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Putting land to work: An evaluation of the economic effects of recultivating abandoned farmland

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ABSTRACT

Agricultural land abandonment is a relevant occurrence in mountainous and peripheral regions all over the world. While both positive and negative environmental consequences of this abandonment are documented (depending on the specific location and scale), in rural areas it is always linked to a reduction in production and income. To address some of these problems, the several administrative layers within the European Union (EU) have put in place public policies that focus either on the immediate causes or on the consequences. Policies aimed at promoting recultivating formerly abandoned fields have usually tried simultaneously to address both the causes (e.g., to increase farm productivity/output) and the consequences (i.e., to manage fields according to specific criteria), but the potential economic outcomes of these measures are unknown. In this paper, we estimate the effect of recultivation of abandoned farmland on the economy of a case study region in NW Spain (Galicia). We propose that this effect can be used to guide decisions on the viable expenditure levels of recultivation policy. Concerning the methodology, we relied upon geographic information systems to show the area of land suitable for recultivation is relevant: i.e. recultivation policies could result in an increase of at least 16% of current farmland. Using Standard Production Coefficients per hectare we show that the total output (at constant prices) generated by the recultivation of abandoned land would amount to 413.3 million euros/year. Calculations based on input output methods suggest that the benefits of the recultivation policies would be an increase of 1% of the total regional Gross Value Added (GVA). We show that the input-output methods underestimate the benefits of cultivation policies based on total factor productivity (TFP) improvements, which fundamentally come from the reallocation of factors among the rest of the sectors of the economy. In particular, if recultivation policies increase agricultural TFP by 26% (in order to increase the demand of land by 16%) the overall effect rises to around 3% of the total regional GVA. These results suggest that the margin for the implementation of recultivation policies before they turn unadvisable from a purely economic point of view is rather ample.

1. Introduction

Abandonment of previously cultivated agricultural land is one of the dominant processes of change in rural areas of Europe, North America and some regions in Asia (MacDonald et al., 2000; Munroe et al., 2013; van Vliet et al., 2015; Lasanta et al., 2017). This is an ongoing trend and will continue into the next few decades (van der Zanden et al., 2017). Farmland abandonment is largely concentrated in mountains, in remote regions, or in regions where, for any other reason, agriculture becomes a less profitable use of land. Depending on the specific locations where abandonment takes place and on its scale, the resulting environmental impacts can either be positive or negative (Munroe et al., 2013). In low-intensity farming systems characterized by a diverse mosaic of land covers, farmland abandonment is associated with the loss of traditional,

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environmentally valuable, agricultural landscapes. Moreover, in areas around the Mediterranean basin, it is also associated with vegetation encroachment that can increase the probability and severity of wildfires (e.g. Sil et al., 2019; Montiel Molina et al., 2019). Therefore, farmland abandonment is mostly perceived as a policy challenge (van der Zanden et al., 2017). Specific approaches have been designed during the last few decades at different administrative levels in an effort to revert this abandonment or, at least, to reduce its negative outcomes. Examples at European level include the preparation of indicators of abandonment risk (Terres et al., 2015) and the proposal of agricultural and trade policy reforms (Renwick et al., 2013). National and regional administrations, on the other hand, have proposed land reform programmes (e.g. land consolidation, land banking) in order to reduce property fragmentation and, eventually, abandonment (van Dijk and Kopeva, 2006; Hartvigsen, 2014).

As the negative or positive environmental consequences of farmland abandonment crucially depend on local conditions, there is some debate in the scientific literature on whether abandoned fields should be left to their spontaneous evolution or, on the contrary, they should be actively managed (Lasanta et al. (2015) have composed a review of the arguments on both sides). Proponents of passive management have argued that spontaneous revegetation can allow the populations of certain species to recover from human intervention and help to restore natural ecosystem processes (Romero-Díaz et al., 2017). On the other hand, other authors have suggested that maintaining some degree of active management (e.g. extensive grazing by goat and sheep flocks) can result in positive effects on biodiversity (Halada et al., 2017) and on an effective reduction of fuel loads and, therefore, on wildfire risk (Ruíz Mirazo et al., 2011). In general, except when local factors make it preferable to let vegetation autonomously evolve, active management seems a reasonable choice. This is particularly true in areas where historic human intervention has resulted in mosaic systems of high natural and cultural value (Lomba et al., 2014).

Not all farmland abandonment in Europe has taken place in marginal areas, from the point of view of agricultural production. Social and institutional changes have resulted in large tracts of good productive land not being farmed. This was often the case following the collapse of the Soviet Union and other socialist regimes in Eastern Europe, for example (e.g. Dara et al., 2020). Since then, market forces have been acting to bring the most productive areas back into production (Smaliychuk et al., 2016). Nevertheless, in areas with strong handicaps to agricultural production, which are often located away from consumption centres and/or with strong conditioning arising from land ownership structures and land market mobility, it seems unlikely that market forces alone would achieve the recultivation or active management of abandoned land. In these areas, policy makers face the challenge of reactivating agricultural management in order to reorganize the spaces and to prevent further economic collapse (Lasanta et al., 2015). Policies aimed at promoting recultivation of formerly abandoned fields can address simultaneously both the causes (e.g. increasing farm productivity/income) and the consequences (managing fields according to specific criteria). Implemented measures can act indirectly on the recultivation process, by setting up instruments that increase agricultural productivity (e.g. land consolidation, land banking, pre-emptive property rights arrangements, improvement of accessible information about land markets.) and demand of land (van Holst et al., 2014).

In this paper, we evaluate the potential economic effects of public policies directed at promoting the recultivation of suitable abandoned land for agricultural production. While the actual cost of recultivation policies is unknown and hard to estimate, their expected economic outcome can be used as a reasonable upper expenditure threshold. More specifically, we propose three complementary methods that one may use to estimate the effect of recultivation on the Gross Value Added (GVA) of the agricultural sector and the total GVA of the regional economy in both the short run and the long run. For the purposes of this work, we used a broad definition of abandoned farmland that includes all current shrublands and rangelands that are potentially suitable for agriculture or livestock grazing. Specific techniques used for the paper include geographic information systems (to estimate the quantity and quality of abandoned land), average productivity values for the agricultural sector (to estimate the direct effects), standard input-output economic analysis (to determine the short-term effects) and Computable General Equilibrium (CGE) models (to determine the long-term effects) to simulate the impact of an external shock on the agricultural sector productivity.

2. Study area

In this paper, we focus on the Spanish region (NUTS 2) of Galicia as a case study. Located in a peripheral position on the northwest of Spain, this region has a rather hilly topography. Small-scale family farms (average farm UAA was 8.1 ha according to FSS data in 2016, about a third of the Spanish average; INE, 2017) clearly predominate with a very fragmented property system (average land plot is 0.25 ha; DGC, 2019). A general trend of farmland abandonment has occurred simultaneously with the depopulation of rural areas since the 1960s. In fact, after the accession of Spain to the European Economic Community in 1986, the total number of farms decreased at the same rate at which agricultural areas accelerated (Corbelle Rico et al., 2015). As a consequence of land use/cover changes over the last half century, the territory has undergone intense spatial specialization, with wood production dominating the western third, dairy production dominating the central third, and spontaneous vegetation encroachment being dominant in the eastern mountainous areas. The combination of high natural biomass productivity, forest expansion in the west, and spontaneous vegetation growth in the east, with short periods of draught during the summer, has resulted in a very high risk of wildfires. This is of greater concern in the wild-urban interface between populated and semi-natural areas (Chas-Amil et al., 2013) and it caused a steady increase of yearly public spending in fire suppression equipment and infrastructures that reached 173 million euro in 2020 (Xunta de Galicia, 2020).

During the last six decades, the area devoted to crops and pastures was constrained to a small portion of the territory (just over 20%), while the agro-livestock uses of hill land, which were very important up to the mid-twentieth century, disappeared. All this led to a remarkable expansion of abandoned land and has had a major impact on the dynamics of the agricultural sector, limiting farm sizes and causing an increasing intensification in a small portion of the territory. Because of all this, we are faced with the paradoxical case of a region in which the land has historically been, and remains today, a scarce production factor in the agriculture industry, characterized at the same time by a significant farmland abandonment (López-Iglesias et al., 2013). Therefore, throughout the last two decades, successive regional governments have attempted to implement legal norms and regulations intended to reduce the extent of abandoned farmland, including land consolidation, land banking, and experimental creation of legal arrangements for collective management of land that overcome the deadlocks caused by absentee owners (Coimbra (2011)).[1] The last instalment of this series is the *Law for the recovery of agricultural land of* Galicia (passed in May 2021). This law sets up a combination of zoning regulations, information systems about land markets, creation of administrative departments specialized in facilitating agreements concerning property rights and legal instruments for the regulation of property rights, with the final aim of promoting recultivation of formerly abandoned land. The motivation behind this and former legal instruments is two-folded: 1) to improve the farming sector's economic viability at the same time as its environmental sustainability, by reducing the livestock intensity in some areas;

[1] Regional autonomy in Spain is very strong, including significant legislative powers. From a comparative perspective, the Regional Authority Index ranks Spanish regions in the World TOP-5 in 2010. See https://www.arjanschakel.nl/index.php/regional-authority-index

Table 1
Summary of areas potentially useful for recultivation, by suitability class and inclusion in Natura 2000.

Suitability class	Inside Natura 2000		Outside Natura 2000	Total
Class 1	498 ha	(4.3%)	11,092 ha	11,590 ha
Class 2	1514 ha	(3.6%)	40,590 ha	42,104 ha
Class 3	1376 ha	(2.4%)	55,003 ha	56,379 ha
Class 4	28,175 ha	(12.5%)	197,042 ha	225,217 ha
Class 5	50,243 ha	(28.4%)	126,771 ha	177,014 ha
Total	81,808 ha	(16.0%)	430,500 ha	512,308 ha

Source: Authors' elaboration from IGN (2019) and Díaz-Fierros Viqueira and Gil Sotres (1984).

and 2) to reduce wildfire risk. The main reasoning for the reduction of wildfire risk lies in the overall reduction and fragmentation of the total biomass above the terrain.

3. Materials and methods

For the methodology, we followed four sequential steps. In the first step, we used a geographic information system to estimate the total amount of abandoned land that might be useful for recultivation. In the second step, using average statistical figures for the farming sector from two different sources (resulting in a low and a high estimation) we estimated the direct impact of recultivation on the agricultural output and GVA. In the third step, using standard input-output economic analysis, we estimated the total (direct and indirect) short-run effects on the whole regional economy, both in terms of employment and total GVA. Finally, in the fourth step we used a simulation built on a CGE model to estimate the (direct and indirect) total long-run impacts on relative prices and on the GVA for the whole regional economy when computed after factorial reallocation and process adjustments.

3.1. Estimation of amount and location of abandoned areas suitable for crops or grasslands

As mentioned above, for the purposes of this paper, we define abandoned agricultural land as any area suitable for agricultural use that is presently covered by shrubs or woody vegetation. To determine the location of these areas in the region, we used two main cartographic sources: the latest edition (2014) of the SIOSE Spanish land use/cover maps (IGN, 2019) and the Soil Capability Map produced by Díaz-Fierros Viqueira and Gil-Sotres (1984). We performed the spatial analysis using GRASS GIS (GRASS Development Team, 2018).

SIOSE 2014 is the most up-to-date source available about land use/ cover for a region. Instead of assigning each patch a single category, this map records the proportion of a patch area covered by each single category. We considered patches of total areas that were covered at least 50% by shrubs and woody vegetation (SIOSE categories 300 and 320) to be potentially suitable for recultivation. We also recorded the existence of nature conservation areas (Natura 2000).

We determined the suitability for agricultural use using the estimation provided by Díaz-Fierros and Gil-Sotres (1984), who categorized all regions in terms of suitability for maize and pastures into five classes. Following FAO's (1976) recommendations, A1 represents highly suitable land; A2, intermediate; A3, marginal; and N1 and N2 are not suitable. Using this information, we prepared a set of five combined suitability classes by merging suitability for maize and pastures (See Table A.1. in Appendix A). Class 1 includes highly suitable areas for both uses. Suitable areas for maize that are highly suitable for pastures fall in Class 2. Class 3 includes areas that are marginal for maize but suitable or highly suitable for pastures. Unsuitable areas for maize but that are suitable or highly suitable for pastures fall in Class 4. Finally, Class 5 refers to marginal areas for pastures that are not suitable for maize.

3.2. Estimations of the direct economic effects on the agricultural output and GVA

We based the estimation of recultivation's direct economic effects on two main variables. First, we assigned areas of land that had previously been identified as potentially suitable for recultivation to specific agricultural uses or productions, based on their estimated suitability. Second, we applied standard or reference values of economic output per hectare for each kind of agricultural use. Different statistical sources allow for different approaches to the estimation of those reference values. Standard Production Coefficients published by the Spanish Ministry of Agriculture (MAPA, 2017) are useful in estimating the economic output per hectare of different agricultural productions at the regional level. Other sources, like Farm Structure Surveys and Spanish Farm Accountancy Data Network (MAPA, 2018), use farms as the basic sampling unit and, therefore, land suitable for a given agricultural use is not, strictly speaking, assigned to one particular crop/production, but rather to a type of farming (productive system). Hence, the expected output from a given piece of land for certain farm types is not just the output associated with the production but the output per hectare of the whole farm, as an economic unit. This is particularly evident in cattle farms. When a piece of land is assigned to cattle farming, the expected output produced is not just the value of forage but the value generated by the farm that is associated with the additional forage produced. For this paper, we relied upon the two aforementioned data source types to produce two estimates of the production value that could be allocated to currently abandoned land.

3.2.1. The value of production based on standard production coefficients

In the first calculation, we estimated the value of agricultural production in re-cultivated land by applying Standard Production Coefficients per hectare, at the regional level and for the different types of crops or land uses, as published by the Spanish Ministry of Agriculture. Production values correspond to the average for the period 2011–2015 (MAPA, 2017).

Applying the respective Standard Production Coefficient, we assigned land to a unique production (See Table A.2 in Appendix A), corresponding to each of the five suitability classes identified in Table 1. At least part of the land that was included in Class 1 could be useful for crops of higher value than maize (e.g. vineyards, vegetable gardens, etc.). Unfortunately, the data in the original suitability map does not allow for further refining this classification. Hence, the estimation resulting from this assignment should be considered to be rather conservative. We selected forage maize for the first two classes as it occupies the vast majority of maize crops in the region: Grain maize only represents about 20% of total maize area according to the Yearly Agricultural Statistical Data published by the regional government (CMR, 2018).

Once we estimated the increase in agricultural output that would result from the recultivation of these areas, we calculated the impact on GVA by applying the GVA/total output ratio indicated by the economic accounts of Galician agriculture. We carried out this analysis at both the regional and the municipal (LAU 2) levels. The municipal level's aim is to identify which areas within the region could see a larger boost to their economic activity.

3.2.2. The value of production based on productive systems

As a robustness check of results, we implemented a second approach to estimate the value of the agricultural output resulting from recultivating abandoned land. This approach relies on values from Farm Structure Survey 2016 (as published by the Spanish Statistical Office).[2] The main difference between the two approaches, as mentioned above, is that Farm Structure Surveys do take into account the whole productive system, instead of only specific crops. Accordingly, we assigned the

[2] We rule out FADN data because of its limited representativeness.

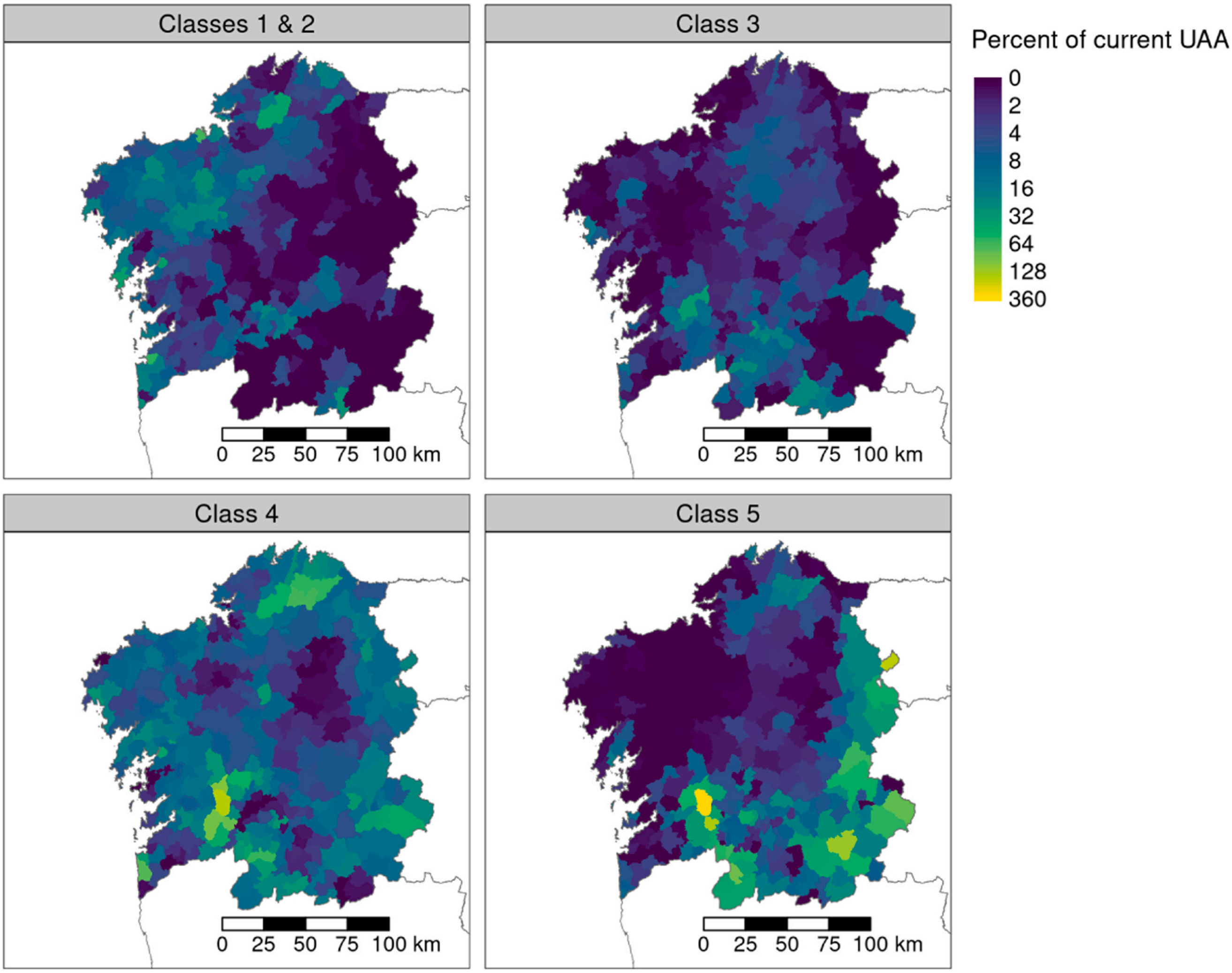

Fig. 1. Distribution of land potentially useful for recultivation across municipalities, expressed as percentage relative to current utilized agricultural area in each municipality, by combined suitability classes.
Source: Authors' elaboration from IGN (2019) and Díaz-Fierros Viqueira and Gil Sotres (1984).

most probable farming system to each suitability class, using average production values from the Farms Structure Survey (for details, see Table A.3 in Appendix A). As in the previous case, some of the abandoned land could be part of different farming systems from those indicated in the table. The assignment is based on the most common farming systems present in the region.

3.3. *The estimation of recultivation's short-run indirect economic effects*

The Economic Impact Assessment (EIA) can be considered a method for providing arguments for governments to undertake policies offering the necessary information (Philippidis et al., 2019; Taks et al., 2011). Moreover, Burgan and Mules (2001) demonstrated the EIA's potential under the presumption that resources are underused.

For our purpose, following Kwiatkowski (2016) recommendations, we chose the input-output methodology in order to estimate sectorial interconnections and short-run multiplier effects. One of the most common tools is Input–Output (IO) tables, which capture the structure of linkages among the production sectors of the local economy (Miller and Blair, 2009). While the Social Accounting Matrix (SAM) could be more appropriate (Allan et al., 2011), in our case IO tables were more operative.

We used the IO tables provided by the Galician Statistical Institute (IGE) for the regional Galician economy in 2016. Following the IO methodology, we estimated the matrix of technical coefficients (A = [aij]) from the IO tables. We then used the matrix to estimate the effects on the different sectors' production due to the increase in expenses. One advantage of this method is that it allowed us, without the need of simulation, to get the value of multipliers through the 'inverse matrix' (I-A)$^{-1}$.

Specifically, the methodology is as follows (Allan et al., 2014). From the above matrix of technical coefficients A:

$$A = x \cdot [diag(q)]^{-1}$$

$$a_{ij} = \frac{u_{ij}}{q_j}$$

Where a_{ij} is the total production of sector j; u_{ij} is the value of sales of intermediate products that sector i provides to sector j, and q_j measures the percentage of sector j production that comes from sector i. It is transformed into:

$$q = [1 - A]^{-1} \cdot FD$$

Where FD is the final demand.

The inverse matrix is obtained from matrix A:

$$B = [1 - A]^{-1} - 1 = b_{ij}$$

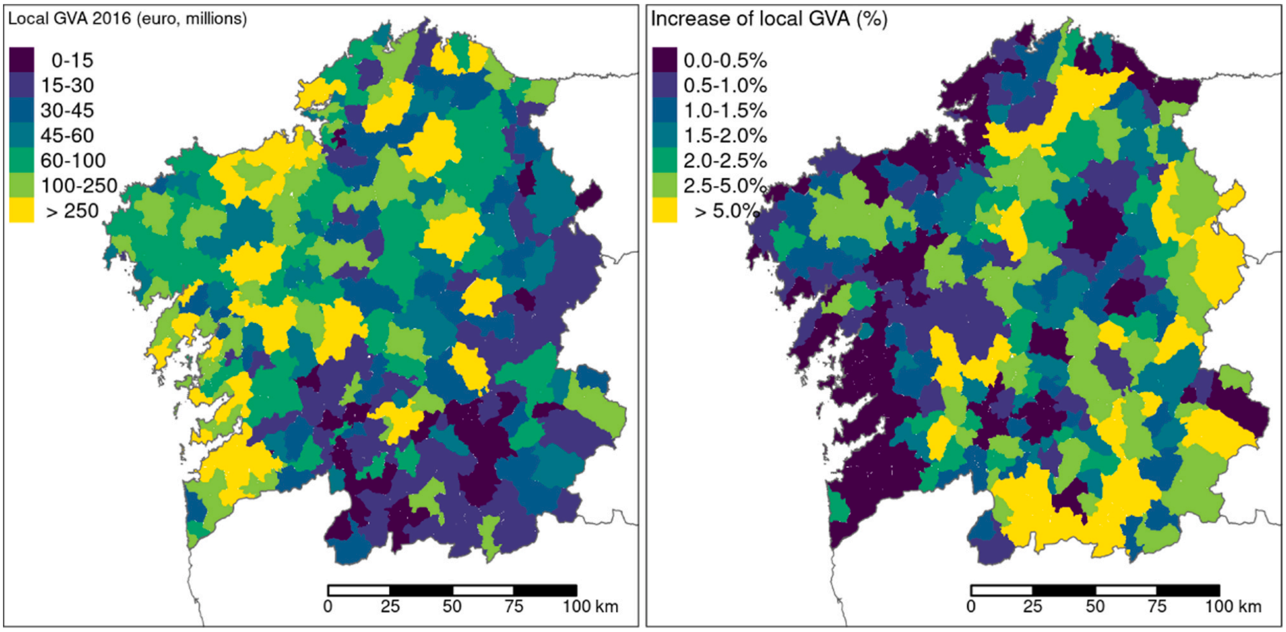

Fig. 2. Local GVA (2016, millions of Euro) and estimated increase of local GVA resulting from recultivation of abandoned land (percentage over total local GVA in 2016).
Source: Authors' elaboration.

Table 2
Short run total (direct and indirect) economic effects by main branches.

Code	Branch	%
R01	Agriculture, livestock, hunting and related services	84.5%
R46	Retail trade and trade intermediaries, except motor vehicles	3.1%
R10D	Products manufacturing for animal feed	2.0%
R49	Land and pipe transport	1.2%
R74_75	Other professional, scientific, technical and veterinary activities	1.1%

Source: Authors ́ elaboration from survey data

Table 3
Short run impact on the main economic aggregates resulting from increased agricultural production derived from the valuation/mobilization of abandoned lands.

	Estimated Impact		
	Mean	Minimum	Maximum
Production (million euros)	1.004,1	678,9	1.329,4
Total GVA (million euros)	473,8	357,6	589,9
Employment (number of jobs)	10.209	6.902	13.515

Source: Authors ́ elaboration from survey data

Coefficients in this matrix provide information about the multiplier effect. Specifically, each one of those coefficients offers the added increase in the production of each sector i due to one unit of increment in the final demand on sector j. The B matrix is known as the 'impact multipliers matrix'. We will use it to estimate the impact induced by the new situation of recultivation.

3.4. The impact of an external shock on the agricultural TFP

In order to estimate the total long-run effects, we relied upon a different methodology, one that allowed us to capture more sophisticated effects, involving changes in relative prices and labour reallocation. Specifically, we used a CGE model based on Kehoe and Kehoe's (1994) work. In recent years, a large amount of literature has been generated that uses CGE to analyse the impacts of agricultural policies

Table 4
Intrasectoral impact: input and real output reallocations.

	Baseline economy		Simulated economy	
Agricultural TFP (domestic firms	4.7782		6.0235	
$\beta_{agr,\ d}$)	194.50		225.62	
Total Land	35,313.30		36,414.91	
Total Labour	1101.61		998.59	
	693.40		748.41	
- Agri	33,518.29		34,667.91	
- Food Man	17,656.60		17,656.60	
- Other	550.81		484.19	
Total Capital	346.70		362.88	
	16,759.09		16,809.52	
- Agri				
- Food Man				
- Other				
	real output	price	real output	price
- Agric	4260.45	1.00	4673.75	0.9145
- Food Man	7566.37	1.00	7912.99	0.9993
- Other	124,086.98	1.00	126,462.20	1.0184

Source: Authors' elaboration from CGE model.

(Carvalho et al., 2017; da Silva et al., 2017; Jendrzejewski, 2020; Milczarek-Andrzejewska et al., 2018; Shikur, 2020; Zavalloni et al., 2021). Models similar to the one presented here are regularly used for the evaluation of ecosystem services (e.g. Wang et al., 2020). We built a three-sector economy and used an IO table as the data source for calibrating the model.

We followed a conservative approach by using the minimum value estimated for the increase of agricultural production as input for the model. Note that we aggregated several food manufacturing sectors into a unique 'food manufacturing sector' and the rest of the economy into the 'other sector'.

The model matches the 2016 input-output table of the Galician economy (the baseline economy): that is, the model matches all the transactions observed in the real world. For this reason, the calibration is based on the own 2016 input-output table reported in the appendix. This procedure is standard in the literature (see Kehoe and Kehoe, 1994). The columns show the expenditures of each sector in intermediate goods and imports, and the amount of land, labour, and capital rents generated in

Table 5
Simulated Economy after factor reallocation and prices response following impact of the recultivation of abandoned land (million euro).

	Agr.	F. Man.	Other.	Con.	Inv.	Exp.	Total
Agriculture	413	1615	196	852	132	1066	4274
Food Manufacturing	945	812	1530	2513	25	2081	7907
Other sectors	545	1507	50,083	42,776	8.744	25,138	128,793
Imports	696	2850	24,982				28,528
Land rents	176						176
Labour Compensation	999	748	34,668				36,415
Returns to Capital	499	377	17,734				18,207
Total	4274	7907	128,793	46,141	8901	28,285	

Source: Authors' elaboration from CGE model.

Table 6
Impact on national income product accounts (million euro).

	Baseline economy		Simulated economy	
	Product	Income	Product	Income
Consumption	44,764		46,141	
Investment	8635		8901	
Net Exports	-235		-243	
Labour Income		35,313		36,416
Capital Income		17,657		18,207
Land income		196		176
Total regional GVA	53,164	53,164	54,799	54,799

Source: Authors' elaboration from CGE model.

the sector. The rows show the income received. The three first figures are intermediate goods (agricultural firms sell by value of 1653 million euros to food manufacturing firms). Finally, the model is solved assuming economic rationality (For details, see Tables A.4–A.6 in Appendix A).

Once the model is calibrated we simulate the impact of increasing the TFP of the agricultural sector and the total labour supply of the economy. In this new economy all the previously underused land is cultivated (i.e, the demand of land increases) and the real output of the agricultural sector increases.

4. Results

4.1. Potentially suitable abandoned areas for agriculture

We identified 512,308 ha of potentially useful land for recultivation that is currently not being used by agriculture (Table 1). Most of the area (78%) fits into classes that are suitable for pastures but not for crops (Classes 4 and 5), with only a relatively small fraction being suitable for the latter. Compared with the current agricultural area (UAA, estimated around 672,291 ha, based on SIOSE 2014 data), (re)cultivation of all of the land included in the first three classes would mean an increase of around 16%. Recultivation of land included in the five suitability classes would almost duplicate the current UAA, as it would result in an increase of around 76%. Areas designated for nature protection (Natura 2000) represent a small fraction (2.4–4.3%) of the first three suitability classes, but they increase their presence in suitability Classes 4 (12.5%) and 5 (28.4%).

The distribution of potentially useful land for recultivation across municipalities revealed an interesting pattern from the coastal areas in the west to the mountainous areas in the east (Fig. 1). Recultivation of land in Classes 1 and 2 would increase the current UAA by as much as 40–60% in municipalities at lower altitudes, while Class 5 would be more important in mountainous areas, where it could double or triple the current UAA. Classes 3 and 4 appear more evenly distributed (particularly Class 4). This pattern reflects the current distribution of both the UAA and the suitability of soils for agricultural use: currently, the UAA represents a much smaller share of the total municipal area in mountainous municipalities, where the recultivation of relatively large, but relatively marginal, areas would boost the current UAA. At the same time, the larger presence of Class 5 in mountain areas is expected and related to the lower suitability for crops in those places.

4.2. The direct effect of recultivation on agricultural output

Based on the standard production coefficients for the value production in each suitability class, the total output generated by the recultivation of abandoned land would amount to 413.3 million euros/year. Most of that output is generated by land in suitability Classes 3 and 4 (300.9 million euros/year, 73% of the total). Most of the remaining output value would be produced in land of Classes 1 and 2 (94.1 million euros/year), even if they occupied a much smaller area than Class 5 due to the lower productivity of the latter (18.2 million euros/year). The resulting increase in the agricultural GVA of the region would be around 264.5 million euros/year, which would mean a relative increase of 14.4% and a direct impact on the total regional GVA of 0.49%.

In the second calculation performed, based on the allocation of complete farming systems to each suitability class, using data from Farm Structure Survey 2016 as a reference, we estimated the total output derived from the recultivation of abandoned land to be much higher, at 809.3 million euros/year. The increase in the GVA of the agricultural sector reached 420.8 million euros, 22.9% in relative terms, and the direct impact on the regional total GVA would amount to 0.79%. Most of the difference between both approaches is due to the inclusion, in the second one, of the coupled effects with other production (e.g. cattle) that the first approach did not account for.

The increase of the municipal GVA would be proportionately greater in municipalities that currently have lower values (Fig. 2). The economic importance of the recultivation of abandoned land, therefore, would be greater in remote and relatively marginal municipalities.

4.3. Total (direct and indirect) short-run effects of recultivation on the whole regional economy

In order to estimate the induced economic impact, it is necessary to estimate multiplier effects. According the IO methodology, the first step is to identify the branches with a direct effect from recultivation. We considered the whole direct effect to be that which corresponded to the branch R1 “Agriculture, livestock, hunting and related services”. Table 2 provides a summary of the most- affected main branches.

From calculating the impact on the total production of the Galician economy using the initial shock data quantified in the preceding section, we obtained an amount ranging from almost 700 million to over 1300 million euros: between 678,875,884 and 1,329,410,469. The total impact (direct plus induced) on the output of the Galician economy in the short run is about 1.7 times larger than the increase on agricultural production. We also looked at the relationship between this magnitude and the GVA for each branch. Once again, the input-output framework provides this information through the percentual distribution of intermediate consumption for the branch under analysis. We then obtained the full impact on the regional GVA as quantified within a range of over 350 million and almost 600 million euros (specifically between

357,626,087 and 589,926,926 euros).

This global impact resulting from the initial shock represents an average of around 1.0% of the total GVA of the Galician economy. Most of this increase would be concentrated in the direct and induced growth in the GVA of the agricultural sector.

Finally, using the work coefficients provided by the Input-Output Framework, we quantified the total employment to be created in the Galician economy as a result of increased production in the different branches. Based on the aforementioned figures, we obtained an average impact on employment of about 10,000 new jobs, corresponding to an interval of between 6902 and 13,515 jobs. These figures comprise more than 1% of the total employment of the region (specifically a 1.2%). Table 3 reflects the main effects resulting from a hypothetical mobilization of currently abandoned land.

4.4. The total long-run effects of recultivation on the whole regional economy

Table 4 shows the impact of an external shock on the TFP of the agricultural sector. In it, a 26.06% increase of TFP of the agricultural domestic firms (6.0235/4.7782), and a 3.11% increase of labour supply (36414.91/35313.30) results in an increase of the total area of cultivated land of 16% (225.62/ 194.50), which is the amount of the potentially recultivated land in the benchmark economy. Note that recultivation policies that increase TFP in the agricultural sector reallocate capital and labour among sectors. Therefore, final real output increases in the three sectors: 413.3, 346.62 and 9762.5 millions in the agricultural, food manufactured and other sector, respectively. Finally, it should be noted as well that recultivation policies that increase agricultural TFP also reduce prices of agricultural goods.

Table 5 shows the whole simulated economy after factor/real output reallocation and prices response and Table 6 represents a summary of these impacts and relates the IO table to the national income product accounts. After taking these factors into account, we found that the long-run full impact on the regional total GVA would be 1635 million euros/year (a 3.08% increase).

5. Discussion

The direct increase of GVA by agriculture and animal husbandry produced by recultivating formerly abandoned farmland would be rather significant: At 265–410 million euros/year, depending on the calculation method, it would represent about a 14–23% increase over the sector's current 1800 million euros/year (IGE, 2019). This potential increase would result from the cultivation or grazing of an additional 76% of the land, although the largest contribution in economic terms would be generated by just a small fraction of it (i.e., Classes 1–3, representing about 22% of the potentially re-cultivated land and about 16% of the current agricultural area).

The best potentially useful lands (Classes 1–3) are concentrated in economically active areas where the farming sector is relatively healthy. Thus, although the contribution of land suitability Classes 4 and 5 toward increasing the farming sector's GVA is relatively lower (per unit of area and on the whole), their impact on the local economy would probably be much greater, as these classes are concentrated in mountain areas where farmland abandonment, depopulation, and population ageing are prevalent. In these locations, the potential societal benefits of recultivating abandoned land may be more important because of its contribution to the development of neglected rural communities rather than because of its contribution to the primary sector's total economic output.

The impact on the whole regional economy would be much lower, due to the share of agriculture over total economic activity. Still, the short-run effect of recultivation would be a noticeable additional 1.0% of the total GVA and about 10,000 additional jobs in the region, around 1.2% of total employment. The long-run effects would naturally be higher (3.08% increase). The validity of these results depends on the assumption that 1) all the necessary economic and labour resources could be correctly mobilized in order to initiate cultivation or grazing of all the additional land and 2) demand of land from the farming sector would be enough to absorb the additional supply of land. In regard to the first question, we argue that the factors that may drive this recultivation of abandoned land are institutional changes (e.g. those included in the recent *Law for the recovery of agricultural land of Galicia*) or policy regulations (e.g. mechanisms currently in discussion in the Spanish implementation of EU Common Agricultural Policy for the period 2023–2027, such as convergence of basic aid per hectare, eco-schemes or agri-environmental aid for extensive livestock). Concerning the second assumption, it should be noted that Spain has been a net importer of biomass from agriculture, particularly of cereals and forage crops, for several decades (Soto et al., 2016; Rodríguez and Camacho, 2020). Within this context, Galicia played a twofold core-periphery role, acting as sink of natural resources from lower income countries and as a source towards wealthier areas in Spain and Europe (Piñeiro et al., 2020). Much of this is related to the needs of dairy farms, currently unable to produce locally all the forage they consume (and, therefore, forced to import it at a higher cost). Production, therefore, is arguably constrained by land, rather than by capital or labour, with the non-use of land mainly explained by an institutional problem affecting property rights. The main interventions required to change the game would be mainly regulatory (van Holst et al., 2014) and do not necessarily involve a significant increase in public expenditure. However, the estimated 3.08% increase of total GVA provides an upper limit for the combined public and private expenditure that would make recultivation economically sustainable.

Concerning the possible environmental effects of such recultivation programme, it must be noted that only a small part (16%) of the potentially recultivated land is currently included in protected areas (Natura 2000). While we kept these areas in the analyses for practical reasons, they could easily be spared with just a marginal effect on the overall economic outcome if recultivation or grazing were perceived as threats to their conservation values. On the other hand, even outside protected areas, one could argue that the recultivation of large tracts of previously uncultivated land could harm the environment. This might be true in some locations, particularly in areas where intensive agricultural uses currently dominate the landscape. In these areas, abandoned pieces of land may actually be beneficial as they increase the local diversity of habitats at the landscape level. In the mountainous areas of the region (mostly in its eastern half), where shrublands and abandoned farmlands dominate the landscape, recultivation or increasing grazing pressure may actually contribute to maintaining or recovering a mosaic of different land covers and therefore increase the habitat diversity (e.g., Katayama et al., 2015; Zakkak et al., 2015; Sasaki et al., 2020). The overall environmental effects would largely depend on the spatial configuration of the specific recultivation projects. Finally, the recultivation of abandoned farmland may reduce the amount of biomass on the terrain and, more critically, disrupt its continuity. This could potentially reduce the risk of large wildfires (Lasanta et al., 2018). To this end, the prioritization of areas to be recultivated should be integrated into a larger framework of wildfire prevention at the landscape level (e.g. Alcasena et al., 2019). For a region badly affected by large wildfires and spending a significant amount of public resources on firefighting each year, this could be a more compelling reason to increase the management levels of the land than the increase of economic output.

6. Conclusions

In areas affected by recent farmland abandonment trends, land potentially suitable for recultivation may amount to a significant total area. Areas affected by abandonment, nevertheless, tend to be less suitable for agriculture, which means that potentially useful land for agriculture or animal grazing usually comprises large areas of relatively marginal land.

In the case of the region studied in this work (Galicia, in NW Spain), the recultivation of abandoned land may significantly increase the farming sector's GVA (direct effect). We have estimated the total economic effect to be higher because of the multiplier effect that an increase of production in the agricultural sector would cause on other economic sectors. The amount of the effect increases further if estimated for the long run. Nevertheless, while the effect on the regional economy would be noticeable, it would be more easily appreciated at the local level. On the other hand, the cost of the recultivation measures is not calculated in this work, but the fact that the beneficial effects on the economy are considerable suggests that the upper threshold that would make recultivation costs not practical is rather high.

Results from our study case suggest that, from a local standpoint, the economic impacts of recultivation would be more significant in mountainous areas. On the one hand, the amount of land available for recultivation is expected to be higher in these areas (even though suitability for agriculture would be lower due to biophysical constraints). On the other hand, the relative importance of the agricultural sector in the local economy is expected to be higher in these areas, which makes the effect proportionately higher. Therefore, polices oriented toward facilitating recultivation can be a highly useful tool for rural development policy and for dealing with relevant targets such as depopulation and the marginalization of mountainous areas.

In this case study, natural protected areas only amounted to a relatively small proportion of potentially useful areas for recultivation, particularly those concentrated in the least productive categories. If recultivation of these areas was acknowledged as a threat to conservation, they could easily be spared with little influence on the total economic effect. In any case, the kind of use that would be more likely to take place in the more marginal areas (extensive grazing) has the lowest economic effect anyway. On the other hand, regardless of its economic output, extensive grazing may also be used in marginal areas (or at least in part of them) as a measure to reduce vegetation encroachment, to improve the coverage diversity at the landscape level and to reduce wildfire risk.

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Appendix A

See Tables A.1-A.6.

Following Kehoe (1994), we calibrate the model so that, in equilibrium, the agents' transactions in the model reproduce the baseline input-output matrix (Galicia 2016). For instance, we know that the domestic consumer solve:

$$\max \theta_{agr,d} \ln c_{agr,d} + \theta_{food\ man,d} \ln c_{food\ man,d} + \theta_{other,d} \ln c_{other,d} + \theta_{invr,d} \ln c_{inv,d}$$

$$s{\cdot}t{\cdot} p_{agr,} c_{agr,d} + p_{food\ man,} c_{food\ man,d} + p_{other}\, c_{other,d} + p_{invr}\, c_{inv,d} = r\,K + w\,L + q\,H$$

Normalizing prices, i.e. $p_{ag} = p_{food\ ma\ n} = p_{other} = p_{invr} = r = w = q = 1$ we calibrate endowments to be equal to the land rents, labor compensation and total returns to the capital, i.e.

$H = 194$, $L = 35{\cdot}313$ and $K = 17{\cdot}657$,
and solving the consumer's problem,

$$c_{j,d} = \theta_{j,d}\,(K + L + H) \text{ for } j = agr,\ food\ man,\ other\ man,\ inv$$

we obtain.

$$\theta_{agr,d} = c_{agr,d} / (K + L + H) = 826 / (17{\cdot}657 + 35{\cdot}313 + 194) = 826 / 53{\cdot}164 = 0.0155,$$

and following the same procedure.

$$\theta_{food\ man,d} = c_{food\ man,d} / (K + L + H) = 2{\cdot}438 / 53{\cdot}164 = 0.0459 \text{ and}$$

$$\theta_{other,d} = c_{other,d} / (K + L + H) = 41{\cdot}501 / 53{\cdot}164 = 0.7806{\cdot}$$

The calibration of the foreign consumer's utility parameters follows the same procedure.

The calibration of the unit input requirements, a_{ij} , is equally easy. Since we know that 402 units of agrcultural goods, 842 of agricultural

Table A.1
Combined suitability classes. Figures in parentheses indicate area in the class that is covered by shrubs and total area in the class, in thousands of hectares.

Suitability for maize	Suitability for pastures				
	A1	A2	A3	N1	N2
A1	Class 1 (11.5 / 170)	Ne	Ne	Ne	Ne
A2	Class 2 (42.1 / 415)	Ne	Ne	Ne	Ne
A3	Class 3 (56.3 / 485)		Ne	Ne	Ne
N1	Class 4 (225.2 / 898)		Class 5 (177.0 / 924)	(0.1 / 1)	Ne
N2				(29.5 / 74)	(196.3 / 413)

Ne: non-existent.
Source: Authors' elaboration from land use and soil suitability maps.

Table A.2
Assigned production to combined suitability classes of abandoned land and standard production coefficients (average values 2011–2015).

Suitability class	Assigned production type	Standard production coefficient (euro / ha)
Class 1 – highly suitable for maize and pastures	Forage maize	1753.1
Class 2 – suitable for maize, highly suitable for pastures	Forage maize	1753.1
Class 3 – marginal for maize, suitable for pastures	Sown grasslands	1068.7
Class 4 – not suitable for maize, suitable for pastures	Sown grasslands	1068.7
Class 5 – not suitable for maize, marginal for pastures	Other pastures and meadows	102.9

Source: Authors' elaboration. Standard Production Coefficients as published by the Spanish Ministry of Agriculture (MAPA, 2017).

Table A.3
Assigned farming systems to combined suitability classes of abandoned land and average production values as indicated in Farm Structure Survey from 2016.

Suitability class	Assigned farming system	Average value of production (euro / ha)
Class 1 – highly suitable for maize and pastures	Dairy cattle farming	5120.9
Class 2 – suitable for maize, highly suitable for pastures	Dairy cattle farming	5120.9
Class 3 – marginal for maize, suitable for pastures	Beef cattle farming	1449.3
Class 4 – not suitable for maize, suitable for pastures	Sheep / goats	1125.3
Class 5 – not suitable for maize, marginal for pastures	Sheep / goats	1125.3

Source: Authors' elaboration. Average value of production taken from 2016 Farm Structure Survey.

Table A.4
Computable General Equilibrium (CGE) model.

Agents	Mathematical representation	Variables	
Domestic firms	Production function	x_{ij}	Expenditures of sector "j" in sector "i"
produce	$y_{i,d} = \min\,[\{x_{ij} / a_{ij}\}_{i=agr,food\ man,\ other},\ \beta_{i,d}\, h_i^{\gamma}\, k_i^{\alpha}\, l_i^{1-\alpha-\gamma}]$	$y_{i,d}$	Output of domestic firms
interm.	Profits	$p_{i,d}$	Price of domestic good
goods	$\pi_{j,d} = p_{i,d}\, y_{i,d} - p_{agr}\, x_{agr\ j} - p_{food\ man}\, x_{food\ manj} - p_{other}\, x_{other,j} - q\, h_i - r\, k_i - w l_i$	$k_i,$	Capital of domestic firms
		l_i	Labour of domestic i ms
		h_i^d	Land (ha) of domestic firms
Retailers produce	Production function	$y_{i,f}$	Output of foreign firms
final	$y_i = \beta_i\, y_{i,d}^{\rho}\, y_{i,f}^{1-\rho}$	$p_{i,f}$	Price of foreign good
goods	Profits	y_i	Output of final goods
	$\pi_j = p_i\, y_i - p_{i,d}\, y_{i,d} - p_{i,f}\, y_{i,f}$	p_i	Price of final goods
Investment firms	Production function	$x_{i,inv}$	Expenditures of investment firms in sector "i"
	$Y_{inv,d} = \min\,\{ x_{i,inv} / a_{i,inv}\}_{i=agr,food\ man,\ other}$	$y_{inv,d}$	Domestic investment
	Profits	p_{inv}	Price of invest. goods
	$\pi_{inv,d} = p_{inv}\, y_{inv,d} - p_{agr}\, x_{agr,inv} - p_{food\ man}\, x_{food\ man,inv}\ p_{other}\, x_{other,inv}$		
Domestic consumers	Utility	c_i	Consumption (of "i" good)
	$\theta_{agr,d} \ln c_{agr,} + \theta_{food\ man,d} \ln c_{food\ man} + \theta_{other,d} \ln c_{other} + \theta_{invr,f} \ln c_{inv}$	c_{inv}	Consumption of invest. goods
	Budget constraint	$r_,$	(real) interest rate
	$p_{agr,} c_{agr,} + p_{food\ man,} c_{food\ man} + p_{other}\, c_{other\ man} + p_{invr}\, c_{inv} = r\,K + w\,L + q\,H$	w	wage
		q	rental price of Land (ha)
Foreign consumers	Utility	$c_{i,f}$	Consumption (of "i" good)
	$\theta_{agr,f} \ln c_{agr,f} + \theta_{food\ man,f} \ln c_{food\ man,f} + \theta_{other,f} \ln c_{other,f}$	$c_{inv,f}$	Consumption of invest. goods
	$+ \theta_{invr,f} \ln c_{inv,f}$	e	Real exchange rate
	Budget constraint		
	$p_{agr,} c_{agr,f} + p_{food\ man,} c_{food\ man,f} + p_{other}\, c_{other,f} + e\, c_{inv,f} = e\ e\ Income_{,f}$		

Source: Authors' elaboration.

manufactures and 476 of goods of the other sectors are required to produce 3566 units of agricultural goods ($y_{agr,d}$ =4260 – 694 = 3566) we calibrate the unit input requirements of the domestic agricultural sector to be equal to.

a_{11} = 402/3566 = 0.1127, a_{21} = 842/3566 =0·2360 and a_{22} =476/3566 = 0.1335·

We obtain the other a_{ij} following the same procedure.

For calibrating factor shares, we asume that labour (income) share, 1-α, in the non agricultural sectors is equal to 2/3. In the agricultural sector we use the first order conditions (f.o.c.) of the domestic firm to compute factor shares. Land income share, γ, is equal to the land rents over value added,

γ = 194/(551+194+1102)= 0.1050,

and capital share in the agricultural sector is equal to the return of capital in agriculture over value added, i.e.

551/(551+194+1102) = 0.2983·

Then from $y_{agr,d} = \beta_{agr,d}\, h_{agr}^{\gamma}\, k_{agr}^{\alpha}\, l_{agr}^{1-\alpha-\gamma}$ □that $y_{agr,d}$= 4260 – 694 = 3566□$194^{0.1050}\ 551^{0.2983} 1102^{1-0.1050-023983}$□746.37. Then.

$\beta_{agr,d}$ = 3566 / 746·37 = 4·7782·

Table A.5
Baseline Economy. Input-Output Galicia 2016 (million euro).

	Agr.	F. Man.	Other.	Con.	Inv.	Exp.	Total
Agriculture	402	1653	210	826	143	1027	4260
Food Manufacturing	842	761	1496	2438	25	2006	7566
Other sectors	476	1385	48,035	41,501	8467	24,223	124,087
Imports	694	2727	24,069				27,490
Land rents	194						194
Labor Compensation	1102	693	33,518				35,313
Returns to Capital	551	347	16,759				17,657
Total	4260	7566	124,087	44,756	8634	27,256	

Source: Authors' elaboration.

Following the same procedure we have $\beta_{food\ man,d} = 8.7929$ $\beta_{other,d} = 3.7596$.

For calibrating the Armington aggregators for agriculture, food manufactured goods and other goods produced by retailers we use the problem soved by the retailers firms.

$$\min y_{i,d} + y_{i,f} \ s\cdot t\cdot y_i = \beta_i \ y_{i,d}{}^{\rho} \ y_{i,f}{}^{1-\rho}$$

From the f.o.c.

$$1\text{-}\rho_i = y_{i,f} / y_i$$

we have.

$$1\text{-}\rho_{agr} = 694/\ 4260 = 0.1690,$$

$$1\text{-}\rho_{food\ man} = 2{\cdot}727/7{\cdot}566 = 0.3604 \text{ and}$$

$$1\text{-}\rho_{other} = 24{\cdot}069/124{\cdot}087 = 0.1940$$

(i.e. ρ_{agr}=0.8371, $\rho_{food\ man} = 0.6396$ and $\rho_{other} = 0.8060$). Finally, using the production function.

$$y_i = \beta_i \ y_{i,d}{}^{\rho} \ y_{i,f}{}^{1-\rho}$$

we have $\beta_{agr} = 3566^{0.8371}\ 694^{0.1690} / (3566 + 694) = 2737.8 / 4260 = 1.5597$.

Definition equilibrium

1. Given prices of intermediate, $p_{i,d}$, foreign, $p_{i,f}$, and final goods, $p_{i,d}$, wage, w, real interest rate, r, and rental price, q:
   a. (domestic, retailors an investment) firms minimizes cost,
   b. (domestic and foreign) consumers maximizes utility subject budget constrain.
2. Given firms and consumers demands (and supplies) prices satisfies

Table A.6
Model calibration.

Agents	Parameter		Values	
Domestic firms	a_{ij}	Technical coefficients (model) of sector "j" in sector "i"	a_{ij}	0.1127 0.3416 0.0021 0.2360 0.1572 0.0150 0.1335 0.2863 0.4803
	$\beta_{i,d}$	Total Factor Productivity of domestic firms	$\beta_{i,d}$	4.7782 8.7929 3.7596
	$\alpha_{i,d}$	Capital (income) shares	$\alpha_{i,d}$	0.2982 0.3333 0.3333
	$\gamma_{i,d}$	Land (income) shares	$\gamma_{i,d}$	0.1053 — —
Retailers	β_i	Productivity	β_i	1.5597 1.9226 1.6355
	$\rho_{i\$}$	Int. goods (final output value) shares	ρ_i	0.8371 0.6396 0.8060
Investment firms	$a_{i,inv}$	Technical coefficients (model)	$a_{i.inv}$	0.0165 0.0029 0.9806
Domestic consumers	$\theta_{I,d}$	Budget shares	$\theta_{I,d}$	0.0155 0.0459 0.7806
Foreign consumers	$\theta_{I,f}$	Budget shares	$\theta_{I,f}$	0.0165 0.0029 0.9806
Endow. Million euros	K,	Capital endow. of the economy		17,657
	L	Labour of the economy		35,313
	H	Land of the economy		194.5
	,f	Income		10,000,000

Source: Authors' elaboration.

a. zero profit (free entry) condition, and
b. markets clearing conditions:
   i. $y_{i,d} = x_{i,agr} + x_{i,food\ man} + x_{i,other} + c_{i,d} + x_{i,\ inv} + x_{i,inv\ f} + x_{i,f}$
   ii. c_{inv} +e $c_{inv,f} = y_{inv}$
   iii. $L = l_{agr} + l_{food\ man} + l_{other}$
   iv. $K = k_{agr} + k_{food\ man} + k_{other}$
   v. $H = h_{agr}$
   vi. $p_{agr}\ (x_{agr,f}$ -,e $y_{agr,f}) + p_{\ food\ man}(x_{foof\ man,f}$ -,e $y_{food\ man,f}) + p_{other}\ (x_{other,f}$ -,e $y_{\ other,f}) + p_{inv,}\ x_{inv,f} = 0$

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