Working Paper

Hybrid (survey and non-survey) methods for the construction of subnational/regional IO tables with insights for their construction for Deltaic environments

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Abstract:

The following article is intended to perform a review of the literature of constructing input-output tables (IOTs) with hybrid (survey and non-survey) methods, with strong emphasis on the second type. We first move from the general context of non-survey methods to particular issues such as the questions of import and domestic matrices, make and use tables, and biases and limitations particular of developing countries. Then we place the focus on the insights for regionalization and construction of tables for the study of Deltaic areas, under the project DEltas, vulnerability and Climate Change: Migration and Adaptation (DECCMA). Location quotient-type methods are identified as popular and useful tools for the process of downscaling info from the closest tables available (administrative regions that comprise the Deltas), given the flexibility to use different data source types. In order to give priority to ‘‘superior’’ data, to make the best use of the available local data and avoid possible biases, we design templates and algorithms to accommodate multiple sources, combining them in flexible forms. This is complemented by adjustment rules ensuring that the sub-flows match the superordinate flows in sum, and some final RAS type methods can reconcile conflicting external data with constrained optimisations.

Keywords: Non-survey methods; input-output; regional analysis; Deltaic environments.

1. Introduction

As summarized by (Oosterhaven 2005), the lack of good survey-based input–output (IO) tables has been plaguing spatial economics and economic geography for a long time (Miller and Blair 1985; Richardson 1985). Non-survey, location quotient-type methods of estimating regional multipliers (Schaffer and Chu 1969b) have been shown to produce a systematic upward estimation bias because of their implicit or explicit minimizing of inter-regional cross-hauls (Richardson 1972), especially for smaller regions (Willis 1987). This systematic bias can only be neutralized when a considerable amount of ''superior'' data are added (Czamanski and Malizia 1969; Hewings and Jensen 1986). The latter implies that non-survey methods gradually—via hybrid methods—turn into almost full-survey methods, which blurs the distinction and leads to the trivial conclusion that the estimation errors reduce when more ''superior'' data are added (West 1990; Lahr 1993). Further review on these key theoretical considerations for the construction of IO tables (IOTs) is presented in the long second section of literature review.

Then we place the focus on the insights for regionalization and construction of tables for the study of Deltaic areas, under the project DEltas, vulnerability and Climate Change: Migration and Adaptation (DECCMA). Together with the aforementioned issues, developing regional tables of these specific Deltaic areas, not matching the economic or political boundaries, poses additional challenges. Among others, we find the need of exploring the biophysical context and structure of the economies studied. Once identified the most important sectors, place a special focus in data compilation for the larger or most important elements of the economies, to include data points and boundaries on some flows. The choice of the departure matrix (normally from an upper regional or national level)when non-survey methods are applied to construct the Delta IO tables (IOTs), values to what extent surrounding or neighbouring region with an economy similar to the one under, considering issues such as the problems of zero location. A final point we will make deals with the match between the political, economic and natural resources (in particular the hydrology defining the Deltas) boundaries and data. Approaches such as FES (Fundamental Economic Structure)and methods for studying structural change are helpful to identify similarities rather than differences in regions economic structures (e.g. for the *Ganges-Brahmaputra*-Meghna (GBM) Delta, involving part of India and Bangladesh).

The remainder of the work is organized as follows. Section 2 presents the review of the literature, moving from the general context of non-survey methods to particular issues such as the questions of import and domestic matrices, make and use tables, and biases and limitations particular of developing countries. Section 3 focuses on the particularities of our application of a "hybrid method" for the compilation of the tables in Deltaic areas in developing countries. Section 4 concludes and extends the discussions.

2. Review of the literature

<u>Survey, hybrid and non-survey methods in general</u>

As reviewed by (Bonfiglio and Chelli 2008), in the literature two main aspects of the behaviour of the methods have been discussed: their capability to replicate true multipliers and the direction of bias. With respect to the first aspect, in the literature, there is sufficient agreement in stating that hybrid methods perform better than non-survey techniques[1]. As reviewed by (Imansyah 2000a, 2000b) hybrid methods cover three approaches: top down, bottom up and

[1]The top-down approach is the most recognized and widely used due to the availability of national input-output tables. This approach takes advantage of the availability of national input-output tables as reference tables. On the other hand, the bottom up approach appears to be appropriate for small regions only because resources are based on regional data. Therefore, the larger the region, the more data is required. The horizontal approach is usually assumed for updating regional tables.

horizontal. As far as non-survey methods are concerned, different methods have been labelled as more effective on the basis of empirical results.

Several studies among the earliest ones identified the Simple Location Quotient as the best method (Schaffer and Chu 1969b, 1969a; Morrison and Smith 1974; Eskelinen and Suorsa 1980; Sawyer and Miller 1983). Successively, following the introduction of new techniques based on location quotients, the Flegg et al. Location Quotient (Tohmo 2004a; Flegg and Webber 1997, 2000; Flegg et al. 1995) was defined as the best alternative, variants of which have been recently developed and defended as superior, as the industry-specific FLQ (SFLQ, where industrial specifics determine the propensity to import) (Kowalewski 2012). Based on both theory and results, approaches using location quotients have been heavily criticized by (Jensen and Hewings 1985a, 1985b; Brand 1997, 1998) and (Tohmo 2004b). This last work compared the results of the LQ, Cross Industry Local Quotient (CILQ) and Flegg's Location Quotient (FLQ) modifications of the Finnish input–output table with a table produced by survey for a region, finding that the Simple Location Quotient (SLQ) and CILQ both produce misleading coefficients and results. (Riddington et al. 2006) confirmed some of these earlier findings that the national or location quotient approaches may produce misleading results, while they found that the gravity model-based approach, on the other hand, produces similar results to the survey and had the added advantage of being comprehensive and compatible with the other tables produced for other areas of Scotland.

There is a whole literature on non-survey single region methods (see (Batten and Martellato 1985; Canning and Wang 2006). In this literature, (Boomsma and Oosterhaven 1992) plea to use the double-entry properties of a bi-regional IO accounting framework to avoid the systematic tendency to overestimate the intra-regional transactions that is present in most non-survey single region methods. (Oosterhaven 2005), making use of the fundamental distinction between first- and second-order distance decays for the spatial disaggregation of multipliers (formulas found in gravity, entropy and spatial equilibrium models), also shows how an interregional setup is useful when spatially disaggregating national IO tables and especially multipliers.

(Antille 1990), who discussed the compilation of IO tables in an environment where statistical data are scarce, the difficulties encountered when no comprehensive census is available and 'estimated' an IO table using an adjustment procedure, setting boundaries for the most important flows of the intermediate consumption matrix, hinted that the procedure could be useful in situations such as those faced by developing countries and in the elaboration of regional input-output tables where information is scarce. Simply stated, both problems were summarized as follows: given a matrix from another country (in the regional case, given a national table) estimate a country (region) table using all available statistical information to make the necessary adjustments. Some identified insights were that the problem of zero location (zero flows which might not be common for the national and 'true' regional matrix) should not be overlooked, that the inclusion of boundaries on some flows is important to avoid large errors on main flows even if it does not greatly improve the accuracy of other flows, and an apparently obvious recommendation, which is trying to choose a departure matrix of a country with an economy similar to the one under consideration, something very useful to make some hypotheses about the distribution of the coefficients and evaluate, for example, the expected value and the variance of the multipliers as done by (West 1986).

All in all, as indicated by (Sargento 2009b, 2009a) there is a general consensus that the more direct information is incorporated in the table, the more accurately it tends to reflect regional reality. However, the introduction of direct information implies higher costs, which forces the researcher to make this in a selective way (more or less restrictively, depending on the resources available to conduct regional surveys). Besides, even if the research team does not face any restrictions in terms of money, time, manpower or logistic resources, this does not guarantee that a pure survey-based table is completely exempt of errors. In fact, according to (Jensen 1980), errors in survey tables can result from errors in the process of gathering the data (for example: errors arising from incorrect definition of the sample, hiding of information or lack of concern in answering the questionnaires by the respondents) or errors in compilation procedures. Further, other problems may arise whenever the questions included in the questionnaires require very detailed information to which some respondents may not be able to answer. (Jensen 1980)argues that the concept of holistic accuracy must be privileged, meaning that the assembly of direct information should be directed only towards the larger or most important elements of the economy being studied, thus ensuring a correct representation of the structure of the economy, in general terms (Hewings 1983). In other words, *hybrid methods assure the best compromise between accuracy and required resources*.

The question of import and domestic matrices

(Oosterhaven et al. 2007) test four non-survey methods against the semi-survey international IO table for nine East-Asian countries and the USA[2]. The first method assumes that the national IO tables do not contain a distinction between domestic and imported intermediate inputs and final demand. The split-up of the national table into these two subtables is made by using aggregate self-sufficiency ratios by sector by country. The three other methods assume that this split-up is already made in the national IO tables, as it is the case in our tables from GTAP. In the first two methods, the necessary re-pricing of the imports from ex customs' prices into producers' prices and the balancing of the split-up import tables with the aggregate IO export columns is done by applying the GRAS (Generalized RAS[3]) algorithm. In the third method, this re-pricing and balancing is done at the level of the block column matrix with imports per purchasing country. The row totals are derived by applying the export trade destination ratios to the aggregate IO export columns. The fourth method also uses these estimated bilateral export columns, but replaces their implicit country origins with the country origins of the import submatrices.

In our analysis, we construct from the GTAP information both the domestic and import matrix tables of each country. But from there the most important distinction we need to perform then when constructing the tables for the Delta is the distinction between the imports from the rest of the country and the rest of the world. In general the interregional trade within a country may be higher and often very distinct in terms of principal sectors than the foreign trade that this step becomes a must. Although questions such as the discussed above on the methods, the re-pricing and balancing are important, acquiring the maximum good quality primary information and statistics on interregional trade is crucial to accomplish this step. The first structure of IOT for the Delta and Non-Delta regions that we need to accomplish is then shown in Figure 1.

[2] All four methods proceed by the further split-up of the IO import tables over the countries of origin using import ratios derived from the imports trade statistics. In our analysis in principle we do not separate the different origins in the import tables, having only one matrix of imports from the other region in the country (Delta and Non-Delta respectively) and having those from the rest of the world in a row.

[3] The RAS algorithm was developed by Sir Richard Stone and others, to obtain the desired columns and rows totals of a matrix A, pre- and post-multiplying by parameters, generally known as R and S, which are iteratively being adjusted. See e.g. (Lahr and de Mesnard 2004).

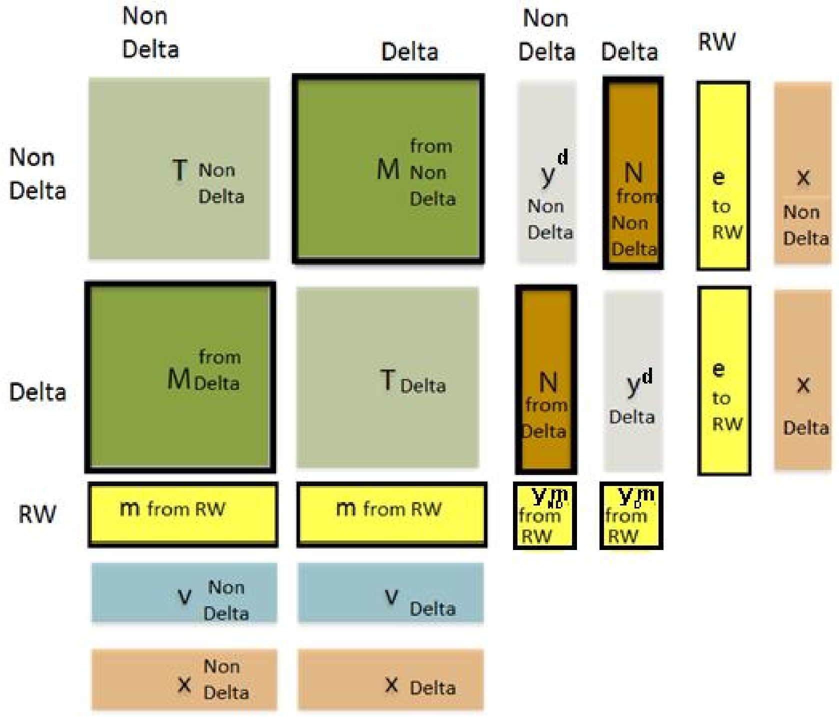

Figure1: MRIO for the Delta and Non-Delta regions.
Source: Adapted from (Kanemoto et al. 2011; Lenzen et al. 2013).

Where **T** are the Intermediate Domestic matrices, **M** the Intermediate import matrices, **y** the final demand excluding exports of final goods and services to the other region, **N** the final demand of exports (or imports respectively for each region) of goods and services from the other region in the same country, **e** are the column vectors of the exports of each of the regions to the Rest of the World (RW), **m** are the row vectors of the imports of each of the regions from the RW, **x** is total gross output, and **v** is the Value Added/Primary Input.

<u>The question of symmetric tables and make and use tables</u>

Traditional input-output models were developed within the symmetric framework, meaning that the supporting input-output tables were product-by-product or industry-by-industry tables. Product-by-product tables have products as the dimension of both rows and columns, showing the amounts of each product used in the production of which other products. In turn, industry-by-industry tables have industries as the dimension of both rows and columns, showing the amounts of output of each industry used in the production of which other industries (UN 1993). Currently, however, most of the countries compile and publish their national input-output tables in the rectangular or Make and Use format (introduced by the United Nations in 1960's). In this framework, two dimensions are simultaneously considered (industries and products) and two tables are essential: the Use table, which describes the consumption of products j by the several industries *i*, and the Make table that represents the distribution of the industries' output by the several products. In conjunction, these tables depict how supplies of different products originate from domestic industries and imports and how those products are used by the different intermediate or final users, including exports (UN 1993). The procedures and hypotheses adopted in input-output table construction as well as in input-output modeling should be suited to fit this data format. In this work, the GTAP tables already have the format of a symmetric table, but obtaining primary information with make and use format is also very welcomed, since there are clear methodologies (EUROSTAT 2008; Rueda-Cantuche et al. 2009; ten Raa and Rueda-Cantuche 2003; UN 2010 (1999, 2008); Miller and Blair 1985, 2009) to treat that information and make use of it in the symmetric tables format.

<u>The questions of biases, limited information and particularities of developing countries</u>

Several of the articles above on non-survey methods point out possible errors and biases of tables construction and regionalization (e.g. (Bonfiglio and Chelli 2008; Rueda-Cantuche et al. 2011)), to which we can add some other recently observed ones. For example, (Kronenberg 2009)note that when constructing regional input-output tables, traditional regionalization methods ignore cross-hauling (the simultaneous exporting and importing of one and the same type of product), resulting in an underestimation of trade and an overestimation of regional output multipliers.

The survey data is of particular difficulty to be obtained in developing countries –what will be our focus in section 3. Although more focused on survey methods (with repeated visits to participant households), (Niang 1982) provides recommendations for collecting input-output farm data for economic planning and decision making for the developing countries, particularly for the African ones. (Hulu and Hewings 1993) reported on the methods used to construct a set of interregional input-output tables for a five-region division of Indonesia under conditions of limited information. Firstly they explored and described the structure of the Indonesian economy; being then revealed through an examination of the fields of influence of some of the analytically important coefficients. Finally, a brief examination of the use of the model in an export promotion strategy was reported. For the same country, the identification of the Fundamental Economic Structure (FES, see (Van der Westhuizen 1992, 1997; Jensen et al. 1988), with some revision) and regression analysis have been used by (Imansyah 2000a, 2000b) following the horizontal method. (Thakur 2008) also used regression analyses to identify the FES (with primary and secondary sectors as components of it) and non-FES cells for the Indian regional economy (what proportions of the cells are predictable, etc.), indeed extending the notion of weak, moderate and strong FES cells. As described in(Thakur 2011),methods for studying structural changeand economic development comprise the “identification of key sectors”(Rasmusen 1956; Riedel 1976; Yotopoulos and Nugent 1973; Lenzen 2003; Cella 1984, 1986; Guccione 1986; Hirschman 1958),“sector composition and economic growth”(Hewings 1983; Kratena 2005; Miller and Blair 1985, 2009), “structural decomposition analyses” (Dietzenbacher and Los 1998, 2000; Dietzenbacher and Stage 2006; Hoekstra and Van Den Bergh 2002)and “spatial structural convergence”(Le Gallo and Dall’erba 2005; Percoco et al. 2007), spatial Markov approach (Rey 2001; Rey and Montuori 1999; Le Gallo 2004)

Another key issue is how interregional trade is estimated, also very much related to the modeling, something which has brought increasing attention with the increasing number of multi-regional input-output (MRIO) models construction. (Okamoto et al. 2005; IDE 2006) explain the compilation procedure of the Asian International IO table (of developing countries such as Thailand, Malaysia, Indonesia, Philippines and China) and the Chenery-Mose (column) model (Chenery 1953; Moses 1955) and proposed techniques for updating or estimating the tables, but the main challenges appear when moving from that national level to the subnational. Many works have estimated interregional input output models for the regions of China (e.g. (Zhang et al. 2011; Shi and Zhang 2012)) and for example (Okamoto 2012) estimate a MRIO model for China under the limitations and constraints of trade flow data over the regions, estimating the interregional trade coefficient using the Leontief-Strout (Leontief and Strout 1963) Gravity (LSG) model. The so used Q parameter, indicating the spatial friction of commodity flows, gives in that work the transportation cost of one unit of a commodity when it is moved, or the relative economic position of a region to the whole nation (the outflow power of the supply side or inflow power of the demand side). This parameter is often estimated as the Transport Distribution Index (Miller and Blair 2009), showing the ratio of the observed interregional transportation data to the transportation data proportionally distributed from total transportation, estimated further here with random variables (uniform/exponential distribution) and distance (railway/road) data.

3. Application to the compilation of the Deltaic areas tables in developing countries

Together with the aforementioned issues, developing regional tables of specific Deltaic areas, not matching the economic or political boundaries poses additional challenges.

All in all we focus on:

- Exploration and description of the structure of the economies studied
- Information directed towards the larger or most important elements of the economies studied and the inclusion of boundaries on some flows.
- The choice of the departure matrix of a surrounding country or region, with an economy similar to the one under consideration and the analysis of the problem of zero location.
- When having to use neighbouring or different scale IO data see if FES approach is helpful to identify similarities rather than differences in regions economic structures (e.g. the Delta at the Ganges river comprises the area of Bangladesh, for which IO/SAM tables exist, but also West Bengal, whose IO data has been studied in (Sengupta and Das 2011).
- The match between the political, economic and natural resources (in particular the hydrology defining the Deltas) boundaries and data.

<u>Exploration and description of the structure of the biophysics and economies (of the Deltas) studied</u>

It is crucial to understand the biophysical context and the structure of the economies (of the Deltas) studied, since the emphasis in the surveys or data collection will have to be steered by the most important sectors of those economies. An example of this information and its translation into the economic sectors is that approximately two-thirds of the Bangladesh people work in agriculture (being the major crops grown in the Ganges Delta, jute, tea, and rice), and grow crops on the fertile floodplains of the delta. Also that fishing is also an important activity in the delta region (gathered in the production of the “Fishing” sector), with fish being a major source of food for many of the people in the area (reflected in the final demand of the “Fishing” sector).

<u>Information directed towards the larger or most important elements of the economies studied and the inclusion of boundaries on some flows</u>

Once the exploration and description of the structure of the economies is performed, collecting relevant data for them, that information will be introduced in the Delta IOTs as constraints and fixed points. In this sense even if some methods of adjustment (e.g. RAS type) are performed, in order to match, complete (usually there are incomplete industry surveys, confidentiality, etc.) or balance the information, the precisely known information (superior data) may be either fixed or having a smaller degree of variation allowed. An example of how this is performed with different RAS variants (GRAS, KRAS,…) can be found in (Junius and Oosterhaven 2003; Lenzen et al. 2013; Lenzen et al. 2007; Lenzen et al. 2009). These external data points are introduced in the system of equations that constrain the unknown matrix elements. Since unknowns usually outnumber external constraints, resulting in the system being underdetermined, that exhibits too many degrees of freedom to be solved analytically, the reconciliation is performed with those constrained optimisations. The methods described above of RAS variants are able to handle conflicting external data and inconsistent constraints. This capability is achieved by introducing standard error estimates for external data.

<u>The choice of the departure matrix of a country, surrounding or neighbouring region with an economy similar to the one under consideration and the analysis of the problem of zero location</u>

One of the first decisions made was working in a framework of an international model, with the different countries in the world, and the split of each of the national tables of Bangladesh, India, Ghana and Egypt between the Delta areas and non-Delta. By default some elements of the chosen GTAP national tables lead us with entire rows and columns of zeros, plus particular zero value elements. For example, only India has information for the sector of

15#Coal (in general is the more complete table).Only India and Egypt have information for the sector of 16#Crude Oil and only Ghana and Egypt have information for the sector (row and column) of 20#Meat products nec. Bangladesh is the region with less information (lacks 12 accounts), especially 12#Wool, silk-worm cocoons, processed meats (19#Bovine meat products and 20#Meat products nec.), 35#Ferrous metals, 40#Electronic equipment, 41#Machinery and equipment nec and some services (53#Insurance, 54#Business services nec) and taxes (Taxes intermediates and Taxes Skilled labor).Ghana also lacks plenty of info (lacks 11 accounts), especially in agriculture and industries: 2#Wheat, 6#Sugar cane, sugar beet, 15#Coal, 16#Crude Oil, 17#Gas, 24#Sugar, 38#Motor vehicles and parts, 39#Transport equipment nec, 40#Electronic equipment, 42#Manufactures nec and 44#Gas manufacture, distribution. Egypt lacks info for (5 accounts) 15#Coal, 12#Wool, silk-worm cocoons, 13#Forestry, and some services (45#Water and 55#Recreational and other services). Finally, India only lacks info of (2 accounts) the account of 20#Meat products nec. and55#Recreational and other services.

Since for some of the Deltas, such as for the Mahanadi, we do not estimate the table of the Delta from the national table but from a regional one (in this case that of the Odisha state -formerly known as Orissa, see Table A1 Tables chosen in the Appendix), this comparison of the national and the closest regional IO table in terms of zero values and sectoral differences is also of notable importance. For example in this case it is worth identifying that Odisha has abundant natural resources (with a fifth of India's coal, a quarter of its iron ore, a third of its bauxite reserves and most of the chromite), a large coastline and a relatively (to the rest of the country) high growing economy. This last aspect becomes crucial to update the input-output table, in this case the most directly available (although not official by a statistical institute, but for the Posco Steel Project)IOT for the state for 2003-4 by and 43 sectors (NCAER 2007).The state has emerged as one of the most preferred destination for investment proposals (in aluminium, e.g. National Aluminium, power, refineries, ports and steel, e.g. with first integrated steel plant in the public sector). It is also worth noting the presence of public sector enterprises like HAL, Sunabeda, NAL IT, consulting firms (Mahindra Satyam, Tata Consultancy Services, MindTree Consulting, PricewaterhouseCoopers, Infosys; setting up development centres of IBM, Syntel and Wipro)(Wikipedia 2014).Apart from the growth in the production of sectors hence the investment column in the final demand is fed from the investment data, which should be apportioned given that the table reflects yearly investments and these are usually long term. As of July 2006, total planned investment in the state was $90 billion, including investment in research, education, hospitals, roads, ports, airports, and hotels. The apportioning also needs to consider the geography, since e.g. there are many multi-state irrigation projects in development, including the Godavari River Basin Irrigation Projects. Finally, particularly for this state with a long coast, and for its Delta table, the already being developed ports with public private partnership need to be reflected in the investments (for the baseline scenario), while for the economic modelling scenarios for the future complementary info might be introduced based on the locations have been identified on Odisha's coast to be developed as ports[4].

All in all, in these processes of updating and regionalization of the tables, and apportioning of investments, the example of a Dynamic Input-Output Model for the economy of the State (Dhal and Saxena 2005) might be also very useful. Ultimately, the more precise the estimation of this sectors, the more accurate could be performed the ultimate link between the impacts of climate change to the economic sectors, and hence the results from the economic model to feed the migration model and related analyses under the DECCMA project. Some insights of this link between the biophysical inputs and the economic model are shown in Appendix B.

[4]Gopalpur (Ganjam district), BahudaMuhan (Sonepur) in Ganjam district, Palur (Ganjam), Bali Harchandi (Puri), Astaranga (Puri), JatadhariMuhan (Jagatsinghpur), BaruneiMuhan (Kendrapara), Dhamra (Bhadrak), Chudamani (Bhadrak), Inchuri (Balasore), Chandipur (Balasore), Bahabalpur (Balasore), Subarnarekha mouth (Kirtania) and Talsara (Balasore).

The match between the political, economic and natural resources (in particular the hydrology defining the Deltas) boundaries and data.

An important issue in this DECCMA project is the focus on the physical boundaries (mainly hydrological, defining the Delta), conditioning the construction of IOTs at this level. This implies in principle having a mismatch with most of the statistical information, political boundaries and economic information, needing to adapt them. Fortunately, a common definition for the deltas was made based on the administrative units, i.e., considering as delta the administrative units which are touched (hence falling inside totally or only partially) by the 5 meter contour (altitude from sea level). But furthermore, in the case of the *Ganges-Brahmaputra-Meghna* (GBM) delta it comprises two countries, so the part of Bangladesh (involving in the final definition also the very important city and port of Chittagong) is derived a split from the Bangladesh table, while the part of India is derived and split from the West Bengal table, using the data and accountancy of the two districts falling at least partially in the 5 meter contour (North 24 and South 24 Parganas). The analysis of these two sides is interesting in itself, as well as examining the possibilities of obtaining the aggregate picture of the two sides together as a unit, where not much formal trade occurs (a frontier established by India, which nonetheless cannot always prevent illegal crossing and captures of fish, livestock or other precious animals and goods) but certainly it does happen biophysical interaction. In any case, this implies identifying the differences in technology structures and techniques, e.g. in agricultural production or in the fishing sector. For example, interestingly, the highest levels of aquaculture in India are found for the West Bengal (Katiha et al. 2005), while a structural analysis on the region can be also followed from (Sengupta and Das 2008). Also within the Indian side, for example, notable differences are found between the Sunderbans[5] production structure -where notably agricultural production (rice, but also particularly local types of production such as honey, etc.) and fishing are more predominant- and the West Bengal region as a whole -where the mega-city of Calcutta and areas outside the Sunderbans comprise many other industries (e.g. mining) and services (notably retail trade, but also other forms of transport, etc.). In the case of the Volta delta in Ghana, since the size of the 9 districts is relatively small, the outside part of those falling at least partially in the 5 meter contour is not too big, and here a bigger challenge is obtaining the data for the required time and form given the many changes of boundaries and name definitions of these administrative units[6].

A final summary of the procedure taken

As hinted above, a priorization procedure is used to make use of multiple data sources (production, employment, number of vehicles by type, beds and equipment in hospitals, etc.), combining them in flexible forms, in line with (Wenz et al. 2014) to construct a delta-non delta table in the form presented above. We implement algorithms of 1st, 2nd, 3rd,…best solutions, depending on the data available. Later on, a RAS type (KRAS, see Lenzen et al. 2009) adjustment is performed, in order to match, complete (usually there are incomplete industry surveys, confidentiality, etc.) and balance the information, the precisely known information (superior data) is fixed or having a smaller degree of variation allowed.

Regarding the departing matrices, in general the national input-output table of GTAP for 2007 is used, and then in the cases of available regional tables (only in India) and data, these are used, at least to calculate the quotients of the delta. As studied in (Flegg et al. 2015; Flegg and Tohmo 2013; Kowalewski 2012), the FLQ, AFLQ (with higher δ) or SFLQ (with the interesting variation in δ_j that implies that industrial specifics determine the propensity to import, which also requires additional information) appear to be the most suitable LQ currently available, but more importantly, they conclude that it should be applied to input–output tables

[5] North 24 Parganas and South 24 Parganas data.

[6] Ningo Prampram (former Dangme west), Ada west and Ada east (former Dangme east), Central Tongu (integrated in North Tongu depending on definitions), Akatsi South (generally integrated in Akatsi depending on definitions), South Tongu, Keta Municipal, Ketu South and Ketu North.

that exclude foreign imports. This means that in our setup, to construct the domestic delta table, the FLQ is used. A key decision in the beginning was the choice of the boundaries of the delta, making use of the district level (in the case of Ghana) and Parganas levels data, including those (and the portion –measured by a combination of surface and population/economic activity- of those partially) falling in the 5 meter contour (5 meter elevation from the sea). A strong emphasis was put since the start of the work in the identified (from the study, reading, questioning, etc. about the biophysical and socioeconomic context) most important sectors and elements of the economies studied (usually agriculture, fishing and forestry, sometimes also agri-food transformation and textile) and of the desired main elements of the table, in this case with a strong emphasis on intraregional and interregional trade. Hence the data collected from the institutions

4. Conclusions

The review of non-survey and hybrid methods has lead us to identify how the lack of good survey-based input–output (IO) tables has been plaguing spatial economics and economic geography for a long time. To overcome this issue, location quotient-type methods of estimating regional cells, multipliers, etc. have been shown to be the most used ones, together with "real", ''superior'' data, added to make the best use of the available local data and avoid possible biases. Given that particularly for developing countries these superior data is often even harder to acquire, we focus on the exploration and description of the structure of the economies studied, in order to steer the data search towards the larger or most important elements of the economies studied, identifying also the key similarities and differences with the (comprising/surrounding) region for which the departure matrix was chosen. For this reason, we particularly need to use the necessary tools and learn to understand the (mis-)match between the political, economic and natural resources (in particular the hydrology defining the Deltas) boundaries and data. Taking all this into account, we design templates and algorithms to accommodate multiple data sources, combining them in flexible forms. The downscaling procedure from the closest tables available (administrative regions that comprise the Deltas, having always the national tables from GTAP, distinguishing the domestic and import tables, SIOT Variant B type, for which LQ methods can be applied) is complemented by an adjustment rule ensuring that the sub-flows match the superordinate flow in sum, and the approximation improves along several iteration steps depending on the first, second, third…best possible available data sources.

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Appendix A

Table A1: Input-output tables used and link to the Deltaic Areas.

	GBM Delta, Bangladesh and India	Nile Delta, Egypt	Mahanadi Delta, India	Volta Delta, Ghana
National GTAP table	Bangladesh and India	Egypt	India	Ghana
National GTAP table non-zero sectors	43	52	55	44
Regional closest IO table	Bangladesh and West Bengal state, India	Egypt	Odisha (Orissa) state, India	Ghana
Regional closest IO table non-zero sectors		52		44
Size of Regional closest IO table ($10^3 km^2$)		24.9		2.43
Regional closest IO table population ($x10^6$people)		47.8		0.38
Size of delta($10^3 km^2$)	87.3 (66% in Bangladesh; 33% in West Bengal, India)	24.9	5.91	2.43
Delta population ($x10^6$people)	111	47.8	3.88	0.38

- To observe the analogous information of the Deltas of area and population, rivers/catchment area and annual discharge, sediment input, typical crops, livelihoods, etc., see the delta site comparison of (Nicholls 2014).

Appendix B

Model: Inputs/impacts associated to our sectors:

- Productivity fish: % reduction in fishing (by marine, freshwater fish and aquaculture).

- Productivity crop land: % reduction of land (by type, ideally by each of the 8 crops in GTAP) due to sea level rise.
  % worsening of land (by type) due to salt intrusion, to erosion and inundation …
  (even if desired, split by reason).

- Productivity pasture land: % reduction of land (by type, ideally by each of the 4 animal productions in GTAP) due to sea level rise.
  % worsening of land (by type) due to salt intrusion, to erosion and inundation …
  (even if desired, split by reason).

- Forestry sector.

- Water availability (due to salt intrusion, etc., affecting every sector that uses it?, also mainly water sector, electricity sector…)

- Coastal protection: Affects Investment (crows out other investment?): in construction, Machinery and equipment nec, etc.
  Mainly dikes (beach nourishment minor but significant; ports, etc. negligible globally), see (Nicholls et al. 2010). Calculated direct costs globally, and clear methodology Related to Public Administrations. A scenario of protection, another without.

- Changes in tourist behaviour, affecting recreation and tourism ("Recreational and other services" in GTAP, no different "Hotels and restaurants"), several sources (e.g. hours of sun; SLR, risk of flooding, tsunami…; biology when tourism related to biodiversity).

- Possible inundation: From GIS, which villages/areas affects? What is produced there? Economic sectors… Public Administrations, construction sector, water sector, electricity sector…Health sector, Financial and insurance sectors, Dwellings

- Increased storm surges (a coastal flood or tsunami-like phenomena of rising water commonly associated with low pressure weather systems).
  From GIS, does it affect villages? What is produced there? Economic sectors… Public Administrations, construction sector…Health sector, Financial and insurance sectors, Dwellings

- Erosion -> fisheries; recreation and tourism ("Fishing" and "Recreational and other services" in GTAP).

- Input of **population/migration**: Ideally, loop at several decades: impacts and population (affects final demand, labour data…) -> economic model run -> economic impacts affect migration -> new labour endowment, etc.

- In (Ciscar et al. 2012): "Damage estimates for land loss, migration and sea floods taken from the DIVA model" (the model, developed among others by R. Nicholls is also used in articles such as(Hinkel et al. 2014)).