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The Cost of Housing Construction in Portugal:

AN INPUT-OUTPUT PROPOSAL

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1. Introduction and the Construction Tailors

Attributes the winds that blow in the economic and social landscape are also touching on real estate.

Attention is focused on houses with smaller areas, more modern and efficient, with greater luminosity and outdoor spaces (Sorvig & Thompson, 2018).

Dwellings are just buildings that offer a roof and a floor, but it is families who turn them into homes (Houghton, 2022).

We say that these could be times that bring together a kind of "*construction tailors*" (Sousa, 2023) to make housing a true social asset worthy and available to all.

2. Modernize the Building Processes and the Constructive Speed

There has been, although for a very few years now, an enormous evolution in terms of construction quality, with a change being observed that we might call the *optimization of construction processes*, that is, fast and differentiating construction methods.

Today, the buying and renting market demands a quantity and constructive capacity that calls for modernization or, in other words, "*reduce, reuse, recycle*", in the words of Peterson et al. (2013).

Buildings are being worked on more in the architectural project phase, in economic and financial viability projects, more standardized and with production chains that allow to reveal, in their fair measure, a set of indicators, e.g., the gross construction area, as a basis for determining the "*construction speed*" (Stoy, 2007).

3. The Tangible Housing Construction Costs and the Well-being

Technological innovation accelerates the development of construction techniques for residential buildings and has attracted much attention from stakeholders who promote technological innovation (Ma et al., 2023).

Prefabrication is now a reality to stay, and may be the right choice for anyone looking for a comfortable, flexible and adaptable space to different needs.

On the other hand, land acquisitions are already being made and with more standard construction projects, with more accessible construction costs, in the sense that they are even more attractive products for the renting area.

3. The Tangible Housing Construction Costs and the Well-being

In Portugal, the shortage of housing supply "*results from the combined effect of bad government housing policies and wrong incentives to housing developers offered by the tax system, particularly in the housing rental market*", which has motivated the rise in prices and rents (Euroconstruct (2022, 346).

A second reason was trends in housing demand, which took shape during the pandemic and are here to stay. The transaction of houses became more rational. Builders quickly adjust to current developments and trends.

The market will continue to feel that people are thinking less and less about a house for life. And even if they remain in the house, what we see is that people get tired of seeing the house always the same.

4. The Application of the Input-Output Model: Methodology for the Portuguese Case

In economic science, the input-output model is a way of quantitatively representing the interdependence between the sectors that make up an economy, and is based on linear algebra, more specifically, matrices and linear systems.

The main objective underlying this strategy is to match the demand for housing in Portugal with the construction of houses through intermediate products and services that are not only necessary, but also essential for added value along the construction value chain, enabling a building upgrade.

Based on the model presented and developed by Williams (2013, 75-80), we assume that the output of housing in Portugal is formed by 5 types of sectors: construction costs, reinforced concrete structures, cement, transport and labour.

4. The Application of the Input-Output Model: Methodology for the Portuguese Case

We consider a matrix whose lines (inputs) are constituted by the 5 sectors of inputs that contribute to the final construction of housing.

To calculate the value of each coefficient for each sector, we used the relative weighting of each industrial sector as a function of final production measured by the Gross Added Value (GAV), based on available statistical data.

The direct content of national production can be broken down by the necessary inputs for this production, e.g., national intermediate inputs (produced internally) and inputs designated as primary, consisting of imported inputs, taxes and subsidies on GAV inputs and components (wages, employer social contributions, other taxes, net of subsidies, on production, consumption of fixed capital and net operating surplus).

5. Data Analysis

Inputs	Outputs			
	Construction	Reinforced Concrete Structures	Cement	Transport
Construction	0,2	0,3	0,3	0,2
Reinforced Concrete Structures	0,2	0,1	0,2	0,2
Cement	0,1	0,3	0,1	0,2
Transport	0,3	0,1	0,2	0,1
Labour	0,2	0,2	0,2	0,3
Total Inputs	1	1	1	1

The proposed Input-output matrix ("C") represents the housing sector in Portugal. The matrix shows the inter-relations between the 4 sectors: construction, reinforced concrete structures, cement and transport (*labour is represented in the matrix*).

5. Data Analysis

The Leontief equation relates the production of the total sectors (p), final demand (d) and the input-output matrix (C):

$$\boldsymbol{d = p - C \cdot p}$$

The production of all the sectors considered (GAV) in our model will contribute to the final demand and to the demand of the other sectors (internal demand of the sectors).

The amount of production necessary to sustain intersectorial needs and a final demand is given by:

$$\boldsymbol{p = (I - C)^{-1} \cdot d}$$

Production (p), is our objective, and can be calculated by the inverse Leontief matrix multiplied by the final demand of all sectors (4 in this economic model).

$\boldsymbol{(I - C)^{-1}}$ is known as the Inverse Leontief Matrix ("I" is the identity matrix and "C" our matrix input-output).

5. Data Analysis

Using the Leontief equation as bases, we aim to answer the following question:

What should be the production level for each sector in order to maximize the amount of housing available, at the end of a time period?

In our case, maximizing the housing available is translated into maximizing the final demand (d) for the "*construction sector*" (there are more sectors in the economy).

However, since resources are not infinite, there are constraints on the total amount that the economy can devote to any single sector.

5. Data Analysis

The Constraint Programming is known as a technique to solve mathematical equations while respecting constraints on the possible solutions (e.g., we can't put everything into construction; what about the other sectors? How would we eat?).

In particular, linear programming is a technique that allows the solving of mathematical equations with constraints for optimizing a specific goal.

Our aim is to use linear programming to support the representation of the housing economy (the 4 sectors), through the input-output analysis (“C”), to propose production strategies in order to reach our goal of maximizing housing construction.

6. Conclusions

Going in a different direction from conventional activation methods, the strategies proposed in this work admit the low use of natural materials in Portuguese housing.

Until a few years ago, more energy-intensive processes were used in construction, the use of chemical activators, calcination and curing at high temperatures to promote rapid reactions, the improvement of hydration reactions and the performance of binders that were carried out by increasing of materials, e.g., natural low-carbon materials over fast-reacting materials.

The model allows the exploration of complementary future studies in the area of housing construction, creating more competent and versatile potential future synergies, something that becomes increasingly important in the professional world when comparing among countries.

Dzięki