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Regional Purchase Coefficients Estimates from Value-Added Tax Data

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Abstract. Regional input-output models are generally developed with non-survey methods that adjust the national table to reflect a region. These adjustments require data on the regional output levels, data on how value-added in a particular industry differs between the region and the nation, and the degree of trade between the region and the rest of the world. While data are readily available on the first item, typically they are not on the other two. Traditional methods of handling the imports are to estimate regional purchase coefficients (RPCs) based on location quotients (LQ), supply-demand pooling (SDP) or econometric models. A number of regional modelers have suggested that RPCs are the weakest link in non-survey I-O methods. This paper describes a Value-Added Tax (VAT) method of estimating RPCs that is theoretically superior to traditional methods. Then empirical estimates of RPCs are developed using the VAT, LQ, and SDP methods for the North-Trondelag County in Norway. The SDP multiplier impact estimates were often many times that of the VAT estimates. The impacts on specific sectors are overestimated even more. These results suggest the VAT should be used when available for developing RPCs for non-survey models. In the United States and Australia, the only two major countries without VAT, the results suggest that primary data methods should be used for estimating the RPCs in principal sectors.

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1. Introduction and Overview

Regional input-output models are generally developed using non-survey methods that adjust the national input-output table to reflect a regional economy. These adjustments require data on regional output levels, on how a particular industry's value-added margins differ between the region and the nation, and on the degree of trade between the region and the rest of the world. Although data are readily accessible on regional output levels, regional value-added and trade data are typically not available. Regional trade statistics are needed to estimate regional purchase coefficients (RPCs), which input-output modeling uses to determine whether an economic impact stays in the regional economy and reverberates throughout its various sectors or whether it quickly leaks out and is absorbed by the national economy.

The traditional methods of generating regional purchase coefficients are based on location quotients, supply–demand pooling or econometric methods. Regional modelers (Ralston S., Hastings S., Brucker 1986; Garhart 1987; Stevens, Treyz, and Lahr 1989) generally agree, however, that the RPC estimates these methods generate are the weakest link in non-survey I-O methods. This article describes an alternative and more effective method of estimating RPCs that relies on Value-Add Tax (VAT) data. Since the quality of the VAT data used is so high and the assumptions needed are more limited, the VAT based RPCs are likely to be more accurate than estimates developed through other methods.

This article also compares empirical estimates of RPCs for Nord-Trongdelag County, Norway using the VAT, location quotient, and supply demand pooling methods. The comparison of various estimates shows that the traditional SDP and LQ non-survey methods overestimate the potential economic impacts.

2. Theoretical Issues in Estimating Regional Purchase Coefficients

Non-survey regional input-output models generally assume that the production technology is the same at the regional level as at the national level. That is, the expenditure patterns for a given industry, as shown in the technical coefficients matrix, are identical for the regional and national tables when imported products are included. Naturally, a region might not be self-sufficient in some product and need to import it. Even when the local supply is sufficient to cover local demand, there often are both exports and imports. The typical means of adapting the national input-output model to a region in the nation are to take the following steps:

1) Collect data on the output levels of sectors at the regional level and eliminate the sectors for which there is no production;
2) Adjust each row of technical coefficients to remove the imports for each commodity; and
3) Constrain total local use to supply (including imports) available.

While output data are readily available for the first step, the second step has been problematic. Especially at the county level there have been no data on the imports by commodity. In order to adjust each row of technical coefficients, data on the proportion of the total regional requirements of a good that come from suppliers within the region (or regional purchase coefficients or simply RPCs) are developed. However, the RPCs might be the weakest link in non-survey input-output models (Ralston S., Hastings S., Brucker 1986; Garhart 1987; Stevens, Treyz, and Lahr 1989). Next we examine the theory behind the non-survey models.

Assume the national economy is described by an n*n matrix A of technical coefficients a_{ij}. Even assuming that the technology is the same for the nation and the region and that the value-added margins are equal, the regional coefficients might be less because of the need to import some of the intermediate products. In the extreme case where there is no regional production, the a_{ij} falls to zero and the import coefficient for that sector becomes $m_{ij} = a_{ij}$. When there is some regional production, the regional input coefficient will be equal to or lower than the regional technical coefficient, which in turn is constrained by the SDP ratio. Each technical coefficient a_{ij} is the sum of the regional input coefficient r_{ij} plus the import coefficient m_{ij}, as shown in equation 1:

$$a_{ij} = r_{ij} + m_{ij} \quad (1)$$

By simply solving for r_{ij}, each element of the new regional technical input matrix (R) can be expressed as follows:

$$r_{ij} = a_{ij} - m_{ij} \quad (2)$$

Where: r_{ij} = regional input coefficient without imports; a_{ij} = national technical coefficient with imports; m_{ij} = regional import coefficient for ith good for jth industry.

A widely used assumption is that the proportion of imports for a given commodity will be the same across all industries (Miller and Blair 1985, p. 295). This means that the relationship between r_{ij} and a_{ij} is constant across the entire row of the national technical matrix (A). This proportion, known as the supply percentage or the regional purchase coefficient can be defined as follows:

$$p_i = (X_i - E_i)/(X_i - E_i + M_i) \qquad (3)$$

Where: p_i= regional purchase coefficients; X_i = output; E_i = exports, M_i = imports (for commodity i).

The numerator of equation 3 shows the amount of the ith good that is supplied regionally, and the denominator shows the total amount of the good demanded within the region. Thus, a value of $p_i = 1$, indicates that there are no imports. Low values of p_i indicate that local suppliers only provide a small percent of the total local demand. For example, $p_i = .35$ for a given good means that for each additional dollar of local demand, only 35% will come from regional firms. Once p_i is estimated for each sector, the regional input coefficients are calculated by pre-multiplying the regional technical coefficients matrix by the diagonal matrix of p_i elements.

$$R = \hat{p} A^r \qquad (4)$$

where: R = matrix of regional input coefficients; $\hat{p}$ = diagonal matrix of p_i coefficients; and A^r = regional technical coefficients matrix.

Now the question is how do we estimate $\hat{p}$ for region r since data generally do not exist on E_i and M_i for the region in question. The next section looks at traditional methods for estimating the RPCs.

3. Traditional Methods of Estimating Regional Purchase Coefficients (RPCs)

While there have been many means of estimating RPCs, we will focus on three traditional ones before introducing the value-added tax (VAT) estimates of RPCs. The three traditional methods we will examine are: 1) simple location quotients, 2) supply-demand pooling, and 3) econometrically derived RPCs. A brief introduction will be given to each, followed by the problems inherent in each method.

Simple Location Quotients (LQ):

The LQ (for region r and good i) is defined as:

$$LQ_{ri} = (X_{ri}/X_r)/(X_{ni}/X_n) \qquad (5)$$

where: X_{ri} = regional output of ith good; X_r = total regional output; X_{ni}= national output of ith good, X_n = total national output.

When the LQ_i is greater than one, the region is assumed to be self-sufficient and have no imports for that good. In contrast, when the LQ_i is less than one, it is assumed that the technical coefficient falls in proportion to the location quotient. That is:

$$p_i = LQ_i \quad \text{if } LQ_i < 1 \qquad (6)$$
$$p_i = 1 \quad \text{if } LQ_i >= 1$$

There are two major weaknesses with the LQ approach. First, it does not allow cross-hauling (both importing and exporting). If the local production intensity for a given industry is very large relative to the nation, the LQ will exceed one and this approach will assume that the RPC is one. Second, this approach requires the implicit assumption that the regional and national structures are identical, which if true does not require any RPC adjustments. This assumption can be seen by considering the case where a region's production of an intermediate product (say corn) is twice the national average but it is demanded much more heavily by other sectors within the region (say livestock). The true RPC might be less than 1 even though the LQ is greater than 1. In this example, the supply implied that by using the LQ approach would be larger than the actual supply.

<u>**Supply-Demand Pooling (SDP):**</u>

The SDP approach to estimating the RPC requires two steps. First, the estimated regional output for sector i is computed using the national coefficients for both intermediate and final demand. That is,

$$\tilde{X}_{ri} = \sum_j a_{ij}^N X_{rj} + \sum_f c_{if}^N Y^f \qquad (7)$$

where: $\tilde{X}_{ri}$ = required regional output (assuming national coefficients are correct for region) a_{ij}^N = national technical coefficients; X_{rj} = regional output for sector j; c_{if}^N = national person consumption coefficients; Y^f = Final demand expenditures.
Second, the regional commodity balance is calculated as:

$$b_i = X_{ri} - \tilde{X}_{ri} \qquad (8)$$

where X_{ri} = actual regional output of ith good.

The regional purchase coefficient is then less than one if the regional commodity balance is negative and equal to one if it is equal to zero or positive. That is,

$$p_i = X_{ri} \big/ \tilde{X}_{ri} \quad \text{if} \;\; b_i \; < \; 0 \qquad (9)$$

$$p_i = 1 \qquad\qquad \text{if} \;\; b_i \; >= 0$$

The major weakness in the SDP approach is that it requires all local production to be used locally before exporting. It assumes that there are no exports if that commodity supply is insufficient to meet the local needs. This assumption often runs counter to observed facts. Frequently, local goods get exported at the same time that foreign goods are imported.

<u>Econometric RPC Estimates</u>:

In contrast to the above methods, some preprogrammed economic I-O models favor the use of econometrically estimated RPCs (IMPLAN 1996). This approach assumes that the percentage of a commodity purchased locally is a function of some measurable independent variables of the region. It is reasonable that a region's ability to produce commodities locally is related to characteristics of the region. However, it is unreasonable to assume that this relationship is simple and homogenous across significantly different economic regions. In some cases, the equations for estimating the RPCs use items such as the area in square miles, the population, the presence of dummy variables representing the presence of different industries, and other socio-economic characteristics. However, studies that have compared econometric estimations and "best guess" RPCs do not inspire confidence with their low explanatory power (Stevens, Treyz, and Lahr 1989). This is not surprising, given the ambitious job of correctly estimating the dependent variables (RPCs), developing a realistic model and its empirical estimation.

The econometric models have several weaknesses. First, correct estimates of the RPCs are needed as the dependent variables in order to estimate the coefficients of the independent variables. Second, the correct model needs to be specified to get unbiased and efficient estimates for the model. Third, the appropriate data for testing these models is needed. If the initial estimates of the RPCs are not correct, the best of models and data on independent variables will not yield good RPC estimates. Yet, currently the econometric estimates are widely used (IMPLAN 1996).

4. Introduction to Value-Added Tax Data for Estimating RPCs

This section includes a brief description of the value-added tax (VAT) and a discussion of Norway's VAT system. It also gives an explanation of how VAT data can be used to generate RPC estimates.

Introduction to VAT:

The value-added tax (VAT) is a tax common throughout the world. In fact, only two of the major industrialized countries (the United States and Australia) do not have a national version of this tax in place. The following sections will outline some of the basic ideas and issues of a VAT.

The VAT tax is collected over the value added at each stage of the production process (Ernest and Whitney 1995). The accounting system requires businesses that are responsible for a VAT to track from whom they have purchased intermediate goods and services and paid a VAT (Ernest and Whitney 1995). The system also requires firms to track to whom they have sold and to distinguish between final and intermediate consumption. The basic concept of VAT is fairly simple. The government requires businesses to collect a tax as a percentage of their sales and to be paid to the government on a regular time basis. However, VAT accounting allows businesses that collect VAT to reduce their payment to the government by the same amount that they paid in VAT to other firms in order to produce their sales. Businesses that fail to account for these purchases and sales find themselves facing financial penalties. A business that fails to separate input costs and the VAT paid on them faces cost increases by overestimating their own value added which results in additional VAT being assessed on their firm. This mismanagement will quickly show up in the market place when a firm becomes more expensive than its competitors. Similarly, a business that does not maintain a system to track to whom they have sold product might be liable for VAT that they never collected. Likewise, VAT transactions arise from disbursements or collecting cash or from taking on debt with or giving credit to another company. These types of accounts receive careful auditing due to their vulnerability to embezzlement (Ernest and Whitney 1995). All of these reasons give firms ample reason to carefully track and account for their VAT liabilities.

In fact, VAT accounting occurs as a natural part of the business's operation. This integration makes the resulting numbers more reliable than surveys that often depend on memory or ad hoc data sources.[1]

This brings us to the government's role in VAT administration. The government agency responsible for VAT collection needs to cross check the claims of VAT paid with the VAT reported. Many countries maintain a small army of tax auditors to help insure compliance with VAT. These auditors and inspectors have an intimate knowledge of the businesses and economic sectors that they monitor. Their repeated analysis of the VAT records of some industries makes them experts in the methods of production as well. They know what constitutes a normal intermediate factor purchase report and when a report seems out of line with the rest of the industry. The value of this expertise was an important part in this project to produce the regional purchase coefficients.

Some governments also maintain extensive databases that augment the data reported by the individual businesses. In some countries, VAT does not cover services due to the difficulty of tracking and enforcing their collection (Ernest and Whitney 1995).

Norwegian VAT:

The VAT tax was first used in Norway in 1970 after the passage of the Value Added Tax Act of June 19, 1969 (Ernest and Whitney 1995). Today, the Norwegian VAT rate is 23 percent, one of the highest in the world. The rate is set annually by Parliament. It is the principal indirect tax in Norway and a major source of governmental revenues. The Regional County Tax Office (for domestic goods) and the Customs Authorities (for imported goods) carry out the administration of the VAT (Skattedirektoratet 1993).

A firm must register if it has taxable sales in excess of 30,000 NOK (approximately $4,000 U.S. in 1997) in a twelve-month period. Even governmental bodies are liable for VAT if they are found to be competing with private firms.[2]

In general, the sale of all Norwegian goods or services is covered by VAT unless specifically exempted by the Act. The main group of items found in the exempt category is in the services sectors. Goods and services for export are also exempted for VAT to encourage the sale of Norwegian goods and services outside of the territory. However, the tax authority retains the VAT paid on the production up to the point that the

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[1] The VAT estimates do not include any intermediate inputs which are internal to the firm or nonmarket transactions. In this respect, it is identical to all other regional input-output models.

[2] While we lack data to verify this, we are confident that the $4,000 limit excludes a very small fraction of the total output in this region. Most of the firms that would fit this criterion would be too small to support one person full-time. In general, these firms are part-time service sector activities that are not covered by VAT anyway.

goods or service leave Norway (Ernest and Whitney 1995). To sum up we can say that Norwegian activities producing for domestic use pay VAT on almost all goods but on only a few services.[3]

5. Data Collection and Estimation Methods for RPCs

VAT Data Collection:

A major advantage of the VAT method is that it can be done with very current data since the VAT is collected so frequently. Our data were obtained by auditing the VAT data for manufacturing firms (sectors 1.6-3.1, see Table 1.). The agricultural (sectors 1.1-1.5), governmental, and non-profit sectors (sectors 3.2-4.7) were not surveyed in this study for several reasons. The agricultural sectors consist of many small firms that presented sampling problems and required resources beyond the scope of the project. Most service sector and public sector activities are exempt from VAT.

In this study we collected data from North Trondelag County, Norway for the year 1992. This year was used to allow us to compare the results with the Norwegian PANDA model for North Trondelag County that was calibrated for 1992.

Data were collected on individual firms on the following items: 1) total sales in 1992, 2) sales to firms or final consumers within North-Trondelag County (called "local"), 3) sales to Rest of Norway, 4) exports outside Norway. While the firms must keep records on each sale, the data are available electronically only for the above totals and not for each individual transaction. This was the reason that our study focused on the RPCs rather than on the technical coefficients. The VAT system does have all of the data necessary for estimating the full economic structure but tax auditors do not look at this unless the firm is being audited. While the cost of using this data for estimating the full structure would be much higher than for estimating RPCs, the cost of the VAT data would probably be less than for survey methods and the quality would be better.

For firms producing several commodities, the above data were estimated for each commodity. The North-Trondelag County tax auditor and the authors reviewed the files for each firm audited in order to collect the above data. The major benefit of using auditors as a source of the market orientation derives from their access to the firm's files, direct knowledge about many of the firms, and the availability of supporting information. The quality of the estimates is directly related to the auditor's ability to understand all the support data and interpret it

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[3] Additional detail on the exemptions is available in Swanson 1998.

correctly. This places a large emphasis on explaining to the auditor the concepts being measured.

Table 1 shows the total value of sales in each industry. The manufacturing firms accounted for a third of the regional GDP as measured by the Central Bureau of Statistics. Five industries account for 82.4% of the total sales, with the pulp, paper and paper products industry accounting for 48% of the manufacturing sales, other food products making up 15% of the sales, and oil platforms covering another 9.1%. This concentration of VAT and sales is typical. A study by the European Union found that 4 to 10% of the largest taxable entities generate somewhere between 70 to 80 percent of the tax revenue (European Union 1995).

Column (1) in table 1 shows the value of the gross output (= Total Sales) of these firms based on their VAT data for 1992.[4] Column (2) was determined from the individual firms' market data on their VAT records. It takes into account each firm's sales distribution between local and non-local sales. The total local demand data in column (3) was obtained from the Central Bureau of Statistics in consumer prices. It shows the total local consumption of the commodities associated with that industrial sector. Column (4) is the RSC (regional sales coefficient) and it shows the percent of local sales of the total. The percentage (1 - RSC) is exported to the rest of Norway or internationally. Column (5) shows the regional purchase coefficients.

<u>RPC Estimation Method:</u>

The final step is to simply carry out the RPC calculation described in equation 3. The numerator is the total local sales and the denominator is the total local demand. The RPC is calculated at the consumer price level to make it equivalent to the VAT price basis.

The regional purchase coefficient is the percent of local demand that was supplied by local suppliers. For instance, Wood and Wood Products (sector 1.9) sold 547 million NOK of output in 1992. Of that amount, they sold 301 million NOK locally. In comparison, the local market consumed 417 million NOK of these products in 1992. Thus, the RPC for Wood and Wood Products is 72.1% (in North-Trondelag, Norway).

In summary, the VAT estimates for RPCs are theoretically superior to the traditional methods and even to survey estimates of RPCs. None

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[4] Since the VAT rate varies annually, one reviewer questioned whether this might lead to variation in the RPCs over time. While many factors could lead to variation in the RPCs over time, including new technologies, varying prices by region, weather, and changes in demand, the changes in the VAT will not lead to variation in the RPCs. This is because the VAT is uniform nationally so domestic imports are not influenced. For foreign exports and imports, the VAT rules eliminate the influence of the VAT. For exports, there are rebates on all VAT taxes and or imports, VAT is added so that the imports do not have an advantage over locally produced goods.

of the strong assumptions required for the LQ or SDP methods are necessary for the VAT estimates. Further, accurate projections with the econometric models would require strong initial estimates of RPCs, well-specified models, and good fits for the models. In contrast, the VAT estimates come directly from firm data. Further, the VAT estimates are likely to be superior to survey based RPC estimates. There are no memory problems with the VAT and the VAT data is an audited data source with built in incentives for accuracy. We are claiming that the VAT based RPCs are superior to a survey based regional I-O model where all transactions in the USE and MAKE matrixes (see Miller and Blair 1985) are directly obtained since there are no memory problems and there are incentives to get the VAT estimates correct.

RPC Results:

Only one sector has an RPC above 50% (wood and wood products with 72%) and twelve of the twenty sectors have RPCs of under 20%. Eight of these sectors have RPCs of less than 10%. The overall picture is that the degree of aggregation in the industries results in local consumers preferring to import many products from the rest of Norway or from international sources. Only the refined petroleum products and publishing/printing sell most of their output locally (95% and 88% respectively) and still import considerable proportions of their total local demand (93% and 61% respectively).

On the export side, ten of the sectors sell over 50% to exports with the largest (pulp, paper, and paper products) and third largest (oil platforms and modules) exporting 99% or more from the region.

Table 2 compares the RPCs estimate via the VAT data with those using the simple location quotient (LQ) and the supply demand pool (SDP). For example, the wood and wood products VAT based RPC is 72.1% while both the LQ and the SDP estimates are 1 and, therefore, 40% higher. The VAT estimates are lower than the LQ estimates for every sector except publishing. Likewise, the VAT estimates are lower than the SDP estimates for all but the textiles industry. Theoretically, this is an impossible result. The textiles industry VAT results suggest that more of demand is satisfied from local supplies than actually exists. In both cases, the absolute difference is very small. There are two possible explanations for the SDP result on textiles. First, there might have been data reporting or interpretation errors. Second, the secondary data on local demand might have been in error. The important point is that only one sector violates this constraint. At the other extreme there are six sectors with over five times the VAT estimates for both LQ and SDP. Given the theoretical case that the VAT estimates are superior to these traditional ones, these results suggest that the traditional methods of LQ and SDP for regionalizing the national table are likely to grossly overstate the local impacts. While we argued that the VAT estimates are also superior to econometric ones, we have not been able to test the differences for these.

Table 1: Regional Purchase Estimates Based on VAT Data by Industry, North-Trondelag, Norway, 1992.

Industry Code	Industry Description	Firms Audited for VAT Data	Total Sales (1)	Local Sales (2)	Total Local Demand (3)	Percent Local Sales (4)	Regional Purchase Coefficient (5)
1.6	Fish and fish products	7	142	28	108	20%	26.0%
1.7	Other food products, beverages etc.	36	1,166	567	3,389	49%	16.7%
1.8	Textiles, wearing apparel, leather	6	67	36	775	53%	4.6%
1.9	Wood and wood products	42	547	301	417	55%	72.1%
2.0	Pulp, paper and paper products	2	3,720	7	856	0% #	0.9%
2.1	Publishing, printing, reproduction	17	201	178	456	88%	38.9%
2.2	Refined petroleum products, chemicals	(*)	125	119	1,663	95%	7.1%
2.3	Rubber and plastic products	7	254	18	256	7%	7.1%
2.4	Other non-metallic mineral products	17	87	69	285	80%	24.3%
2.5	Basic metals	3	15	0#	226	2%	0.1%
2.6	Fabricated metal products	19	193	47	422	24%	11.2%
2.7	Machinery and equipment n.e.c.	40	156	55	317	35%	17.4%
2.8	Electrical and optical equipment	11	124	77	568	62%	13.5%
2.9	Oil platforms and modules	(*)	709	6	231	1%	2.8%
3.0	Transport equipment	9	148	38	384	25%	9.8%
3.1	Furniture, other manufacturing, etc.	7	104	18	403	17%	4.4%

Source: Swanson 1998. Derived from VAT data from the North-Trondelag County Tax Office, Norway, 1996 (1) and (2) were estimated from VAT data for North-Trondelag: (3) Provided by Central Bureau of Statistics; (4) Percent Local Sales = Local Sales/Total Sales; (5) RPC = Local Sales/Total Local Demand. Numbers in columns (1), (2) and (3) are in millions of NOK. The number of firms is less than four. # = rounds to zero.

is the result of a long-standing effort to improve the single county economic model available to researchers and policy makers. In order to achieve that goal, the implementers of PANDA have developed methods to estimate the data needed to produce a single county model. These methods involve using both a questionnaire from the Central Bureau of Statistics (CBS) and the RAS method for regionalizing the results (Miller and Blair 1985). The CBS in Norway periodically conducts a partial survey to develop additional information on delivery distributions. This data plus the regional statistics developed by the CBS can be combined using the RAS method to develop regional input-output accounts for each county in Norway.

These regional accounts have as their basis the same data used in the other methods to produce the technical coefficients matrix and final demand vectors. However, the PANDA model is aggregated to have fewer sectors of detail. This fact forces the comparison to be made on the PANDA basis of detail and with its numbering scheme. It is possible to aggregate the VAT based estimates of RPCs to the same basis as the PANDA model. The following table shows both the aggregation scheme used in PANDA and the RPCs for both methods. It should be noted that the PANDA model loses much of its detail in the critical manufacturing sector.

As shown in Table 3, overall the PANDA and VAT estimates are considerably closer than either the LQ or the SDP estimates. The mean difference between the PANDA and VAT is only 0.07 compared to 0.46

for the LQ and 0.56 for the SDP. Further, two-thirds of the differences are less than 0.15 and none are greater than 0.32. It is interesting to note that in the twelve sectors where the PANDA and VAT estimates are truly comparable they match up in reasonable manner. However, there are some important differences between the PANDA estimates and the VAT based estimates that need to be highlighted. In sector 7 (under the PANDA numbering), the PANDA RPC is significantly higher than the VAT based estimate although the basis of comparison is almost the same. This difference reflects an emphasis in the PANDA model on the regional flows at the intermediate factor level (Johansen and Stokka 1996). It is quite possible that if the VAT data were segmented to reflect a split between intermediate and final demand flows that the two numbers would be more alike. In fact, an estimate based strictly on intermediate and final demand would be useful for a regional modeler. It would allow the segmentation of impacts from different sources whether from intermediate or final demand. However, this type of segmentation of demand would impose another level of data complexity on the model.

The other sector that should be noted for its significant difference between the PANDA and VAT estimate is sector 13 (PANDA numbering). The "Minerals and Iron" sector represents a relatively small sector of the Nord-Trondelag economy. The PANDA model shows a RPC of 36% while VAT estimates a value of 4%. These two approaches should be consistent in their definition of that sector for data purposes. However, it is difficult to know the number and nature of firms sampled by the CBS in that sector. Generally, the CBS surveys a smaller number of firms than the VAT data selected by the million NOK sales criteria. In some cases, the CBS only surveyed a single firm in a sector for purposes of estimating the geographical trade flows for Nord-Trondelag. Often times, the firm represents the largest firm in the county, but such a limited number of observations reduces the confidence of any estimate based on that sample. This also points out the difficulty of comparing estimates from a proprietary system where by definition procedures are not open to observation.

6. Type I Output Multiplier Comparisons: VAT vs. Traditional LQ and SDP Methods

The practical reason for concern about the accuracy of RPCs is the impact they have on the multipliers and economic impact estimates. This section first compares the type I output multipliers estimated by VAT methods with the traditional LQ and SDP methods. Then comparisons are made between the VAT estimates and the Norwegian PANDA input-output model.

Table 2: Regional Purchase Coefficients, VAT based Estimates compared to Simple Location Quotient and Supply Demand Pool, North-Trondelag, Norway 1992.

Sector	VAT Based RPCs	Location Quotient RPCs	Supply Demand Pooling RPCs	Ratio LQ/ VAT	Ratio SDP / VAT
Wood and wood products	0.721	1.000	1.000	1.4	1.4
Publishing, printing, reproduction	0.398	0.363	0.553	0.9	1.4
Fish and Fish Products	0.260	0.393	1.000	1.5	3.8
Other non-metallic mineral products	0.243	1.000	0.985	4.1	4.1
Machinery and equipment n.e.c.	0.174	0.670	1.000	3.9	5.7
Other food products, beverages, & tobacco	0.167	1.000	1.000	6.0	6.0
Electrical and optical equipment	0.135	0.563	1.000	4.2	7.4
Fabricated metal products	0.112	0.913	0.884	8.2	7.9
Transport equipment	0.098	0.324	0.500	3.3	5.1
Refined petroleum products, chemicals	0.071	0.128	0.083	1.8	1.2
Rubber and plastic products	0.071	1.000	1.000	14.1	14.1
Textiles, wearing apparel, leather	0.046	0.107	0.026	2.3	0.6
Furniture, other manufacturing, recycling	0.044	0.538	0.404	12.2	9.2
Oil platforms and modules	0.028	1.000	1.000	35.7	35.7
Pulp, paper and paper products	0.009	1.000	1.000	111.1	111.1
Basic metals	0.001	0.002	0.116	2.0	116.0

Source: Swanson 1998.

Table 3: VAT based RPCs compared to PANDA RPCs, Nord Trondelag, Norway 1992

PANDA Sector	VAT based RPCs	PANDA RPCs	Ratio Panda to VAT	Absolute difference
6, Fish and Fish Products	0.260	0.309	1.188	0.049
7, Other Food Products	0.167	0.421	2.523	0.254
8, Textile Production	0.046	0.187	4.058	0.141
9, Wood and Wood Products	0.721	0.653	0.905	-0.068
10, Pulp and Paper	0.009	0.044	4.889	0.035
11, Publishing and Printing	0.389	0.392	1.008	0.003
12, Chemical Production	0.142	0.153	1.080	0.011
13, Minerals and Iron	0.040	0.360	8.996	0.320
15, Machinery	0.381	0.254	0.667	-0.127
16, Ships and Oil Platforms	0.056	0.050	0.893	-0.006
17, Furniture and other	0.044	0.214	4.867	0.170

Source: Swanson 1998

Table 4 reports the type I output multipliers for VAT, LQ, and SDP methods. However, since the VAT data did not cover all of the sectors the RPCs in some sectors are estimated by the LQ and SDP methods, with column 4 including SDP estimated RPCs. Table 4 shows that the LQ and SDP estimates for the region are lower than the national multipliers. That is to be expected simply due to structural differences between the two economies and the fact that a sub-region will always have more leakage than its national economy. As expected, VAT multipliers are lower than their counterpart measure (VAT with SDP vs. SDP) in every sector. The absolute difference in multipliers is not very large, however. For example, the mean difference between the VAT (with SDP) and SDP multipliers is only 0.10. While these seem very small, we will show that these small differences may lead to major differences in impact estimates for specific sectors.

Table 4 shows that the VAT multipliers (with SDP RPC's for certain sectors) differ from the SDP multipliers for all sectors. The reason for this is that each method of multiplier estimation is based on the inversion of a unique regional coefficient matrix. If one element in the regional coefficient matrix differs from one method to the other, then all multipliers (in principle) may differ.

While overall, the VAT and SDP methods track each other quite closely, there are some critical sectors where the differences are worth investigating. For example, while the "wood and wood products" sector (1.9) output multiplier differs by only 0.105 (8.6%), almost the entire difference can be found in the cell relating to Forestry and Logging sector (1.2). The Location Quotient method estimates 100% of this input comes from local sources. In contrast, the Supply/Demand Pooling method estimates that only 47 percent originate locally. Since this is the most important intermediate input by far for this sector the final results change significantly. It is quite likely that the intensity of the production activity in the region surrounding North-Trondelag results in greater imports, suggesting that the SDP estimates are more realistic. These important differences give the researcher incentive to review carefully the RPCs developed by LQ and SDP.

The differences between the VAT (with SDP) and the PANDA multipliers are shown in Table 5. The VAT and PANDA methods track each other consistently. Sixty percent of the VAT multipliers are higher than the PANDA multipliers. On average, the VAT multiplier estimates are less than one percent different from the PANDA.

7. Economic Impacts of VAT vs. Other Multipliers

This section illustrates the impact of different RPC estimates on the results of an economic analysis using an I-O model. The whole point of this research is to improve the reliability of a parameter estimate that will be incorporated into a larger analysis effort. If the model does not respond to changes in the value of that parameter, it makes little sense to invest much effort in improving that estimate. However, as this section will demonstrate, the RPC estimates for crucial sectors can significantly change the final result of the impact analysis. This would reinforce the time and effort put into using VAT where and when it is available. In an earlier work (Swanson 1998), the sectors were evaluated as possible candidates for export expansion. Export expansion is one of the most common proposals for economic stimulation. In order to choose a reasonable candidate for export expansion, five different sectors were evaluated based on their current level of sales and exports (see Table 6). Obviously, a sector currently exporting a large amount of goods or services makes for a better expansion candidate than a non-existent or small noncompetitive sector. After choosing a number of suitable candidates for export expansion, two Type I multipliers were applied to the proposed export shock. Both Type I multipliers were based on the same national technical coefficient, but they used different RPCs. The resulting differences in the final impacts illustrate the critical nature of this parameter to the overall model. The differences result from an interaction between the critical nature of the intermediate inputs and the RPC.

Table 4: Type I Output Multipliers: LQ and SDP vs. VAT Based Estimates, Norway and the North-Trondelag County, 1992

Industry Group	Sector Description	National Multiplier	Location Quotient Multiplier	North-Trondelag Supply Demand Pool Multiplier	VAT Multipliers (w/SDP RPC for * sectors)
1.1	Agriculture and hunting	1.568	1.471	1.471	1.120*
1.2	Forestry and logging	1.099	1.075	1.056	1.045*
1.3	Fishing and fish farming	1.565	1.419	1.442	1.149*
1.4	Oil and gas extraction	1.082	1.041	1.070	1.068*
1.5	Mining and quarrying	1.186	1.072	1.103	1.084*
1.6	Fish and fish products	1.846	1.701	1.781	1.543
1.7	Other food products, beverages and tobacco	2.014	1.932	1.959	1.410
1.8	Textiles, wearing apparel, leather	1.123	1.037	1.034	1.019
1.9	Wood and wood products	1.495	1.432	1.327	1.222
2.0	Pulp, paper and paper products	1.553	1.494	1.426	1.109
2.1	Publishing, printing, reproduction	1.461	1.258	1.266	1.093
2.2	Refined petroleum products, chemicals	1.425	1.057	1.245	1.234
2.3	Rubber and plastic products	1.236	1.061	1.065	1.032
2.4	Other non-metallic mineral products	1.315	1.210	1.222	1.116
2.5	Basic metals	1.441	1.078	1.115	1.066
2.6	Fabricated metal products	1.339	1.072	1.112	1.036
2.7	Machinery and equipment n.e.c.	1.253	1.101	1.156	1.031
2.8	Electrical and optical equipment	1.194	1.069	1.124	1.028
2.9	Oil platforms and modules	1.428	1.211	1.286	1.044
3.0	Transport equipment	1.272	1.102	1.151	1.032
3.1	Furniture, other manufacturing, recycling	1.264	1.120	1.126	1.063
3.2	Electricity, gas and water supply	1.077	1.049	1.070	1.045*
3.3	Construction	1.510	1.375	1.403	1.174*
3.4	Wholesale and retail trade	1.202	1.108	1.151	1.110*
3.5	Repair of motor vehicles and goods	1.194	1.109	1.145	1.111*
3.6	Hotels and restaurants	1.196	1.120	1.154	1.090*
3.7	Inland water and ocean transport	1.352	1.062	1.096	1.068*
3.8	Transport via pipelines	1.010	1.004	1.006	1.006*
3.9	Other transport activities	1.390	1.122	1.302	1.279*
4.0	Post and telecommunications	1.240	1.163	1.165	1.118*
4.1	Financial intermediations	3.139	3.060	3.062	3.019*
4.2	Real estate activities	1.107	1.086	1.087	1.064*
4.3	Renting and business activities	1.225	1.152	1.190	1.161*
4.4	Public administration and defense	1.146	1.086	1.116	1.083*
4.5	Education	1.112	1.055	1.088	1.075*
4.6	Health and social work	1.105	1.039	1.048	1.028*
4.7	Service n.e.c.	1.204	1.097	1.107	1.078*

Source: Swanson 1998. Data from the Central Bureau of Statistics Norway 1996. For sectors 1.1-1.5 and 3.2-4.7, the RPCs were estimated by SDP (*).

The total indirect impacts of using the SDP approach vs. the VAT approach are shown in Table 7. We examine the indirect impacts only to exclude the initial direct impacts since the multiplier effects are the focus of an economic impact analysis. Column 3 shows the amount by which the SDP estimate of indirect impacts exceeds the VAT estimates. That is, the SDP estimate exceeds the VAT estimate for food processing by the value of $54,900. Column 4 reports the VAT estimate of total impacts as a percent of the SDP estimate. For example, the food processing sector VAT estimate is only 42.8 % of the SDP total impact estimate.

8. Summary and Conclusions

This paper has presented a case that Value-Added Tax (VAT) data provide a means of estimating regional purchase coefficients which is theoretically superior to traditional non-survey RPC estimation methods (location quotients, supply demand pooling, econometric estimates). Further, the VAT estimates are superior to survey based RPCs because they are based on audited accounting data rather than on memory or unaudited firm records.

The empirical results for North-Trondelag County, Norway demonstrate that supply demand pooling and location quotient estimates of RPCs overestimate the true value of RPCs based on VAT estimates. On average the output multipliers from supply demand pooling and location quotient were about 10 percent higher than the VAT multipliers.

Two of the traditional methods of estimating RPCs (location quotients and supply demand pool) lead to even greater changes in the individual sectors within the economy than shown by the output multipliers. For some sectors the difference between VAT and supply demand pooling output multipliers is traceable to just a few large input sectors where the estimated RPCs are very different. The total indirect impacts from an export expansion were considerably lower for VAT estimates than for SDP estimates. The VAT estimates ranged from only 16% to 68% of the SDP estimates.

In contrast, the survey based RPCs used in the PANDA model resulted in multipliers about the same as the VAT multipliers. This result is consistent with the hypothesis that the VAT estimates are very close to reality and that good survey results would also be fairly close to reality. No econometric based RPCs were available for this region so it was not possible to empirically test the differences between VAT and econometric results.

This study focused on RPCs but the VAT data makes it possible to estimate technical coefficients and import coefficients. Firms are required to keep data on all intermediate transactions. However, they are only required to report their total intermediate transactions and total sales with sales location. The tax auditors could construct the full structure if they did an audit. But relative to the cost of estimating the RPCs the cost would be very high. While clearly the quality of the

VAT estimates would be superior to that of survey methods, it is unclear whether the costs would be higher or lower. Additional research is needed on this issue.

Table 5: VAT vs. PANDA Type I Output Multipliers, North-Trondelag, Norway, 1992

Sector	PANDA Based Multipliers	VAT Based Multipliers	Difference
1, Agriculture	1.207	1.215	-0.008
2, Forestry	1.065	1.072	-0.007
3, Fishing	1.084	1.084	0.000
4, Fish Farming	1.190	1.183	0.007
5, Mining	1.153	1.168	-0.015
6, Fish and Fish Products	1.538	1.605	-0.067
7, Other Food Products	1.587	1.657	-0.070
8, Textile Production	1.036	1.037	-0.001
9, Wood and Wood Products	1.214	1.338	-0.124
10, Pulp and Paper	1.078	1.116	-0.038
11, Publishing and Printing	1.176	1.149	0.027
12, Chemical Production	1.075	1.097	-0.022
13, Minerals and Iron	1.064	1.069	-0.005
14, Public Services	1.109	1.123	-0.014
15, Machinery	1.049	1.054	-0.005
16, Ships and Oil Platforms	1.049	1.047	0.002
17, Furniture and other	1.089	1.092	-0.003
18, Power, water distribution	1.156	1.149	0.007
19, Building, Construction	1.205	1.249	-0.044
20, Oil and gas extraction	1.028	1.000	0.028
21, Retail, Wholesale	1.061	1.070	-0.009
22, Hotel, restaurant	1.206	1.207	-0.001
23, Ocean Transport	1.063	1.000	0.063
24, Coastal Transport	1.279	1.249	0.030
25, Post, telecommunications	1.135	1.081	0.054
26, Banking, Insurance	1.059	1.041	0.018
27, Business services	1.073	1.086	-0.013
28, Private services	1.073	1.069	0.004

Source: Swanson 1998, and PANDA model and VAT data from North-Trondelag, Norway, 1996.

Table 6: Evaluation of an Export Expansion of the value of $100,000 North-Trondelag, Norway, 1992

Industry Group	Sector Description	Shock as % of Final Demand	Shock as % of Export
1.7	Other Food, Beverages, and Tobacco	0.3%	1.7%
1.9	Wood and Wood Products	1.6%	4.1%
2.0	Pulp, Paper, and Paper Products	0.4%	0.3%
2.7	Machinery and Equipment	3.3%	10.1%
2.9	Oil Platforms and Modules	0.7%	1.4%

Source: Swanson 1998. Data from the Norwegian Central Bureau of Statistics.

Table 7: Total Indirect Economic Impacts of the value of a $100,000 Expansion in Exports, SDP vs. VAT Estimates, North-Trondelag, Norway, 1992

Sector Description	SDP Indirect Effect*	VAT Indirect Effect*	Absolute Difference (SDP - VAT)*	VAT as percent of SDP
Other Food, Beverages, and Tobacco	95.9	41.0	54.9	42.8%
Wood and Wood Products	32.8	22.4	10.4	68.3%
Pulp, Paper, and Paper Products	42.6	11.0	31.6	25.8%
Machinery and Equipment	15.6	3.3	12.3	21.2%
Oil Platforms and Modules	28.8	4.6	24.2	16.0%

Source: Swanson 1998

Note that the VAT estimate, as a percentage of the SDP estimate, ranges from 16% for oil platforms and modules sector to over 68% for wood and wood products. Assuming, as we argued earlier, that the VAT results are closer to the truth, the difference (column 3) exceeds the indirect impacts in all but one sector.

* in thousands of dollars

Another future research project relates to returns to scale. The current data does provide information on value-added by firm so questions of returns to scale could be examined with the current VAT data.

In conclusion, it appears that the VAT based estimates of RPCs are theoretically superior to the traditional methods of estimating RPCs. The empirical estimates of VAT based vs. LQ and SDP estimates of RPCs suggest that there are important empirical differences between the methods, with these two traditional methods overestimating the impacts by fairly significant amounts.

While most nations could use this VAT based method, researchers in the United States and Australia will not be able to do this. In these two countries, this research demonstrates the need to use primary data to estimate the RPCs for the principal sectors in non-survey models. While non-survey methods are likely to continue to be popular, these results suggest that this is not acceptable for the principal sectors in the non-survey models. While it might not matter for the sector being directly impacted, some attempt should be made to collect primary data on the major indirect and induced sectors. This research tends to reinforce the earlier work by Ralston, Hastings and Brucker (1986) in which they call for some primary data estimates. Whether this is done by a survey of firms or by industry informants, the results are likely to be more reasonable than simply using traditional SDP or LQ estimates.

Since the econometric RPCs seem to generally be lower than SDP or LQ estimates, it is an open question whether they would be closer to VAT estimates or not. Future research might look at Michigan's Single Business Tax (a type of VAT) to see if a similar methodology could develop RPC estimates for Michigan for comparison with econometrically estimated RPCs for Michigan. Additional work comparing the VAT estimates with traditional methods might provide a means to benchmark the traditional methods. This could prove particularly valuable to researchers in nations that do not have a VAT.

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