From the Douro Valley to Oporto Cellars: the Port wine value chain

From the Douro Valley to Oporto Cellars: the Port wine value chain

João Pedro Ferreira

GOVCOPP, Faculty of Economics, University of Coimbra, Portugal

Pedro Ramos

CEBER, Faculty of Economics, University of Coimbra, Portugal

Luís Cruz

CEBER, Faculty of Economics, University of Coimbra, Portugal

Eduardo Barata

CEBER, Faculty of Economics, University of Coimbra, Portugal

Michael Lahr

Edward J. Bloustein School of Planning and Public Policy, Rutgers, The State University of New Jersey, USA.

(accepted for publication by the *British Food Journal* on July 7, 2018)

Structured Abstract

Purpose

This paper aims to offer an insight into the fundamental changes taking place in Port wine production value chains. Specifically, we examine two distinct production regimes: when Port is aged and sold in the Greater Oporto and, alternatively, when it is produced, aged and sold in Douro.

Design/methodology/approach

The authors apply a tri-regional input-output model (Douro, Greater Oporto and Rest of the Country) for Portugal's economy. This framework comprises a significant level of detail, with 431 products and 136 industries, the corresponding supply and demand for the products, by industry (for intermediate consumption) and final demand.

Findings

This study shows that the two regimes generate noteworthy, but quite heterogeneous, regional impacts. In both cases, the distribution of value added generates international and interregional trade flows. Moreover, the study reveals a greater capacity to capture national value added by getting the supply chain more intensive in localized services and by using state-of-the-art production techniques.

Originality/value

Using detailed regional data, we use disaggregated information, both for industries as well for territories, overcoming a common limitation in similar works that are grounded in international databases. Additionally, our approach integrates the trade interactions among industries and regions, which proves essential to uncovering spillovers resulting from the (direct and indirect) use of inputs from other regions and other countries.

Introduction

Port wine (or simply Port) is a Portuguese product that is celebrated worldwide. The first official documents referring to the production of Port date from the 12th century (Carrera, 2002). Following the 1703 Methuen Treaty, between Portugal and England, a significant expansion occurred in Port wine production. This expansion deeply influenced the development of two particular locations: the Douro demarcated region (in the interior North of Portugal), where the grapes are produced; and Gaia, near the city of Oporto where the wine has been traditionally stored and aged and where the headquarters of most companies are located. Historically, since the 15th century, Oporto city has been a relatively more robust and innovative economy, consistently reinforcing its position as the most important regional trade centre. Otherwise, the Douro region has been characterized by poor working conditions and by the concentration of low-income and low-skilled workers in agriculture and grape harvesting. So, for some time now, each region's role has been well-identified in the Port value chain (Brito, 2006). But, more recently, two major changes have made the value chain of Port more spatially dispersed and complex. First, in 1986, Portugal became a member of the European Community and new legislation was adopted that opened the way for wines to be exported directly from growers in the demarcated Douro Region, bypassing the Gaia hub. Second, following several decades of steady growth and investment, new services, machinery and other technological improvements have been progressively implemented. Such changes have significantly modified the Port wine value chain and, thus, has induced changes in regional economic structures with consequences for GDP, jobs and other economic measures (mainly on the two core study regions—Greater Oporto and Douro—as well as the rest of Portugal).

This work has two major aims. First it discloses the Port wine value chain in the context of the Portuguese economy and analyses the relative significance of the different processes (performed in distinct regions) incorporated in Port's final value. For this, we focus upon two distinctive regimes: when Port follows its traditional course and is aged and sold in Gaia - Greater Oporto; and, alternatively, when the winemaking, bottling, ageing and selling facilities are all located in Douro. Next, by comparing the national and regional impacts generated in these two regimes, we intend to derive policy recommendations that will foster economic growth and promote regional cohesion.

This research uses a multiregional input-output (MRIO) model for Portugal, with three regions – Douro (a NUTS III region, comprising 95% of the grape production region), Greater Oporto (also a NUTS III region, where the traditional wine cellars are located) and the Rest of the Country. This model allows us to assess the overall impact on Portugal of Port production by accounting for all of the direct and indirect effects that are generated through the production chain. This analysis also allows us to identify the industries and regions that generate the Gross Value Added (GVA), as well as the products more intensively traded to satisfy the final demand for Port. Further dimensions embodied in the Port production chain are also considered, namely the share of imported inputs, employment and taxes less subsidies.

Value Chain Analysis

Value chain analysis aims to uncover the trail of all value-creating activities for a specific product or service. It counts all activities on the path from the development of raw materials to the final product delivered to the consumer, including the various firms and geographical regions involved in this process. This technique has been applied to myriad cases, and wine is no exception. Deconinck and Swinnen (2014) estimate the expected potential impacts of a change in planting-rights legislation in the European Union (EU) to wine's value chain as well as the effect of this policy on local producers. Bernetti *et al.* (2006) compare various wines produced in Italy (a traditional wine producer) with wines produced in emerging economies (following a mass-production scheme), and concluded that wines produced with more industrialised processes tend to depend more heavily on large retail firms to distribute their wares. This comports with findings of Gwynne (2008) and Ponte and Ewert (2009) regarding Chilean and Southern African wines, respectively. More recently, Mann *et al.* (2018) highlight that grape production in Lithuania is decoupling from wine trade at both the international and regional levels.

Overall, this literature illustrates that when considering all production requirements, it is possible that, e.g., to satisfy Port wine production, the production of shipping equipment anywhere in the world might also be affected, albeit perhaps undetectably. Accordingly, value chain analysis is data-intensive as globalization deepens (Grossman and Rossi-Hansberg, 2006). To meet increasing requirements, input-output data availability and

techniques to analyse value chains have developed rapidly, particularly since the advent of global input-output tables (Timmer *et al.*, 2015).[i] Unfortunately, international databases fail to recognize the desirability of technological diversity, both within an industry as well as across territories. For example, such analyses assume that establishments in a given industry, e.g., beverages, wine and food production, have the same input structure. Thus, an intra-national multiregional input-output framework can be an interesting alternative to international databases, especially when the former offers significantly greater sectoral detail. Some studies on value chain analysis and international linkages have been based on the use of multiregional input-output data (Midmore *et al.*, 2006; Titze *et al.*, 2011). These studies support the notion that regional policy decision-making and coordination can be improved when considering reliable quantitative evidence available with greater spatial detail (Dietzenbacher *et al.*, 2013; Steen-Olsen *et al.*, 2016; Cruz *et al.*, 2017). Nevertheless, models focused only upon specific regions within a country also present shortcomings. Indeed, if the rest of the world is not considered endogenously, these models can fail to account for the national value-added embodied in gross imports. But, since Portugal's economy is small, such spillovers are likely negligible.[ii]

Port wine's production technology is spatially and technologically fragmented with distinct features of the production process distinctly staged in the different regions. Industrial clusters may arise from such spatial differentiation and influence linkages that can be either vertical, moving from supplier to client, or horizontal, among similar firms or between firms and several forms of economic infrastructures (Padmore and Gibson, 1998). This spatial fragmentation mirrors each region's special characteristics. Indeed, global or regional value chain analysis influence and are influenced by the creation of new localized clusters, as specialized, innovative work necessarily involves the generation and exchange of knowledge that is immobile and, thus, must be exploited locally if it is to be exploited at all (Sturgeon et al., 2008). So, to enable modelling of each region's critical contribution, we suggest that a more disaggregated framework is in order.

Port wine production across Portugal's regions

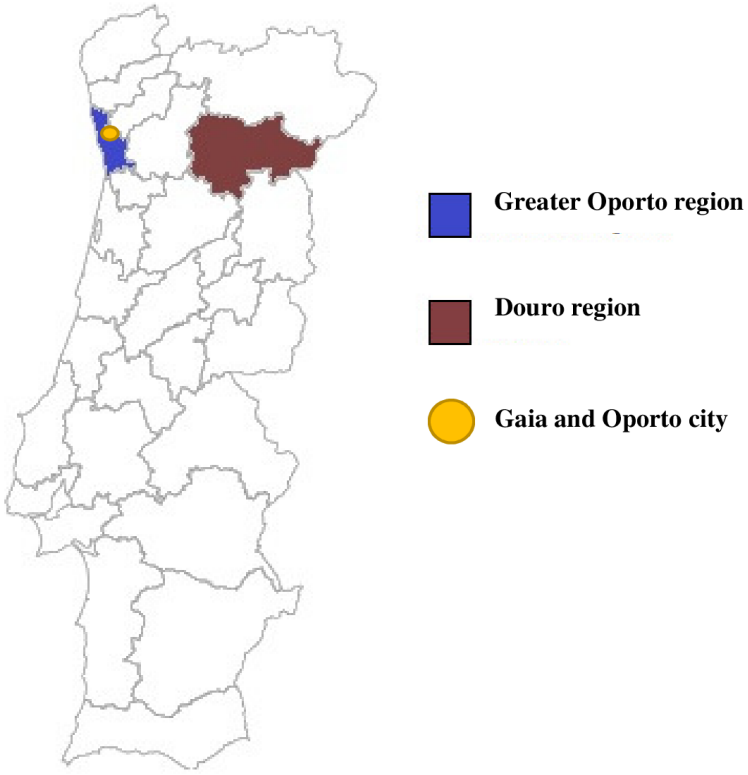
Let us focus on how Port wine is produced in the different regions of Portugal. Greater Oporto and Douro regions depart from a specific reality in terms of economic structure,

location of specialized services and innovation and entrepreneurship traditions. So understanding the significant changes that have occurred in the Port wine industry, particularly those that took place in the last decades of the 20th century, accrues acknowledgment into to these features of the local economies.

The wine industry is one of civilisation's oldest. Port wine has been heavily exported from the Portuguese territory since the 17th century. In 1703, more favourable conditions (e.g., less duties than wines from France) for the importation of Portuguese wines were a lynchpin to the Methuen Treaty between Portugal and England. They secured Port's status among England's posh, which led to unprecedented growth in its production, as illustrated by an quote from John Croft's *A Treatise on the Wines of Portugal* (1788, p. 7): "an Englishman of any descent, condition, or circumstances, cannot dispense with it [Port] after a good dinner".

An initial surge in the demand for Port instigated difficulties associated with its supply shortages and, hence, with quality standards – as largely the production region expanded beyond the pre-Cambrian schist and granite that under lays the Douro River Valley (Sequeira, 2011). By 1756, things got so bad that Marquês de Pombal (the Portuguese prime minister) felt forced to demarcate the Douro Wine Region as the only source of "true" Port wine. Indeed, this region has been recognized as one of the world's oldest to have an official registered designation of origin for its wines, surpassed only by Chianti in 1716 and Tokaj in 1730 (Martins, 2000). Even this far back in time, two wine categories were produced in the region – namely "ordinary" wine (consumed only in the Portuguese taverns) and "shipping" wine. This second, typically of higher quality, was the predecessor of Port wine. The implementation of wine typing brought a new wave of economic expansion to Douro and Portugal. By the end of the 19th century, the relative value share of Port wine in Portuguese total exports consistently varied between 20% and 40% (Lopes, 1998). Naturally, co-located auxiliary production activities deeply influenced the regional economies of Douro and Greater Oporto. (Figure 1 depicts both regions in the context of the mainland Portuguese territory.)

Figure 1. Greater Oporto, Douro and the Rest of the Country regions



So by proclamation Port could only be produced from grapes grown and processed in the demarcated Douro region, an area with 2,474 km^2 that is almost fully within the borders of the NUTS III region labelled Douro.[iii] No Port grapes are grown in Greater Oporto; instead, this more innovative and 'cosmopolitan' region specializes in the processes of storing, ageing and trading the wine, which require high-skilled labour, and where other specialized services (as advertising, consultancy, scientific, technical activities and other support service activities) are abundant. Of course, in historical terms, the proximity to the Atlantic Ocean and the entrepreneurial culture enabled by the agglomeration of merchants in the Greater Oporto metropolitan region led to the establishment of Port firms headquarters in Oporto and Gaia. Many key enterprises were owned by English entrepreneurs. Firms such as Taylor's, Sandeman, Burmester and Croft were founded by English businessmen in the 17th and 18th centuries (Carrera, 2002; Brito, 2006), which from the start headquartered at the mouth of the Douro River.

In the 18th century, laws forced Port (the "shipping" wine) to be exported exclusively from Gaia cellars in the Greater Oporto region, where it was stored and aged (Martins, 1988). Needless to say, laws and regulatory measures designed to protect the "shipping" wine also tended to benefit the economy of Greater Oporto and reinforced, for centuries, the economic disparity contrast with the more agriculturally intensive regions, like Douro. In Port's case, no essential rule changes were until 1986, when Portugal joined the European Economic Community. This was when wine producers were first legally allowed to install wine cellars in Douro and to sell the wine abroad directly.

Contemporaneously, innovations and technological progress have been largely related with three different facets: the adoption of renewed marketing and public relations strategies (Rebelo and Muhr, 2012); product innovation (as the appearance of Port-related food products, like jams, pastry products and chocolates, as well as the upgrading of wine tourism, as referred by Inham *et al.*, 2013); and the introduction of new storage and quality-control methods (Santos and Ribeiro, 2012)[iv]. Such changes reduced costs, enhanced productivity and ultimately affected the production structure. Many of these new developments resulted from R&D projects developed in technologically advanced centres located in Greater Oporto, Greater Lisbon or other regions outside Douro.

To sum up, Port wine has shaped the economic, cultural and social landscape of the Douro and Greater Oporto regions. By no means does this suggest that the two economies are similar, however. The Douro region remains comparatively undeveloped region, with a population of about 200,000 inhabitants and 100,000 jobs. A significant share of the jobs is focused on vineyards and related activities that are part and parcel to Port and other wines sales. Meanwhile, Greater Oporto is a metropolitan area with nearly 1.3 million inhabitants – about 12% of Portugal's population – and nearly 600,000 jobs. Here the share of employment in the primary sector is less than 1% and in the tertiary sector is above 70%, while in the Douro region the primary sector is responsible for 38% of the employment. In terms of innovation, Greater Oporto and Douro are also distinct: as an example, in 2014 the number of establishments created in Greater Oporto was more than ten times higher than the number created in Douro; these new establishments tend to concentrate in technological and scientifically demanding products. Indeed, the share of revenues in high and medium-

high technology manufacturing industries among all the industries in the Greater Oporto is above the national average at 27%, while in Douro they represent less than 10%.

Methodology and data

The MULTI2C framework

This work uses the MULTI2C framework. Researchers at the University of Coimbra (Portugal) produced this multisectoral and multiregional input-output model using 2010 National Supply and Use Tables. The framework comprises 431 products and 136 industries, the corresponding supply and demand for the products, by industry (for intermediate consumption) and final demand, for the Portuguese NUTS III regions.[v]

The regional matrices depict "domestic shipments", i.e., they show what products are produced within regional and national boundaries and their uses (international imports are treated separately). Transactions are in "basic prices", i.e., they exclude value-added (VAT) and other taxes, less subsidies, on products. Trade and transportation margins are treated as inputs either to other industries or to final demand, provided by retail and wholesale trade industries or transport services, as opposed to being embodied in purchasers' prices. The MULTI2C framework further disaggregates some Portuguese National Accounts industries. First, electric power industry is divided into ten sub-industries to account better for its different modes of production. Secondly, due to the critical relevance in the research reported here, the MULTI2C framework splits "Agriculture and animal farming activities" into two different sub-industries: "Agriculture" and "Animal farming". This improves the accuracy of our model, since among the main input for Port production is grapes, which is a crop. The technology for producing grapes is quite distinct from that used in raising livestock.

The wine (products and industries) specificities

As already demonstrated, the MULTI2C framework focuses particular attention to wine and related products. Official data provided by the Portuguese National Accounts (NA) are suitably disaggregated into six wine products: (1) Sparkling wine; (2) Still (nonliqueur) wines with quality certification produced in a demarcated region; (3) Still (nonliqueur)

wines without quality certification; (4) Liqueur wines; (5) Must and (6) Waste from wine production including lees. For the main part, in Portugal's NA these various items were combined into a single aggregate industry "Manufacture of wines". Otherwise, for the purpose of this work, this industry was split into two sub-industries: "Manufacture of liqueur wines" (producing as primary products liqueur wines and must for use on these wines production processes) and "Manufacture of other (non-liqueur) wines" (including sparkling and still wines).[vi] The mix of inputs – the technology – of the two sub-industries is deemed to be different. In particular, liqueur wines are produced quite differently from other wines; we were able to distinguish these technologies at the regional level using NA statistical data, as well as data from the Port and Douro Wines Institute (IVDP) as well as expert contributions from the port industry.

Since there are relevant disparities among the production phases associated with the two Port wine production regimes the inputs used in the industry as a whole and in each of Greater Oporto and Douro were carefully defined–namely, grape production, grape treading, fermentation, fortification, ageing and sales, complemented by the ancillary activities developed in firms' headquarters. We found that the production of Port uses 151 different products as direct inputs and fully 420 both directly and indirectly. The most important direct inputs (beyond must and grapes) include hollow glass (bottles), cork products, distilled brandy, advertising services, wholesale margins, financial services and oil derivatives. This multitude of products, together with other marginally consumed, constitute the required ingredients to produce Port wine. In this vein, the greater sectoral disaggregation within the MULTI2C framework becomes a particular advantage since it also articulates the different product requirements used within each region. The disaggregate data are first handled in purchasers' prices. So, before their insertion into the model, one has to make the corresponding adjustments needed to obtain the equivalents to total domestic flows and basic prices.

As a consequence of the important differences by region discussed earlier, the Liqueur wines industry located in Greater Oporto directly consumes large shares of secondary and tertiary products, as it is shown in Table 1.

Table 1. Input structure of Liqueur wines industry by region (%)

	Greater Oporto	Douro Valley
Primary	0.0	54.7
Secondary	65.6	37.5
Tertiary	34.4	7.8

Another relevant transformation within the MULTI2C framework concerns the imputation of more gross production of Liqueur wines to the Douro region (and at national level), corresponding to the wines not ready for final consumption. These are transferred from Douro to the Greater Oporto region as an intermediate good only.[vii] They are produced in Douro and used by the Liqueur wines industry in Greater Oporto. Generically, we tagged wine must to this specific product and estimated it at production costs. Indeed, the main consumption of intermediate products from the secondary sector by the Greater Oporto Liqueur wines industry in Table 1 is from this 'must' produced by Douro's Liqueur wines industry. Douro by and large consumes grapes from local vineyards, the product of which comprises more than 97% of the primary products used by the Douro Liqueur wines industry.

Interregional trade

We estimated interregional trade within the MULTI2C framework by using a tri-regional format. The three regions were the Greater Oporto and Douro NUTS III regions plus the Rest of the Country. The guiding concept in that task was that products have different levels of "tradability" among the regions (Ramos *et al.*, 2015). So use of local production versus regional inflows required a "tradability" typology by product. Using such a classification we then estimated gross interregional inflows. We subsequently estimated net interregional trade using the commodity-balance technique (Miller and Blair, 2009). Finally, adding up net outflows and gross inflows yielded an estimate of gross exports by products.

Port (including wine must transferred to Port wine producers in Greater Oporto) is the most important export product of Douro. Although identified separately, "other wines" are also an important export industry there. But the value of net exports of Port wine in Greater Oporto is greater than that for the sum of all wine products exported from Douro. Indeed, Port wine ranks fourth (in terms of net trade) for Greater Oporto. It is the second most

important manufactured product in this region, following only "Refined petroleum products". Other export-based products in Greater Oporto are associated with the metropolitan area's large service economy. In any case, it is clear that Port wine production is important to both the Greater Oporto and Douro regions. It also underlines the importance of comparing both regimes' value chains for addressing policies aimed promoting the evolution of the economy of the less-developed Douro region.

The Leontief inverse

To examine the supply chains we use the Leontief inverse. It allows estimates of the direct and indirect effects associated with changes in a product's demand and production that have impacts on the industries located in the different regions. Ours is a rectangular model, the starting point is the **A** matrix, as presented in Equation (1).

$$\mathbf{A} = \begin{bmatrix} 0 & \mathbf{B} \\ \mathbf{D} & 0 \end{bmatrix} \qquad (1)$$

A is a square matrix (although **D** and **B** are rectangular) of dimension 1,701 [(431 products + 136 industries) x 3 regions].

The bottom left partition of matrix **A** (labelled **D**) is the Make (or supply) matrix. It shows the location of products produced by the different industries. The upper right partition (**B**) is the Use matrix, which displays the intermediate consumption of production by industry. This matrix also provides the region of origin of each product used as intermediate consumption in each region. This means that the regionalized use matrix (**B**) is composed of nine partitions, each of which contains the flows among industries between the regions identified in superscripts, as follows.

$$\begin{bmatrix} \mathbf{B}^{GO,GO} & \mathbf{B}^{GO,D} & \mathbf{B}^{GO,RC} \\ \mathbf{B}^{D,GO} & \mathbf{B}^{D,D} & \mathbf{B}^{D,RC} \\ \mathbf{B}^{RC,GO} & \mathbf{B}^{RC,D} & \mathbf{B}^{RC,RC} \end{bmatrix} \qquad (2)$$

The standard input-output procedure for calculating the impacts of any given final demand is then presented as follows.

$$\mathbf{x} = (\mathbf{I} - \mathbf{C})^{-1}\,\mathbf{y} \qquad (3)$$

where **y** is the 1,701 x 1 vector of exogenous final demand by product and region. The 1,701 x 1,701 **C** matrix is the coefficient matrix (estimated by dividing each cell of matrix **D** by the total products output and each cell of the regionalized matrix **B** by the total industries output, in each region), and **I** is an identity matrix of conforming size. Thus, **x** is the total outputs vector by region of dimension 1701 x 1.

Let us more simply denote the Leontief Inverse matrix as **L** such that:

$$\mathbf{L} = (\mathbf{I} - \mathbf{C})^{-1} \quad (4)$$

Recall that **L** necessarily has a dimension of 1,701 x 1,701. Let us now also label its four partitions as follows:

$$\mathbf{L} = \begin{bmatrix} \mathbf{L^1} & \mathbf{L^2} \\ \mathbf{L^3} & \mathbf{L^4} \end{bmatrix} \quad (5)$$

Partition $\mathbf{L^3}$ deserves particular attention, as it shows the effects of changes in the final demand of products on the industry production by region. Using $\mathbf{L^3}$ we can present an extended overview of Port wine production impacts and their ramifications within Portugal's (multiregional) economy.

Results and Discussion

We now consider value chains of Port wine via the two production regimes identified at the outset of this paper. Namely these are the traditional regime in which the Port is aged and sold only in Greater Oporto (hereafter designated as GOPW); and the alternative in which Port is produced, aged, and sold in the Douro region (from now on designated as DVPW). Regardless of the regime, however, grape production and its transformation into 'must' remain located in the Douro Valley.

Table 2 shows the results of our assessments by displaying the value-added (VA) shares of final output by region. In particular, it presents the contribution of the Port wine value chain by region and international imports, with all remaining value corresponding to taxes less subsidies on production. The national average is also included and corresponds to the combination of the Port wine produced in both regions.

Table 2. VA shares in final Port wine sales (at basic prices) per region and international imports (%)

	GOPW	DVPW	National Average
Greater Oporto	33.7	2.1	28.1
Douro	14.4	40.0	19.9
Rest of the Country	24.0	23.7	23.9
National VA	72.0	65.8	70.9
International Imports	24.2	29.1	25.1

Table 2 highlights the differences between the two regimes' value chains in terms of national value-added share. In the GOPW regime, the national value generated by share of output is six percentage points higher than that for the alternative DVPW regime. Note that in the GOPW regime the relevance of the Douro region's contribution to VA is just over 14%. This is probably less than most would intuit, given the critical importance of grape production that is restricted here to the Douro Valley. Regardless, production in the Rest of the Country production is consistently relevant to Port production, seemingly independent of the GOPW or DVPW regime. Its relative importance is similar to that of the Rest of the World. Indeed, the openness of Portugal's economy is recognized by Port wine's fairly strong need for imported inputs (29% and 24%, in the DVPW and GOPW regimes, respectively).

It perhaps then follows that a more detailed analysis by industry could give added insight as well. Table 3 highlights the direct plus indirect VA generated in Portugal by aggregate industry by region.

Table 3. National VA shares in final Port wine sales (at basic prices), per region and per industry (%)

	GOPW			DVPW		
	Greater Oporto	Douro	Rest of Country	Greater Oporto	Douro	Rest of Country
Agriculture, forestry and fishing	0.1	10.4	3.4	0.1	29.1	8.4
Industry	22.3	1.8	5.4	0.7	5.1	3.7
Contribution of the Port Wine Industry	*20.8*	*1.7*	*0.0*	*0.0*	*4.9*	*0.0*
Energy, water supply and sewerage	0.3	0.1	1.5	0.2	0.2	1.6
Construction	0.4	0.3	0.4	0.0	0.7	0.4
Wholesale and retail trade plus accommodation and food service	3.0	0.6	4.2	0.4	1.6	3.3
Transportation and storage; information and communication	1.7	0.4	2.4	0.3	1.0	1.7
Financial, insurance and real estate activities	3.0	0.4	3.4	0.2	1.2	2.2
Other services activities	3.1	0.4	3.4	0.3	1.2	2.4
Total	***33.7***	***14.4***	***24.0***	***2.1***	***40.0***	***23.7***

The column totals in Table 3 match the column values presented in Table 2, as they represent each region's total contribution to the national VA creation. For the GOPW regime, much of Greater Oporto's VA contribution is due to the Port wine industry itself (nearly 62%). As expected, the interdependencies established with Douro are largely a consequence of Agriculture (about 73%) although the Port wine industry also contributes much of the remaining (almost 12%), largely due to grape and must production. Interdependencies with the Rest of the Country are spread fairly well across all major industries, although manufacturing, wholesale and retail services are particularly prominent. All told, the GOPW regime incorporates 36% of tertiary products as inputs, 44% of secondary products and 20% of agriculture products. These findings are substantially different from those presented in Table 1 in which tertiary industries account for 34.4% and secondary industries for 65.6% of inputs. Of course, the figures in Table 1 account only for direct inputs. This highlights the more expansive role of indirect effects.

In the DVPW regime, Greater Oporto's role is practically a residual (2.1%) and Douro locally generates an important share of the industries total VA contribution to the national economy. This is particularly the case for agricultural production. Meanwhile the Rest of the Country's role vis-à-vis the DVPW versus the GOPW regime only rises much

through linkages established via the primary sector. In general (with the exception of the "energy, water supply and sewerage" industry), however, VA shares provided by this regime are slightly smaller than in the GOPW case. In the DVPW case, agriculture, industry (including energy production and construction) and services have shares of 57%, 18% and 24%, respectively. Thus, the difference between the value chains of the two regimes should deter further notions that the development of both products and their impacts are uniform across geography.

Finally, Table 4 summarizes the results in terms of the (direct and indirect) employment requirements associated with the total production of Port wine (distinguishing GOPW and DVPW regimes), emphasising their regional significances.

Table 4. (Direct and Indirect) Employment required to satisfy total Port wine sales (number of full-time equivalent jobs)

Region	Direct requirements	Indirect requirements	Total
GOPW			
Greater Oporto	556	1,521	2,077
Douro		7,980	7,980
Rest of the Country		2,501	2,501
Total	***556***	***12,002***	***12,558***
DVPW			
Greater Oporto		35	35
Douro	202	4,387	4,589
Rest of the Country		904	904
Total	***202***	***5,326***	***5,528***

Table 4 shows that Douro benefits the most from Port wine production, in both regimes. When Port wine is sold out of the Greater Oporto region, 7,980 jobs are created Douro (61% of the total). But, when the product is sold from Douro, the region is able to capture more than 80% of all jobs generated. Either way, it is clear that the production of Port wine is important to Douro's regional economy regardless of where it is sold; indeed, almost 14.6% of the region's employment depends on it. (In Greater Oporto, less than 0.4% of employment is generated by the industry.)

Finally, it is also relevant to note that the potential to capture effects beyond those directly driven from the commodity production itself (e.g., crude oil) is what ultimately shapes regions, yielding significant implications for regional macroeconomic structures. In

this vein, input-output analysis and related techniques can critically inform knowledge of regional economies and potentially support the design of more appropriate regional development mechanisms.

Conclusion

This work analyses the Port wine value chain, through the application of a multiregional input-output model. Beyond the novelty of this methodological framework applied in this product, it also emphasizes the potential importance of value-chain-oriented policies. particularly when addressing the disparity between regions concentrating more innovative firms *vis-à-vis* 'cohesion regions'. The applied framework further adds both spatial and sectoral detail to facilitate the uncovering of relative differences between production methods, technological structures and economic impacts, both at industry and regional levels. Spillovers resulting from the (direct and indirect) use of inputs reveal important contributions from both the Rest of the Country and the Rest of the World in the value chains of Port wine products of northern Portugal. Indeed, regardless of where Port is stored, aged and sold, the Rest of the Country and abroad contribute about 50% of the industry's value added. Many of the imported products are affiliated with indirect inputs and the general openness of the Portuguese economy—the case of the crude oil.

One of our most important conclusions is that a single product can have very different value chains depending on the technical production structure of the industry and economic geography of the region in which it resides. Port wine's production technology is more-intensive in the consumption of services. We also find that following state-of-the-art production techniques can lead to a greater capacity to gain national value added. This suggests that a product like Port wine could benefit more from technology transfer rather than from relocation (of the major part of its production process). Since metropolitan regions tend to be more entrepreneurial, this suggests some advantages may result from concentrating more of the activities into Greater Oporto, where agents are more apt to keep abreast of production techniques and where markets are generally more accessible. In Portugal and in the case of Port wine, this happened through history by market operation with some relevant regulatory assistance, even though no grape growing (of the proper variety) takes place in the Greater Oporto region. Considering EU cohesion goals, a distinct

regional policy perspective should discuss measures capable of capturing Douro's entrepreneurial and innovative capabilities in the wine production cluster as a way to increase its regional GVA. This suggests an important recommendation: if the regional development goal is to allow both for more value added nationally and to capture it in areas that are more rural (in this case, Douro), then it would be better to promote the use of services and technological investments to enhance production, rather than to promote economic expansion of business-as-usual.

Further, two major dimensions of regional value chain analysis are reinforced by this study. First, from a regional competitiveness perspective, regions need to learn to posture themselves (low-cost, high-quality or high-tech products) within the production sphere (Pisano and Shih, 2009). Second, from a regional policy perspective, interregional trade interactions are important in enabling reliable assessments of the regional direct, spillover and feedback effects of economic production and consumption activities (McCann and Ortega-Argilés, 2015; Ferreira *et al.* 2017).

Finally, this research shows that trade interactions, input structures, production techniques and the regional economic environment justify the use of MRIO analysis in the design of regional policies, financial support mechanisms, investment schemes and/or regional development programmes. The growing openness of economies can lead to the un-intentional transfer of regional benefits from one region to another and, thereby, mitigate awaited policy outcomes aimed at reducing regional income disparities or at promoting income convergence. This could occur despite the best intentions and critical efforts to support cohesion and equality among territories. Policy-makers must make certain that they have the proper tools and consultants at their disposal to support and implement regional policy.

Acknowledgements

The first author would like to acknowledge the support of the Portuguese Science Foundation through the funding of this work under the Post-Doctoral grant [SFRH/BPD/115133/2016].

References

Bell, M., and Giuliani, E. (2007). "Catching up in the global wine industry: innovation systems, cluster knowledge networks and firm-level capabilities in Italy and Chile". *International Journal of Technology and Globalisation*, 3 (2-3), 197-223.

Bernetti I., Casini, L., and Marinelli, N. (2006). "Wine and globalisation: changes in the international market structure and the position of Italy". *British Food Journal*, 108 (4), 306-315.

Brito, C. (2006). "A network perspective of the port wine sector". *International Journal of Wine Marketing*, 18 (2), 124-138.

Carrera, C. (2002). *Vinho do Porto e a região do Douro: história da primeira região demarcada*. Sintra, Portugal: Colares Editora.

Croft, J. (1788). *A Treatise on the Wines of Portugal.* Porto, Portugal: IVDP and GEHVID.

Cruz, L., Ramos, P., Barata, E., and Sargento, A. (2017). "Assessing an agri-food development strategy: a bi-regional input–output model with resource-constrained sectors". *European Review of Agricultural Economics*, 44 (5), 860-882.

Deconinck, K., and Swinnen, J. (2014). "The economics of planting rights in wine production". *European Review of Agricultural Economics*, 42 (3), 419-440.

Dietzenbacher, E., Lenzen, M., Los, B., Guan, D., Lahr, M. L., Sancho, F., and Yang, C. (2013). "Input-output analysis: the next 25 years". *Economic Systems Research*, 25 (4), 369-389.

EXIOBASE (2012). *EXIOBASE*. Delft: Exiobase Consortium.

Ferreira, J-P., Ramos, P., Cruz, L., and Barata, E. (2017). "The opportunity costs of commuting: The value of a commuting satellite account framework with an example from Lisbon Metropolitan Area", *Economic Systems Research*, 30 (1), 105-119.

Giuliani, E., Morrison, A., and Rabellotti, R. (2011). *Innovation and technological catch-up: The changing geography of wine production*. Cheltenham, UK: Edward Elgar Publishing.

Grossman, G. and Rossi-Hansberg, E. (2006). "The rise of offshoring: it's not wine for cloth anymore". *Proceedings - The new economic geography: effects and policy implications symposium*, 59-102. Wyoming, USA: Federal Reserve Bank of Kansas City.

Gwynne, R. (2008). "UK retail concentration, Chilean wine producers and value chains". *The Geographical Journal*, 174 (2), 97-108.

Humphrey, J., and Schmitz H. (2002). "How does insertion in global value chains affect upgrading in industrial clusters?". *Regional Studies*, 36 (9), 1017-1027.

Inham, L., Ferreira, J., Marques, C. and Rebelo, J. (2013). "An innovation paradox in wine cluster: The case of Douro region (Portugal)". *Revista de Administração de Empresas*, 53 (3), 256-271.

Lenzen, M., Moran, D., Kanemoto, K. and Geschke, A. (2013). "Building Eora: a global multi-region input–output database at high country and sector resolution". *Economic Systems Research*, 25 (1), 20-49.

Lopes, T. (1998). *Internacionalização e concentração no vinho do Porto, 1945-1995: uma abordagem pelos custos de transação.* Oporto, Portugal: GEHVID.

Mann, S., Beciu, S., and Karbauskas, A. (2018) "Globalising chains – decoupling grape production, wine production and wine exports", *British Food Journal*, 120 (3), 703-713

Martins, C. (1988). "Os ciclos do vinho do Porto: ensaio de periodização". *Análise Social*, 24 (100), 391-429.

Martins, J. (2000). *Tudo sobre o vinho do Porto: os sabores e as histórias*. Lisbon, Portugal: Dom Quixote.

McCann, P. and Ortega-Argilés, R. (2015). "Smart specialization, regional growth and applications to European Union cohesion policy". *Regional Studies*, 49 (8), 1291-1302.

Midmore, P., Munday, M. and Roberts, A. (2006). "Assessing industry linkages using regional input–output tables". *Regional Studies*, 40 (3), 329-343.

Miller, R., and Blair, P. (2009). *Input-output analysis: foundations and extensions*. Cambridge, UK: Cambridge University Press.

OECD (2015). *OECD Inter-Country Input–Output (ICIO) Tables*. Paris, Organisation for Economic Co-operation and Development.

Padmore, T., and Gibson, H. (2008). Modelling systems of innovation: II. A framework for industrial cluster analysis in regions. *Research Policy*, 26, 625-641.

Pisano, G., and Shih, W. (2009). "Restoring American Competitiveness". *Harvard Business Review*, 87 (7/8), 114-125.

Ponte, S., and Ewert, J. (2009). "Which way is "up" in upgrading? Trajectories of change in the value chain for South African wine". *World Development*, 37 (10), 1637-1650.

Ramos, P., Cruz, L., Barata, E., Parreiral, A., and Ferreira, J.-P. (2015). "A Bi-Regional (Rectangular) Input-Output Model for Portugal: Centro and Rest of the Country", in P. Godinho and J. Dias (Eds.), *Assessment Methodologies: energy, mobility and other real world applications*, 265-286. Coimbra, Portugal: Imprensa da Universidade de Coimbra.

Rebelo, J., and Muhr, D. (2012). "Innovation in wine SMEs: the Douro Boys informal network". *Studies in Agricultural Economics*, 114 (10), 1-15.

Santos, J., and Ribeiro, J. (2012). "Estratégias empresariais de base territorial: o caso Symington e a produção de vinho do Porto". *DRd-Desenvolvimento Regional em debate*, 2 (1), 134-155.

Sequeira, C. (2011). *O Alto Douro entre o livre-cambismo e o protecionismo: a "questão duriense" na economia nacional*. Oporto, Portugal. CITCEM, Afrontamento.

Steen-Olsen, K., Owen, A., Barrett, J., Guan, D., Hertwich, E., Lenzen, M., and Wiedmann, T. (2016). "Accounting for value added embodied in trade and consumption: an intercomparison of global multiregional input–output databases". *Economic Systems Research*, 28 (1), 78-94.

Sturgeon, T., Biesebroeck, J., and Gereffi, G. (2008) "Value chains, networks and clusters: reframing the global automotive industry". *Journal of Economic Geography*, 8, 297-321.

Timmer, M., Dietzenbacher E., Los B., Stehrer R., and de Vries, G. (2015). "An Illustrated User Guide to the World Input–Output Database: the Case of Global Automotive Production". *Review of International Economics*, 23 (3), 575–605.

Titze, M., Brachert, M., and Kubis, A. (2011). "The identification of regional industrial clusters using qualitative input–output analysis (QIOA)". *Regional Studies*, 45 (1), 89-102.

[i] Four major databases can be identified as the ones that have been mostly applied in such cases: the EORA (*Lenzen et al.*, 2013), the Exiobase (Exiobase, 2012), the OECD Inter-Country Input-Output Tables (OECD, 2015) and the World Input Output Database (Timmer *et al.*, 2015).

[ii] According to OECD Trade in value-added database (OECD, 2015), the content of Portuguese value-added in Portuguese gross imports was, in 2014, less than 0.5%.

[iii] In 2010, 95% of the grapes used in Port wine production had their origin in the Douro NUTS III region. The remaining 5% came from neighbouring regions, which belong to the Douro wine demarcated region, but not to the Douro NUTS III region.

[iv] Similar to the processes described by Bell and Giuliani (2007) and Giuliani *et al.* (2011) concerning other wine production cases.

[v] See Ramos *et al.* (2015) for further details on the MULTI2C framework. This work follows the 2002 geographical distribution of Portuguese NUTS III regions.

[vi] Although MULTI2C explicitly deals with secondary production, in the case of liqueur and non-liqueur wines there is no information neither on the production of still wine by liqueur wine firms or on the production of Port by non-liqueur producers. So, in our model, all the liqueur wine produced by the NA's "Manufacture of wines" industry was allocated to the "Manufacture of liqueur wines" and similar procedure was adopted for the other wines. In other words, all the multi-product producers were notionally split by the two sub-industries, assuming the proportion of the types of wine produced.

[vii] Nonetheless, total Gross Value Added of the Liqueur wines industry remains the same in spite of this imputation.