Economic Systems Research, Vol. 13, No. 2, 2001

Reconciling Domestication Techniques, the Notion of Re-exports and Some Comments on Regional Accounting

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(Received March 2000, revised November 2000)

ABSTRACT *Recent work by Jackson (1998) subtly pointed out a means of forming direct input coefficient matrices from national technology that is di erent from that published elsewhere. In this paper, I rationalize his approach and also point out that prior approaches may still be useful in certain applications where the phenomenon of re-exports (imports that satisfy exports) are explicit in exports accounts. In the second half of this paper, I show some means of developing regional accounts, currently being used in the US, that are more elaborate than those Jackson discussed. For example, I substitute regional shares of employment with earnings shares to obtain productivity adjusted regional output. I also suggest using available regional value added and regional labour income when producing regional Use matrices.*

KEYWORDS: *Regional accounts, commodity-by-industry, international trade*

1. Introduction

In a recent paper, Jackson (1998) presented an approach for developing regional accounts. He did so by first detailing a new approach for estimating industry-by-industry direct input coefficients matrices from national commodity-by-industry accounts. He followed this up with a more pragmatic discussion of the ways in which regional accounts can be constructed from national commodity-by-industry accounts and a modicum of region-specific data. In both parts of his paper, Jackson neglected to discuss the merits of his approach over its predecessors. Indeed, he did not mention any literature on the two subjects that may exist. From this perspective, it was difficult to discern what the paper's contribution truly was.

In an effort to tidy things up, as well as to point out the importance of his work, I first place Jackson's technique for estimating industry-by-industry direct input coefficients matrices from national commodity-by-industry accounts in the

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ISSN 0953-5314 print; 1469-5758 online/01/020165-15 DOI: 10.1080/09537320120052443

context of a predecessor approach. After making a side-by-side comparison of the two formulations, I derive the two approaches analytically and discuss the economic implications of their differences. In Section 4, I show how the two differences can be rationalized through the enumeration of something I call 're-exports'- imports that are exported without processing. With this as an entrée, I discuss the notion of a generalized trade coefficient, which has been presented in Szyrmer & Lahr (1992), where it is termed 'the generalized RPC'. The discussion of re-exports leads me to conclude that Jackson's approach is the better of the two for the purpose of creating industry-by-industry national direct input coefficients.

In Section 3 of his paper, Jackson (1998, pp. 229-235) discusses how he develops regional accounts from the 85-sector US commodity-by-industry accounts published by the US Department of Commerce, Bureau of Economic Analysis. He does so using what he calls (Jackson, 1998, p. 229) a 'general adaptable procedure' that can 'accommodate the introduction of superior data, but does not depend on them for implementation'. As such, this section of his paper is a highly pragmatic description of the way Jackson constructs regional accounts using a small set of available regional data.

The regional economics literature seems to be devoid of any prior blow-by-blow narrative of the development of regional accounts in a commodity-by-industry setting. Thus, this part of Jackson's paper serves as the genesis of a formal document on the subject. As a developer of regional accounts myself, I take the opportunity to present some extensions to Jackson's regional accounting approach in the second half of the paper. I focus on estimating regional output levels and the regional value added accounts. I also lay down some general guidelines that should be followed in producing regional accounts from national accounts when only a modicum of secondary regional data is available.

2. Jackson's Contribution to Trade-Adjusting National Accounts

Using the notation in Table 1, Jackson (1998) obtained an industry-by-industry direct input coefficients matrix, the conventional **A** matrix, by the following means

$$\mathbf{A} = \tilde{\mathbf{D}}\mathbf{B} \tag{1}$$

where

$$\mathbf{B} = \mathbf{U}\hat{\mathbf{g}}^{-1} \tag{2}$$

$$\tilde{\mathbf{D}} = \begin{pmatrix} \mathbf{V} - \mathbf{D}\hat{\mathbf{x}} \\ \mathbf{m}' \end{pmatrix} \widehat{(\mathbf{q} - \mathbf{x} + \mathbf{m})}^{-1} \tag{3}$$

$$\mathbf{D} = \mathbf{V}\hat{\mathbf{q}}^{-1} \tag{4}$$

Table 1. Scheme of commodity-by-industry accounts with a negative entry for competitive imports in final demand

	Commodities	Industries	Final Demand	Total Output
Commodities		**U**	$\mathbf{F}\vert\mathbf{x}\vert(-\mathbf{m})$	**q**
Industries	**V**			**g**
Value Added		**W**		
Total Input	$\mathbf{q}'$	$\mathbf{g}'$		

Note: **F** is the matrix of domestic final demand and **x** is a vector of exports, so that $\mathbf{F}\vert\mathbf{x}$ is a matrix formed by concatenating **x** to **F**.

and ˆ above a vector denotes a diagonal matrix with that vector on the diagonal and zeros elsewhere. Combining (1) and (3) results in

$$\mathbf{A} = \begin{pmatrix} \mathbf{V} - \mathbf{D}\hat{\mathbf{x}} \\ \mathbf{m}' \end{pmatrix} (\widehat{\mathbf{q} - \mathbf{x} + \mathbf{m}})^{-1}\mathbf{B} \tag{5}$$

This formulation clearly is somewhat different than that proposed by St. Louis (1989, p. 376, Equation (5)),[1]

$$\mathbf{A} = \mathbf{D}(\mathbf{I} - \hat{\mathbf{m}}(\widehat{\mathbf{q} + \mathbf{m}})^{-1})\mathbf{B} \tag{6}$$

an apparent trade-adjusted correction of Miller & Blair's (1985, pp. 159-174) formulation. The difference between Jackson's and St. Louis's formulations is in Jackson's application of exports ($\mathbf{x}$) in both terms of the right-hand side of (3). Since exports are not part of the input technology of any industry, it is not immediately clear why Jackson applies them. Although not explicit in his work, the logic he uses in explaining the use of exports is not unlike that used by Miller & Blair (1985, p. 47) for regional supply percentages, which are used to regionalize national direct requirements matrices. Indeed, as I will show in the next section, Jackson's formula is identical in both purpose and content to Miller & Blair's regional supply percentages.

In an effort to diffuse any possible controversy between the two approaches, I investigate briefly why and when the two different formulations might be warranted. In order to undertake such an investigation, I review the principles of a generalized formula for trade adjustment that I co-developed elsewhere (Szyrmer & Lahr, 1992).

3. Derivation of Jackson's Approach and the Concept of Re-exports

The supply-demand equilibrium condition in input-output analysis can be expressed as

$$\mathbf{Ui} + \mathbf{Fi} = \mathbf{q} - \mathbf{x} + \mathbf{m} \tag{7}$$

where $\mathbf{i}$ is a summation column vector of 1s, $\mathbf{i} = [1, 1, \ldots, 1]'$, with a dimension equal to the number of modelled industries.[2] Let us then define

$$\left.\begin{aligned} \mathbf{U} &\equiv \mathbf{U}^n + \mathbf{U}^m \\ \mathbf{F} &\equiv \mathbf{F}^n + \mathbf{F}^m \\ \mathbf{x} &\equiv \mathbf{x}^n + \mathbf{x}^m \end{aligned}\right\} \tag{8}$$

where the superscript m denotes that portion of the economy that is composed of imports and n where it is supplied from intranational sources. The least clear of the above components is $\mathbf{x}^m$, which can be interpreted as re-exports-exports that are fulfilled directly by imports. In most survey-based models, re-exports enter only indirectly in such sectors as Transportation Services, Warehousing, and Insurance, since re-exports almost by definition are non-competitive imports and, therefore, should not enter the intermediate accounts.[3] Without survey work, which is the situation for a very large share of existing subnational economic models, model developers cannot identify the competitive status of imports (often called 'in-flows' in a regional context). Since such non- or semi-survey models rely on secondary data sources, re-exporting is likely to be viewed as part of the more general phenomenon of crosshauling unless additional insight from industry experts can be obtained.

Now from (7) and (8) we can derive

$$\mathbf{U}^n\mathbf{i} + \mathbf{F}^n\mathbf{i} + \mathbf{U}^m\mathbf{i} + \mathbf{F}^m\mathbf{i} = \mathbf{q} - \mathbf{x}^n - \mathbf{x}^m + \mathbf{m} \tag{9}$$

And, as long as there are no re-exports, then

$$\mathbf{U}^n\mathbf{i} + \mathbf{F}^n\mathbf{i} = \mathbf{q} - \mathbf{x}^n \tag{10}$$

but typically, as in the case of the US, we do not know the import composition of each industry's inputs, so neither $\mathbf{U}^n$ nor $\mathbf{U}^m$ is known. Nor do we know the import composition of final demand, **F**. Thus, trade adjustment is relegated to the application of estimated vectors for imports (**m**), exports (**x**) and output (**q**). Since, according to Table 1, export and import information is available only by commodity, the trade adjustment of technology necessarily is performed across rows. Thus, regionalizing or 'domesticating' national technology transforms (10) into

$$\hat{\rho}\mathbf{U}\mathbf{i} + \hat{\rho}\mathbf{F}\mathbf{i} = \mathbf{q} - \mathbf{x} \tag{11}$$

Solving[4] for ρ,

$$\rho = \frac{\mathbf{q} - \mathbf{x}}{\mathbf{U}\mathbf{i} + \mathbf{F}\mathbf{i}} \tag{12}$$

Substituting, using the equilibrium relationship expressed in (7) leaves us with

$$\rho = \frac{\mathbf{q} - \mathbf{x}}{\mathbf{q} - \mathbf{x} + \mathbf{m}} \tag{13}$$

the equation for supply percentages in Miller & Blair (1985, p. 47).

Now, to derive Jackson's equivalence to this measure we factor $\hat{\mathbf{q}} - \hat{\mathbf{x}}$ out of the top partition of the first term of (5), giving us

$$\mathbf{A} = \begin{pmatrix} \mathbf{D}\widehat{(\mathbf{q} - \mathbf{x})} \\ \mathbf{m}' \end{pmatrix} \widehat{(\mathbf{q} - \mathbf{x} + \mathbf{m})}^{-1}\mathbf{B} \tag{14}$$

Expanding we get

$$\mathbf{A} = \begin{pmatrix} \mathbf{D}\widehat{(\mathbf{q} - \mathbf{x})}\,\widehat{(\mathbf{q} - \mathbf{x} + \mathbf{m})}^{-1}\mathbf{B} \\ \mathbf{m}'\widehat{(\mathbf{q} - \mathbf{x} + \mathbf{m})}^{-1}\mathbf{B} \end{pmatrix} \tag{15}$$

The lower term of the right-hand side of (15) estimates the disposition of imports in the economy: thus, it technically is not part of a national direct input coefficients matrix, a minor error with which we can easily reckon through omission. This leaves us with the more appropriate formulation

$$\mathbf{A} = \mathbf{D}\widehat{(\mathbf{q} - \mathbf{x})}\,\widehat{(\mathbf{q} - \mathbf{x} + \mathbf{m})}^{-1}\mathbf{B} \tag{16}$$

or, applying Hadamardian notation,

$$\mathbf{A} = \mathbf{D}\left(\widehat{\frac{\mathbf{q} - \mathbf{x}}{\mathbf{q} - \mathbf{x} + \mathbf{m}}}\right)\mathbf{B} \tag{17}$$

Note that the centre term of the right-hand side of (17) is the 'regionalizing' or 'domesticating' parameter ρ in (13), thus ending the search for equivalence. Note that (17) could also be rewritten as

$$\mathbf{A} = \mathbf{D}\left[\mathbf{I} - \left(\widehat{\frac{\mathbf{m}}{\mathbf{q} - \mathbf{x} + \mathbf{m}}}\right)\right]\mathbf{B} \tag{18}$$

St. Louis's formulation, shown in (6), thus differs only in its 'failure' to subtract exports, **x**, from the denominator of the trade adjustment parameters, ρ. That is, St. Louis's equivalent of (18) is

$$\mathbf{A} = \mathbf{D}\left[\mathbf{I} - \left(\widehat{\frac{\mathbf{m}}{\mathbf{q} + \mathbf{m}}}\right)\right]\mathbf{B} \tag{19}$$

and his equivalent of (17) is

$$\mathbf{A} = \mathbf{D}\left(\widehat{\frac{\mathbf{q}}{\mathbf{q} + \mathbf{m}}}\right)\mathbf{B} \tag{20}$$

4. ρ Generalized

After analysing the above approach to domesticating/regionalizing technology matrices, Szyrmer & Lahr (1992) showed that one could generalize ρ so that re-exports can be taken explicitly into account. They investigated the possibility of such a generalization due to some slightly unsettling empirical results they obtained using some highly aggregated hypothetical regional models. The generalized formula for trade coefficients, ρ, that they derived is

$$\rho = \frac{\mathbf{q}}{\mathbf{q} + \mathbf{m} + (\eta - 1) \times \mathbf{x}} \tag{21}$$

where η is a parameter that adjusts ρ for exports to obtain the proportion of exports that is derived from local sources only. That is, $\eta = \mathbf{x}^n/(\rho \times \mathbf{x})$ so that $\mathbf{x}^n = \eta\rho \times \mathbf{x}$, where $0 \leqslant \rho \leqslant 1$ and $0 \leqslant \eta \leqslant 1/\mathbf{r}$, given that **q**, **m** and **x** are non-negative and $\mathbf{q} + \mathbf{m} > \mathbf{x}$. The various possibilities of the generalized purchase coefficients, so named by Stevens & Trainer (1976), or supply percentages are displayed in Table 2.

Table 2. Variants of generalized ρ

Variant	Assumption	η	ρ formula
Re-exports only	All exports are imported	$\eta = 0$	$\frac{\mathbf{q}}{\mathbf{q} - \mathbf{x} + \mathbf{m}}$
Large re-exports	Exports are composed of more imports than are local deliveries	$0 < \eta < 1$	$\frac{\mathbf{q}}{\mathbf{q} + \mathbf{m} + (\eta - 1) \times \mathbf{x}}$
Average re-exports	Exports and local deliveries are composed of equal proportions of imports	$\eta = 1$	$\frac{\mathbf{q}}{\mathbf{q} + \mathbf{m}}$
Small re-exports	Exports composed of fewer imports than are local deliveries	$1 < \eta < \frac{1}{\rho}$	$\frac{\mathbf{q}}{\mathbf{q} + \mathbf{m} + (\eta - 1) \times \mathbf{x}}$
No re-exports	No exports derive from imports	$\eta = \frac{1}{\rho}$	$\frac{\mathbf{q} - \mathbf{x}}{\mathbf{q} - \mathbf{x} + \mathbf{m}}$

Source: Szyrmer & Lahr (1992).

In defining η, $\eta_i = 0$ is the case where all exports (outflows) are derived from imports (inflows). Alternatively, this means that all local production is locally consumed, the situation, say, of wine in the Philadelphia metropolitan area, where virtually all local production is locally consumed. When $\eta_i = 1$, the ρ_i for exports is the same as for intermediate deliveries. When $\eta_i = 1/\rho_i$ no re-exporting exists. Thus, one can readily interpret the formula used by St. Louis (1989) to be that where $\eta = 1$ and exports and local deliveries are composed of equal proportions of imports.

Interestingly, Szyrmer & Lahr (1992) compiled evidence showing that the approach used by St. Louis (1989) may be more appropriate for regionalization as opposed to the national domestication of technology. An argument was made that Armington's (1969) explanation for crosshauling due to product differentiation may not be pertinent in confined economic spaces.[5] For this reason and others, not the least of which was the principle of Occam's razor, I continue to support the application of the approach used by St. Louis (1989) and Szyrmer (1992), although only in cases where the exports vector is replete with re-exports, as in the case of most subnational regions and especially those with major entrepôts. When re-exports are known not to be in the exports vector, as in the case of accounts created using the United Nation's system of national accounts, Jackson's (1998) should be preferred.

5. Regionalizing National Accounts

After describing how to domesticate national Make and Use tables, Jackson (1998, p. 235) mentions that the approach shown in (5) above 'can now be applied to the regional accounts to construct the basis of a regional accounting framework'. In presenting how to produce a set of regional accounts, however, he neglected to mention several key points and principles underlying his approach that bear some significant recognition. Others, he mentioned in passing and could use some reiteration. Thus, I will discuss each in turn here.

First let me cover three main principles that have been used over the course of time in the development of regional accounts when little or no survey-based data are available for the region.

- *When producing regional accounts from national accounts, use as much sectoral detail as there is available*. According to the literature on the effects of aggregation in input-output analysis, the conditions for zero aggregation bias are highly restrictive.[6] Sawyer & Miller (1983) and Stevens & Lahr (1993) point out further that, in the case of non-survey regional input-output accounts, aggregation further manifests itself through possible improper specification of regional industry mix within the aggregated sectors and through post-aggregation regionalization of national accounts.
- *When 'regionalizing' national accounts, one assumes that technology is spatially invariant within a nation*. This principle has been used by producers of industry-by-industry regional input-output models at least since Isard (1951). This assumption allows us to use the national Use coefficients matrices, albeit with some adjustment(s).
- *Regionalization typically should be performed on domesticated national accounts*. Most means of quantifying interregional trade fail to account for national exports originating from the region of study or for imports to a nation

destined to the region of study. That is, $\mathbf{x}_q^R$ and $\mathbf{m}_q^R$ are regional ^{R} inflows and outflows of commodities $_q$ that are of national origin only. This is typically true for regional ρ^Rs estimated from national commodity flow surveys and is always true for those based on location quotient and supply/demand pool techniques. In any case, regionalization schemes typically cannot account for international trade, especially imports. Thus, most regionalization methods must be applied *on top of* the domestication of national technology.

5.1. *Regional Output*

Jackson (1998, pp. 231-235) goes a few steps further in laying out the development of regional accounts. He estimates regional industry output by applying the region's employment shares to national output. While he admits that regionally differentiated productivity enhancements should also be used, he fails to mention how to derive them. Economic theory tells us that the gross wages paid to a worker should equal the value of the worker's marginal product. In essence, then, the region's share of the nation's total labour income for each industry is the productivity-enhanced value of Jackson's τ. That is, the region's shares of labour income by industry should be preferred over its shares of national employment as the set of parameters to derive regional output from national output.

Furthermore, regional output is often directly available either through government sources or through trade sources. In the US, the federal government provides estimates of industry revenues for many industries via the Economic Census.[7] For some commodities, like those of agriculture and mining in the US, and in certain other countries, regional data on output are available on an annual basis. In such cases, one need not apply Jackson's equations (17) and (18) to obtain estimates of regional output by industry.

5.2. *The Regional Make Table*

Jackson regionalizes the national Make accounts by applying a rows-only type of approach using output estimates. In doing so, he assumes that *the mix of commodities produced by an industry is spatially invariant*, paralleling the technology assumption of Isard (1951). This is not an insignificant assumption and one that requires further scrutiny through additional research. It is not quite as appealing as Isard's technology assumption across space. On the other hand, since even national Make accounts typically are weighted heavily by transactions on their diagonals, it may well be that this assumption is not very damning.

Jackson probably mentioned only industry-based adjustments because commodity-based data are not generally available for regions. If regional data on output by commodity are also available, the adjustments would necessarily be made columnwise on the Make table. If both industry and commodity output are available, one could conceivably use a biproportional adjustment or mathematical programming procedure, such as those discussed in some detail in Dietzenbacher & Lahr (2001), to balance the regional Make matrix. While meeting regional production in terms of both industry and commodity output, such an approach permits some variation in the mix of commodities produced by an industry but does constrain it to being as close as possible to that of the nation. Naturally, and as Jackson mentions several times throughout this section of his paper, analysts with access to data that are known to be superior to those in any estimated regional account arrays should use this superior data to the fullest extent.

5.3. Regional Value Added

The US Bureau of Economic Analysis, which releases the official US I-O tables, produces a series on value added for states, albeit at a rather aggregated level both geographically and sectorally. This series, the gross state product originating (GSP) series, has about 63 industries compared with about 490 industries in the most detailed set of national accounts. It is, however, not available for a geography smaller than states. Nonetheless, the information does offer the modeller some hope of capturing spatial differences in GSP's three reported components: compensation of employees, indirect business tax and non-tax liability, and property-type income.[8] Thus, it would seem that Jackson was remiss in this one case. Instead, for the US at least, he might have suggested that regional value added be estimated as follows:

$$\bar{\mathbf{W}}^{\mathrm{R}} = (\mathbf{W}\hat{\tau}) \times \left(\frac{\mathbf{W}^{\mathrm{R}}_{m}}{\mathbf{W}\hat{\tau}\mathbf{S}_{m}} \mathbf{S}'_{m} \right) \tag{22}$$

where $\mathbf{S}_m$ is an n-by-m aggregation matrix of ones and zeros that appropriately maps the n input-output industries into the m industries of the known regional value added matrix (moreover, $n > m$) and $\mathbf{W}^{\mathrm{R}}_{m}$ is the k-by-m matrix of regional value added (or value added for a region that embraces the region of study), where k is the number of separate value added accounts. And, again, τ is the share of national output that is produced in the region. (Further refinements, however, can be made if regional labour income is known; hence, I have denoted the left-hand side of (22) with an overbar $\bar{\mathbf{W}}^{\mathrm{R}}$ for the time being. A refinement of (22) is discussed later in the text surrounding equation (24).)

The principle behind this approach is that of applying known spatially differentiated value-added information at an aggregated level to national value added data that has far more detail. In the words of Jackson, this approach permits superior information for a region to take precedent while retaining national information on intrasectoral relationships, where such information does not exist at the regional level.

5.4. Regional Labour Income

Value added, of course, is composed mostly of labour income. Thus, labour income is likely to have among the largest if not *the* largest technology coefficient for nearly all industries. Jensen & West (1980), among others, have shown that the accuracy of the largest elements of a direct requirements matrix concomitantly determines the accuracy of the matrix's Leontief inverse. Thus, getting this component right is particularly crucial. In the US, annual data on wage and salary income by place of work are available at very detailed industry levels through a federal series on private non-farm employment and related payroll, called the ES202 series and released by the US Bureau of Labor Statistics (BLS). Alternatively, in the US a more widely used but lower-quality series for such purposes is the County Business Patterns (CBP) data series produced by the US Census Bureau. While labour income for most industries is composed mostly of wage and salary disbursements, it also includes proprietors' income[9] and other labour compensation.[10] These other types of income, however, are not included in the ES202 or CBP data series. Indeed, they are only available at a more aggregated industry level from BEA, again at best for about 65 industries. Unlike data for value added, however, the labour income data are released for political geographies smaller than states. Unfortunately, in the case of both the BLS ES202 and the BEA earnings series, the data for an industry are publicly released only when more than three firms exist for a specified geography. Thus, anyone outside of the US federal government who creates a US regional account must apply techniques like those described by Gerking *et al.* (2001) to 'fill in' any undisclosed entries.

Assuming all entries are available or estimated for the industrywise detailed wage and salary disbursements and for the more sectorally aggregated labour income data on a region, one can readily estimate detailed labour income by industry, $\mathbf{w}_l^{\mathrm{R}}$. The technique is not unlike that in (22) above.

$$\mathbf{w}_l^{\mathrm{R}} = \mathbf{w}_{w\&s}^{\mathrm{R}} \times \left(\frac{\mathbf{w}_e^{\mathrm{R}}}{\mathbf{w}_{w\&s}^{\mathrm{R}} \mathbf{S}_e} \mathbf{S}_e' \right) \tag{23}$$

where $\mathbf{w}_{w\&s}^{\mathrm{R}}$ is the 1-by-n vector of regional wage and salary disbursements, $\mathbf{w}_e^{\mathrm{R}}$ is the 1-by-p vector of regional labour income, and $\mathbf{S}_e$ is a n-by-p aggregation matrix composed of ones and zeros that appropriately maps the n input-output industries into the p sectors for which regional labour income are known. Since they are based entirely on local data, these estimates of $\mathbf{w}_l^{\mathrm{R}}$ will be far superior to any predicated on a multiplication of the national labour income vector, $\mathbf{w}_l$, and the region's shares of national output, τ.

Once estimates of regional labour income are produced, then the remaining components (rows) of value added should be recalibrated. To do so, one need only subtract labour income from value added and distribute the difference to the remaining components of value added, keeping fixed each component's share of non-labour income value added.[11] That is,

$$\mathbf{W}_{\sim l}^{\mathrm{R}} = (\mathbf{i}'\bar{\mathbf{W}}^{\mathrm{R}} - \mathbf{w}_l^{\mathrm{R}}) \times \frac{\bar{\mathbf{W}}_{\sim l}^{\mathrm{R}}}{\mathbf{i}'\bar{\mathbf{W}}^{\mathrm{R}}} \tag{24}$$

where the subscript $\sim l$ denotes all row sectors except labour income. Regional value added, $\mathbf{W}^{\mathrm{R}}$, then is the result of (23) concatenated to the result of (24).

5.5. The Regional Use Table

Once regional values added and output by industry are estimated, work on the region's Use accounts can commence. First, the so-called fabrication adjustment must be effected. This means modifying $\mathbf{B}$ so that $\mathbf{i}'\mathbf{B}^{\mathrm{R}} + [(\mathbf{i}'\mathbf{W}^{\mathrm{R}})'/\mathbf{g}^{\mathrm{R}}] = \mathbf{1}$, where $\mathbf{g}^{\mathrm{R}}$ is regional output by industry. That is, we must make sure that regional output less regional value added equals regional intermediate use for each industry. We do this by rescaling the columns of $\mathbf{B}$ to adjust for known information on value added and output in the following way

$$\bar{\mathbf{U}}^{\mathrm{R}} = \mathbf{B}(\widehat{\mathbf{i}'\mathbf{B}})^{-1}\{\hat{\mathbf{g}}^{\mathrm{R}} - [(\widehat{\mathbf{i}'\mathbf{W}^{\mathrm{R}}})']\} \tag{25}$$

This differs from the approach applied by Jackson in that it accounts for interregional differences in the accrual of value added by industry. Note, however, that the left-hand side of (25) retains an overbar, which indicates that this is, at best, a rough estimate of the regional Use matrix. That is, more refinements to this version of the regional Use matrix remain. These refinements pertain to the allocation of some of the shipments designated in the Use matrix that are really regional outflows (discussed later in section 5.6) and, as such, should be allocated to a separate account.

5.6. Non-export Regional Final Demand

As in the case of regional output and value added, regional final demand can also be estimated in a somewhat more elaborate manner than that suggested by Jackson. Indeed, Treyz & Stevens (1985, pp. 550-551) discuss a rather elegant econometrically based approach in which the magnitude of each component of final demand depends on regional aggregate disposable income, the level of intermediate activity in the region, and other factors.[12] Nonetheless, in producing estimates of local final demand, most regional practitioners in the US do not deviate far from the methods covered by Jackson.

The only item that could bear extra attention is the region's household consumption pattern, where regional data on personal consumption expenditures can be used. Such data are available in most OECD nations. In the US, for example, BLS releases microdata on this subject through its Consumer Expenditure Survey (CES). And while these data can provide reasonable estimates of consumer spending for very detailed commodities, the geographic scope of a study region can limit the sample size to the point where the CES sample is not representative. Nonetheless, in the US, data on household spending certainly are available by state and also for most large and medium metropolitan areas. To be sure, however, some conversion of the data on retail spending by households may be necessary for proper accounting since such expenditures must be broken into their components of retail and wholesale margins and of producers' prices for the manufactured item purchased.[13]

5.7. Regional Inflows and Outflows

At this point I have suggested some deviations from Jackson's approach for developing a set of regional accounts for all but the flow of commodities in and out of the region- the regional equivalents of national level imports and exports. In line with prior literature on the subject and to avoid misunderstanding, I term these commodity inflows to and outflows, respectively, from a region.

As Jackson (1998, pp. 226-227) tells us

> Modifying the national accounts prior to regionalization is useful, since estimating regional imports and exports is central to this task. It is critical to understand fully and emphasize imports accounting before constructing accounts for subnational regions the economies of which are generally much more open than those of their national counterparts.

I go into far more detail on the importance of accounting for trade in an earlier paper (Lahr, 1993) as well. However, neither of us really gets at the crux of the matter. One must adjust national accounts for trade prior to regionalization simply because most means of estimating the regional in- and outflows of commodities are not founded upon surveys of the ultimate origins and destinations of commodities. That is, very little readily available data exists (in the US in any case) that can inform the developer of accounts about the *international* disposition of regional production in sufficient industrial/commodity detail to be useful.

In the US, at best, the US Department of Transportation (DOT) through its Commodity Flow Survey (CFS) makes available a sample of information on the ultimate *intranational* destination of commodities for shipments by manufacturing establishments. Indeed, these data purportedly are available by industry of the destination establishment as well. Thus, one could conceivably estimate inter-regional trade flows for manufacturing industries, although there might be some problems when the destination establishment is a wholesaler or shipping firm. Even in such a detailed database as this, however, internationally bound shipments are not marked in any special way. Nor are imported goods covered. As a result, developers of regional accounts spatially allocate a nation's exports based on a region's share of national activity, i.e. using τ.

Evoking τ fails, however, to estimate non-internationally bound shipments of goods and services that leave or enter a region- its commodity in- and outflows. There are two options for applying a rows-only type approach when producing an industry-by-industry regional direct inputs coefficients matrix, one is commodity-based the other is industry-based. If commodity-based information is available at the regional level, a regional direct inputs coefficients matrix can be estimated by the following enhancement of (17)

$$\mathbf{A}^{\mathrm{R}} = \mathbf{D}^{\mathrm{R}}\hat{\rho}^{\mathrm{N}}\hat{\rho}_q^{\mathrm{R}}\bar{\mathbf{B}}^{\mathrm{R}} \tag{26}$$

where the superscripts N and R denote 'national' and 'regional', respectively, the subscript q denotes that the parameter is, in commodity terms, $\mathbf{D}^{\mathrm{R}} = \mathbf{D}\hat{\tau}$, and $\bar{\mathbf{B}}^{\mathrm{R}} = \bar{\mathbf{U}}^{\mathrm{R}}(\hat{\mathbf{g}}^{\mathrm{R}})^{-1}$. Further we find that

$$\mathbf{B}^{\mathrm{R}} = \hat{\rho}_q^{\mathrm{R}}\bar{\mathbf{B}}^{\mathrm{R}} \tag{27}$$

and that

$$\mathbf{U}^{\mathrm{R}} = \hat{\mathbf{g}}^{\mathrm{R}}(\hat{\rho}_q^{\mathrm{R}}\bar{\mathbf{B}}^{\mathrm{R}}) \tag{28}$$

This approach is justified by applying regional trade and industry structural differences as a simple multiplicative extension of the national trade effects. It should be used when data on commodity flows, such as the data from the US Commodity Flow Survey, are available.

In the commodity-based case of ρ^{R}, estimates of in- and outflows are immediately apparent when no regional re-outflows exist. This is due to the nature of the formula for ρ^{R} in (13), given that we have an estimate of $\mathbf{q}^{\mathrm{R}} = (\mathbf{i}'\mathbf{V}^{\mathrm{R}})'$. Hence, for outflows

$$\mathbf{x}^{\mathrm{R}} = (\mathbf{I} - \hat{\rho}^{\mathrm{N}}\hat{\rho}_q^{\mathrm{R}})\bar{\mathbf{U}}^{\mathrm{R}}\mathbf{i} + (\mathbf{I} - \hat{\rho}^{\mathrm{N}}\hat{\rho}_q^{\mathrm{R}})\mathbf{F}^{\mathrm{R}}\mathbf{i} \tag{29}$$

where the international proportion of these outflows is estimated as $(\mathbf{I} - \hat{\rho}^{\mathrm{N}})\bar{\mathbf{U}}^{\mathrm{R}}\mathbf{i} + (\mathbf{I} - \hat{\rho}^{\mathrm{N}})\mathbf{F}^{\mathrm{R}}\mathbf{i}$ and the intranational portion is estimated as the difference between this and (29) or $(\mathbf{I} - \hat{\rho}_q^{\mathrm{R}})\hat{\rho}^{\mathrm{N}}\bar{\mathbf{U}}^{\mathrm{R}}\mathbf{i} + (\mathbf{I} - \hat{\rho}_q^{\mathrm{R}})\hat{\rho}^{\mathrm{N}}\mathbf{F}^{\mathrm{R}}\mathbf{i}$. Subsequently, inflows can be derived as suggested by Jackson's equation (23):

$$\mathbf{m}^{\mathrm{R}} = \mathbf{U}^{\mathrm{R}}\mathbf{i} + \mathbf{F}^{\mathrm{R}}\mathbf{i} + \mathbf{x}^{\mathrm{R}} - (\mathbf{i}'\mathbf{V}^{\mathrm{R}})' \tag{30}$$

The distinction between international and intranational origins of regional inflows, while estimable in a fashion similar to the decomposition of outflows, is not as reliable. This is due to their character as a remainder derived from the rows-only techniques used in the regionalization process, which relies heavily on national production and consumption patterns.

In most cases, however, an industry-based approach is applied in the regionalization process, due to the greater availability of industry-based data on employment and labour income dispensed by governments around the world. The industry-based approach to regionalization of a national direct input coefficients matrix is well-known and is written as

$$\mathbf{A}^{\mathrm{R}} = \hat{\rho}_g^{\mathrm{R}} \mathbf{A}$$

or (31)

$$\mathbf{A}^{\mathrm{R}} = \hat{\rho}_g^{\mathrm{R}} \bar{\mathbf{D}}^{\mathrm{R}} \hat{\rho}^{\mathrm{N}} \bar{\mathbf{B}}^{\mathrm{R}}$$

As Jackson (1998, pp. 233-234) mentions, in estimating ρ_g^{R}- the industry-based RPC- supply-demand pool, location quotient, and econometric approaches are often used.[14] He further notes that such industry-based RPC estimates cannot estimate both in- and outflows and estimate only *net* outflows. This is because such techniques cannot permit the crosshauling of commodities that pervades nearly all existing data on interregional trade.

If, however, the RPC estimates are founded on actual interregional trade data, Jackson (1998, p. 234) provides an interesting way to incorporate any such superior data. He also emphasizes (Jackson, 1998, p. 235) that neglecting the possibility of crosshauling 'will result in overestimates of regional supply and correspondingly inflated multipliers when models based on these accounts are used as the basis for impact assessment'.

5.8. Regional Use Accounts Redux

With estimates by commodity of regional output ($\mathbf{q}^{\mathrm{R}}$), final demand ($\mathbf{F}^{\mathrm{R}}$), outflows ($\mathbf{x}^{\mathrm{R}}$), and inflows ($\mathbf{m}^{\mathrm{R}}$) and by industry of regional output ($\mathbf{g}^{\mathrm{R}}$) and value added ($\mathbf{W}^{\mathrm{R}}$), one could conceivably re-estimate the regional Use accounts using a biproportional adjustment approach such as RAS. The marginal totals of the regional Use matrix to be matched during such a process would be

$$\mathbf{U}^{\mathrm{R}}\mathbf{i} = \mathbf{q}^{\mathrm{R}} + \mathbf{m}^{\mathrm{R}} - (\mathbf{F}^{\mathrm{R}}\mathbf{i}) - \mathbf{x}^{\mathrm{R}} \tag{32}$$

and

$$\mathbf{i}'\mathbf{U}^{\mathrm{R}} = \mathbf{g}^{\mathrm{R}} - (\mathbf{i}'\mathbf{W}^{\mathrm{R}}) \tag{33}$$

Naturally, in order for such a procedure to be non-trivial, estimates of either exports or imports would have to derive from a source beyond that described in equations (29) and (30) above.

6. Conclusions

In the first half of the paper, I show how the approach Jackson (1998) presented for adjusting national technology was both novel and correct. I show that the main alternative, which I attribute to St. Louis (1989), does have some merit in certain situations depending on the proportion of imports that is immediately converted into exports (termed here 're-exports'). I then go on to investigate the characteristics of the trade adjustment parameters and present a discussion of a so-called 'generalized regional purchase coefficient', developed in detail by Szyrmer & Lahr (1992).

In the second half of the paper (Section 5), I attempt to elucidate and extend some thoughts that Jackson discussed in his section entitled 'Regionalizing National Accounts'. Foremost, I offer that industry earnings shares should be used instead of employment shares in scaling national output down to regional output since, theoretically at least, earnings explicitly account for productivity differentials. I also show how to adjust national value-added estimates to regions by using both actual regional labour income data and any regional value added data for an embracing geography. Finally I explicitly present how regionalization can be performed if data on interregional trade are collected on a commodity basis, deriving a means of estimating regional outflows, regional exports, and regional inflows.

In summary, rather than a critique of Jackson's (1998) piece, this paper is a vindication and a proponent of it. In addition, I opted to take the opportunity to clarify and elaborate some of the points he made.

Notes

1. St. Louis's definition of his 'domestication parameters' is not entirely clear. In his equation (5), he defines the national direct inputs coefficients matrix as $\mathbf{D}(\mathbf{I}_c - \hat{\delta})\mathbf{B}$, where $\mathbf{I}_c$ is an identity matrix with a dimension the same as the number of commodities that are modelled and $\hat{\delta}$ is 'a diagonal matrix of imports' (St. Louis, 1989, p. 376) as I represent it in equation (6). (Throughout this paper, I assume that the identity matrix, **I**, is always conformable for the operations in which it appears.) St. Louis's equation (4), however, would lead the casual reader to surmise that he must have followed Jackson's (1998) logic. I chose to take St. Louis's word(s) for it. Regardless, Szyrmer (1992), among others, followed this approach to domesticate national technology.
2. That is, throughout this paper, I assume that the summation vector, **i**, is a column vector of 1s that is always conformable for the operations in which it appears.
3. Comments from Jeffery Round, University of Warwick, and other attendees of a presentation of this paper in Macerata, Italy, assure me that while re-exports *should* not enter national accounts that they are often quite difficult to purge. That is, while waterborne shipments arriving into, say, Belgium are readily purged, those arriving via truck or rail can be difficult to tease out since border checks are not necessarily designed to measure the international shipments of goods in an accurate manner. Hence, the implication of the generalized RPCs, which is discussed more fully later, may range wider than I first believed.
4. For simplicity, here and throughout the paper, in the context of vectors, we use the usual algebraic representation of a ratio to denote a Hadamard scalar (element-by-corresponding-element) ratio. Similarly, we use the multiplication symbol, $\times$, to denote Hadamard scalar (element-by-corresponding-element) multiplication.
5. Conversations with M. Henry Robison of Moscow, Idaho, well-known for his work joining input-output analysis with central place theory (e.g. Robison & Miller, 1988; Robison, 1997), have led me to understand that the improper specification in models of economic space is likely to be yet another source of observed cross-hauling. An example of such spatial differentiation would lie in an input-output model (survey-based or non-survey) of the State of Idaho. While potato farmers in southern Idaho deliver their product to many out-of-state locations throughout the US, consumers in the northern panhandle of the State of Idaho largely purchase out-of-state (eastern Washington) potatoes. Thus, while a model of the entire state would reveal significant crosshauling of potatoes, a multiregional model that fully embraces all of Idaho's functional economies would exhibit very little, if any, potato crosshauling for any one of the subregions. The effective economic distance between north and south Idaho compared to that between north Idaho and its potato sources causes this spatial bifurcation in the use of potatoes (among other commodities). One could, however, view such spatial economic differentiation as a very special kind of product differentiation.
6. See Kymn (1990) for a review of this literature. Also see Lahr (1993, pp. 279-280) for a very brief discussion of other pertinent issues and literature.
7. In the US, the Economic Census is available for many, but not all, industries at the state or substate level every five years (e.g. 1982, 1987, 1992, 1997 ...). The US Economic Census does not always report the total output for the industries it does disclose, however.

8. According to BEA, property-type income is the sum of corporate profits, proprietors' income, rental income of persons, net interest, capital consumption allowances, business transfer payments, and the current surplus of government enterprises less subsidies. At both the national and state levels, it includes proprietors' income as capital's share of production: a portion of proprietors' income also represents labour's share of production.
9. Proprietors' income in the US includes both an inventory valuation adjustment and a capital consumption adjustment. Farm income consists of proprietors' income; the cash wages, pay-in-kind, and other labour income of hired farm workers; and the salaries of officers of corporate farms.
10. In the US this 'other' labour income consists of wage and salary disbursements to US residents employed by international organizations and foreign embassies and consulates in the United States.
11. Recall that some of these non-labour components of value added can take on negative values.
12. Treyz & Petraglia (2001) discuss an update of this procedure in more detail. See also West (1994).
13. A referee notes this is not an error-free process that is not readily supported by data, and I agree. One can, however, derive an algorithm that converts the few spending categories available from such a consumer survey, even those related to retail trade, into the full household consumption vector. Benjamin H. Stevens, for example, did this by gauging national spending levels from such a survey to the national household column in input-output accounts. While this approach may not be ideal, as long as the results are deemed reasonable, it is probably better to apply an algorithm like this, which may be less than perfect, than to use the national household column. This is especially true for the US, where industrial composition, culture and climate vary enough to make household spending patterns quite different from one region to the next. In any case, some documented guidance on this subject has been presented recently by Edmonson & Hanson (2000).
14. For a discussion and comparison of location quotient, supply/demand ratio and econometric approaches, see Stevens *et al.* (1989).

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