines a series of lines of action (green transition, digital transformation, territorial cohesion, and gender equality) and their corresponding policy levers. The first phase of the plan has been practically covered, pending the approval of the last disbursements. The allocated money is released as the country meets the targets and implements the agreed reforms. The second phase will be launched soon.

In order to assess the impact of NextGenerationEU funds on the Spanish economy, we first need to elaborate an allocation rule that allows us to distribute the total amount received among the 30 branches of activity that make up our Social Accounting Matrix. For this purpose, the Spanish recovery plan contemplates three main categories which have been previously annualized and deflated in accordance with our database; it contemplates three different categories:

1. Investments managed by the Central Government (around 40%) aimed at digitalization, green transition and sustainable transport, science and health, industry, trade and tourism or social protection and education—in addition to the complementary plans with their corresponding sub-branches.

2. Investments in twelve Strategic Projects for the Economic Recovery and Transformation (PERTE in Spanish, which account for a bit under 30%). We list them in order of budgetary importance: microelectronics and semiconductors, renewable energies, renewable hydrogen and storage, development of the electric and connected vehicle, industrial decarburization, digitalization of the water cycle, social and care economy, cutting-edge health, agri-food, new language economy, aerospace, circular economy, and shipbuilding industry.
3. Investments addressed to regional and territorial administrations through the establishment of a co-governance model (slightly above 30%) It includes the respective participation in the PERTE and the receipt of structurally oriented funds through the REACT-EU instrument.

The NextGenerationEU resource is regarded as a temporal tool since it will last as long as the pernicious effects caused by the Covid-19 pandemic persist, although many voices argue that it would be the time to reinforce the EU budget on a structural basis. Regardless of what might be decided on this issue at a later stage, Spain will continue to receive the already approved share via the EU regular budget which rises to 36 billion Euros for the period 2021-27.

For the evaluation of the impact of the funds we have considered three allocations. The first one, that we call the "planned distribution", is based on the strategic allocation to sectors defined by the recovery plan itself. The other two allocations are hypothetical, and they help is gauging the possible efficiency losses of the planned distribution. The "multiplier distribution" is a theoretical alternative distribution built using the multiplier information to calculate multiplier shares that are used to distribute the total allocated funds. Finally, in the "top 3 multiplier distribution" we hypothetically allocate the funds as a function of the top 3 branches of activity with the best multiplier performance. According to the I-O data for the Spanish economy these sectors turn out to be Foodstuffs (3), Electricity and gas (13) and Metal products (8). We report in Table 4 the three distributions.

Table 4. Allocation rules of NextGenerationEU funds under three scenarios. (In millions of Euros).

Activity branches in SAM Spain 2016	Planned Distribution	Multiplier Distribution	Top 3 Multip.Dist.
1. Agriculture	10348,2	4737,1	
2. Mining	663,7	3206,7	
3. Foodstuffs	3166,3	6147,1	49631,0
4. Textiles and leather	1001,9	3839,7	
5. Wood and paper products	547,2	5798,6	
6. Coke and petroleum	461,7	5351,5	
7. Chemical products	2647,9	4968,7	
8. Metal products	1607,8	5801,1	46837,6
9. Electronic and precision products	14105,4	4127,4	
10. Machinery and vehicles	19969,4	5161,1	
11. Other manufactures	919,0	4233,7	
12. Repair services	283,8	5376,6	
13. Electricity and gas	5920,5	5812,8	46931,8
14. Water	210,4	5283,6	
15. Recycling	549,4	5596,7	
16. Construction	9955,4	5541,2	
17. Wholesale and retail	1818,2	4730,3	
18. Transportation	19397,2	5538,2	
19. Telecommunications and postal	1141,9	4917,9	
20. Hostelry	1447,0	4933,3	
21. Entertainment	402,8	5023,7	
22. Financial services	964,8	4532,5	
23. Real estate	2054,1	3369,2	
24. Professional services	1469,2	4809,8	
25. Commercial services	1918,6	4702,1	
26. Public services	16101,7	4042,2	
27. Education	14105,3	3529,3	
28. Health services	8814,1	4289,2	
29. Recreational services	1048,4	4440,9	
30. Personal services	359,3	3558,4	
TOTAL AMOUNT	143400,5	143400,5	143400,5

Source: Own elaboration. Deflated to 2016 prices.

4. Results

Tables 5, 6, and 7 present a selection of results and indicators. In Table 5 we present the main market indicators resulting from the implementation of the three simulation scenarios and we proceed to compare the results with the benchmark equilibrium.

Table 5. Main labor and income indicators

	Benchmark	Planned Distribution	Multiplier Distribution	TOP3 Multiplier Dist.
CPI	1.000	1.063	1.065	1.067
Wage rate	1.000	1.069	1.070	1.070
Demand influence on wage rate (in %)	-	29.764%	28.683%	26.264%
Supply influence on wage rate (in %)	-	68.827%	69.922%	72.409%
Labor income (% change)	-	5.244%	5.023%	4.425%
Non-labor income (% change)	-	4.899%	5.192%	5.773%
Employment (% change)	-	4.686%	4.561%	4.189%

Source: Own elaboration.

As a result of the reception of the NextGenerationEU funds, the consumer price index (CPI) would grow a 6.3%, being these figures very similar although slightly lower than in the second and third simulations 6.5% and 6.7%, respectively. As regards the behavior of the wage rate, no significant differences are found, being around 6.9-7% points of increase in all scenarios. The contribution to the change in the wage rate to demand and supply influences is, however, a bit different. We have calculated a static decomposition using the standard technique (Rose and Casler, 1996) and find that most of the change in the wage rate is driven by its adjustment to the CPI and its consequent impact on marginal costs. About 70% of the change can be attributed to this supply factor. Labor and non-labor income increase in all three simulations, but the ordering moves in opposite directions. The most favorable scenario for labor income is the least favorable for non-labor income, and the other way around. To finish with this table, we observe that the change in the employment level is not significant if we compare the planned distribution with the multiplier one (slightly higher in the first one with 4.68% versus 4.56%), but clearly lower in the top 3 sectors with a 4.19%. This suggests that even if these 3 sectors have the highest output multiplier, their employment multipliers must not be among the top ones. If this is the case, this would also help in explaining the observed result that labor income would increase the least in this third scenario.

Table 6. Main tax indicators after simulations
(In millions of Euros)

	Benchmark	Planned Distribution	Multiplier Distribution	TOP3 Multiplier Dist.
Indirect tax	31,909	35,751	35,920	35,300
Value added tax	82,388	87,816	88,896	88,175
Corporate labor tax	109,834	115,585	115,332	114,711
Personal labor tax	37,143	39,091	39,009	38,786
Income tax	83,644	87,840	87,939	88,087
Total collections	344,918	363,960	364,908	362,831

Source: Own elaboration.

Table 6 provides information about the tax collections for the 5 tax categories we consider. Even though the results are quite similar, some small differences arise. Total collections increase in all cases reflecting the boost in economic activity driven by the disbursement of the funds. Both labor taxes fall in the hypothetical scenarios vis a vis the planned distribution one, which is coherent with the results reported in Table 5 regarding the fall in the use of labor. For the two indirect tax categories, their collections are a bit higher in the multiplier distribution and bit lower in the top3 multiplier distribution than in the planned allocation. In terms of the income tax, collections would be slightly higher in the hypothetical allocations than in the planned one. All things considered, the multiplier distribution would provide a better tax scenario but overall differences are not significant. Regarding the baseline collections, the planned allocation would drive government income by 5.52% whereas in the two alternative scenarios the growth would be of 5.79% and 5.19%, respectively.

Table 7. Main welfare indicators
(In percentage terms when applicable)

	Benchmark	Planned Distribution	Multiplier Distribution	TOP3 Multiplier Dist.
Disposable income (% change)	-	5.325%	5.457%	5.661%
Real GDP (% change)	-	4.916%	5.001%	5.027%
Output index (% change)	-	4.954%	5.125%	5.697%
Equivalent variation (% over real GDP)	-	3.365%	3.445%	3.573%
Compensating variation (% over real GDP)	-	3.022%	3.095%	3.210%
Könus index	1	0.898	0.899	0.898

Source: Own elaboration.

Finally, in Table 7 we report the performance of some welfare indicators. Disposable income increases from the first simulation (5.33%) to the second (5.46%) and third

(5.66%) as well as real GDP that ranks from 4.92% to 5% and finally 5.03%. In the case of the aggregate output index, we find that both hypothetical distributions show a higher impact than the planned distributions. Since the underlying driving force in these two alternative distributions are the output multipliers, these differences in aggregate output change make economic sense. The equivalent and compensating variations, calculated as a percentage over real GDP, again show a slight difference in favor of the third simulation. Finally, the aggregate Könus index of cost of living is essentially the same in all cases indicating a consistent improvement in this relative welfare index (Guerra et al, 2018). To summarize, the top3 multiplier allocation rule outperforms the other two in the great majority of indicators, followed by the multiplier distribution that although very similar in a great bunch of indicators, seems to behave slightly better than the planned one.

5. Conclusions

In this manuscript we have performed an analytical as well as an empirical exercise. In the analytical part we propose a new approach that allows us to connect the two classical I-O modules. Prices and quantities talk to each other, and thus the classical I-O dichotomy is bypassed. This novel approach provides us with an enhanced version of the input-output model. It maintains the simplicity of the model (i.e., linearity) while at the same time facilitates the calculation of a far larger range of economic indicators and respects the price-quantity interactions that describe market behavior.

We have used the enhanced model to perform an empirical analysis of the impact of NextGenerationEU funds in the Spanish economy. The first step in the analysis requires an allocation rule to assign these funds to economic sectors as new investment. We have used the information in the Recovery and Resilience Plan approved for Spain to elaborate the allocation. In order to allow for comparisons, we have calculated two alternative (and hypothetical) allocation rules. The first one was built using a distribution based on the value of the corresponding output multipliers. The second one would just concentrate this aid in three sectors, those with the best performing output multipliers.

From the previous results, we can conclude that the likely impact of the planned distribution of the NextGenerationEU funds seems to be mostly in tune with that of a hypothetical multiplier distribution. Finally, the results we have reported assume that all budgeted funds are eventually executed. Even if the actual losses in real GDP (of almost 10% in 2020) are not fully recovered, the results show that the boost provided by these funds in real GDP (estimated around 5%) show that policies may indeed be effective to counteract the initial acute fall in economic activity and facilitate the road for a speedier recovery.

We hope that the interactions that this integrated price-quantity model (PQ model) captures can be useful to input-output economists and practitioners. The fact that the interactions between the price and quantity modules are incorporated and integrated into a unified model can provide input-output analysis with an additional layer of economic plausibility as well as a better descriptive capacity in its empirical side.

Disclosure statement

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