Global Resource Input Output Assessment (GLORIA) database

Technical Documentation

Version 1: September 2021

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Introduction

This document serves as the technical documentation for the GLORIA database. The GLORIA database is a multi-regional input-output database that was built by the University of Sydney for the UN International Resource Panel (UN IRP) in the context of the update of the material footprint accounts forming part of the UN IRP Material Flows Database. To use synergies between different UNEP initiatives it was decided to use the GLORIA database also as underlying MRIO dataabse for the Sustainable Consumption and Production Hotspots Analysis Tool (SCP-HAT). As a consequence, additional modifications and quality assurance was needed to allow to apply the GLORIA database also to other environmental categories as raw materials, to ensure environmental flows through the economy are reflected adequately.
This document outlines the construction approach for the MRIO table, lists the source data sets that were used, the quality checks that were performed, and holds additional, method- and data-specific information about the construction process.

31st August 2021

MRIO construction

MRIO structure

The GLORIA database is a time series of multi-regional input-output (MRIO) tables that were constructed using the Global MRIOLab (Lenzen *et al.* 2017a) infrastructure. The tables distinguish the usual components (intermediate transactions block T, final demand block Y, and value-added block V) and are compiled in five levels of valuations. In the MRIO design specific focus was set on the capability to do resource flow analysis (see below). The dimensions of the MRIO time series are the following.

Years covered:	1990-2019
Number of regions:	164
Number of industry sectors:	97
Number of commodity sectors:	97 (labels are identical to industry sectors)
Number of final demand agents:	6
Number of value-added categories:	6
Number of valuations:	5
Unit for monetary values:	thousand USD current price
MRIO format:	homogenous MR-SUT structure throughout

Please refer to the Appendix for a full list of labels for all these dimensions.

Specific remarks about the model structure (specifically regarding co-production)

The GLORIA database is a homogenous multi-regional supply-use table (MR-SUT) featuring identical sector labels for both the industry and commodity sectors. Further, the supply tables are as of now strictly diagonal. While it is acknowledged that co-production should be recorded in the supply tables, this is at present future work and requires further data mining.
Throughout this document, the terms MRIO and MR-SUT are used interchangeably.

Mathematical background of MRIO construction approach used for this project

The construction of the time series of MRIO databases follows a mathematical approach that is implemented in the following basic steps. A detailed description of the MRIO construction process used in the IELab can be found in separate publications (Lenzen *et al.* 2013; Lenzen *et al.* 2014; Lenzen *et al.* 2017b; Lenzen *et al.* 2017c)

1. For an initial year of the time series, construct a fully populated initial table that serves as the starting point for the data compilation process. This initial MRIO table is mathematically referred to as the *initial estimate*.
2. For the initial year, collect superior data sets such as official national IO data, international trade data, and macro-economic information and organise them in a mathematical format, so that the initial estimate can be mathematically adjusted to

reflect the information contained in these superior data sets. The superior data sources are formulated as *mathematical constraints*.

3. Adjust the individual values in the initial estimate according to the mathematical constraints in a way that the initial table is altered as little as possible while ensuring that the resulting table reflects the superior data as closely as possible. This data reconciliation process is achieved through *mathematical constrained optimisation*. The output of this process is the *final MRIO* table for the initial year.
4. For the next year in the time series, use the final MRIO of the previous step as the initial estimate and repeat the steps 2-4 for this next year.

Specifics of the construction process for the GLORIA database and data sources

1. Note that the initial year is usually chosen according to data availability in order to construct a robust initial estimate in the initial year. This initial year does not necessarily have to be one of the end points of the time series. As a result, the iterative construction process might roll forward or backwards through the time series as required. For the GLORIA database, this process was slightly adjusted. Instead of choosing on a specific year as the initial estimate year and rolling the tables forwards and backwards through the time series, each year of the GLORIA database received an individually constructed initial estimate, which was based on the Eora model (Lenzen *et al.* 2012a) for that year. Eora has detailed coverage of many of the nations represented in GLORIA database, and because Eora was constructed using large amounts of national IO data, this approach gives the GLORIA database the necessary foundation in national statistical data.

2. The reconciliation step described under point 3 above was split into several reconciliation steps, which were performed successively. The GLORIA database ranges amongst the largest global MRIO models compiled to date. The model spans a time series of 30 years, with each year featuring five fully populated MRIO sheets, accompanied by five fully populated sheets holding the corresponding standard deviation values. In order to accelerate this compilation process for this vast amount of data, the reconciliation procedure was split into several sub-steps, which are outlined in this section.

3. For the set-up of the GLORIA database, a large amount of manually identified *engineering constraints* were used. Engineering constraints eliminate a common problem when disaggregating source data into the 97 economic sectors used in the GLORIA database. For example, the GLORIA database features the individual economic sectors “Mining of aluminium Ore” and “Mining of copper dominated ores”. A source data set may only feature “mining of non-ferrous metal”. During the data preparation process, the sectors of the source data set were matched against the corresponding sectors in the GLORIA database. In this case, “mining of non-ferrous metal” was linked to “Mining of aluminium Ore” and “Mining of copper dominated ores”. Further processing led to having inputs from aluminium ore mining into “Manufacture and casting of basic copper”, which is clearly unrealistic. In order to prevent this situation, manual adjustments were made to the source data sets and the final GLORIA database in order to prevent unrealistic transaction values.

These manual adjustments are summarised in the term *engineering constraints*. The engineering constrains are described in detail in Section *Data-specific documentation -> Engineering constraints* in this document.

4. As for many countries, the raw data are more aggregated than the 97 economic sectors used in the GLORIA database, the highly disaggregated datasets provided by UN Comtrade (UNSD 2020b) and UN Service trade (UNSD 2020c) were used early in the construction process to provide the necessary detail.

5. Due to the strong focus of the work of the IRP and of the online tool SCP-HAT on resource- and environmentally-intensive economic activities, the following four data sources were identified as crucial for ensuring the necessary quality of the final GLORIA database time series:
   i) the FAOSTAT data on the Value Added of Agricultural Production (FAO 2020b);
   ii) the FishStat Fishery and Aquaculture Statistical Time Series (FAO 2020a);
   iii) the Mining und Utilities database (UNIDO 2020b), and
   iv) the Industrial Statistics Database (UNIDO 2020a).

6. The OECD Inter-Country Input-Output (OECD 2018) Tables track highly aggregated input-output databases for 64 countries at 36-sector detail. This database was used to inform the GLORIA database time series to ensure robust intra-country data.

7. The United Nations Main Aggregates database (UN SNA MA; UNSD 2020a) is the only data source that contains relevant monetary national accounts information. The UN SNA MA database was therefore used in the construction process of the GLORIA database.

Statistical discrepancies

During the compilation of any large-scale MRIO framework, statistical discrepancies will occur and need to be addressed. Mathematical data reconciliation algorithms such as the family of RAS-methods (Lenzen *et al.* 2009; Wiebe and Lenzen 2016) are primarily designed to tackle data discrepancies in general across the various source data sets for MRIO frameworks. Given the complexity of the compilation process, even the most sophisticated mathematical algorithms are unable to remove statistical discrepancies completely from the final database. As a result, basic accounting identities may not be fully adhered to by default.
There are in general two approaches to tackling this issue (see for example the United National Handbook on Supply, Use, and Input-Output Tables with Extensions and Applications (UNSD 2018) and the Eurostat Manual of Supply, Use, and Input-Output Tables (Eurostat 2008)).

i) Allocate all discrepancies to the item “Changes in Inventories”. This approach is the most popular approach, but it 1) changes a country’s GDP value, 2) may lead to faulty source data for Changes and Inventories to remain undetected, and 3) may be unsuitable if a sign reversal is to be expected.
ii) Define a separate sector for “Statistical Discrepancies”. This approach eliminates all concerns raised in the first approach, but introduces an additional, non-

economic sector to the MRIO framework.

During the construction of the GLORIA database, the statistical discrepancies were in the order of or below $100,000 USD, and it was decided to employ the first approach. This issue is discussed in more detail in the Section *Data-specific documentation -> Table rebalancing* of this document.

Reliability information

The GLORIA database is accompanied by reliability information for each value contained in the MRIO (Lenzen *et al.* 2009; Lenzen *et al.* 2012b). The underlying approach is that each value within the MRIO time series is considered to be subject to an underlying distribution (Wilting 2012). Given the lack of information that is available for this distribution, a normal distribution is assumed, of which the value given in the MRIO table is assumed to be the expected value. The reliability for each value is then given by its accompanying standard deviation value. The GLORIA database comes with a full set of standard deviation tables.

Quality checks

All quality checks of the GLORIA database are primarily focussed on assessing how well the source data sets are represented within the final MRIO database. This is achieved by visual and numerical adherence analysis. In the following, the different visual assessment tools are given and interpreted.

Heat maps: visual inspection of MRIO tables

The first method of assessment is a visual representation of the different MRIO components through heat maps. Fig 1 shows the heat maps assessment for the GLORIA database for 2015, which is the last year where all constraints data sets were available. For more recent years, not all data sources offered published data updates. This will change the future, and the visual inspection can then be extended to more recent years.

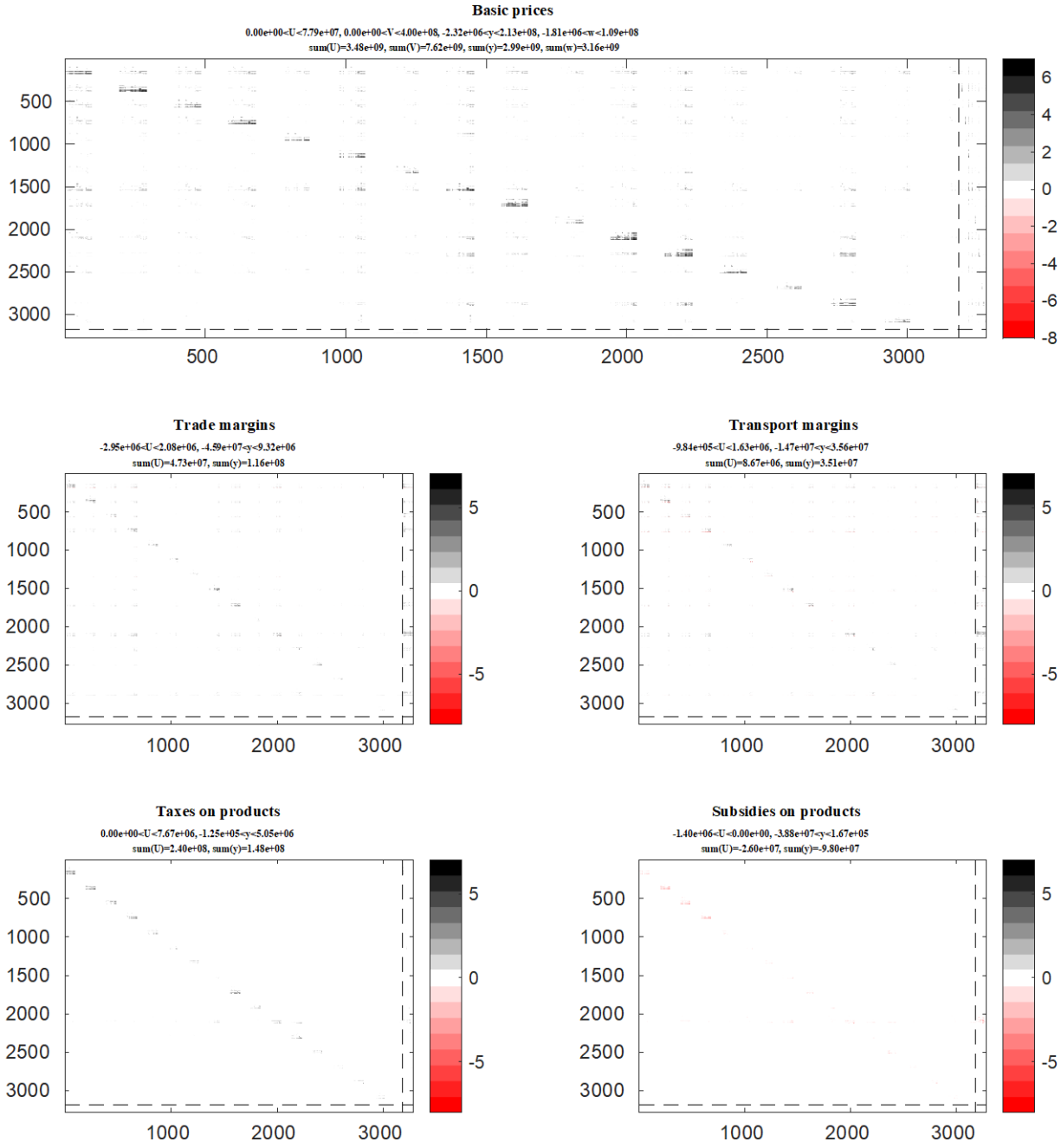

Fig. 1: Heat maps diagnostics for the GLORIA database for 2015. Each plot shows one of the five valuations of the GLORIA database. The dashed line separates the intermediate transaction block from the final demand and value-added blocks. These graphs are provided in high resolution, and the interested reader is encouraged to zoom into the individual plots for more detail.

Inspecting the MRIO through these heat maps representations offers an easy-to-use tool to find major numerical errors. For example, the basic price sheet shows darker shades in the domestic block of the intermediate transaction blocks. This indicates that there is more economic activity within the national markets than through international trade. This is to be

expected, and as such, the heat map block is an initial sanity check that all data were inserted correctly into the MRIO and that the MRIO structure is sound and robust. Further, this chart can identify unexpected negative values. With very few exceptions, the values in the basic price sheet must be positive. Unexpected negative values would indicate that the reconciliation engine does not adhere to the positivity condition.
The fifth valuation layer – subsidies on products – is shown in the bottom right-hand plot of Figure 1. Subsidies are always represented as negative numbers in order to ensure that a summation across the sheets will result in the correct purchasers' price.

Once the general table structure has been confirmed, the adherence of the MRIO to the source data set is validated. The main tool for this is again a visual representation of the adherence, as this offers a fast and reliable way to identify potential problems.

Adherence analysis for superior data sets

For the GLORIA database, separate adherence reports were generated for each data of the seven data sources that were listed further up. Hence, this *Standardised Diagnostics Report* (SDR) features seven individual plots (Figure 2). Four plots in the SDR plot the source data against its representation in the GLORIA database (referred to as a standard adherence plot). In a standard adherence plot, individual data points given in the GLORIA database (usually displayed on the y-axis) are compared to the corresponding data point in the underlying source data set (usually displayed on the x-axis). As such, perfect adherence would be achieved if all values were plotted on the diagonal y=x line. Due to the sheer complexity of the data reconciliation task, conflicting constraints, as well as varying levels of data reliability, perfect adherence cannot be achieved. These visualisations offer a way to quickly assess to what extend underlying databases are adhered to by the GLORIA database. Of the remaining plots, one plot shows the frequency distribution of deliberately excluded transactions (see detailed description in below under point 5), one plot displays information on the statistical reliability of each data point within the GLORIA database, and one plot focuses on the balance requirement for MRIO models.

The different plots of the SDR are

1) UNSD SNA Main Aggregates adherence (standard adherence plot)
   This data source shows the best adherence and is only disturbed by the enforcement of the strict input-output balance. Values that show the least amount of adherence usually coincide with very small countries (such as Guinea-Bissau or Guyana), countries where the underlying data are very uncertain (such as DPR Kora, Iraq, or Liberia), or those countries that underwent break-ups or unifications recently (such as Moldova, Ethiopia, or Sudan).

2) OECD and ICIO adherence (standard adherence plot)
   While not as well represented as the UN SNA MA data set, still shows a very good adherence. We've added a detailed interpretation of the adherence results further down in a separate QA section

3) Commodity production (FAO/Fish/MIN/IND-STAT adherence – standard adherence plot)
   The adherence of this data set is better than that of international data but does not match the adherence quality of the two data sets described previously. Please refer to the QA section below for explanations.

4) UNSD Comtrade adherence (standard adherence plot)
   Similar to the previous three plots, this plot also shows the adherence of the GLORIA database to the underlying dataset, which in this case in the UNSD Comtrade database. Compared to the previous three standard adherence plots, this plot shows the poorest adherence with the GLORIA database. The reason for this is that the UNSD Comtrade dataset displays the most conflicts against other publicly available datasets. As such, adherence of MRIO models with the Comtrade data set is in general poorer, which has also been documented in the construction process of other MRIO data sets such as the Eora model (Lenzen *et al.* 2013).

5) Engineering exclusions (frequency distribution plot).
   The engineering exclusions serve the purpose to ensuring that certain unrealistic or non-existent monetary exchange values in the GLORIA database remain either zero or very low. During the data preparation process, datasets have to be disaggregated, which can lead to the splitting of data in previously aggregated subsectors, which in return can lead to non-zero values in the MRIO table that are in fact required to be zero. These engineering exclusions are handled through a separate data feed (see above). However, due to conflicting information provided by other sources, instead of being fully set to 0, these transactions may receive small but non-zero values. This plot shows the distribution of the values that under the engineering exclusions should be zero. Most of these values range in the area up to 10,000 US$.

6) Input-output balance
   From an accounting viewpoint, each sector in an MRIO tables must be balanced. This so-called input-output balance is a constraint derived from accounting principles and is independent of the actual MRIO table or the underlying data. Due to the conflicting source data, numerical data reconciliation, and varying levels of data reliability, this input-output balance is usually not fully met. Therefore, one of the challenges in the construction of a MRIO database such as the GLORIA database is to achieve input-output imbalances that are as small as possible while ensuring a satisfactory adherence for the other source data sets. This plot shows the x_out values for all rows in the GLORIA database on the x-axis, and the logarithm of the discrepancy with between each row and the corresponding column on the x-axis. Due to the rebalancing step described further up, the GLORIA database displays very small discrepancies for almost all row/column pairs.

7) Standard deviations
   Each value in the GLORIA database is accompanied by reliability measures expressed in standard deviations. This plot shows the size of each value plotted against its own relative standard deviation. In general, MRIO data and statistical data used for MRIO

construction in general follows the notion that larger data points are usually more reliable. This is also observed in this plot for the GLORIA database.

The heat maps and standard diagnostics output plots for all years of the time series are available in Appendix A6.

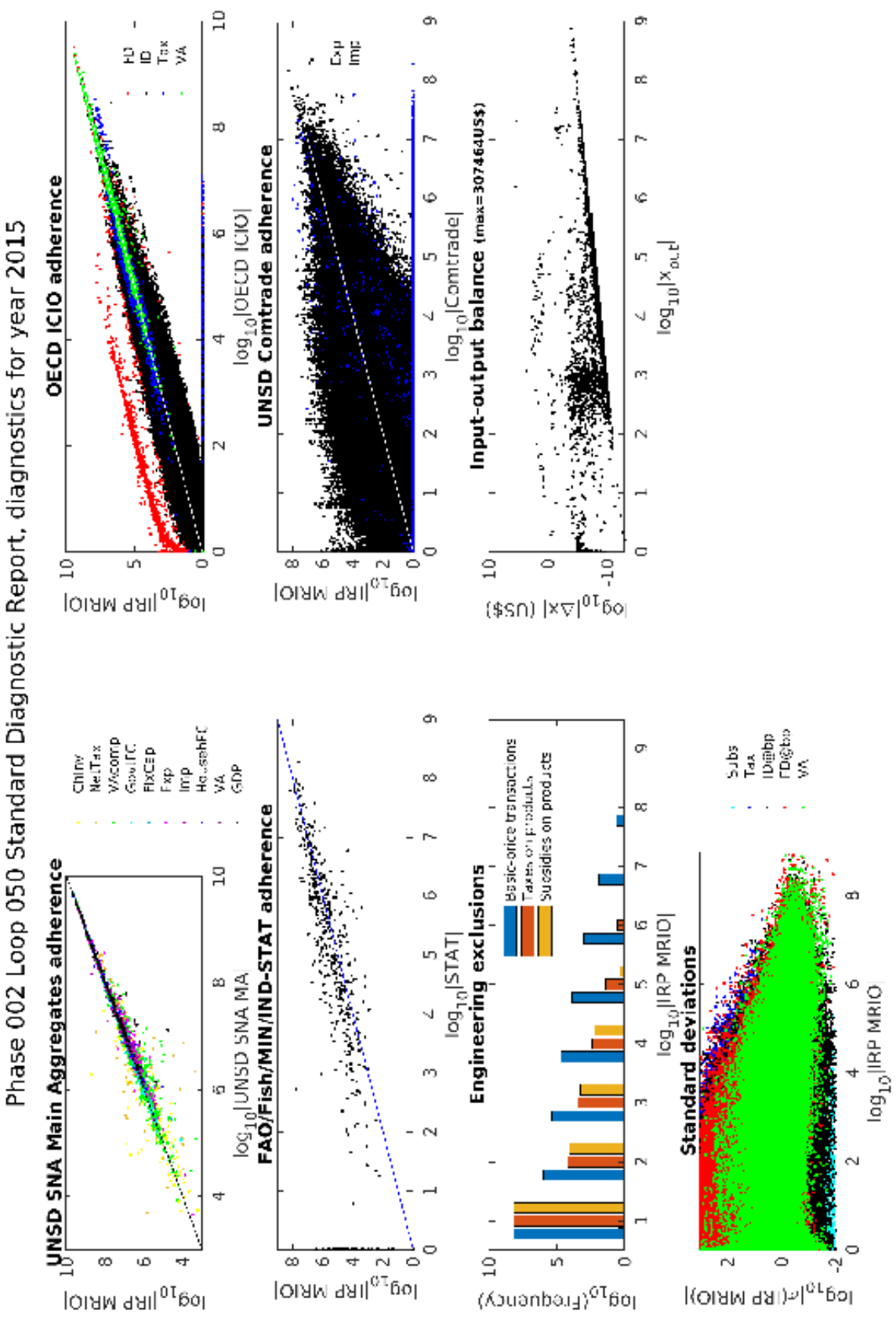

Fig. 2: Standard Diagnostics Report for the GLORIA database for 2015. All monetary values are given in thousand USD current price.

Comparison of macro-economic indicators in OECD-ICIO and GLORIA databases

In addition to assessing the mathematical adherence of individual data points across the entire GLORIA database, further comparison of macro-economic indicators was undertaken. The OECD ICIO dataset has a similar structure to the GLORIA database, although the OECD ICIO offers less sectoral and regional coverage, and its time series does not cover all the years covered by the GLORIA database. Hence, sector-wise comparisons are not feasible. However, for those countries that individually exist in both databases, macro-economic indicators can be compared for years where both databases offer coverage (2005-2015). This section shows an excerpt from this analysis. In the following, the plots for the comparison results for the countries Austria (AUT), Belgium (BEL), Germany (DEU), France (FRA), and Luxemburg (LUX) are listed. Note that for the plots in this section, the GLORIA database is labelled as *UNEP data*. Please refer to the following section for an interpretation of these analyses.

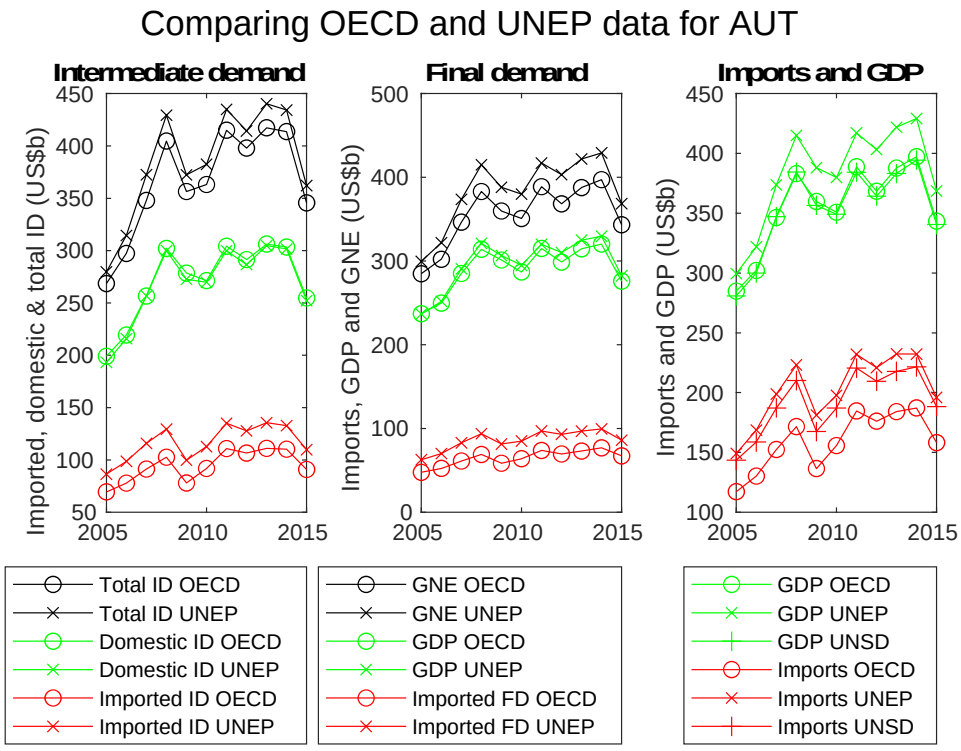

Fig. 3: Comparison of macro-economic indicators for Austria as observed in the OECD ICIO and GLORIA databases

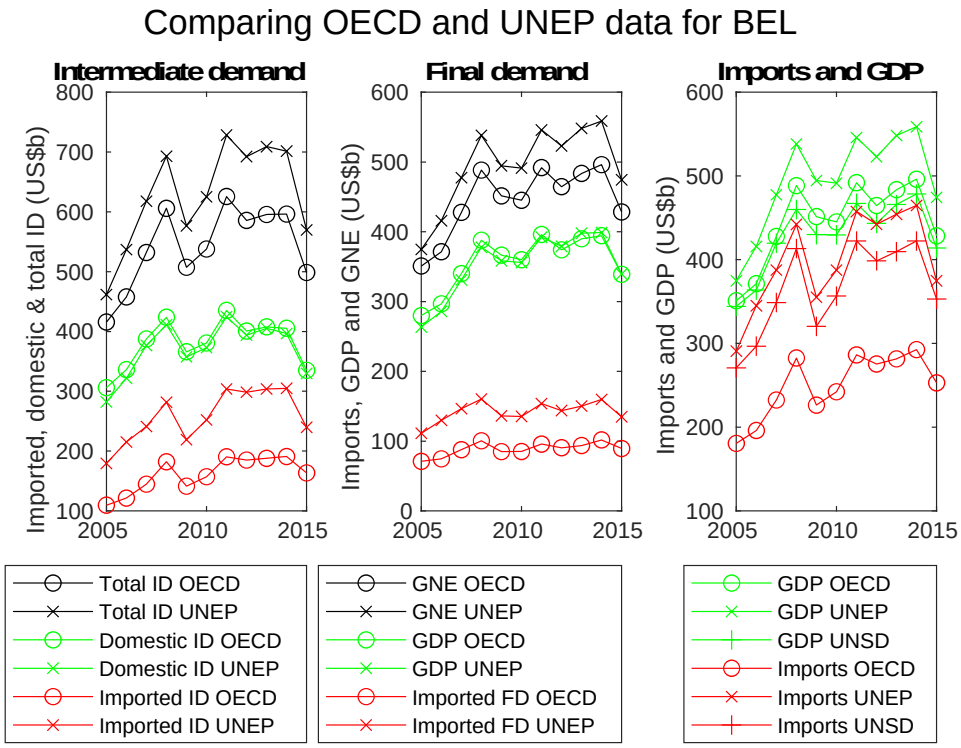

Fig. 4: Comparison of macro-economic indicators for Belgium as observed in the OECD ICIO and GLORIA databases

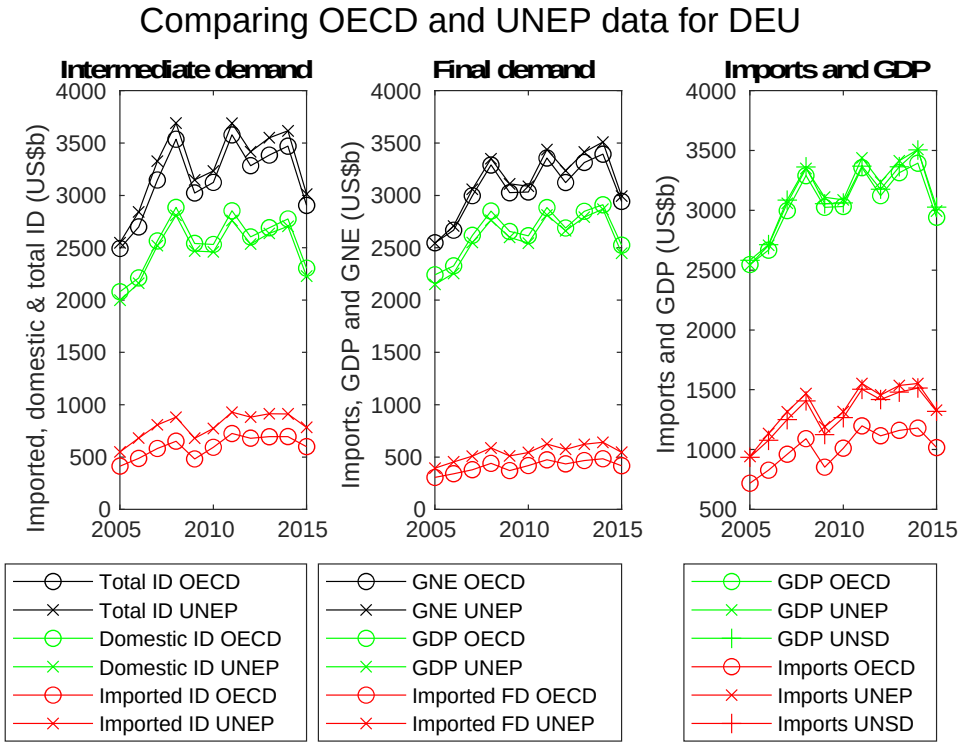

Fig. 5: Comparison of macro-economic indicators for Germany as observed in the OECD ICIO and GLORIA databases

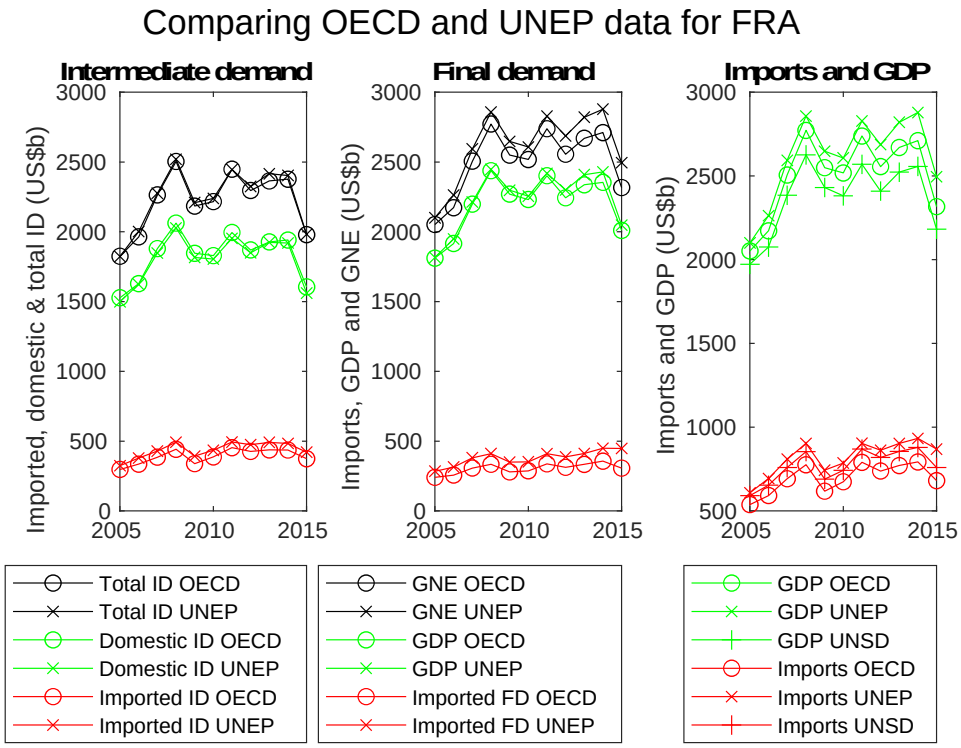

Fig. 6: Comparison of macro-economic indicators for France as observed in the OECD ICIO and GLORIA databases

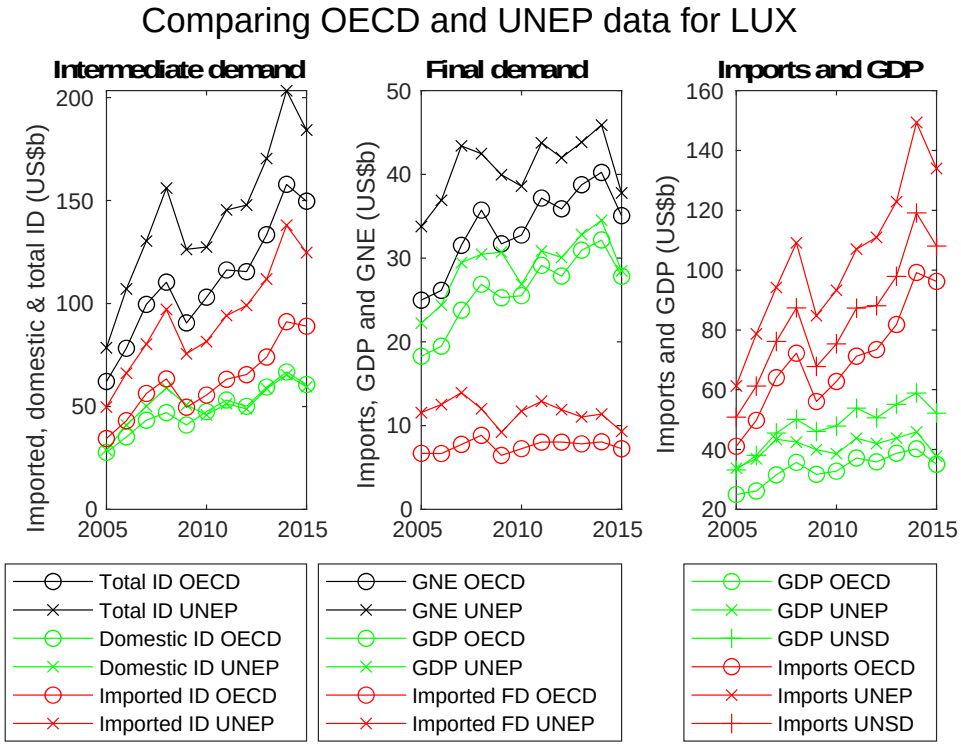

Fig. 7: Comparison of macro-economic indicators for Luxemburg as observed in the OECD ICIO and GLORIA databases

Comparison of macro-economic indicators in UN SNA MA and GLORIA databases

This paragraph describes the QA process for one of the iterations of the GLORIA database during the development stage. The plots shown in this section are not based on the final GLORIA database. This section is intended to showcase how data problems were identified during the development stage, and what measures were taken to resolve these problems. The next section describes how a later iteration of the GLORIA database showed significantly less data problems due to the insights provided by the process described here.

For the majority of countries/regions and years covered in the GLORIA database, the OECD ICIO database does not offer data coverage to carry out the comparisons described in the previous section. The UN SNA MA database, which is also part of the construction process of the GLORIA database, offers a smaller number of macro-economic indicators, but it covers all countries, regions, and years that are covered by the GLORIA database. The plots for this analysis do not have individual labels, and the data are to be interpreted as follows.

- dotted lines refer to the GLORIA database
- solid lines refer to the UN SNA MA database

Axis labels:

- x-axis: year
- y-axis: amount in thousand US$ current price

The colour-coding is as follows:

- black: GDP
- blue: total value added
- magenta: total exports
- red: imports
- green: final demand

In this section, the plots for a small number of countries and regions are displayed. Please refer to the following section for an interpretation of these analyses.

Please refer to Appendix A7 for plots for all 164 regions of the GLORIA database.

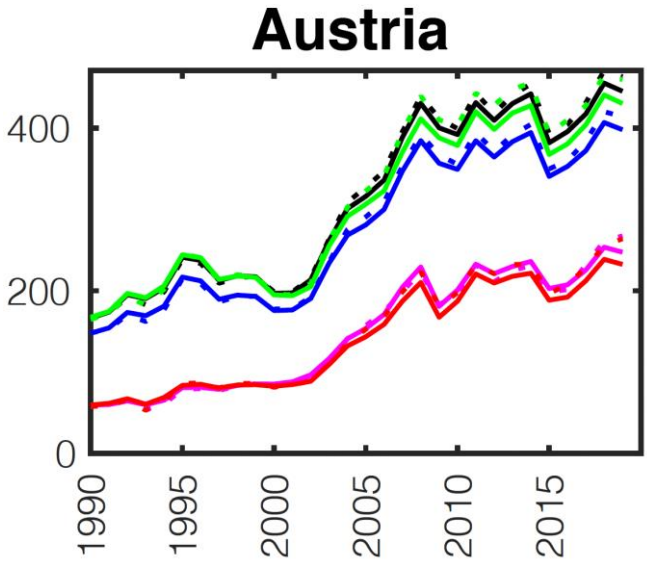

Fig. 8: Comparison of macro-economic indicators for Austria as observed in the UN SNA MA and GLORIA databases

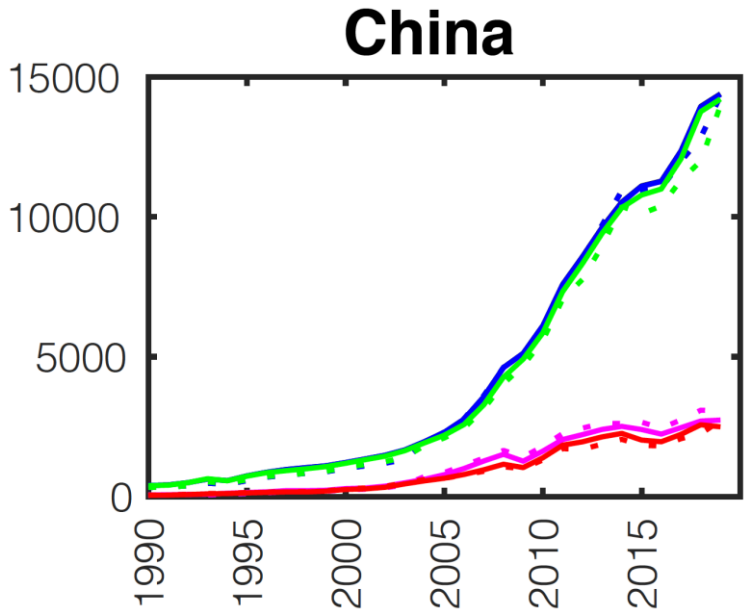

Fig. 9: Comparison of macro-economic indicators for China as observed in the UN SNA MA and GLORIA databases

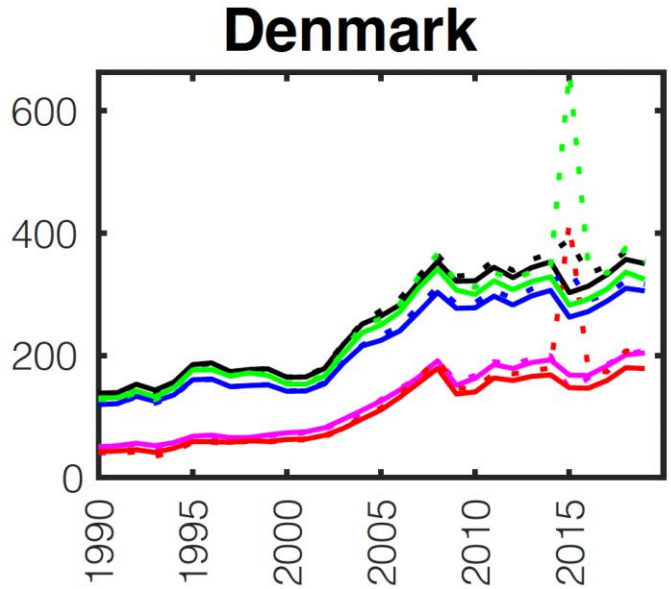

Fig. 10: Comparison of macro-economic indicators for Denmark as observed in the UN SNA MA and GLORIA databases. Note the unrealistic spike in the GLORIA database for 2015. Refer to the discussion further down in this section for an interpretation of this spike.

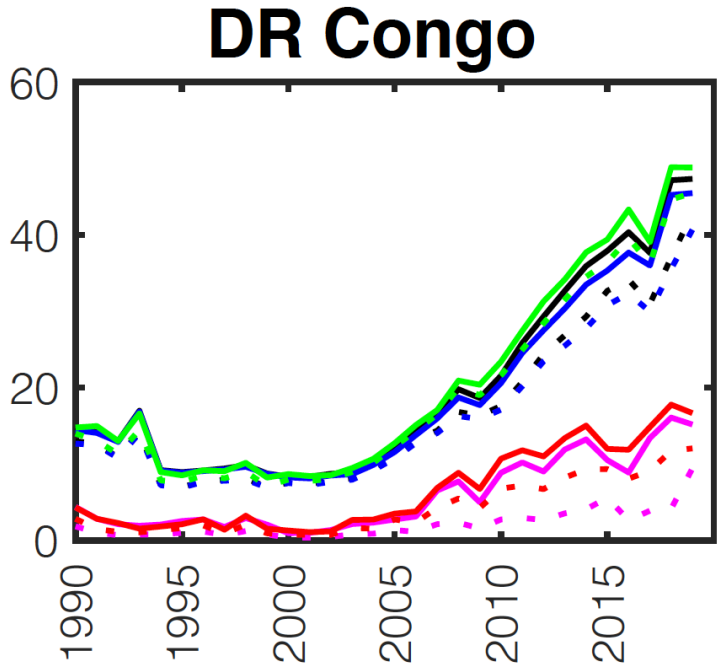

Fig. 11: Comparison of macro-economic indicators for the Democratic Republic Congo as observed in the UN SNA MA and GLORIA databases. Note that there are discrepancies in the data representation. Please refer to the discussion further down in this section for an interpretation of these results.

Interpretation and observation from the quality checks

Several conclusions were drawn from the quality checks outlined in the previous sections. The most important observations are summarised here in dot-form.

- A number of countries show good adherence with source data sets as well as with macro-economic indicators provided by both the OECD ICIO database and the UN SNA MA database. These countries include Russia, New Zealand, Austria, Germany, Belgium, and France. Hence, these countries can be assumed to have a high accuracy in their representation in the GLORIA database.
- Luxemburg's exports and imports are estimated, but the peak observed for 2006 is also shown the OECD ICIO and UN SNA MA databases.
- The stark peak in Venezuela in 2006 is also given in the UN SNA MA database.
- A peak in trade data in Kenya in 2017 is not reflected in the UN SNA MA database.
- Ethiopia, Zimbabwe and Belarus do not show a good adherence with the external data sources. This is currently under investigation, and it is recommended that these countries are excluded from analysis for the time being.
- Tanzania's spike in 2013 is under investigation. It is recommended that Tanzania is excluded from any analysis for 2013 for the time being.
- Several countries show spikes in individual years. These spikes are most likely of numerical nature as the underlying source data do not reflect these spikes. Investigations into these cases is currently underway. These cases include Denmark (2015), Oman (2015), Niger (2012), Macedonia (2011), Slovakia (2014), Israel (2005), Poland (2017), United Arab Emirates (2018), and Georgia (2014).
- Generally, very small countries are expected to be less accurate as they are relatively more affected by global accounting balances (See section *Adherence analysis for superior data sets -> Input-output balances*).

Iterative improvement of the GLORIA database using the example of Denmark

Following the assessment described in the previous section, further investigation into the unrealistic data spikes was undertaken. This is a standard process in the GLORIA database, and this section is intended to describe the process of data validation, using Denmark as an example.

Fig. 10 showed an unrealistic spike in Denmark's 2015 data which were not backed up by the data sources. Further improvement in the handling of conflicting data sources in the data reconciliation routine allowed for a simultaneous adherence of several conflicting data sets. As a result, the analysis for Denmark showed improved source data adherence.

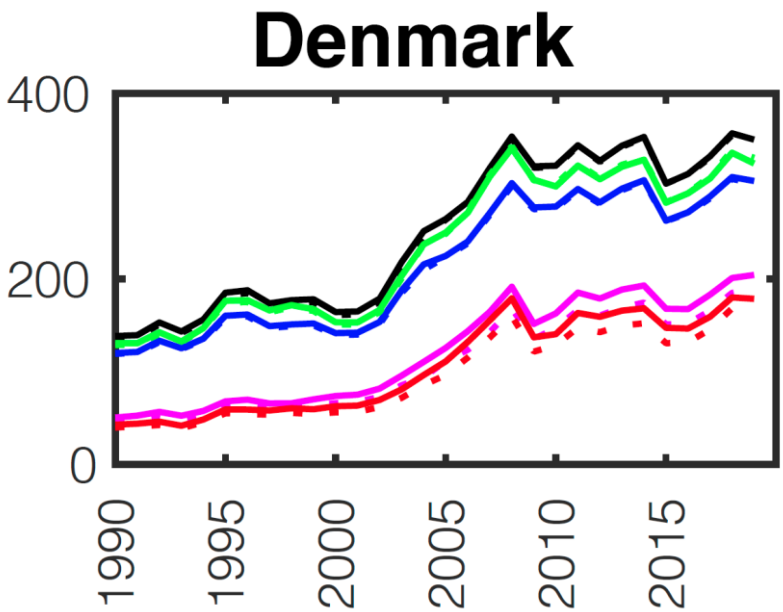

Fig. 12: Comparison of macro-economic indicators for the Denmark following detailed investigation into data spikes. The 2015 data show a significantly improved adherence.

Similar improvements could be achieved for Niger, Macedonia, Slovakia, Israel, Poland, and Georgia.

See Appendix A10 for a full set of charts.

Data-specific documentation

During the construction process of the GLORIA database, several individual data issues were identified, discussed, and often resolved with individual numerical interventions. This section is intended to serve as a documentation of these cases. No specific order is given to the individual points.

Coverage of transport emissions in the GLORIA database

The GLORIA database singles out transport in sector 86 *Land transport and transport except via pipelines*. This means that if this sector is not part of an identified supply chain, then transport emissions for this supply chain will not be recorded in the associated footprinting results.

Table rebalancing

By definition, input-output tables and also supply-use tables should ideally be fully balanced in each intermediate demand sector. A well-balanced table enables more robust footprint calculations. However, despite paying specific attention to this matter in the data reconciliation process, due to the complexity of the data processing and discrepancies in the source data, a perfectly balanced table is usually not achieved. In order to ensure that the balancing condition is fulfilled, the tables of the GLORIA database underwent a rebalancing

process after the main data reconciliation process was finished in order to ensure a best possible balancing outcome. This section is intended to document the approach that was taken in the rebalancing routine.

The fact that MRIO or MR-SUT compilation processes – regardless of the compilation approach – usually yield unbalanced tables is well known and documented. See for example the UN handbook on this topic (p.522) (https://unstats.un.org/unsd/naVonalaccount/docs/SUT_IOT_HB_Final_Cover.pdf).

For the tables of the GLORIA database, the input/output balance is given by (per sector)

outputs in basic price = inputs in basic price + net taxes on products (sum of sheets 4 and 5)

In general, there are two ways to address an imbalance:

a) Within each region: Adjust the outputs by specifically changing the values for changes in inventories for each sector in the final demand block by the balancing discrepancy (output side), or by adjusting the taxes and subsidies sheets to account for the discrepancy (input side). Both approaches change the GDP of the country in question where rebalancing is required.
b) Use the Rest-of-the-world region(s) to absorb the balancing discrepancies. This would effectively change the region “rest of the world” to “rest of the world + discrepancies”.

The UN handbook discusses both options and identifies pros and cons for both options. For the GLORIA database, the first option was chosen (adjustment within the country). Data checks indicated that the data compilation process for the MR-SUT tables already yielded relatively small imbalances, and an absorption of these discrepancies within each country yielded only negligible alterations of the GDP values.

Engineering constraints

The engineering constraints (also called engineering exclusions) are the most powerful and effective way to include information in the GLORIA database that is otherwise not covered by the data sources used during the construction process.

Logic and role of the engineering constraints

While the external data sources mainly provide numerical values that must be matched by the GLORIA database, the engineering constraints offer the inclusion of information that cannot be directly formulated by a linear equation. The main role of engineering constraints is to exclude illogical or wrong exchange values in the GLORIA database. These faulty values can occur when source data sets are more aggregated than the sectoral structure of the GLORIA database, and the disaggregation process may lead to the allocation of previously aggregated values to values in the GLORIA database that in fact need to be either zero or very small (i.e. non-sensical transactions). Hence, the engineering constraints are mainly at providing binary information on whether a specific value in the tables of the GLORIA database should be zero or not.

Defining the engineering constraints

There are no official data sources that track non-sense transactions that could be used to inform the engineering constraints. Defining these exclusions is an iterative process that is informed by subject matter expertise, observations during test calculations, as well as grey literature research. As such, the set of engineering exclusions can always be refined and developed further. Examples for engineering exclusions are that copper is prohibited to flow into aluminium smelting, crops are usually not fed back into crops, tobacco products do not flow into livestock, but crops are allowed to flow into livestock as fodder etc. Using aggregated source data sets such as the OECD ICIO database often do not allow to account for these exclusions. For example, if bauxite ore and copper ore are aggregated into a larger mining sector, then the disaggregation in the GLORIA database might lead to copper serving as an input into aluminium smelting. Hence the need for specific engineering exclusions. Depending on the differences in classifications, these engineering exclusions, although correct, can pose challenges during the data compilation process. For example, the list of engineering exclusions also prohibited mining outputs to flow into agriculture. The OECD ICIO database does in fact state non-zero flows from mining to agriculture. In the US for example, the agricultural sector receives inputs from the fuel mining sector. In order to account for these phenomena, certain transactions need to be allowed, and the engineering exclusions must be removed. For the example above, natural gas and fertilizer minerals were allowed to flow into the agricultural sector.
As a result of these observation, the engineering exclusions logic was extended to allow for country-specific engineering exclusions. For example, some countries produce nuclear fuel and also operate nuclear power stations, other countries do not operate nuclear power stations, but produce the fuel. In one country, the input from nuclear fuels into the energy sector must be permitted, in the other case it must be excluded.

QA processes for engineering constraints

Throughout the construction process of the GLORIA database, many individual transaction values were checked against their adherence with external data sources, and to what extend they might be affected by engineering exclusions. A visual assessment was carried for individual transactions. Although this check is intended to query individual data points, other data points of the corresponding block of the intermediate transaction matrix were visualised to provide context. In the following, assume that one value (called value in question, which is a transaction between an *origin sector* and a *destination sector*) is investigated within a certain block.

Each analysis was visualised in an output chart, which contains four output plots. These are:

Top left: a visual comparison of each value of the block in the GLORIA database against the OECD ICIO model. The value in question is circled in red. The element that shows the transaction of the destination sector with itself (the diagonal elements of the destination sector in that block) is marked by a red cross. The green circle contains those values of the queried transaction that the engineering exclusions allow. Hence, if there is no green circle near the red circle, then the engineering exclusions did not work properly.

Top right: similar comparison as in the previous plot, but this time for the input coefficient (A-matrix). A dot on the diagonal again indicates equality. The red dot marks the transaction in question, the red cross marks the input coefficient of the destination sector into itself.

Bottom left: Heat map of transaction of the sector in the GLORIA database and its "neighbouring" sectors in the OECD ICIO classification. The sum over all transactions is given in the plot title. This visualisation is intended to serve as a high-level comparison of one sector and its neighbouring sectors.

Bottom right: Visualisation of the engineering exclusions. A yellow cell indicates that the transaction is permitted, a blue cell indicates that it is excluded. Further, this plot lists the detailed sector names in the GLORIA database within its broader OECD ICIO "neighbourhood".

In the following, selected QA assessment charts for the engineering constraints are given. Note that the GLORIA database is referred to as the UNEP MRIO in these plots. These graphs are provided in high resolution, and the interested reader is encouraged to zoom into the individual plots for more detail.

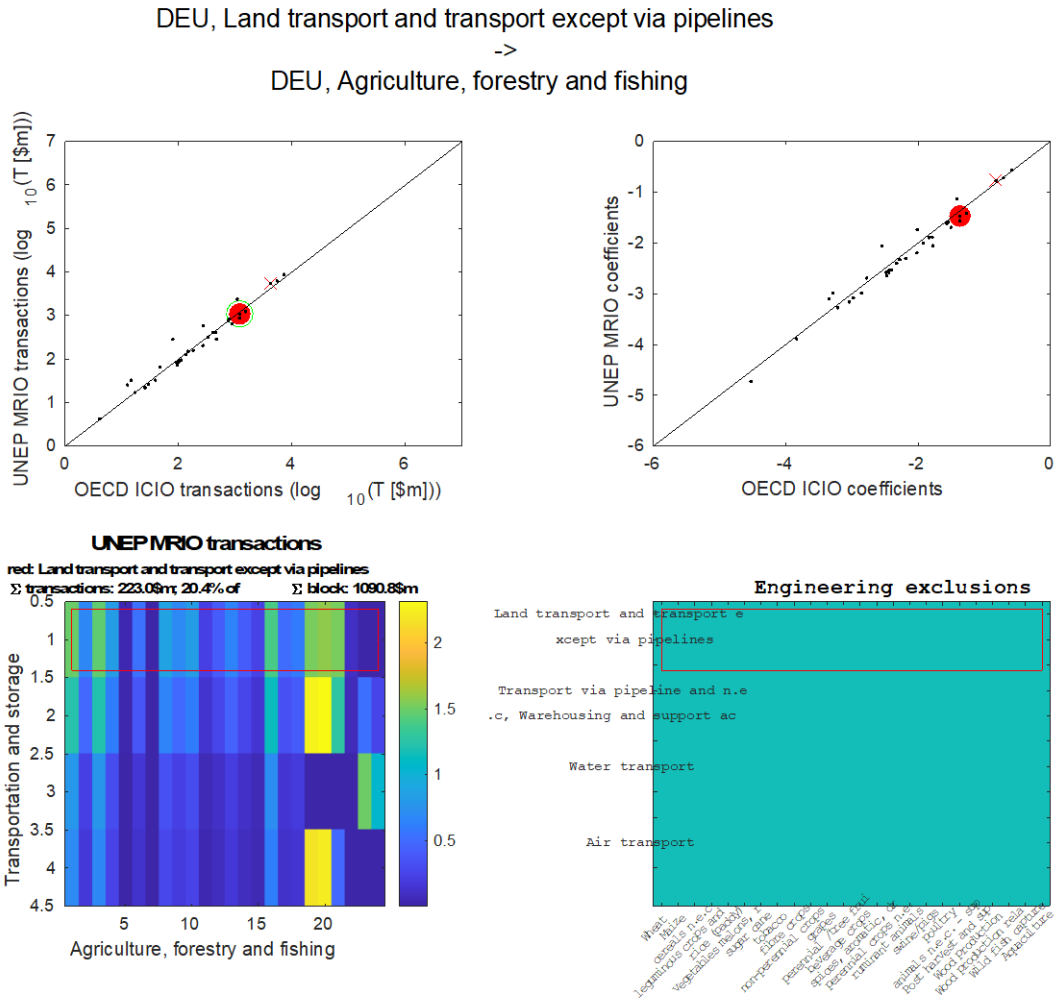

Fig. 13: Chart for the detailed visualisation of the transaction value between *DEU – land transport and transport except via pipelines* and *DEU – Agriculture, forestry and fishing*.

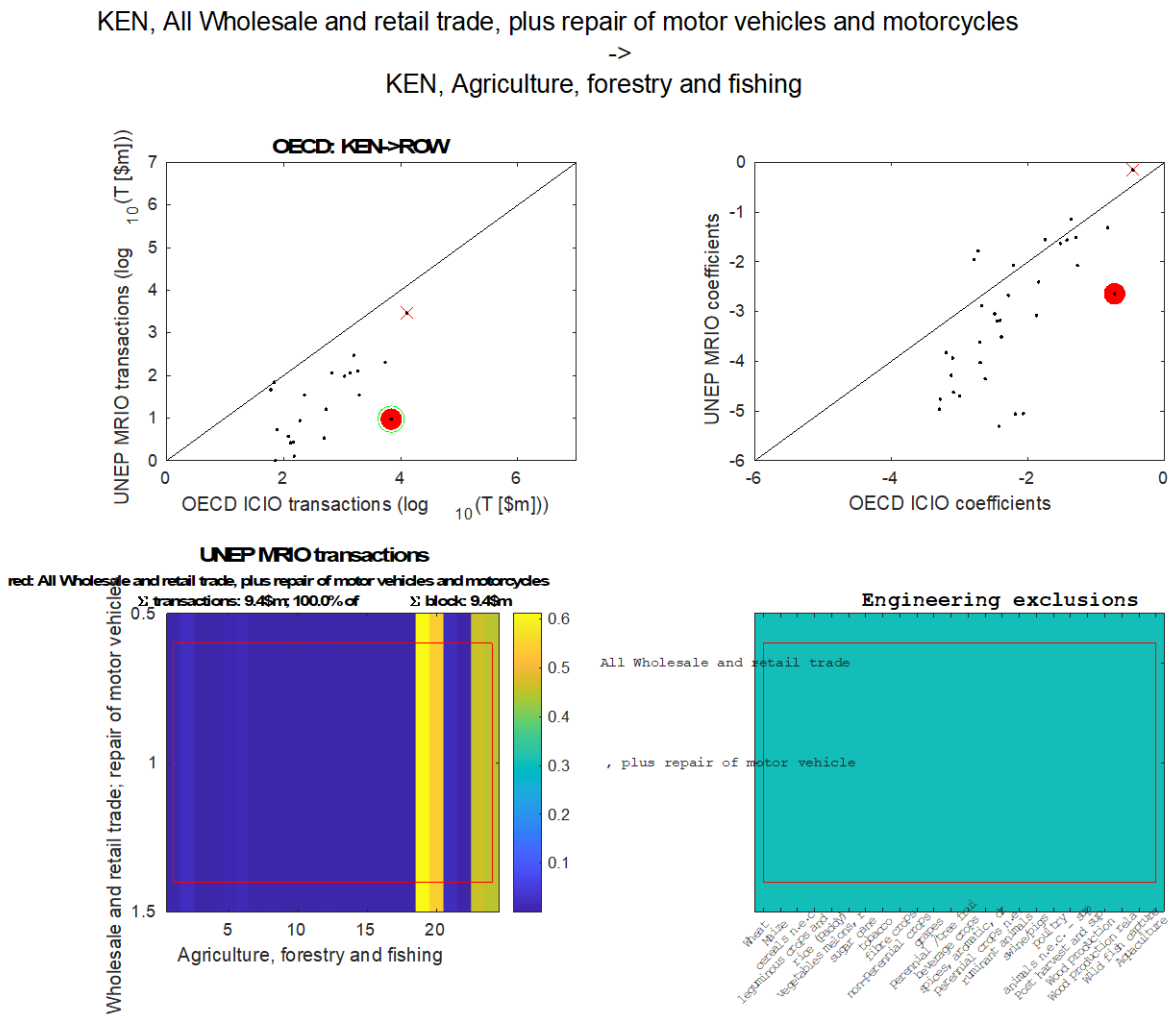

Fig. 14: Chart for the detailed visualisation of the transaction value between *KEN – all wholesale and retail trade, plus repair of motor vehicles and motorcycles* and *KEN – Agriculture, forestry and fishing*.

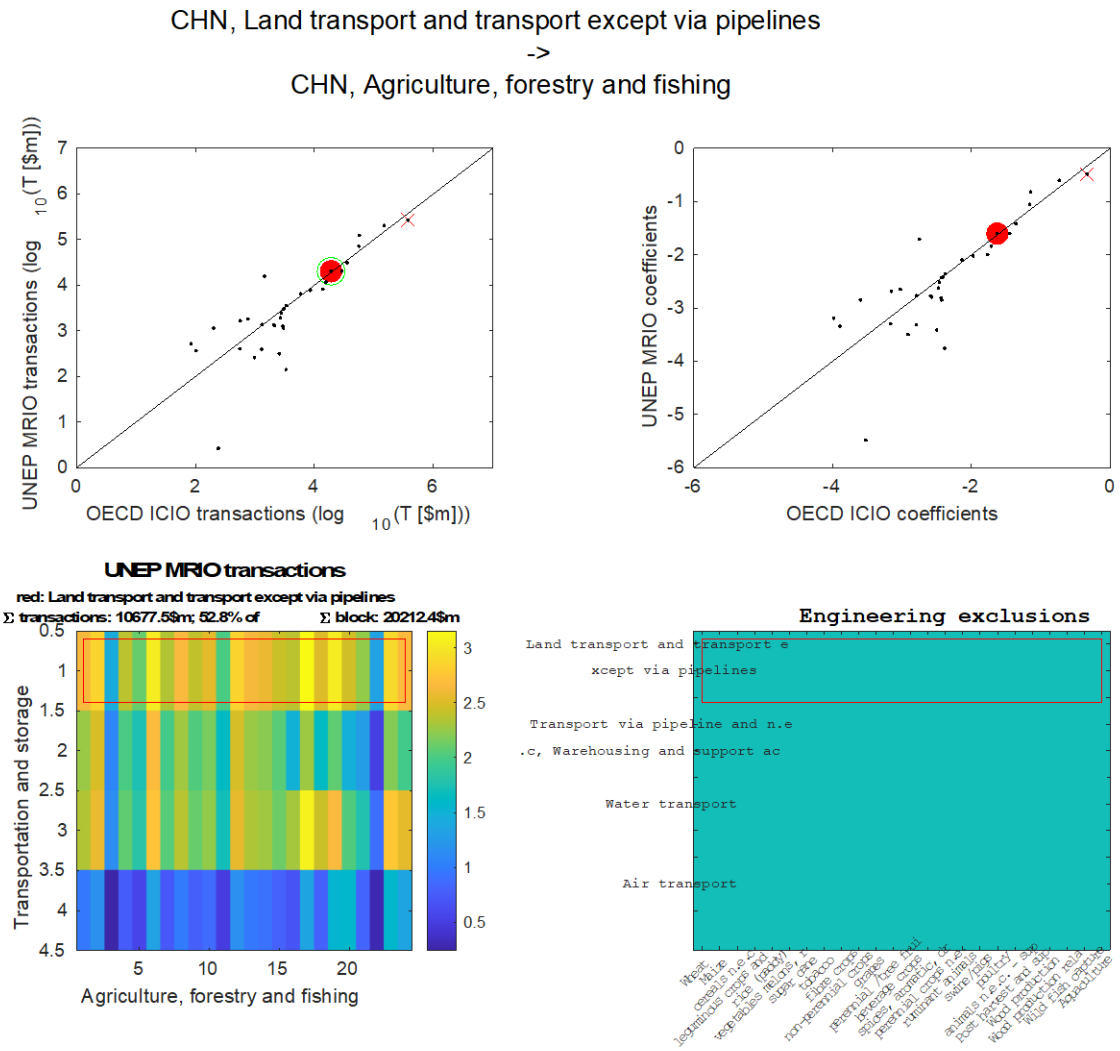

Fig. 15: Chart for the detailed visualisation of the transaction value between *CHN – land transport and transport except via pipelines* and *CHN – Agriculture, forestry and fishing*.

Further charts are available in Appendix A8.

Energy footprint verification

Testing of the GLORIA database concerning global energy footprints lead to a closer look at the MRIO database with specific focus on energy-related footprinting calculations. In cases where the energy footprint showed unexpected behaviour, the MRIO database was further assessed. This section summarises the approach and the main findings of this process.

Comparison of the aggregated GLORIA database with the OECD ICIO database

The first step of the process was the comparison of the GLORIA database to the OECD ICIO database. Given that the OECD ICIO database holds 34 sectors, this comparison could only be carried out at the 34-sector level.

Given that the final demand values are the stressor for footprint calculations, the final-demand trends for both the GLORIA and OECD ICIO databases were compared at the 34-sector level of the OECD ICIO database. The results show that at this aggregated level, the GLORIA database is in line with the OECD ICIO database for the agents *households*, *government*, and *capital*. For *changes in inventories*, the alignment is not that good, which is owed to the facts that the absolute values for this agent are significantly smaller, and that *changes in inventories* are generally used as dummy sectors to ensure sector balancing etc. (see Fig. 15).

Examining the energy footprint at the 97-sector level of the GLORIA database

When using the 97-sector classification of the GLORIA database, a direct comparison of the footprinting results with the OECD ICIO database or other datasets used in the construction process of the GLORIA database is not possible, because the sector detail is not given. During these QA assessments, the energy footprint for individual countries were reviewed in order to identify potential data problems at the 97-sector level. Fig. 16 shows these assessments for New Zealand. The top row of the figure shows the monetary totals for New Zealand, the bottom row shows the energy data (plain energy, energy multiplier, domestic footprint, and imported footprint). The monetary data do not how a spike between 2000 and 2005, but the energy footprint data do. Hence, the energy footprint for these years had to be investigated further.

Examining various energy trends.

Further focus was put on the energy trends by assessing a variety of energy-related calculation results for individual countries. The results for New Zealand are shown in Fig. 17.

Conclusions for the New Zealand case

For the case described in this section, further data analysis was conducted with three main findings:

1. The spikes are also reflected in the OECD ICIO database. Hence, the GLORIA database shows good adherence and appears to inherit the problem from the OECD ICIO database.
2. In particular, the OECD ICIO records imports of utilities such as electricity, water, and gas from other countries. This is virtually impossible as New Zealand does not have underwater cables in place with neighbouring nations such as Australia. Hence, the GLORIA reflects data from the OECD ICIO database that are unrealistic.
3. Further trade data analysis (not shown here) revealed that then GLORIA database shows unrealistic trade of lignite between North Korea and New Zealand. This is a result of the North Korean trade data not being covered by any of the source data sets used. As a result, the IELab data platform uses these unconstrainted values to be able to adhere to constraints imposed elsewhere. Once identified, this issue can be rectified by imposing necessary constraints on the problematic data.

All of these issues can be addressed in subsequent data runs.

Further analyses of this type were carried out for other countries. The results are shown in Appendix A9.

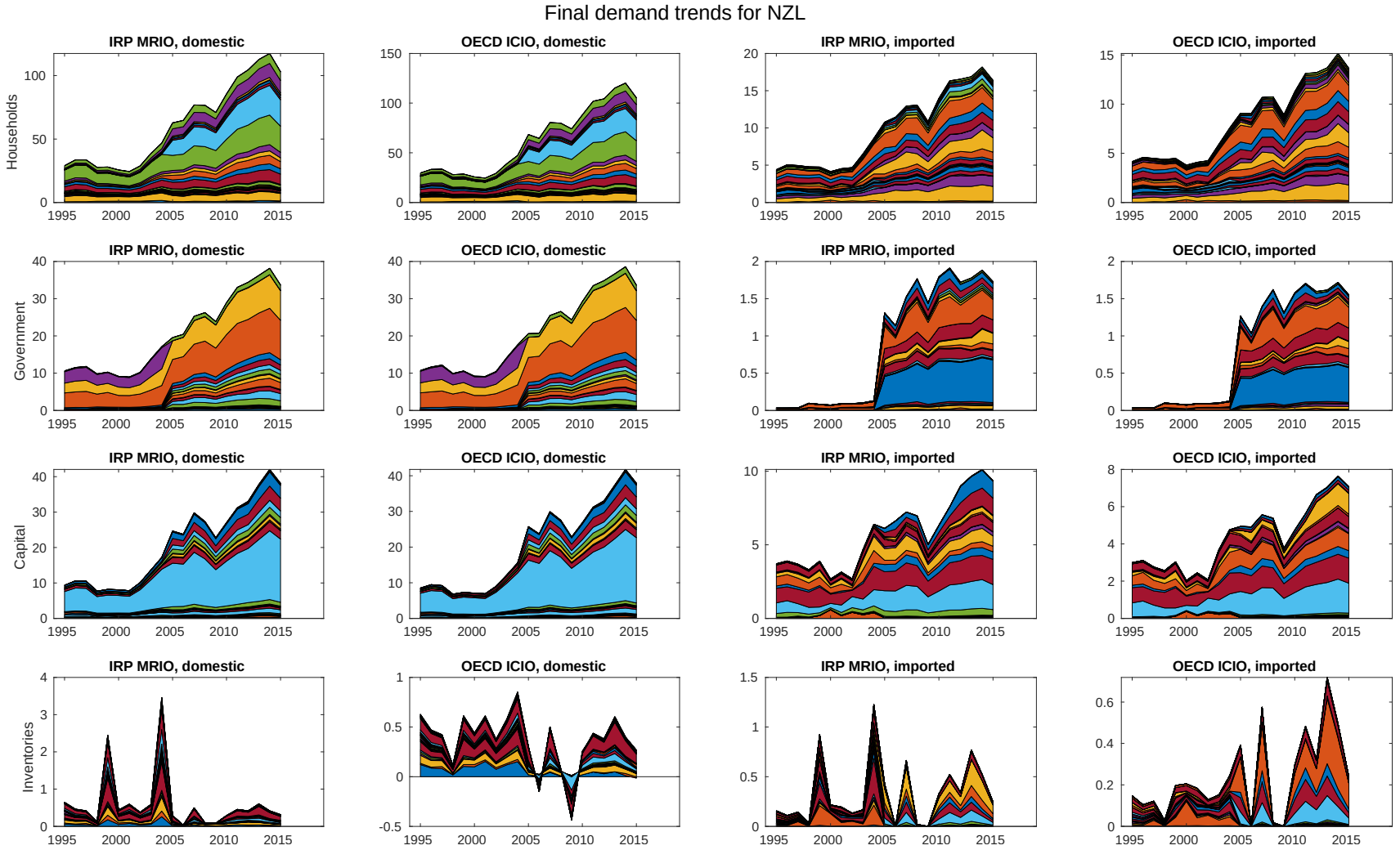

Fig. 16: Comparison of the final demand agents at the 34-sector level of the OECD ICIO. Each row of charts represents one final demand agent. The final demand is separated into domestic and imported final demand. The GLORIA database is referred to as “IRP MRIO”. The different colours bands represent the 34 OECD ICIO sectors, no legend is provided for these sectors.

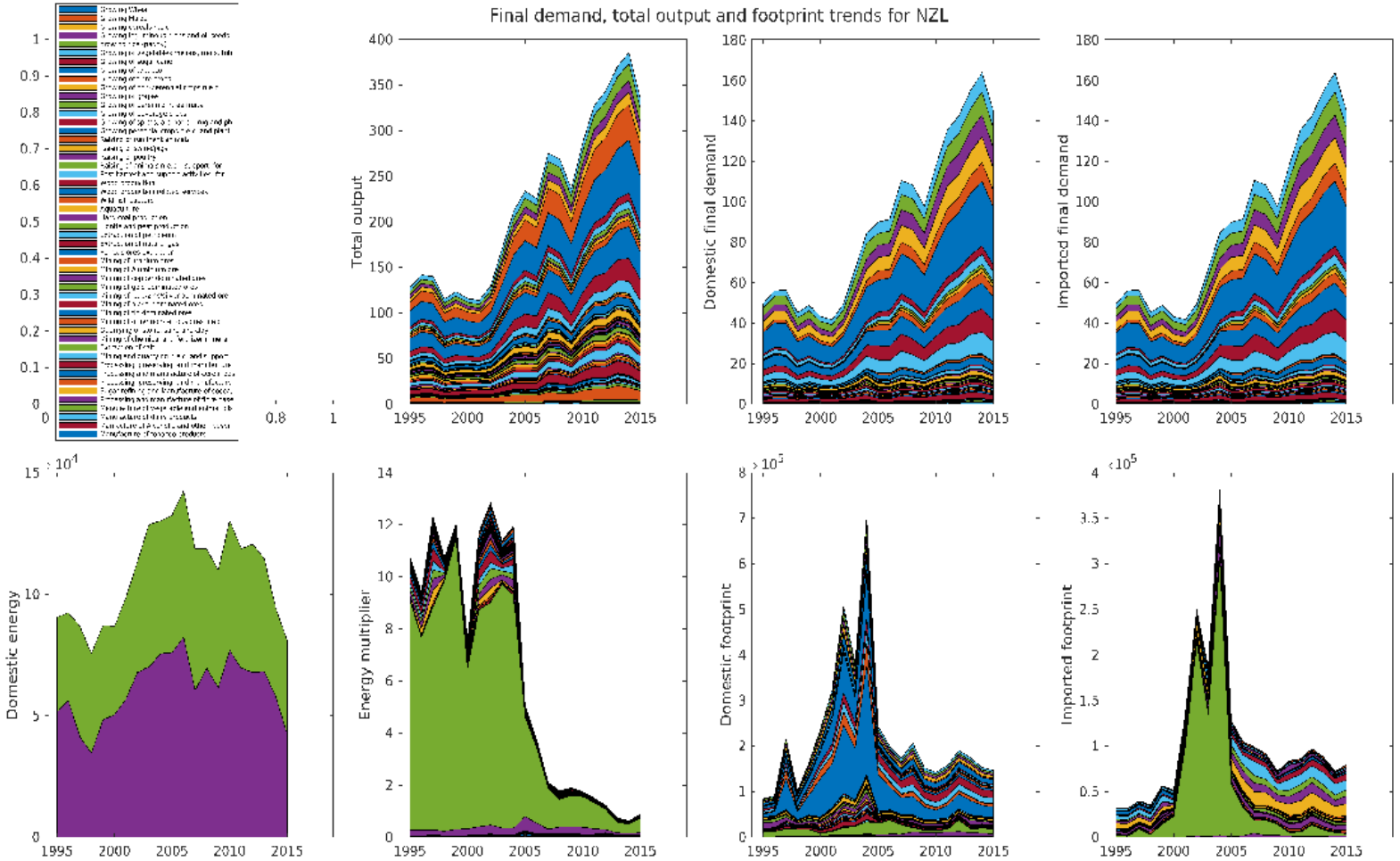

Fig. 17: Detailed analysis of New Zealand's energy footprint in the GLORIA database. The top row shows monetary data, the bottom row energy-related data. The spike in the energy footprints (bottom right plots) is not reflected by a spike in expenses.

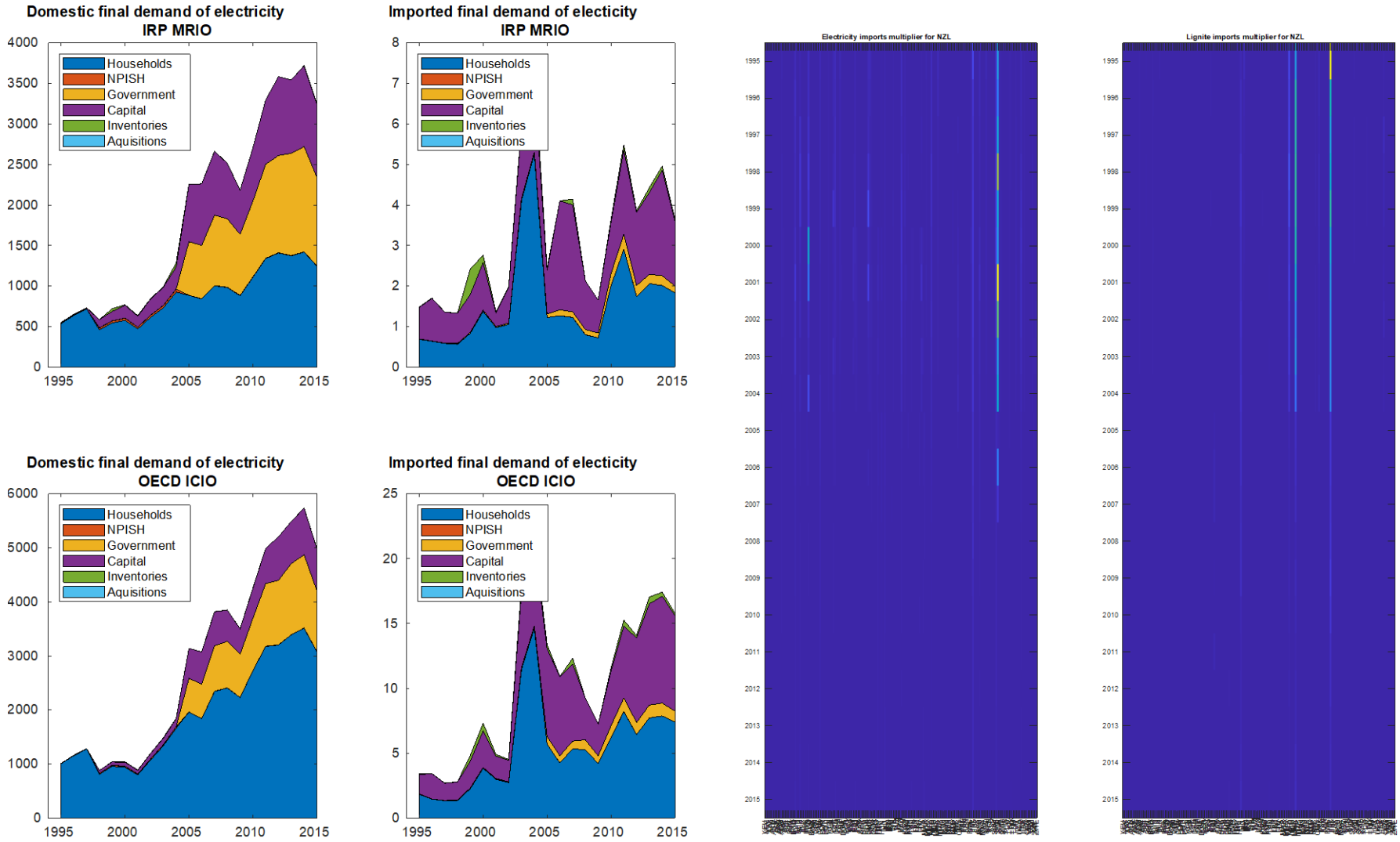

Fig. 18: Various energy trends for New Zealand. The GLORIA database is referred to as the IRP MRIO.

Future work and outlook

The IELab infrastructure on this the data pipeline for the GLORIA database is built is highly flexible and adaptable. As such, further extensions, refinements, and updates of the GLORIA database can be undertaken by building upon the existing data compilation process described in this document.

Specific recommendations for future work are:

- Investigate currently known data issues that so far remain unsolved. Specifically unrealistic spikes in macro-economic data.
- Extending of the currently diagonal supply tables with country-specific co-production data.
- Updating of the currently utilised source data sets once updates become available.
- Further development and refinement of the engineering constraints.

Appendix

Appendix A1: List of regions distinguished in the MRIO (order: top to bottom, left to right)

Afghanistan	DR Yemen (Aden)	South Korea	Paraguay
Angola	Denmark	Kuwait	Qatar
Albania	Dominican Republic	Laos	Romania
United Arab Emirates	Algeria	Lebanon	USSR/Russian Federation (1990/1991)
Argentina	Ecuador	Liberia	Rwanda
Armenia	Egypt	Libya	Saudi Arabia
Australia	Eritrea	Sri Lanka	South Sudan
Austria	Spain	Lithuania	Senegal
Azerbaijan	Estonia	Luxembourg	Singapore
Burundi	Ethiopia/DR Ethiopia (1992/1993)	Latvia	Sierra Leone
Belgium	Finland	Morocco	El Salvador
Benin	France	Moldova	Somalia
Burkina Faso	Gabon	Madagascar	Yugoslavia/Serbia (1991/1992)
Bangladesh	United Kingdom	Mexico	Sudan/North Sudan (2010/2011)
Bulgaria	Georgia	Macedonia	Slovakia
Bahrain	Ghana	Mali	Slovenia
Bahamas	Guinea	Malta	Sweden
Bosnia and Herzegovina	Gambia	Myanmar	Syria
Belarus	Equatorial Guinea	Mongolia	Chad
Belize	Greece	Mozambique	Togo
Bolivia	Guatemala	Mauritania	Thailand
Brazil	Honduras	Malawi	Tajikistan
Brunei Darussalam	Hong Kong	Malaysia	Turkmenistan
Bhutan	Croatia	Namibia	Tunisia
Botswana	Haiti	Niger	Turkey
Central African Republic	Hungary	Nigeria	Tanzania
Canada	Indonesia	Nicaragua	Uganda
Switzerland	India	Netherlands	Ukraine
Chile	Ireland	Norway	Uruguay
China	Iran	Nepal	United States of America
Cote d'Ivoire	Iraq	New Zealand	Uzbekistan
Cameroon	Iceland	Oman	Venezuela
DR Congo	Israel	Pakistan	Viet Nam
Rep Congo	Italy	Palestine	Yemen Arab Republic/Yemen (1989/1990)
Colombia	Jamaica	Panama	South Africa
Costa Rica	Jordan	Peru	Zambia
Cuba	Japan	Philippines	Zimbabwe
Cyprus	Kazakhstan	Papua New Guinea	Rest of Americas
CSSR/Czech Republic (1992/1993)	Kenya	Poland	Rest of Europe
Germany	Kyrgyzstan	North Korea	Rest of Africa
Djibouti	Cambodia	Portugal	Rest of Asia-Pacific

Appendix A2: list of economic sectors distinguished in the SCP HAT MRIO

1. Growing Wheat
2. Growing Maize
3. Growing cereals n.e.c
4. Growing leguminous crops and oil seeds
5. growing rice (paddy)
6. Growing of vegetables melons, roots, tubers, non-perennial fruits
7. Growing of sugar cane
8. Growing of tobacco
9. Growing of fibre crops
10. Growing of non-perennial crops n.e.c.
11. Growing of grapes
12. Growing of perennial /tree fruits
13. Growing of beverage crops
14. Growing of spices, aromatic, drug, and pharmaceutical crops
15. Growing perennial crops n.e.c. and plant propagation
16. Raising of ruminant animals
17. Raising of swine/pigs
18. Raising of poultry
19. Raising of animals n.e.c. - support for animal production - mixed farming - Hunting gathering and related services
20. Post-harvest and support activities for crop production
21. Wood production
22. Wood production related services
23. Wild fish capture
24. Aquaculture
25. Hard coal production
26. Lignite and peat production
27. Extraction of petroleum
28. Extraction of natural gas
29. Ferrous ores extraction
30. Mining of uranium ores
31. Mining of Aluminium ore
32. Mining of copper dominated ores
33. Mining of gold dominated ores
34. Mining of lead/zinc/silver dominated ores
35. Mining of nickel dominated ores
36. Mining of tin dominated ores
37. Mining of other non-ferrous ores n.e.c.
38. Quarrying of stone, sand and clay
39. Mining of chemical and fertilizer minerals
40. Extraction of salt
41. Mining and quarrying n.e.c. and support for petroleum natural gas and mining
42. Processing, preserving, and manufacture of meat and fish-based products
43. Processing and manufacture of cereal based products

44. Processing, preserving, and manufacture of food crop products n.e.c - mixed food and feeds n.e.c
45. Sugar refining and Manufacture of cocoa, chocolate, and sugar confectionery
46. Processing and manufacture of fibre-based products and hide (natural or other) based products
47. Manufacture of vegetable and animal oils and fats
48. Manufacture of dairy products
49. Manufacture of Alcoholic and other beverages
50. Manufacture of tobacco products
51. Sawmilling and planning of wood - Wood based manufacturing excl. pulp and paper
52. Wood pulp and paper production and printing
53. Manufacture of coke oven products
54. Manufacture of refined petroleum products
55. Manufacture of nitrogenous fertilizers
56. Manufacture of non-nitrogenous and mixed fertilizers
57. Manufacture of basic petrochemical products n.e.c.
58. Manufacture of basic inorganic chemicals n.e.c.
59. Manufacture of pharmaceuticals, medicinal chemical and botanical products
60. Manufacture of rubber and plastic products n.e.c.
61. Manufacture of clay building materials
62. Manufacture of other ceramics n.e.c.
63. Manufacture of cement, lime and plaster and articles made there-of
64. Manufacture of other non-metallic mineral products n.e.c.
65. Manufacture and casting of basic iron and steel
66. Manufacture and casting of basic Aluminium
67. Manufacture and casting of basic Copper
68. Manufacture and casting of basic Gold
69. Manufacture and casting of basic Lead/Zinc/Silver
70. Manufacture and casting of basic nickel
71. Manufacture and casting of basic tin
72. Manufacture of basic non-ferrous metals n.e.c.
73. Manufacturing of fabricated metal products, machinery and transport equipment n.e.c., and repair and installation of machinery and equipment
74. Manufacture of computer, electronic, and optical products
75. Manufacture of electrical equipment including metal wiring and cables
76. Manufacture of motor vehicles, trailers, and semi-trailers
77. Manufacture of furniture and other manufacturing n.e.c
78. Electric power generation, transmission, and distribution
79. Manufacture of gas; distribution of gaseous fuels through mains
80. Water collection, treatment and supply, Sewerage, and Steam and air conditioning supply
81. Waste collection, treatment, and disposal
82. Materials recovery
83. Construction of all buildings
84. Construction of roads and railways, utilities, and other civ. engineering inc. demolition and site preparation
85. All Wholesale and retail trade, plus repair of motor vehicles and motorcycles

86. Land transport and transport except via pipelines
87. Transport via pipeline and n.e.c, Warehousing, and support activities for transportation
88. Water transport
89. Air transport
90. Accommodation and food service activities
91. Publishing activities, Telecommunications, Information, and communication n.e.c.
92. Financial, Insurance, and Real estate activities
93. Professional, scientific, and technical activities
94. Public administration, Social security, Defence and public order, and Administrative and support service activities n.e.c.
95. Education
96. Human health and social work activities
97. Arts, entertainment and recreation, Repair of computers, personal and household goods, and Other service activities n.e.c.

Appendix A3: List of final demand agents

1. Household final consumption
2. Non-profit institutions serving
3. Government final consumption
4. Gross fixed capital formation
5. Changes in inventories
6. Acquisitions less disposals of valuables

Appendix A4: List of value-added categories

1. Compensation of employees
2. Taxes on production
3. Subsidies on production
4. Net operating surplus
5. Net mixed income
6. Consumption of fixed capital

Appendix A5: List of valuation sheets

1. basic prices
2. trade margins
3. transport margins
4. taxes on products
5. subsidies on products

Appendix A6: Heat map plots and Standard Reporting Outputs for all years in the time series (1990-2019)

This part of the documentation contains all heat map plots and standard reporting output (SRO) plots for each year of the time series. For a detailed description of the outputs, refer to the *Quality checks* section of this document.

Heat maps and SRO for 1990

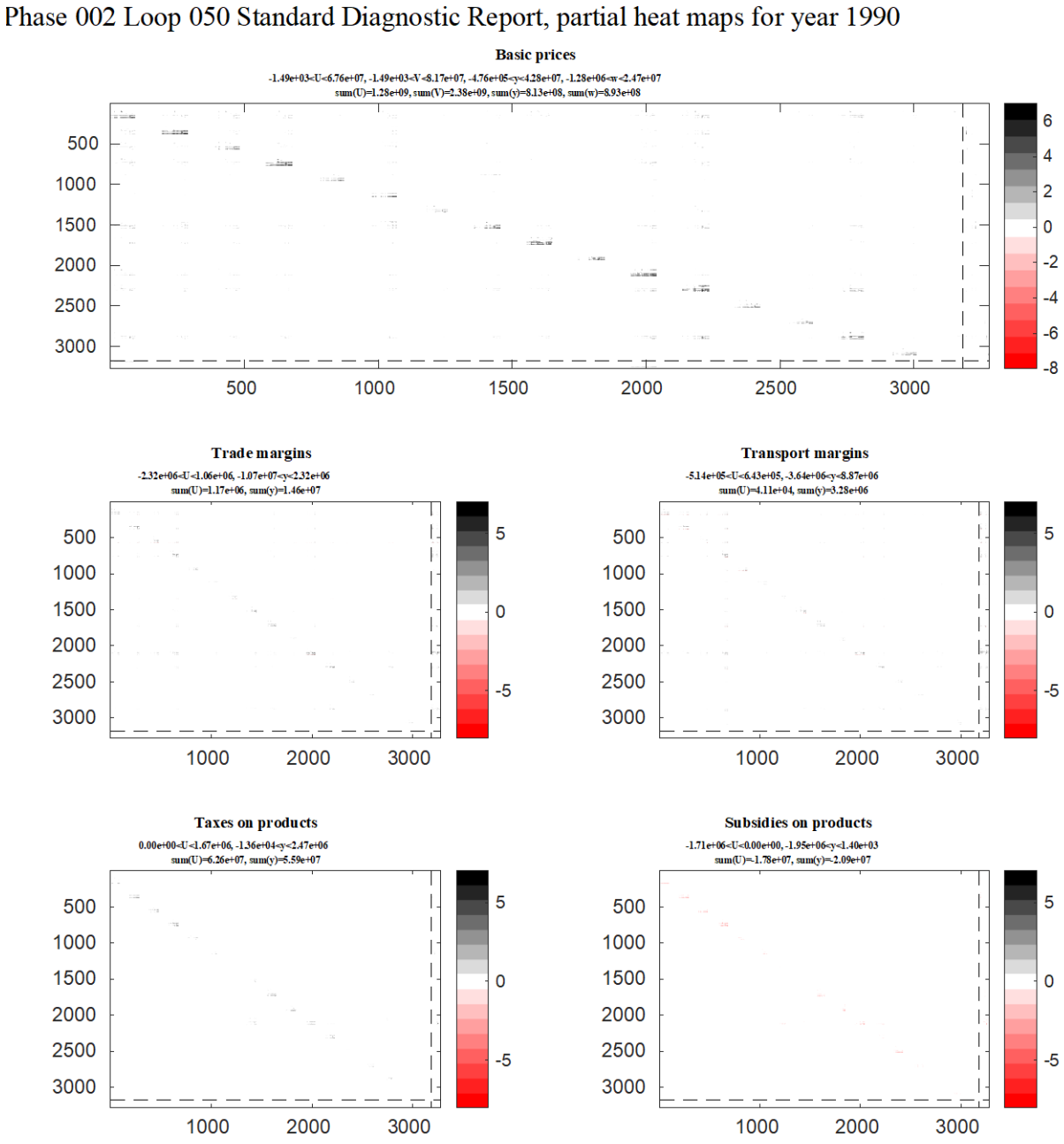

Fig. A1: Heat maps diagnostics for the GLORIA DATABASE for 1990.

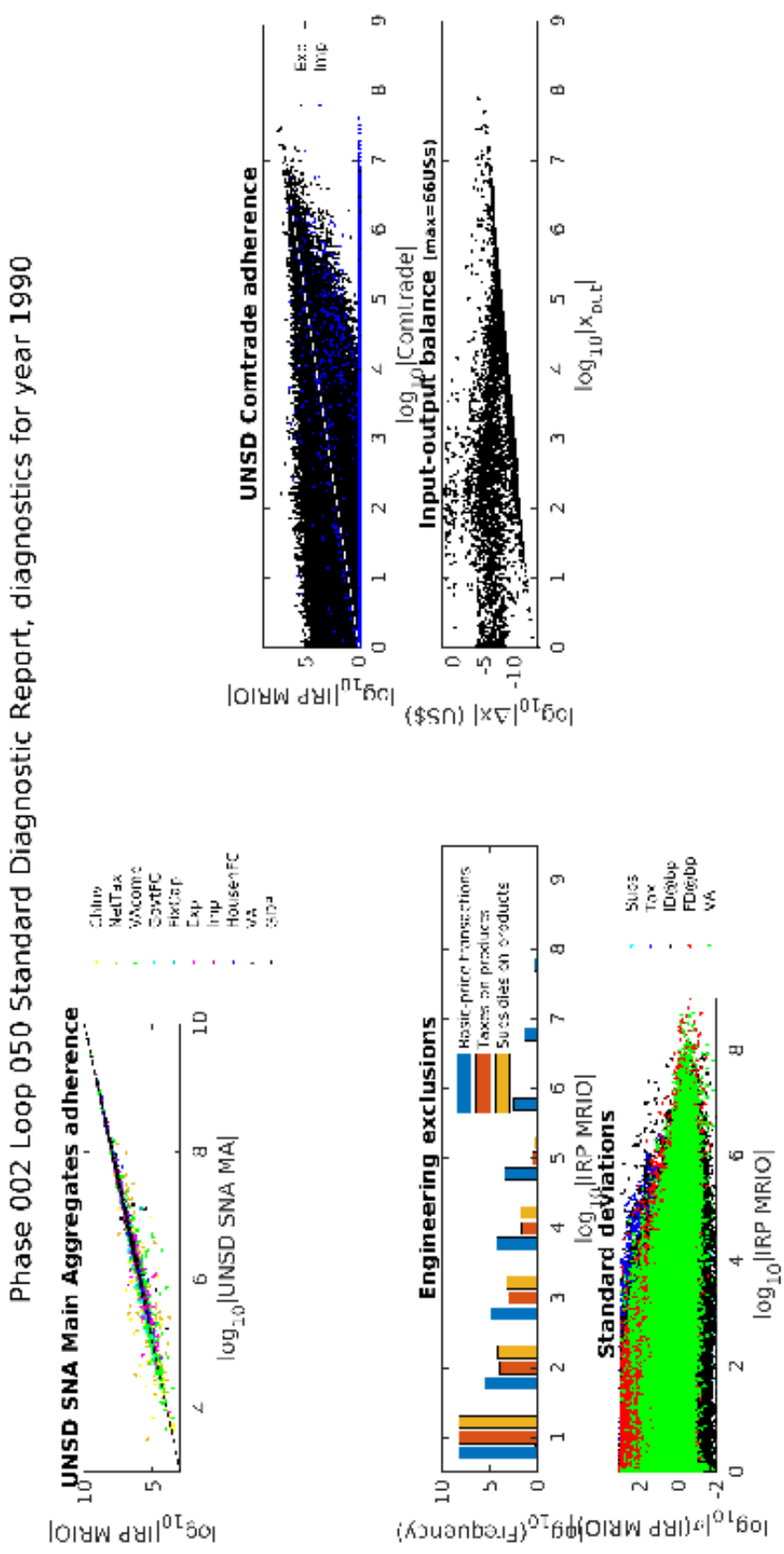

Fig. A2: Standard Diagnostics Report for the GLORIA DATABASE for 1990. Missing plots indicate that this data source was not available for 1990.

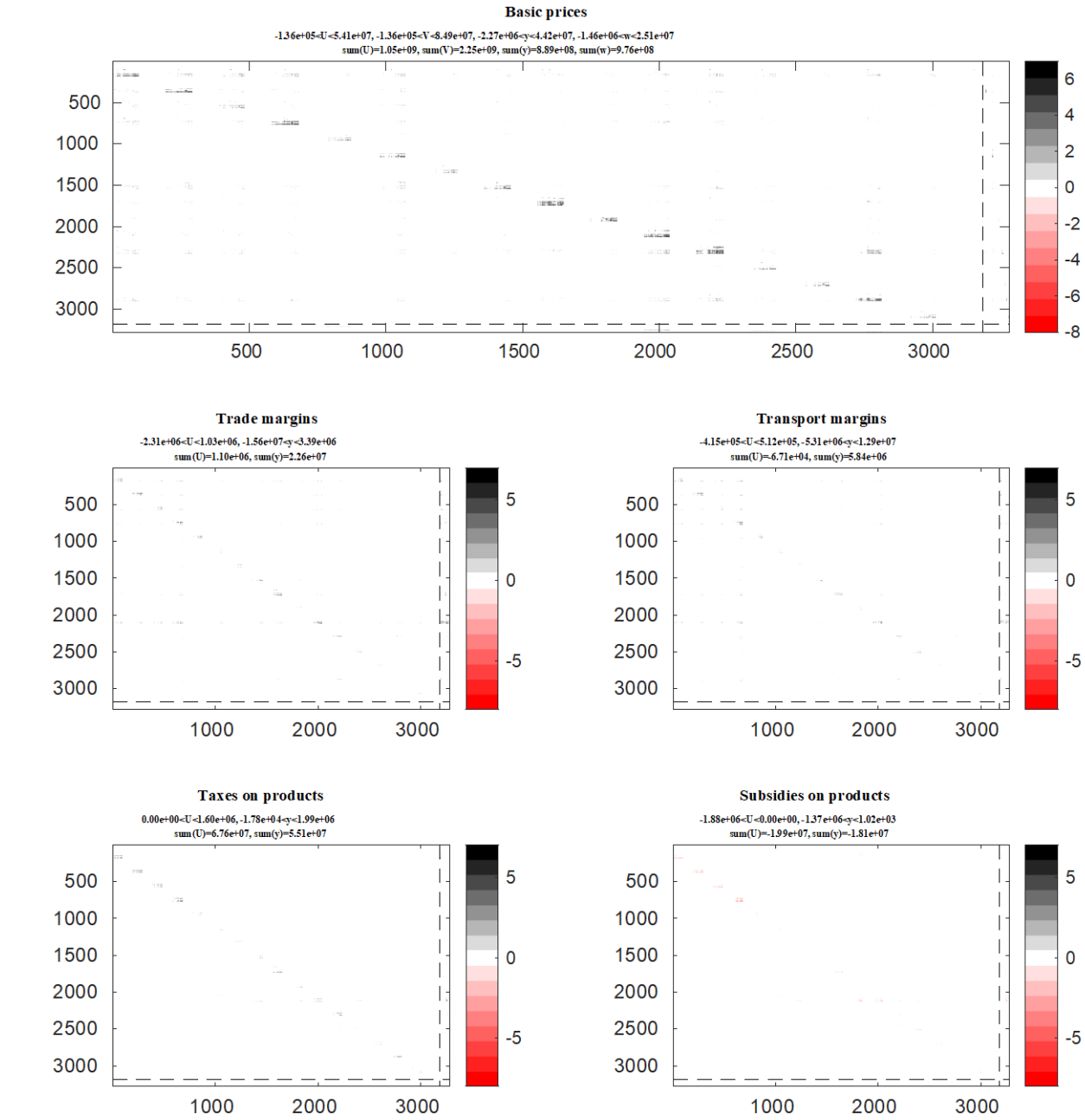

Fig. A3: Heat maps diagnostics for the GLORIA DATABASE for 1991

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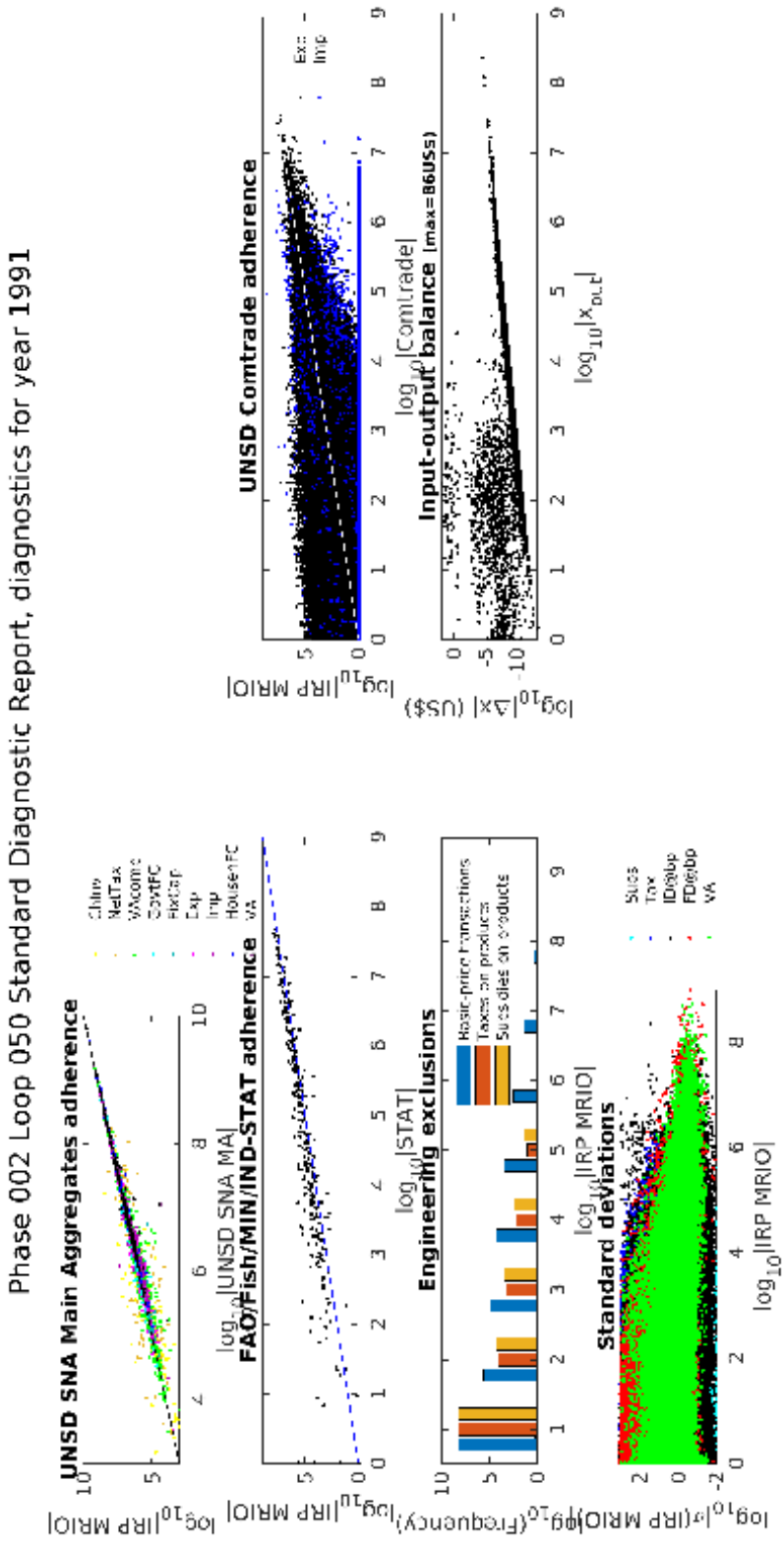

Fig. A4: Standard Diagnostics Report for the GLORIA DATABASE for 1991. Missing plots indicate that this data source was not available for 1991.

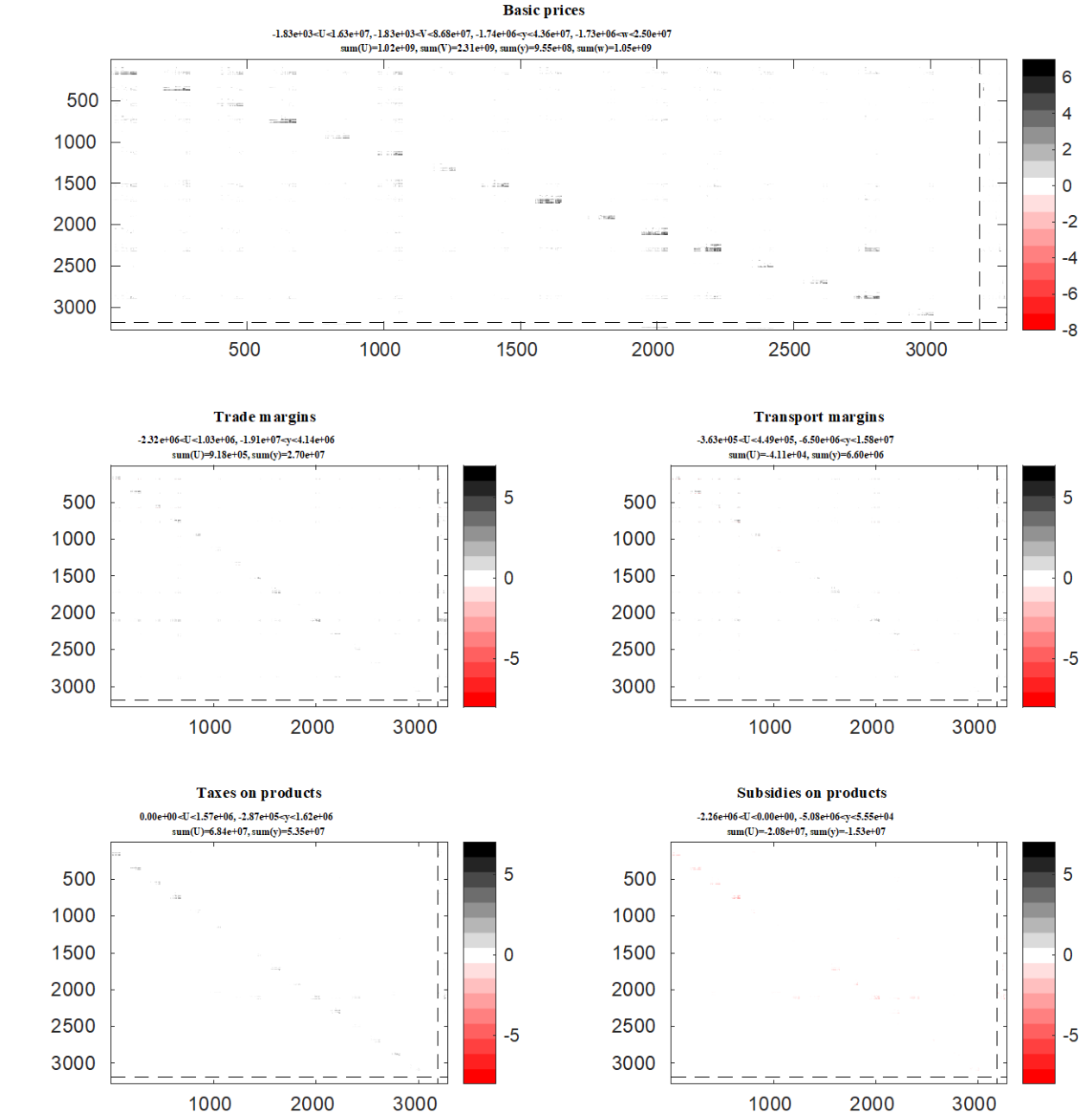

Fig. A5: Heat maps diagnostics for the GLORIA DATABASE for 1992

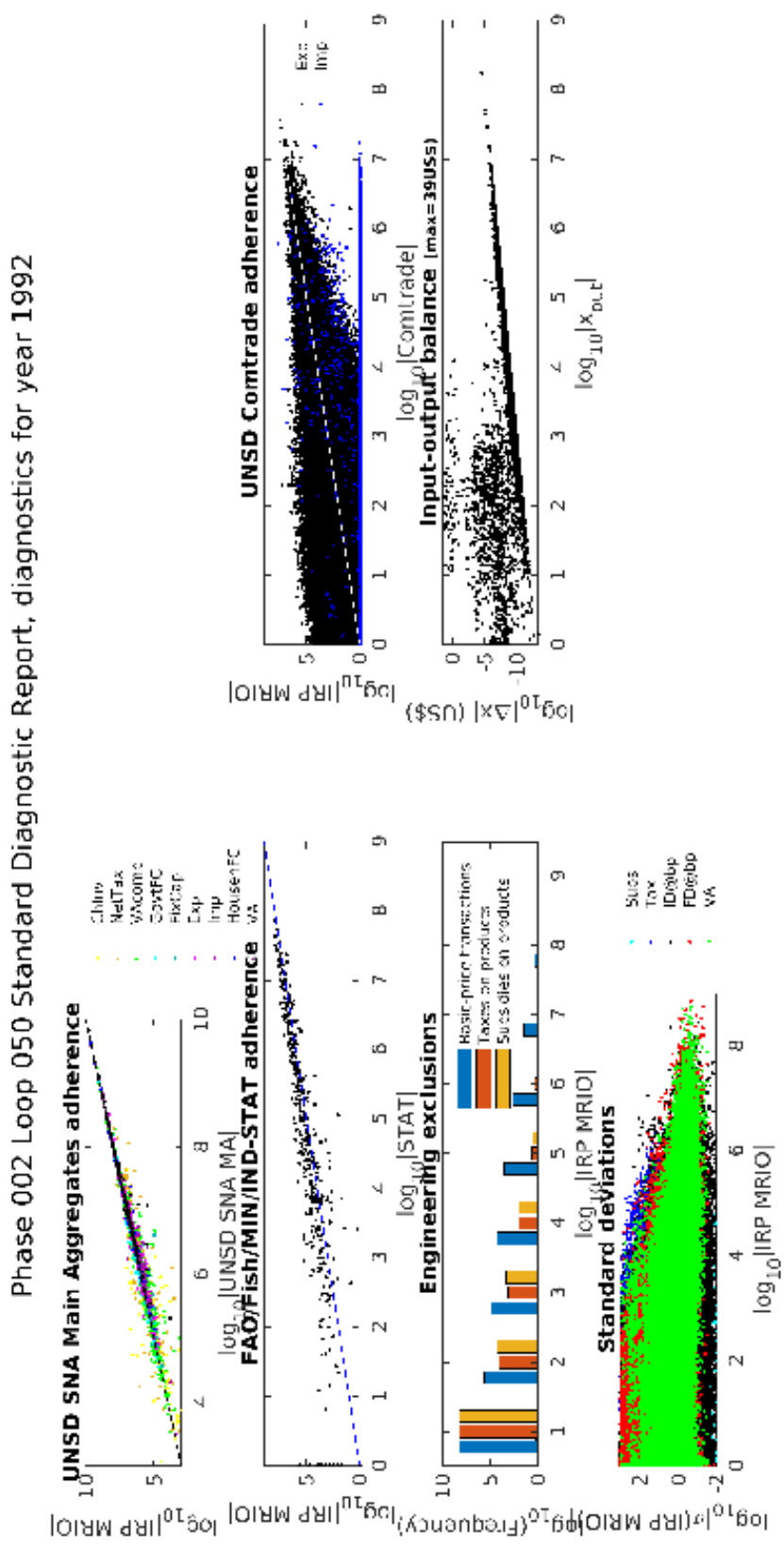

Fig. A6: Standard Diagnostics Report for the GLORIA DATABASE for 1992. Missing plots indicate that this data source was not available for 1992.

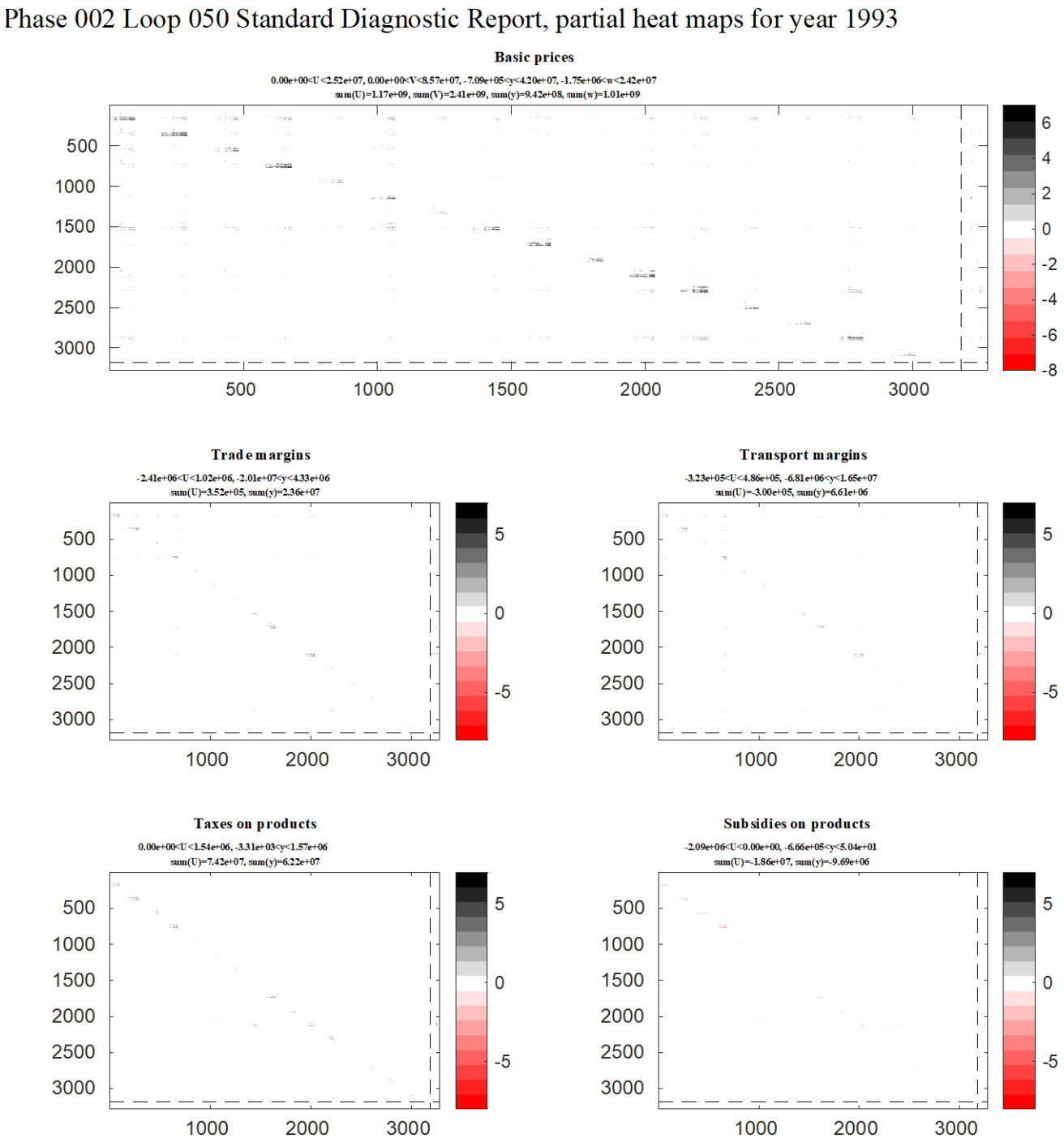

Fig. A7: Heat maps diagnostics for the GLORIA DATABASE for 1993

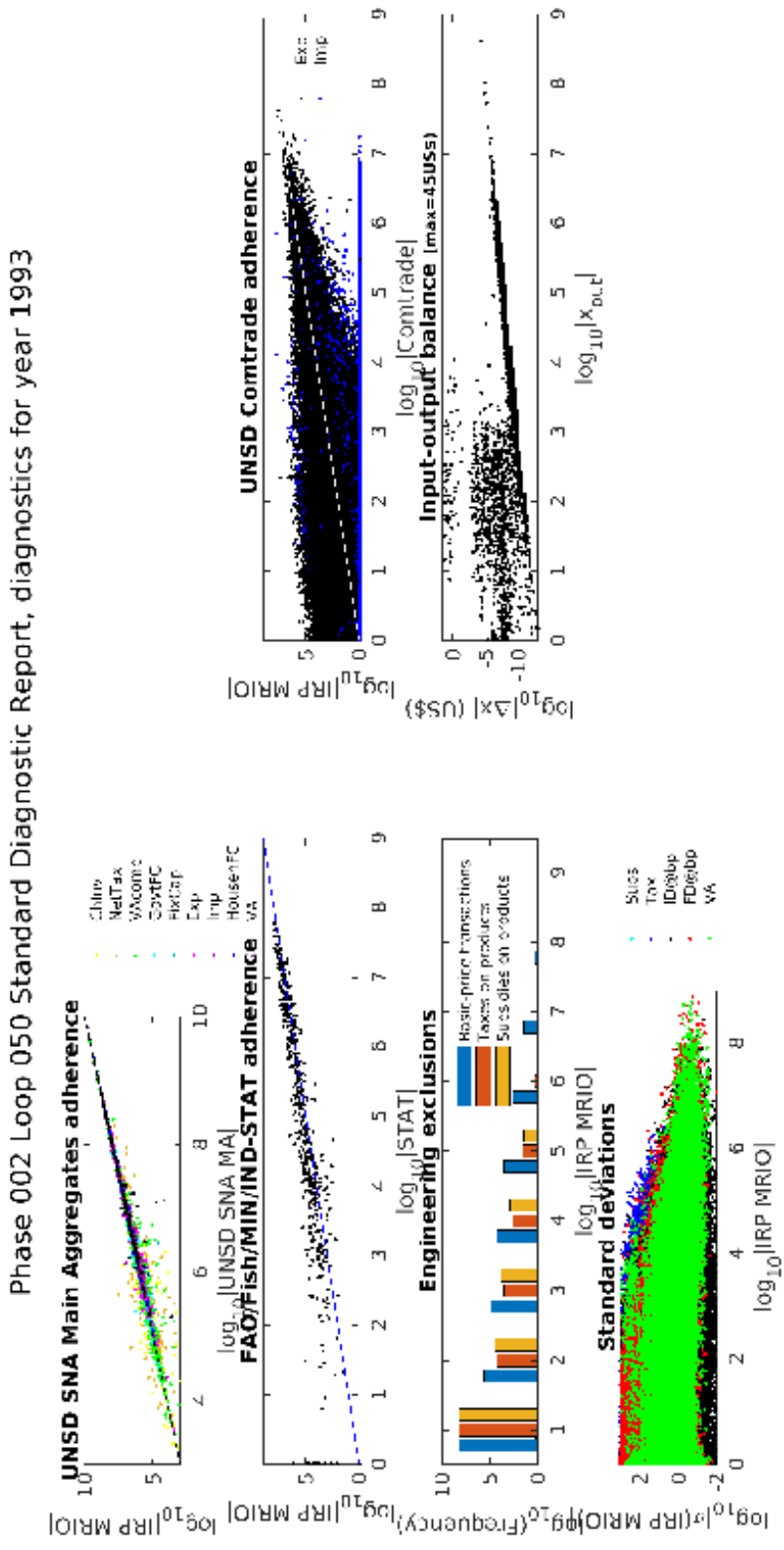

Fig. A8: Standard Diagnostics Report for the GLORIA DATABASE for 1993. Missing plots indicate that this data source was not available for 1993.

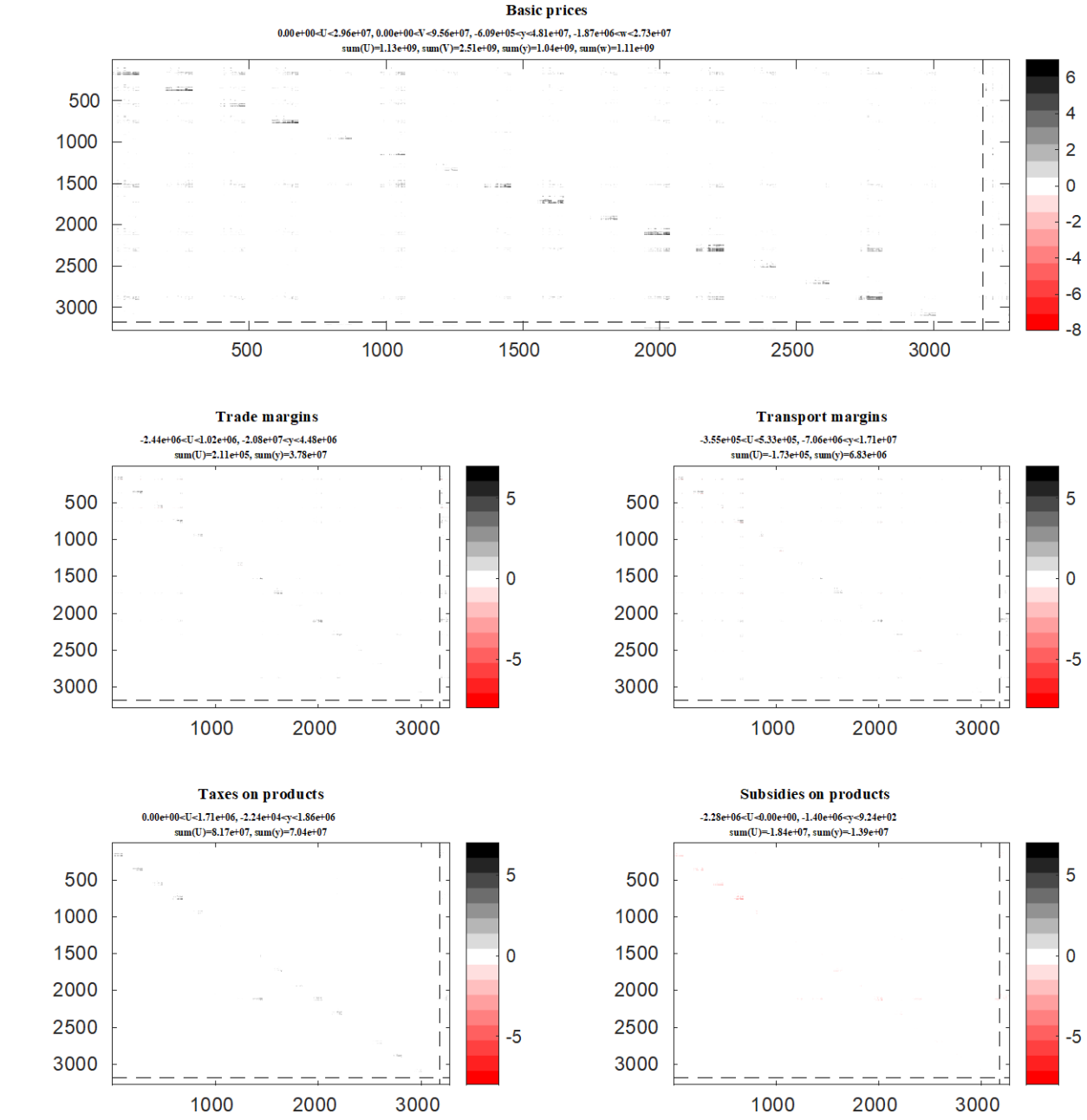

Fig. A9: Heat maps diagnostics for the GLORIA DATABASE for 1994

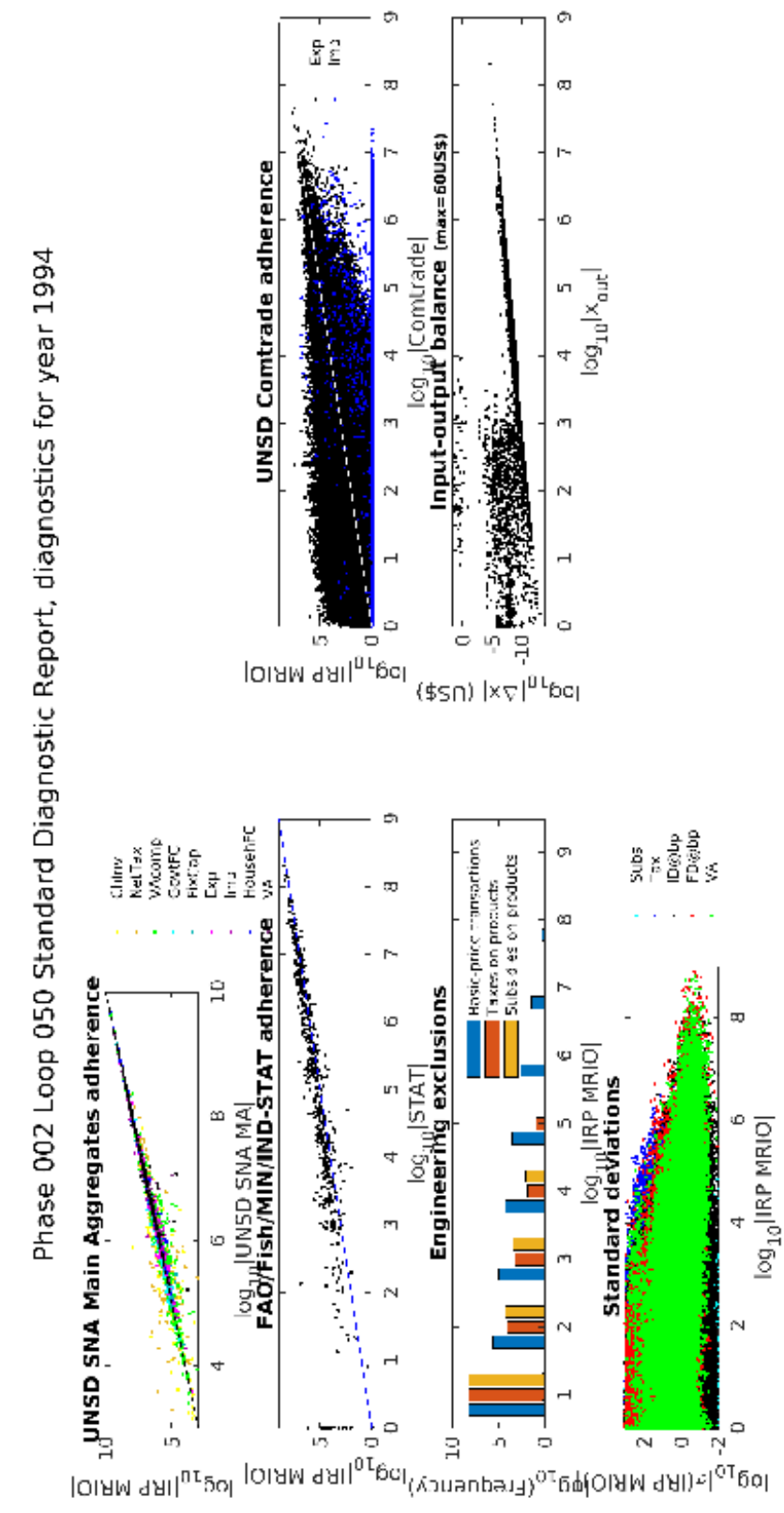

Fig. A10: Standard Diagnostics Report for the GLORIA DATABASE for 1994. Missing plots indicate that this data source was not available for 1994.

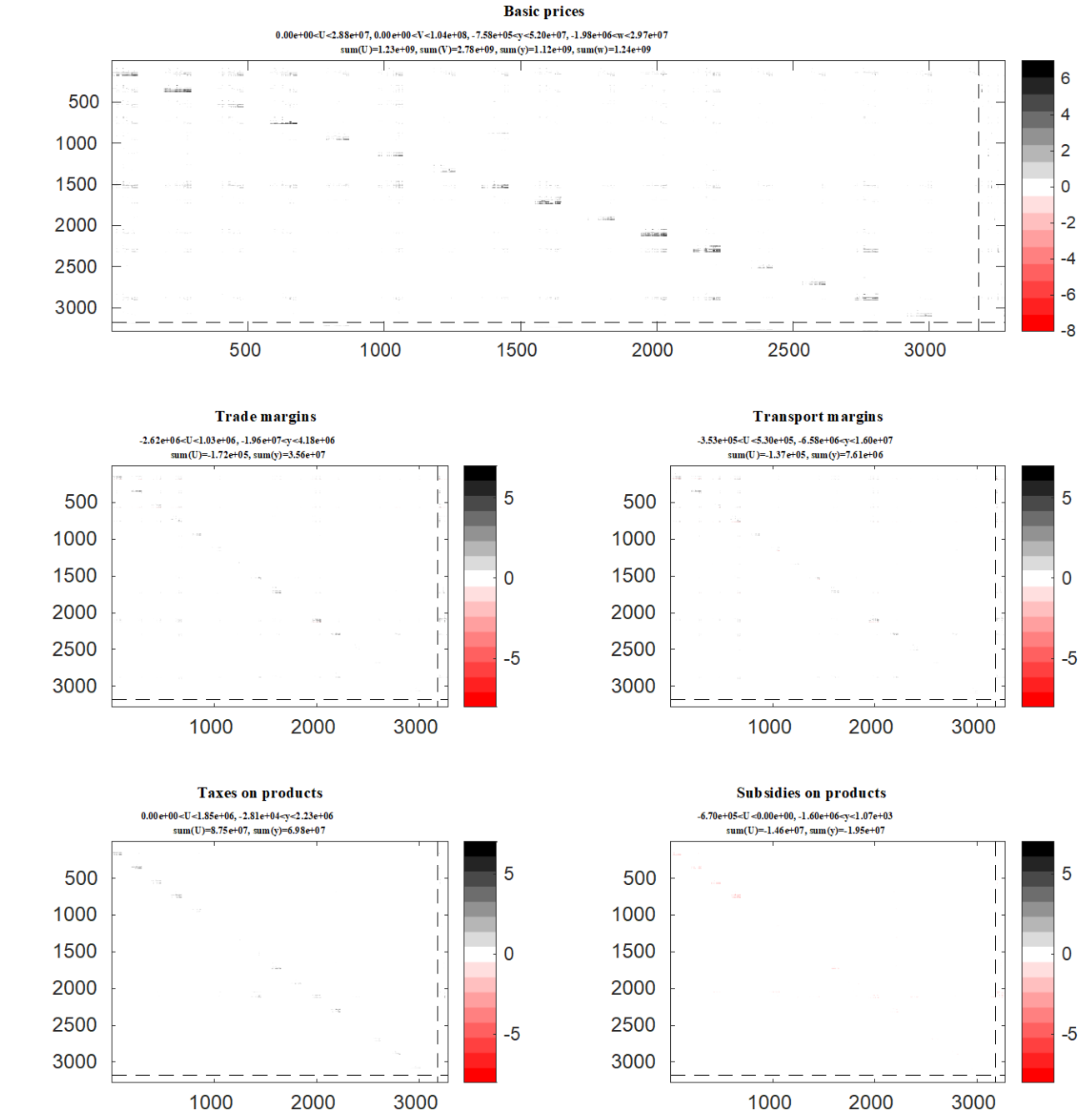

Fig. A11: Heat maps diagnostics for the GLORIA DATABASE for 1995

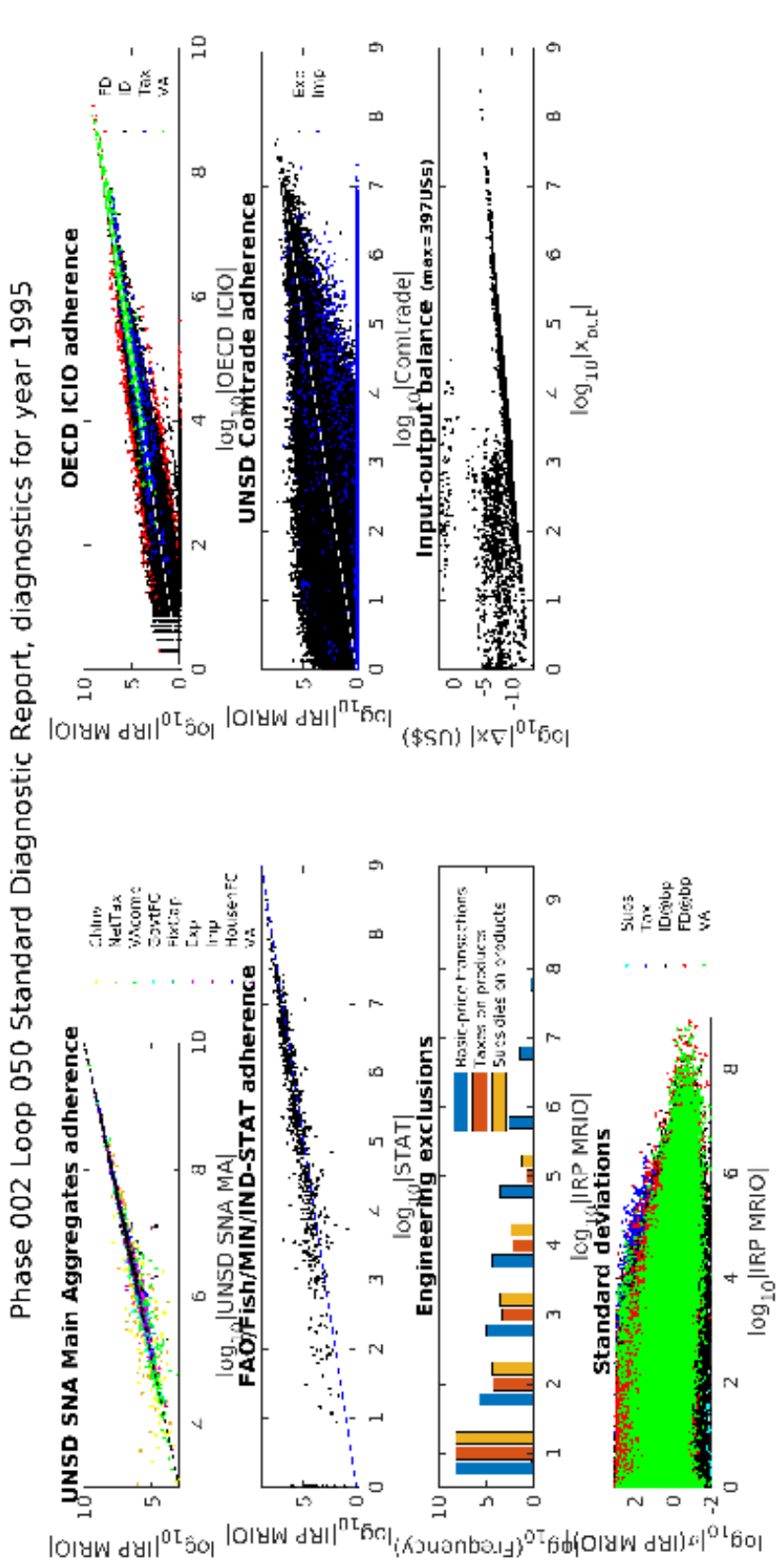

Fig. A12: Standard Diagnostics Report for the GLORIA DATABASE for 1995. Missing plots indicate that this data source was not available for 1995.

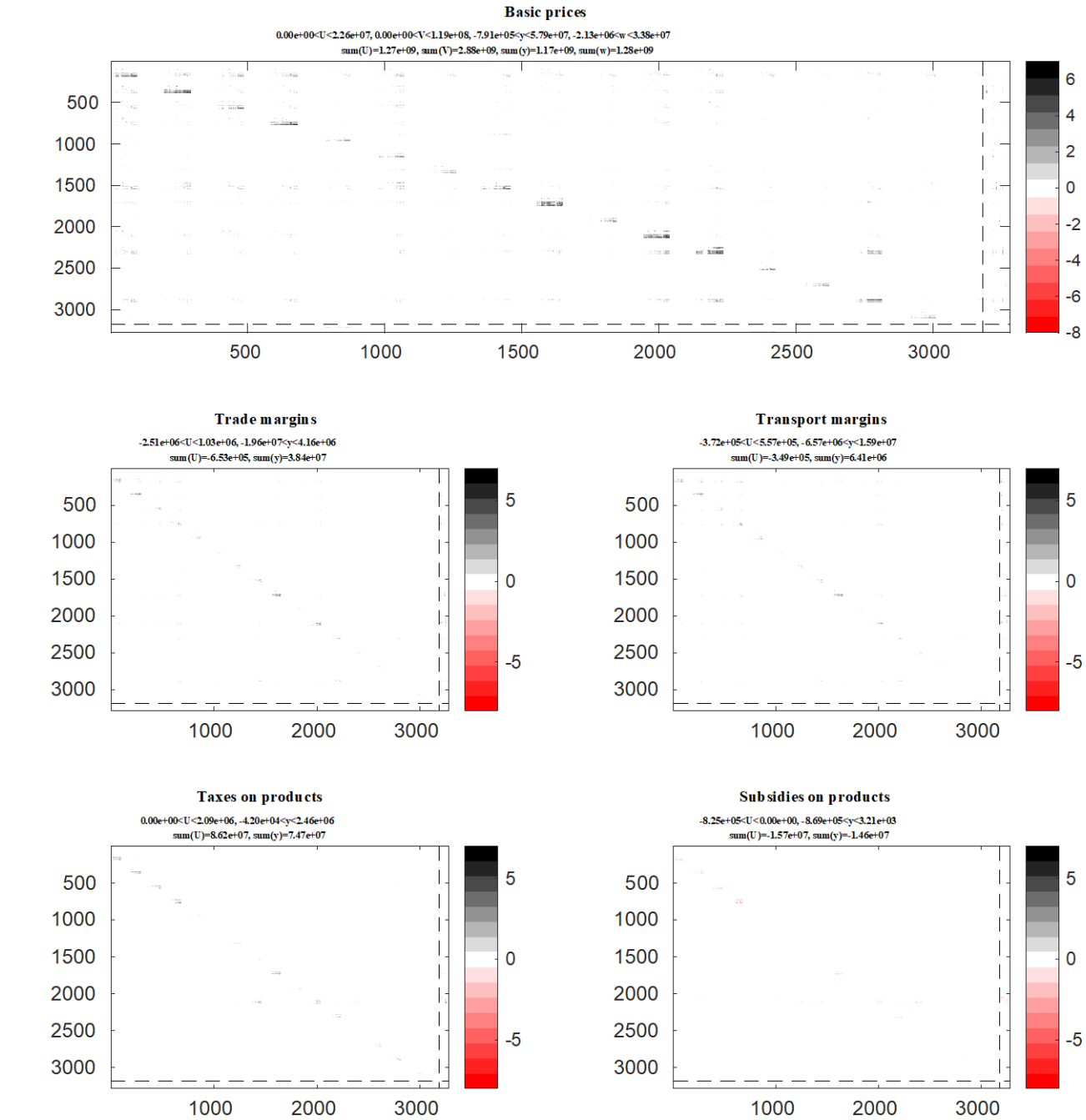

Fig. A13: Heat maps diagnostics for the GLORIA DATABASE for 1996

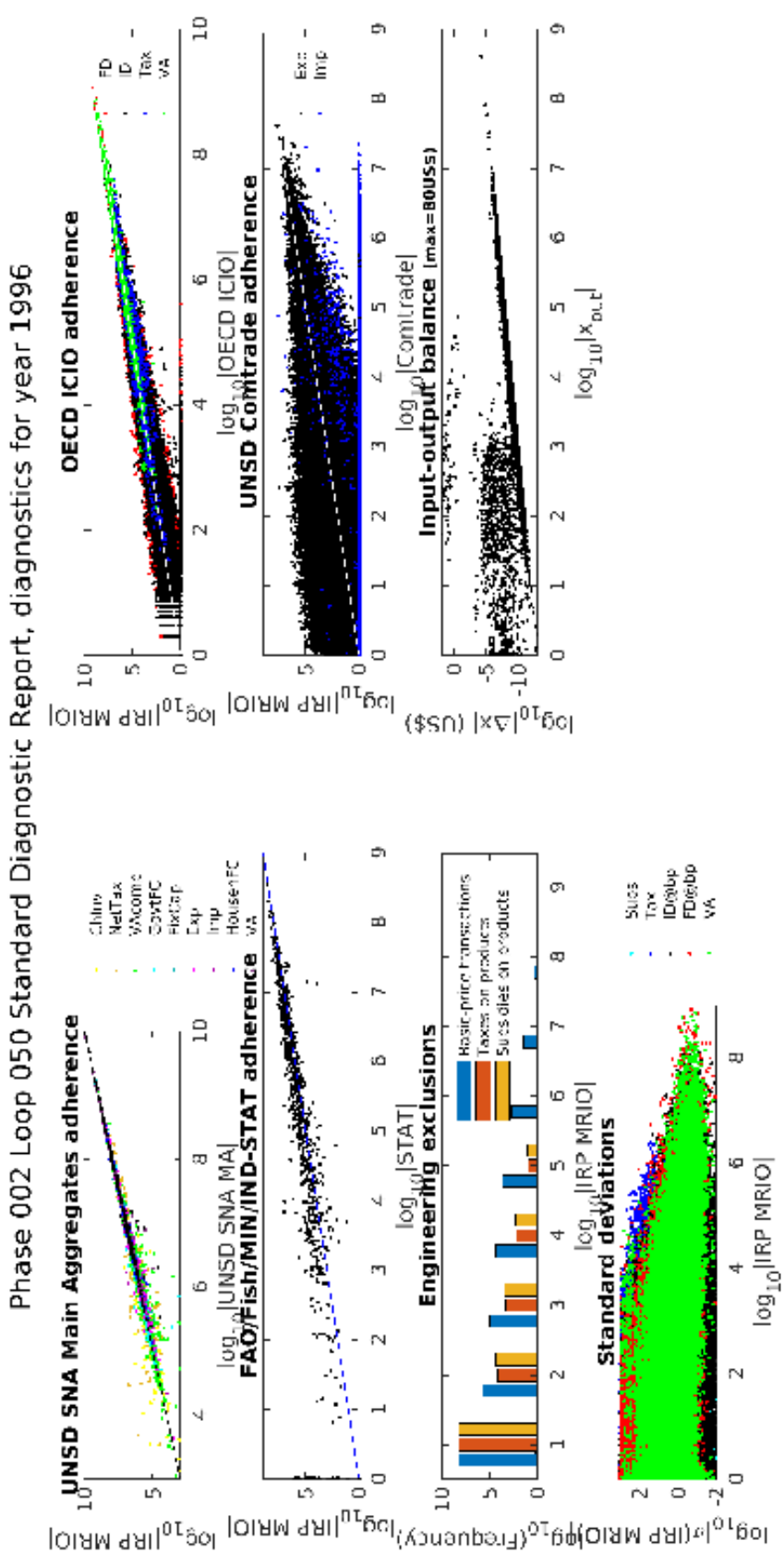

Fig. A14: Standard Diagnostics Report for the GLORIA DATABASE for 1996.

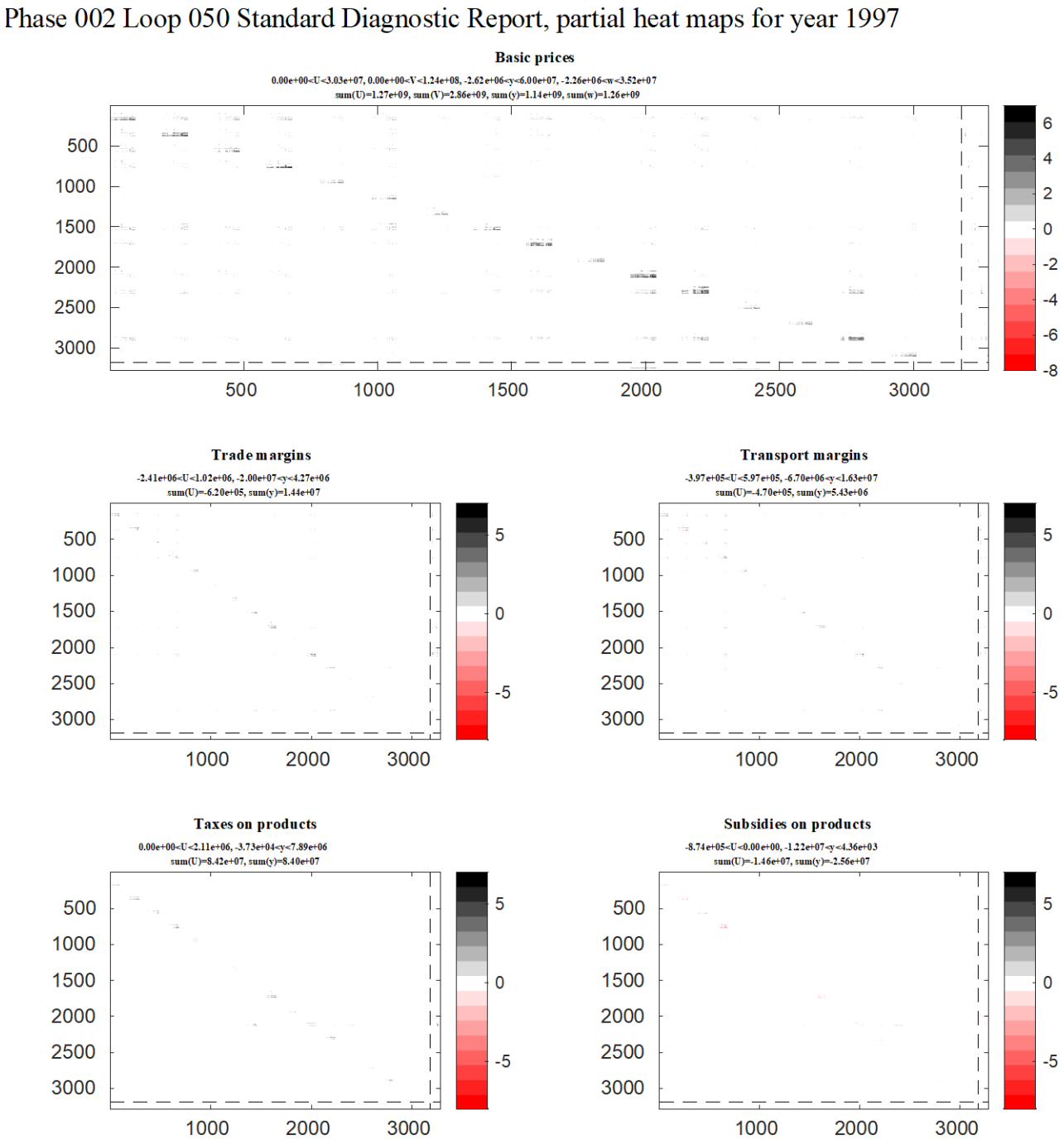

Fig. A15: Heat maps diagnostics for the GLORIA DATABASE for 1997

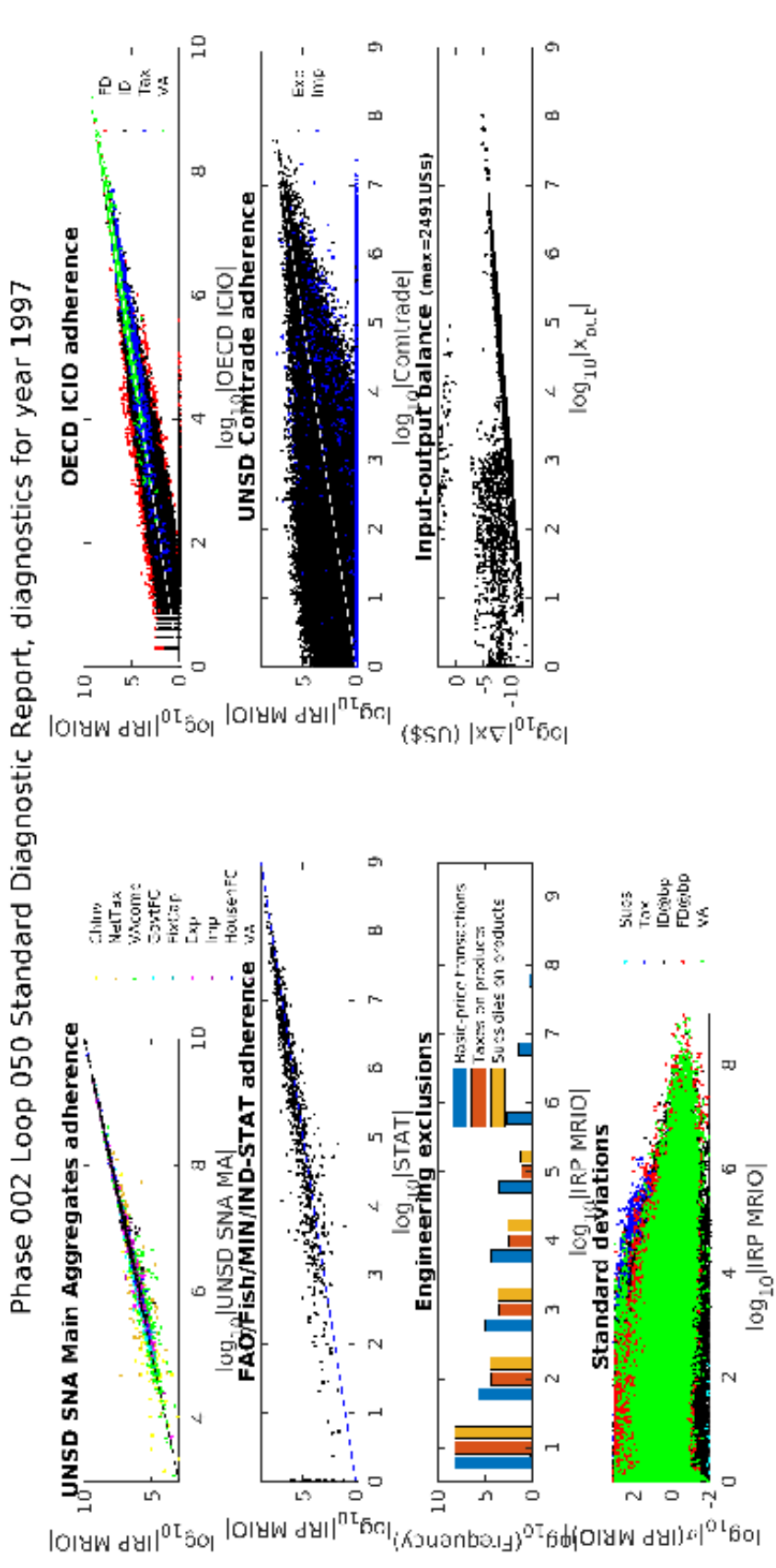

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Fig. A16: Standard Diagnostics Report for the GLORIA DATABASE for 1997.

Phase 002 Loop 050 Standard Diagnostic Report, partial heat maps for year 1998

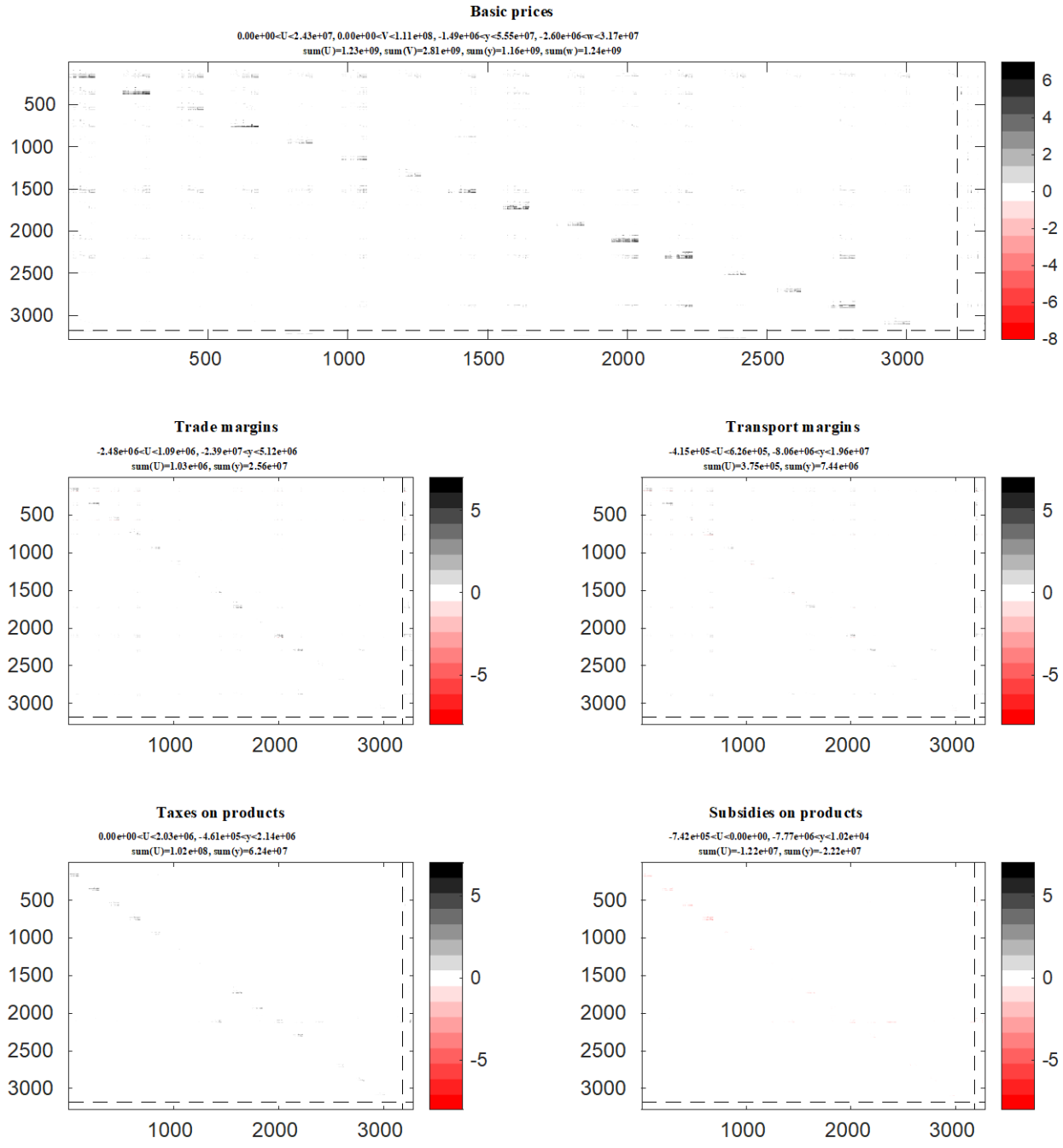


Fig. A17: Heat maps diagnostics for the GLORIA DATABASE for 1998

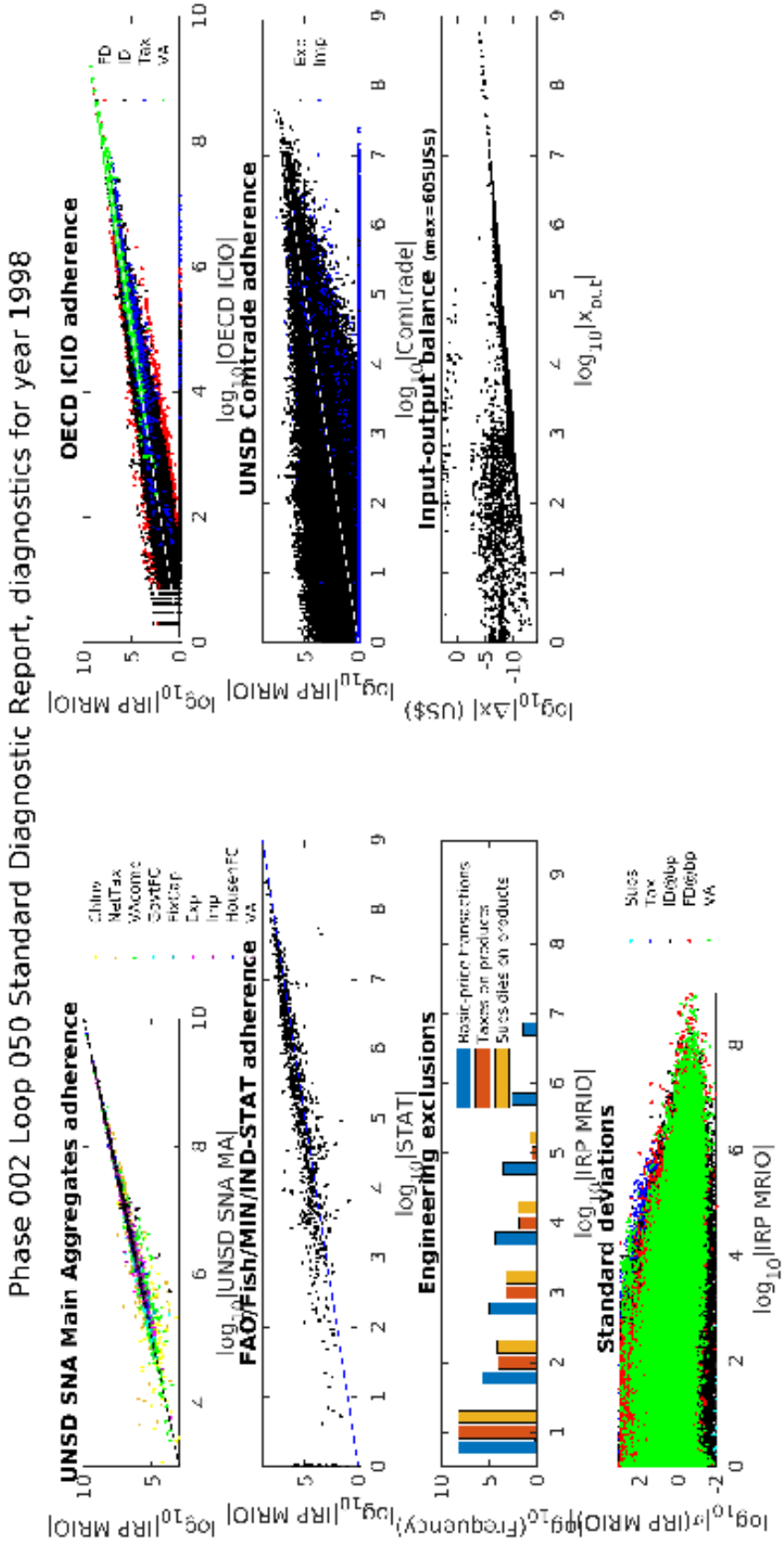


Fig. A18: Standard Diagnostics Report for the GLORIA DATABASE for 1998.

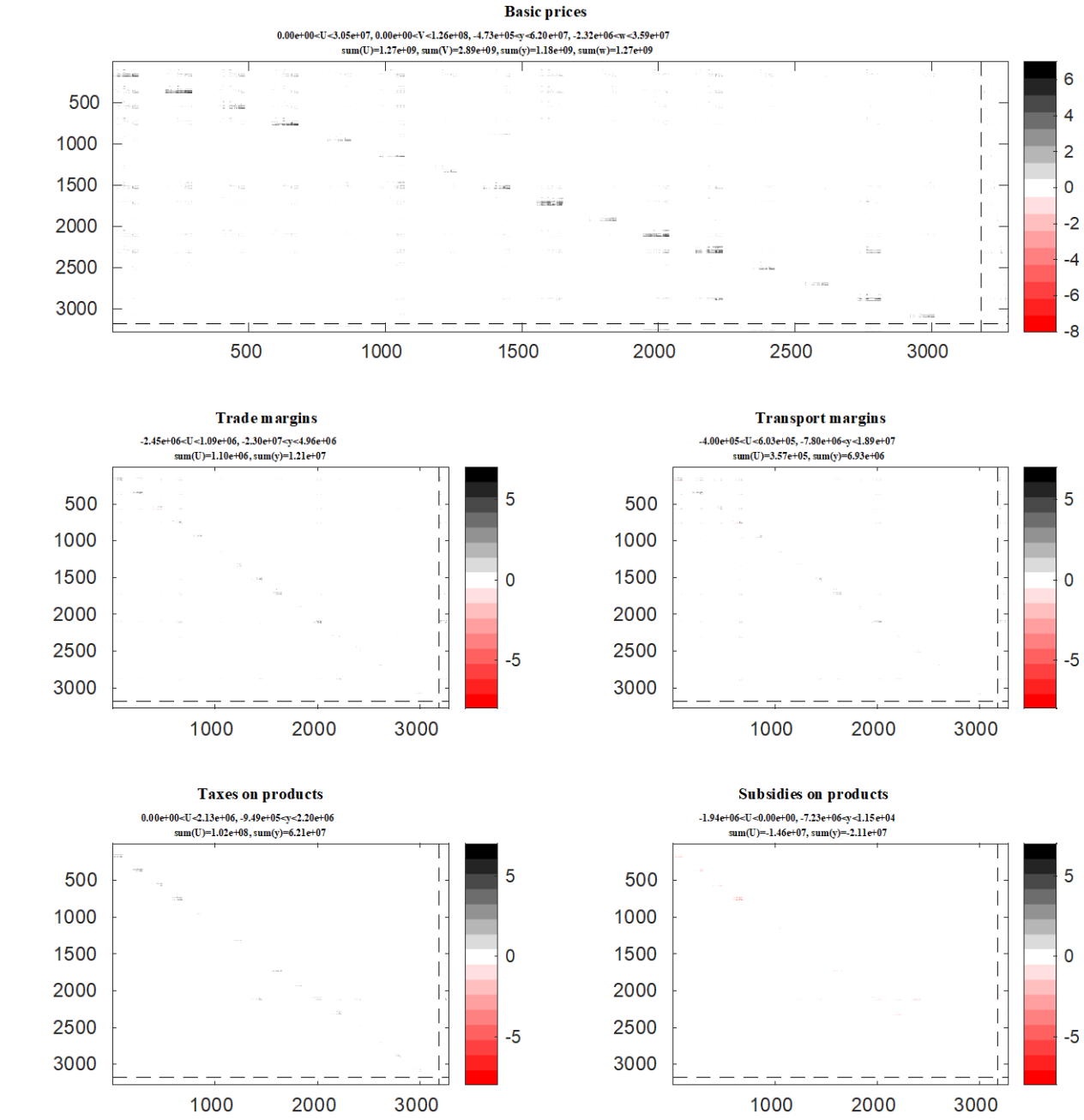


Fig. A19: Heat maps diagnostics for the GLORIA DATABASE for 1999

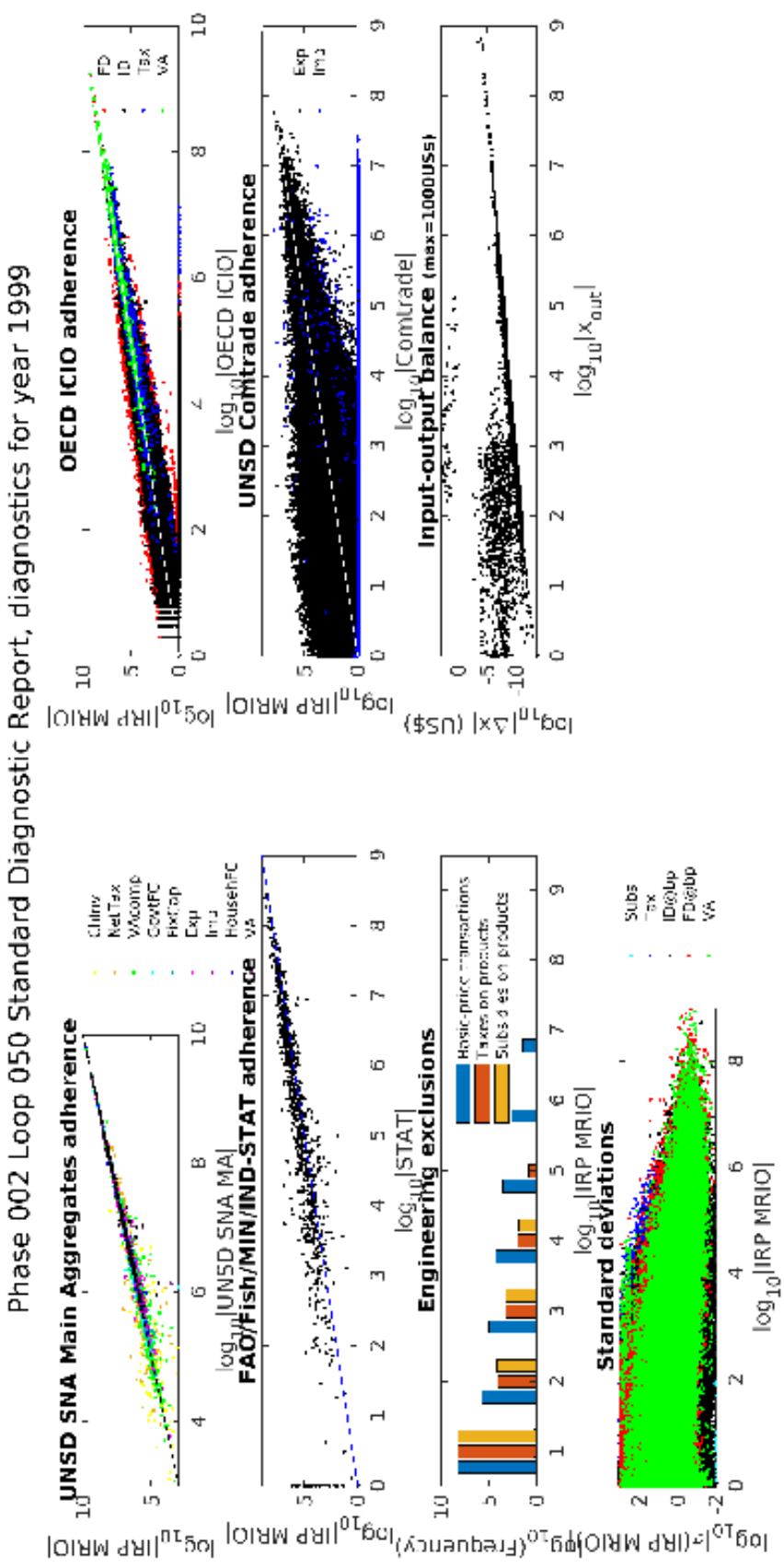


Fig. A20: Standard Diagnostics Report for the GLORIA DATABASE for 1999.

Heat maps and SRO for 2000

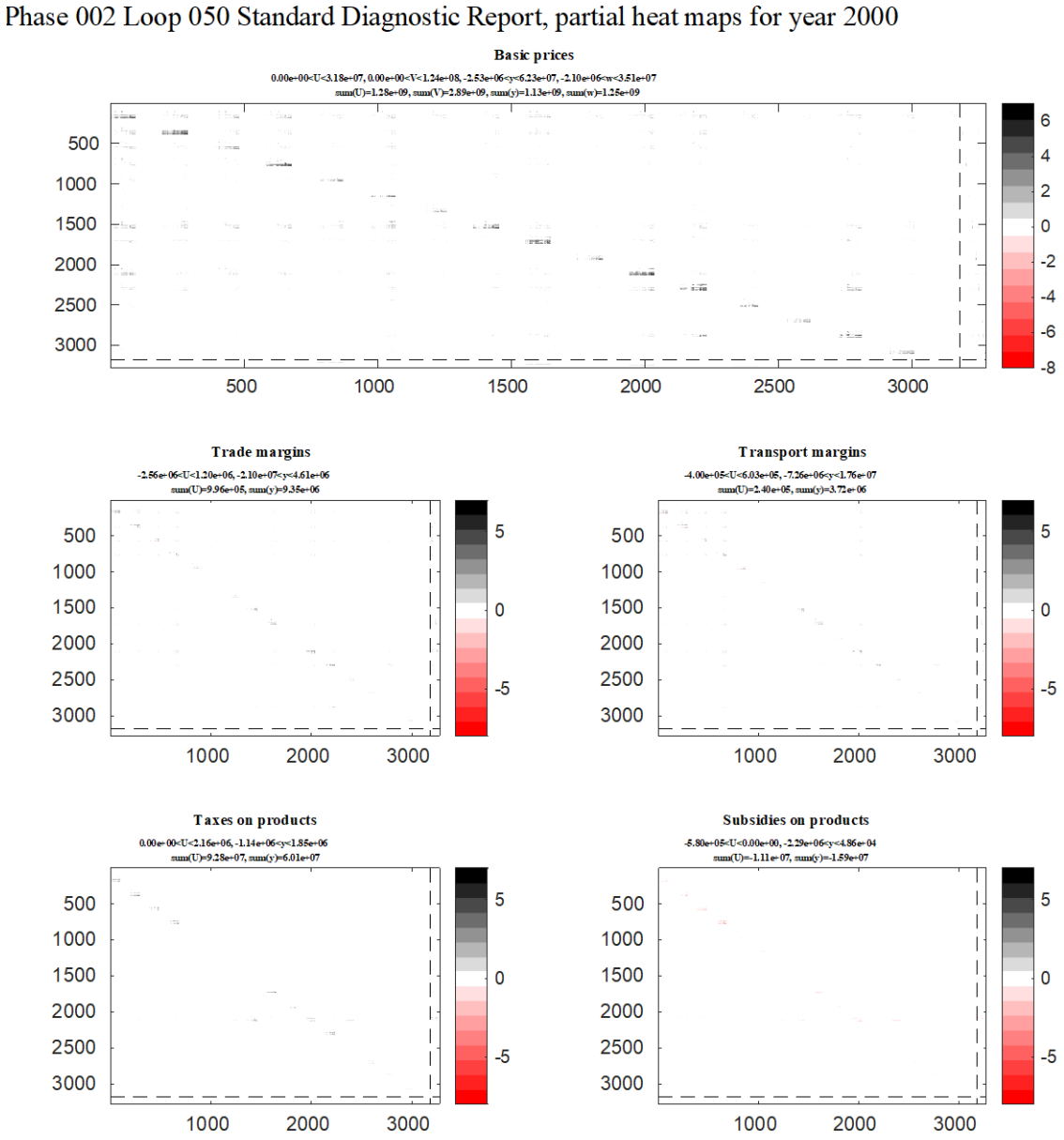


Fig. A21: Heat maps diagnostics for the GLORIA DATABASE for 2000

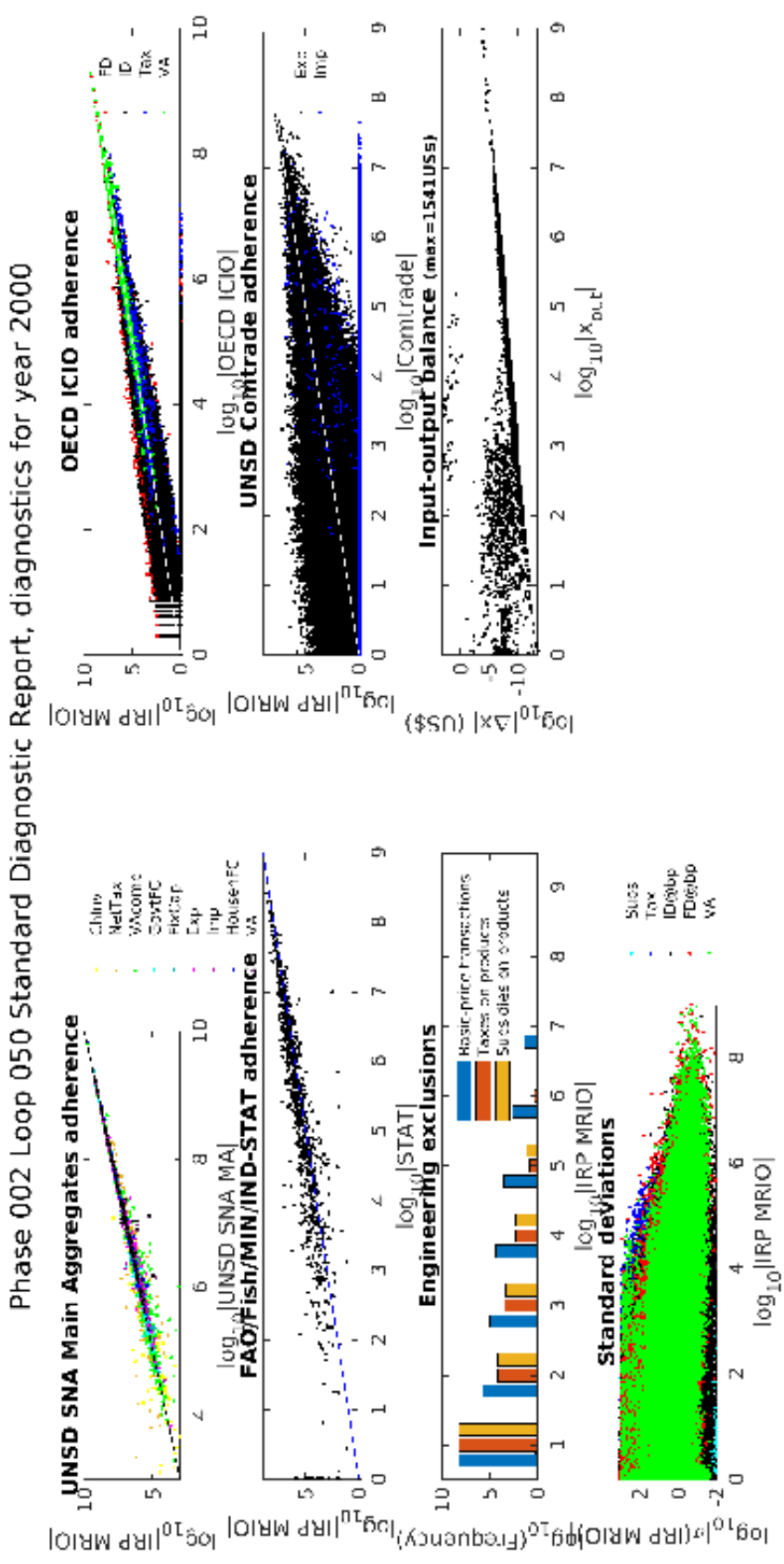


Fig. A22: Standard Diagnostics Report for the GLORIA DATABASE for 2000.

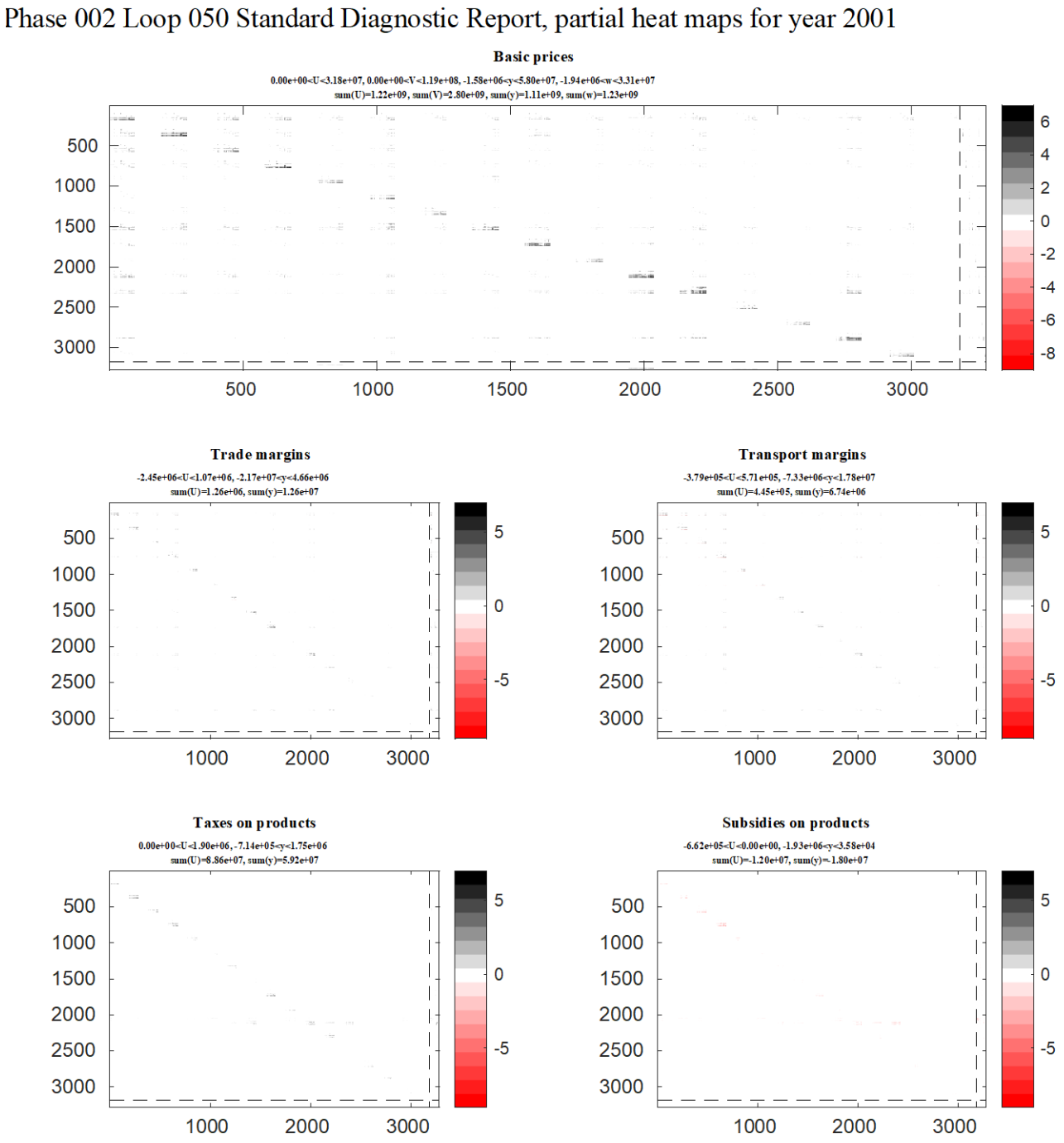


Fig. A23: Heat maps diagnostics for the GLORIA DATABASE for 2001

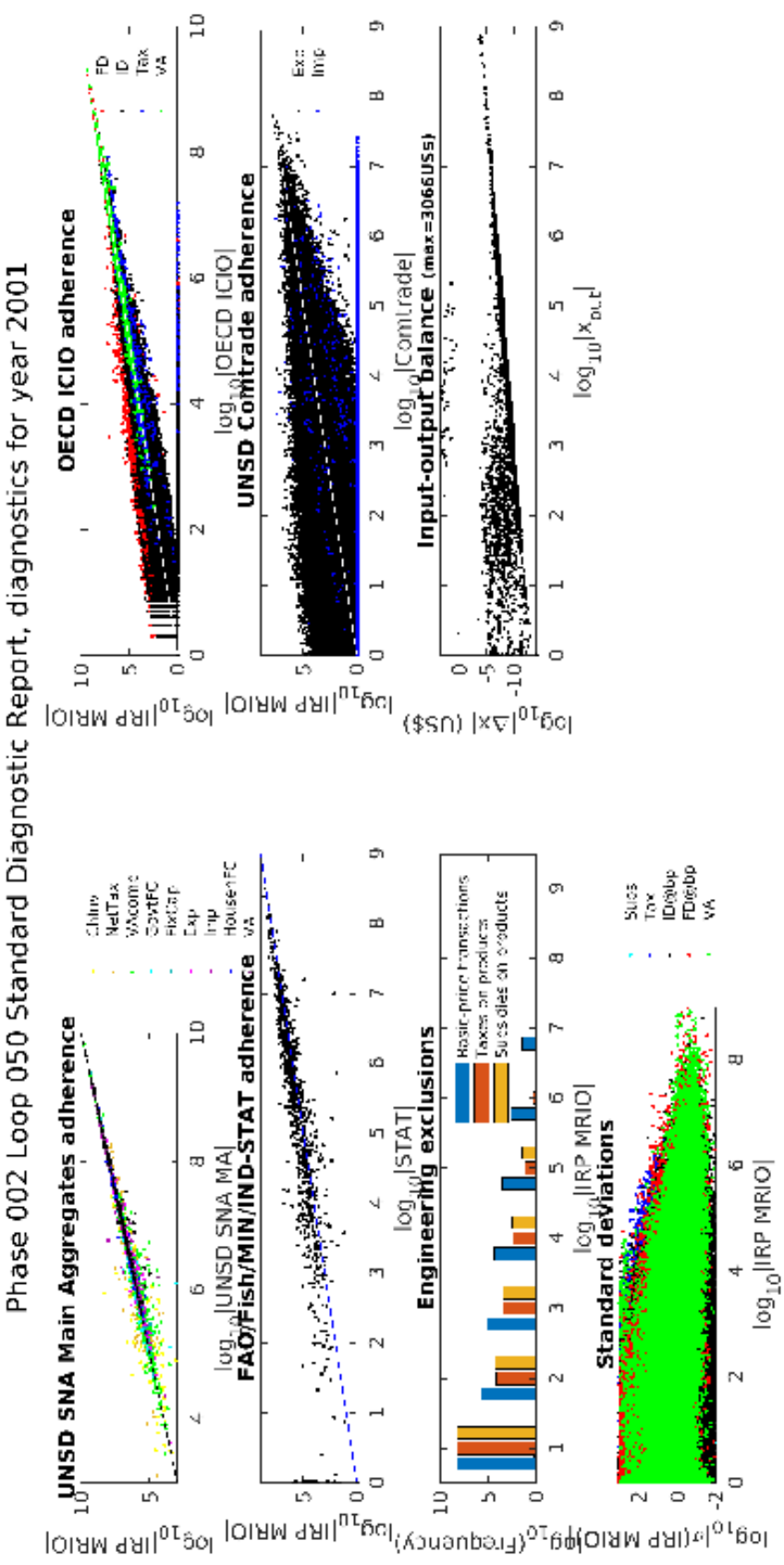


Fig. A24: Standard Diagnostics Report for the GLORIA DATABASE for 2001.

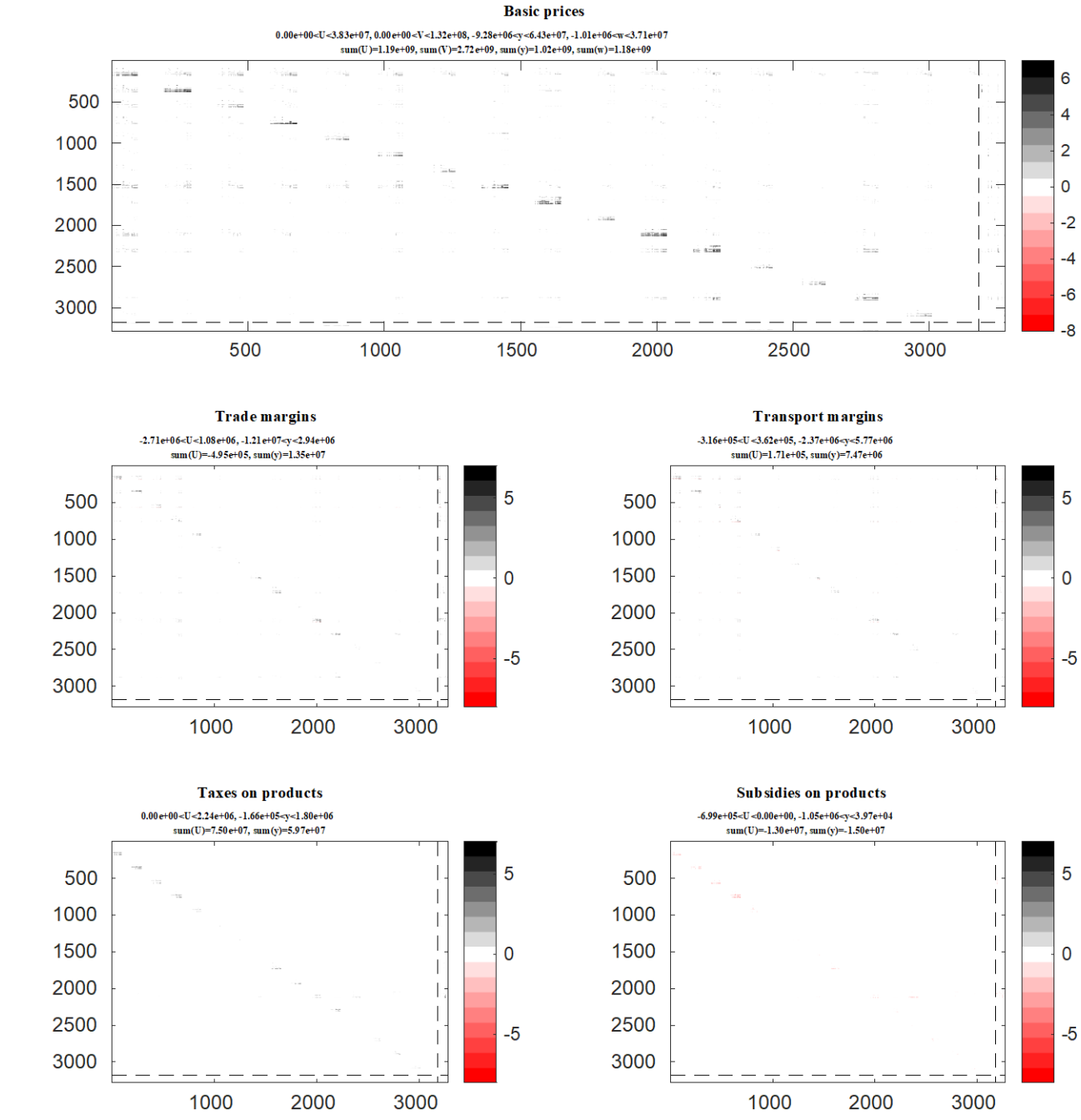


Fig. A25: Heat maps diagnostics for the GLORIA DATABASE for 2002

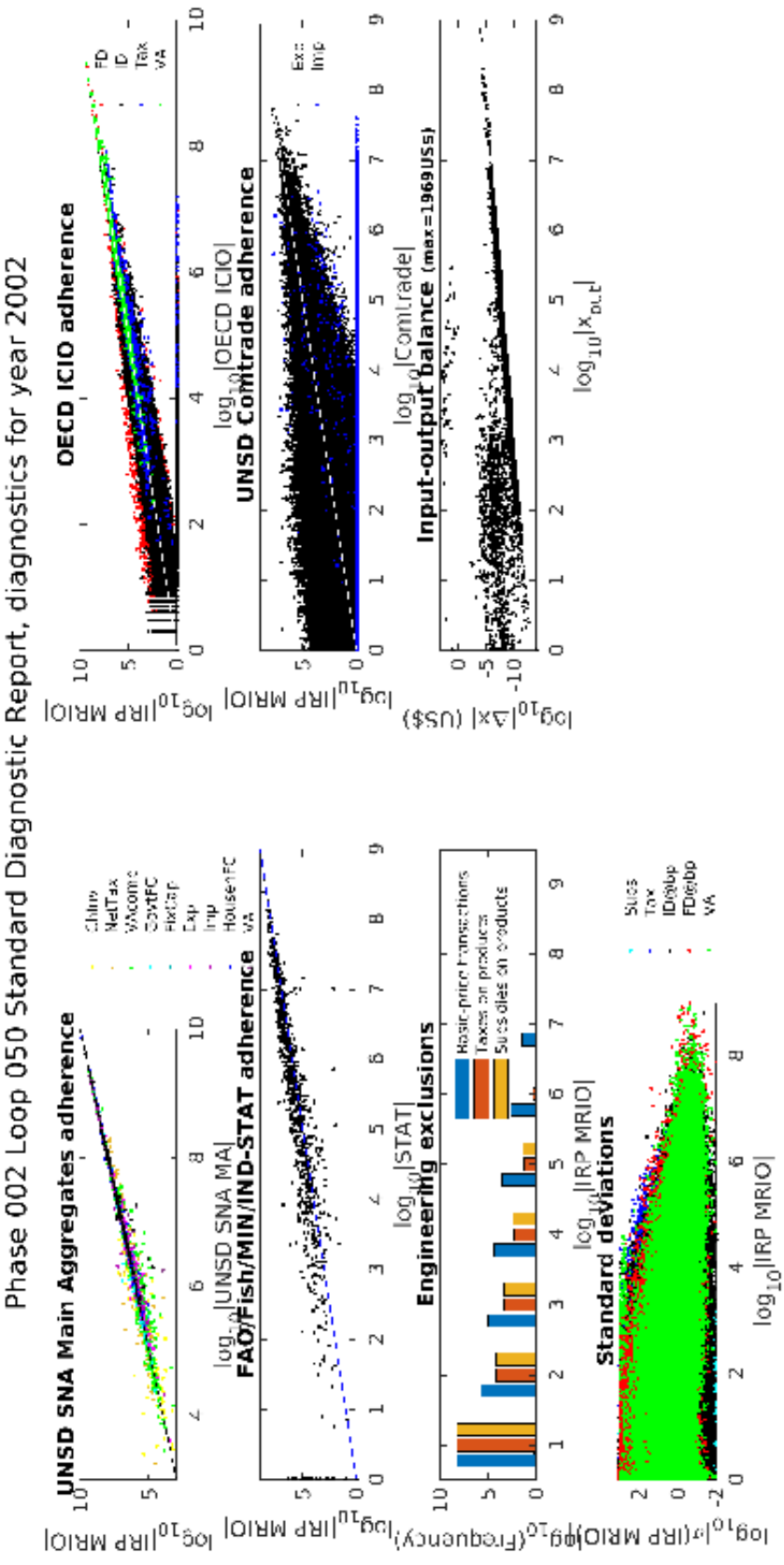


Fig. A26: Standard Diagnostics Report for the GLORIA DATABASE for 2002.

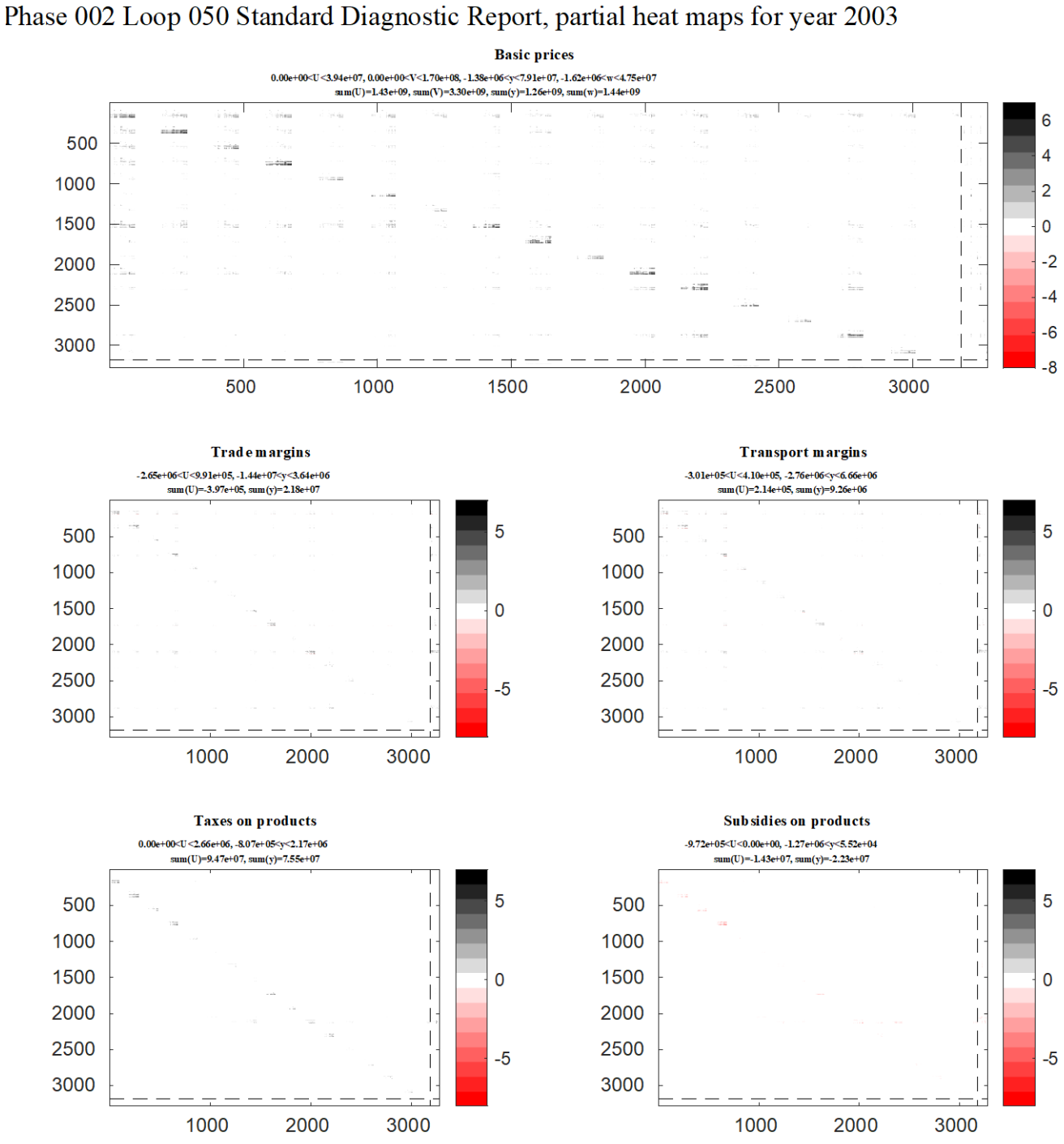


Fig. A27: Heat maps diagnostics for the GLORIA DATABASE for 2003

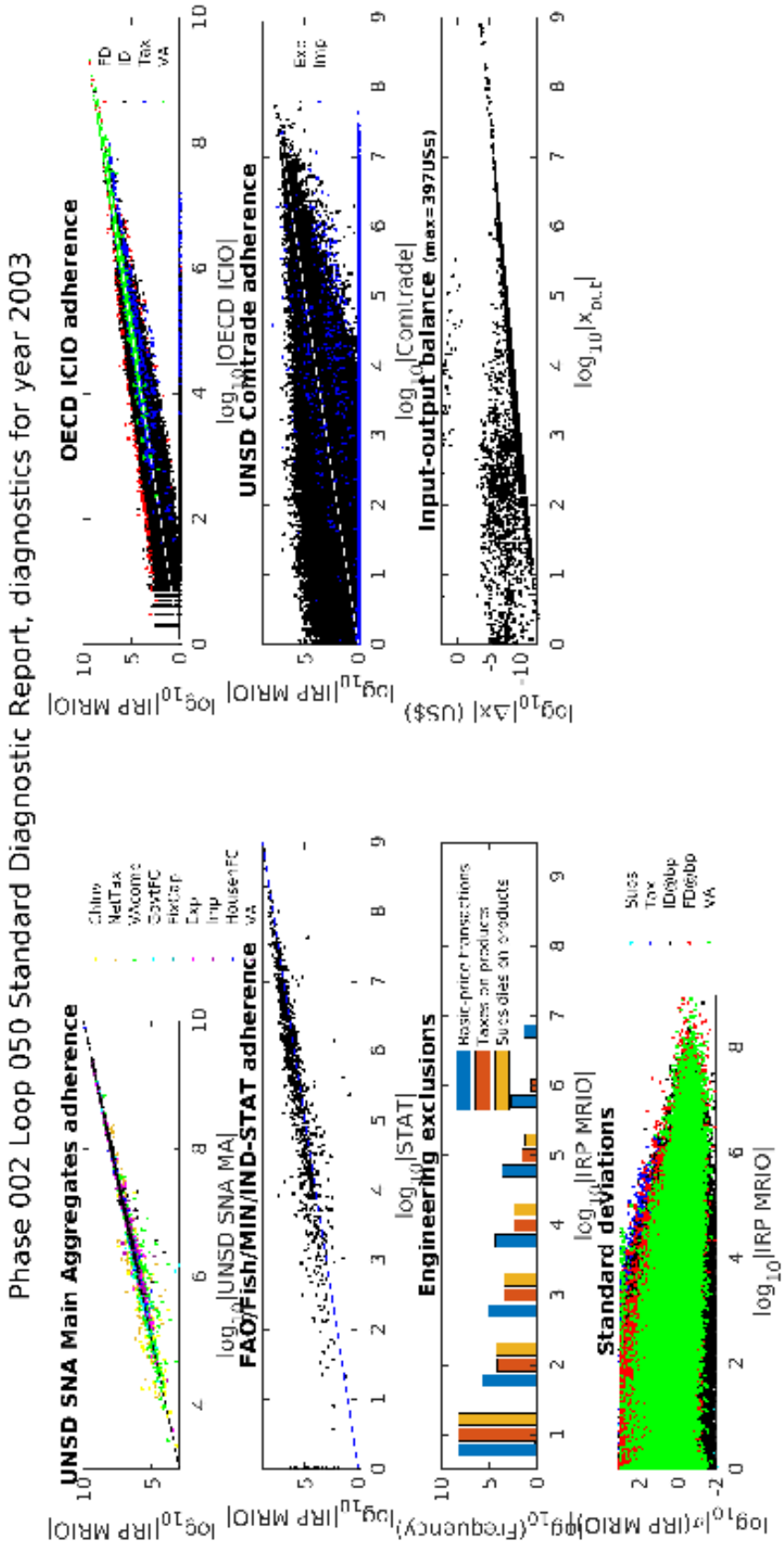


Fig. A28: Standard Diagnostics Report for the GLORIA DATABASE for 2003.

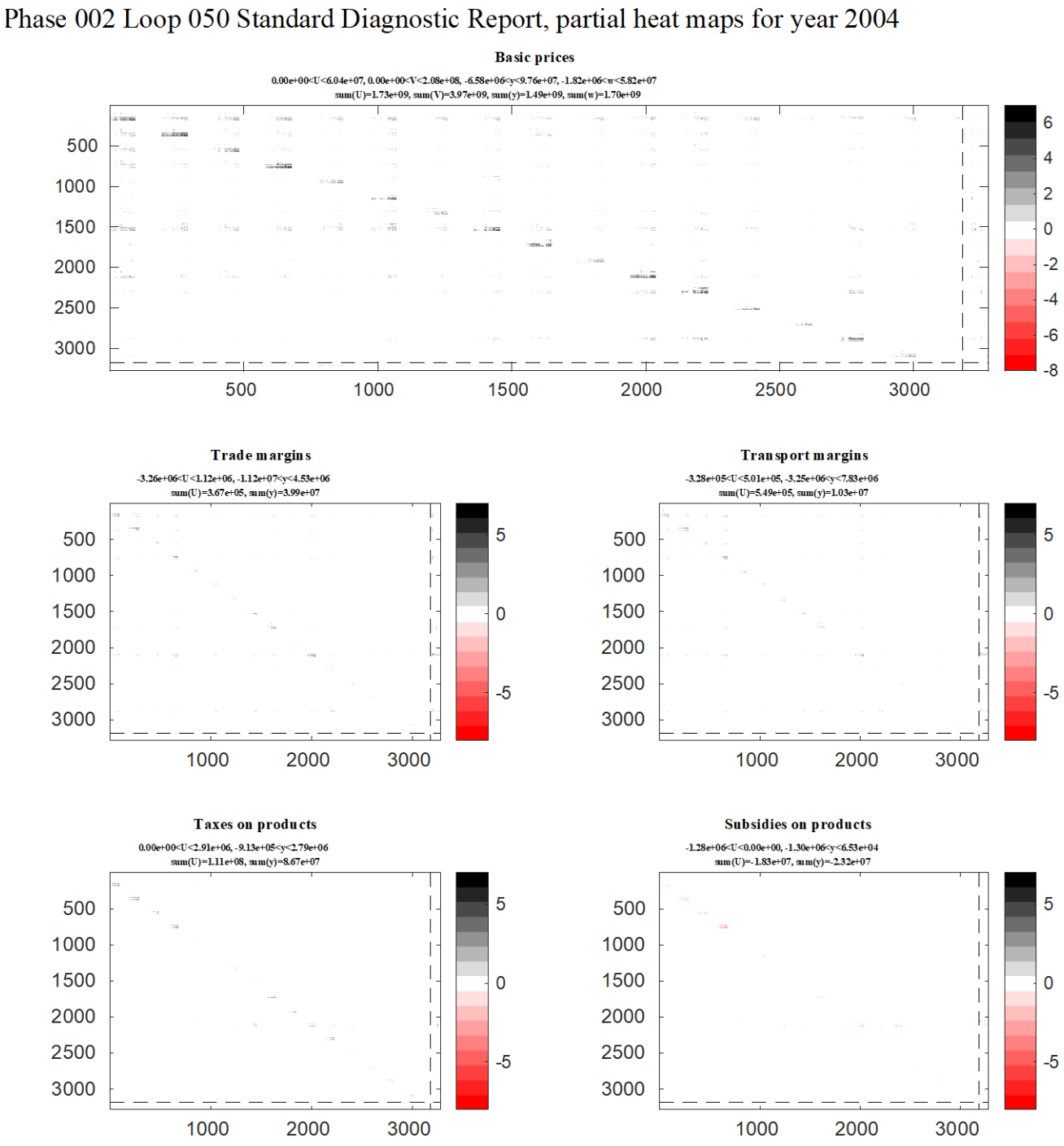


Fig. A29: Heat maps diagnostics for the GLORIA DATABASE for 2004

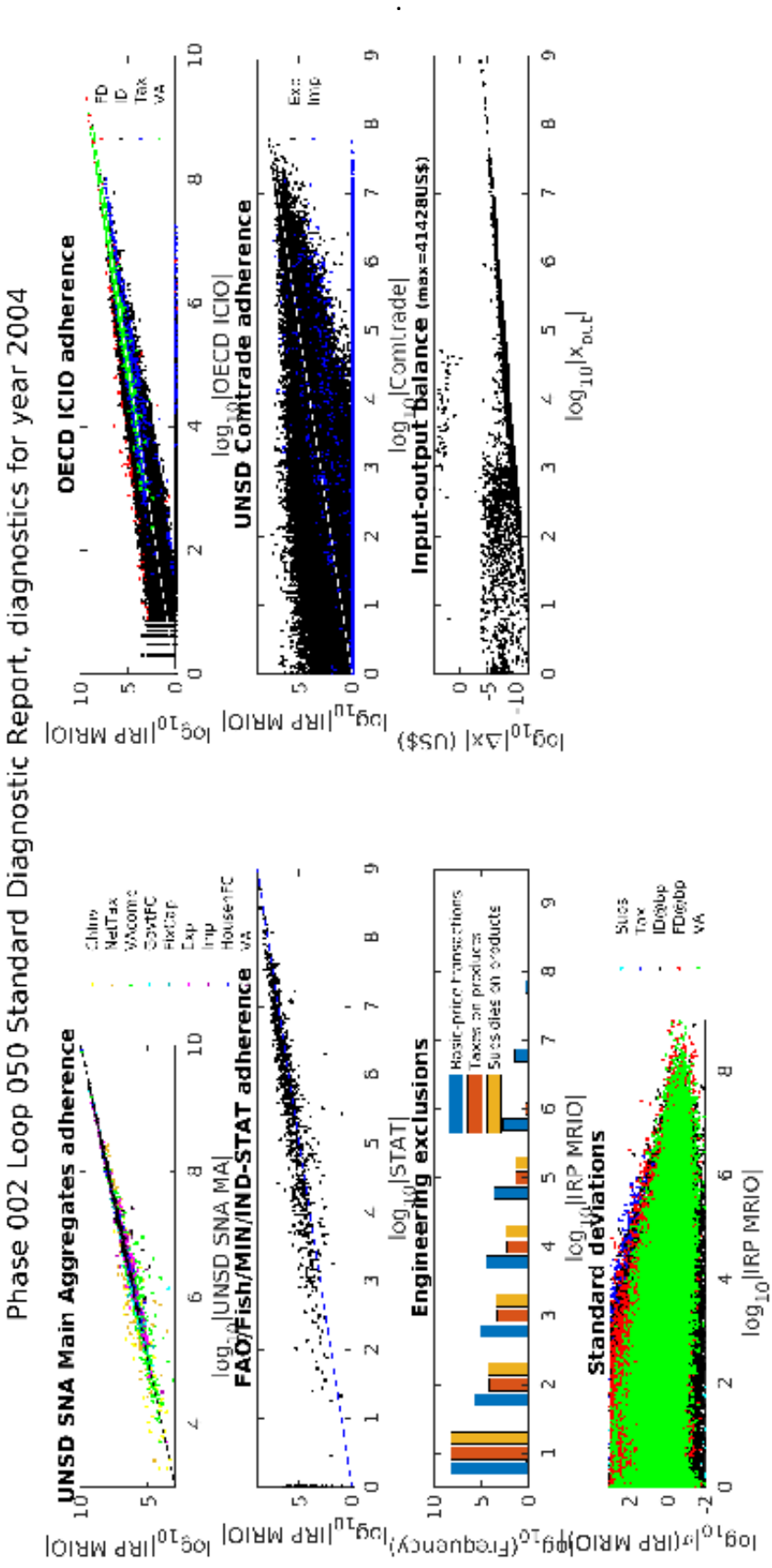


Fig. A30: Standard Diagnostics Report for the GLORIA DATABASE for 2004.

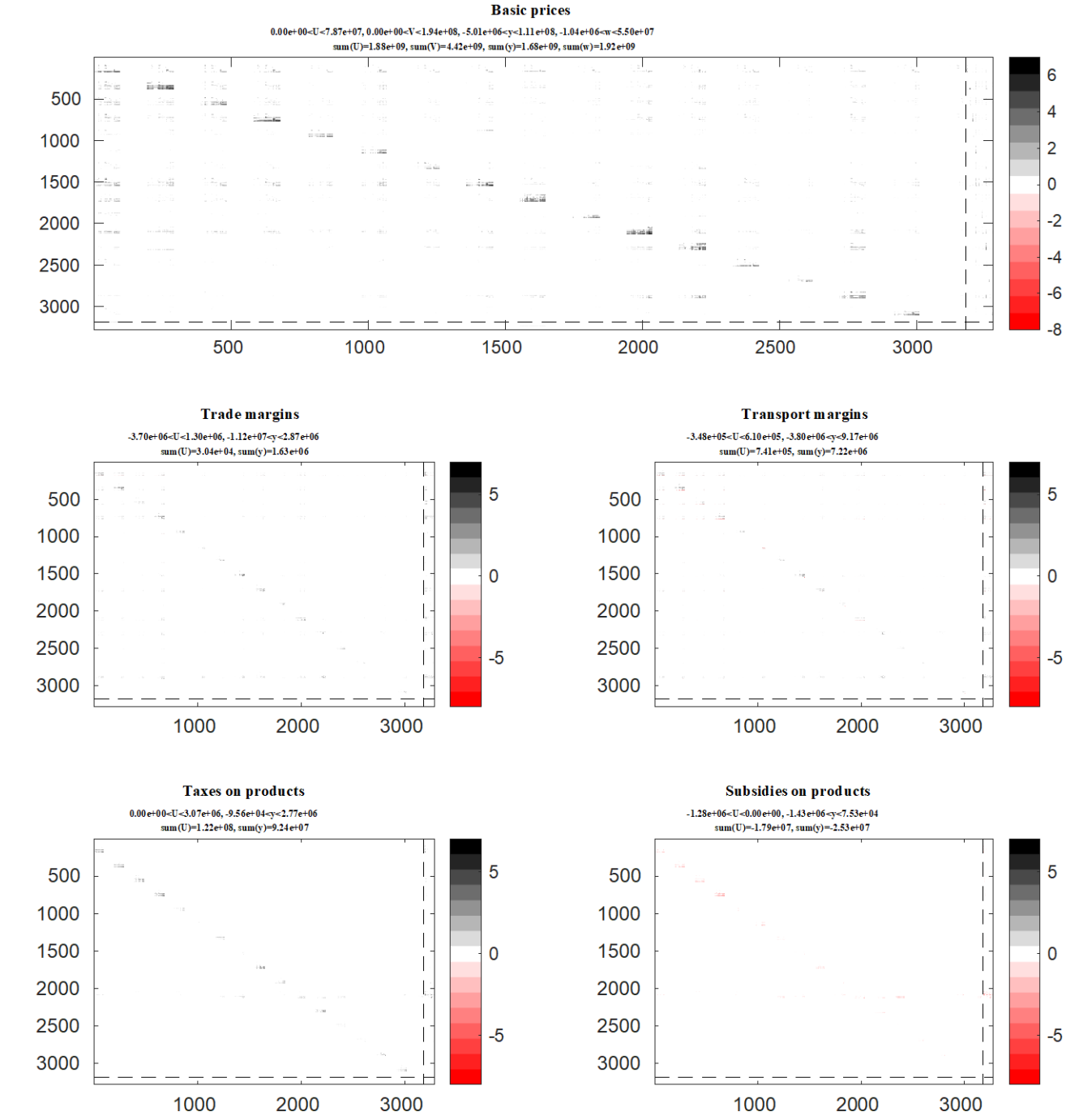


Fig. A31: Heat maps diagnostics for the GLORIA DATABASE for 2005

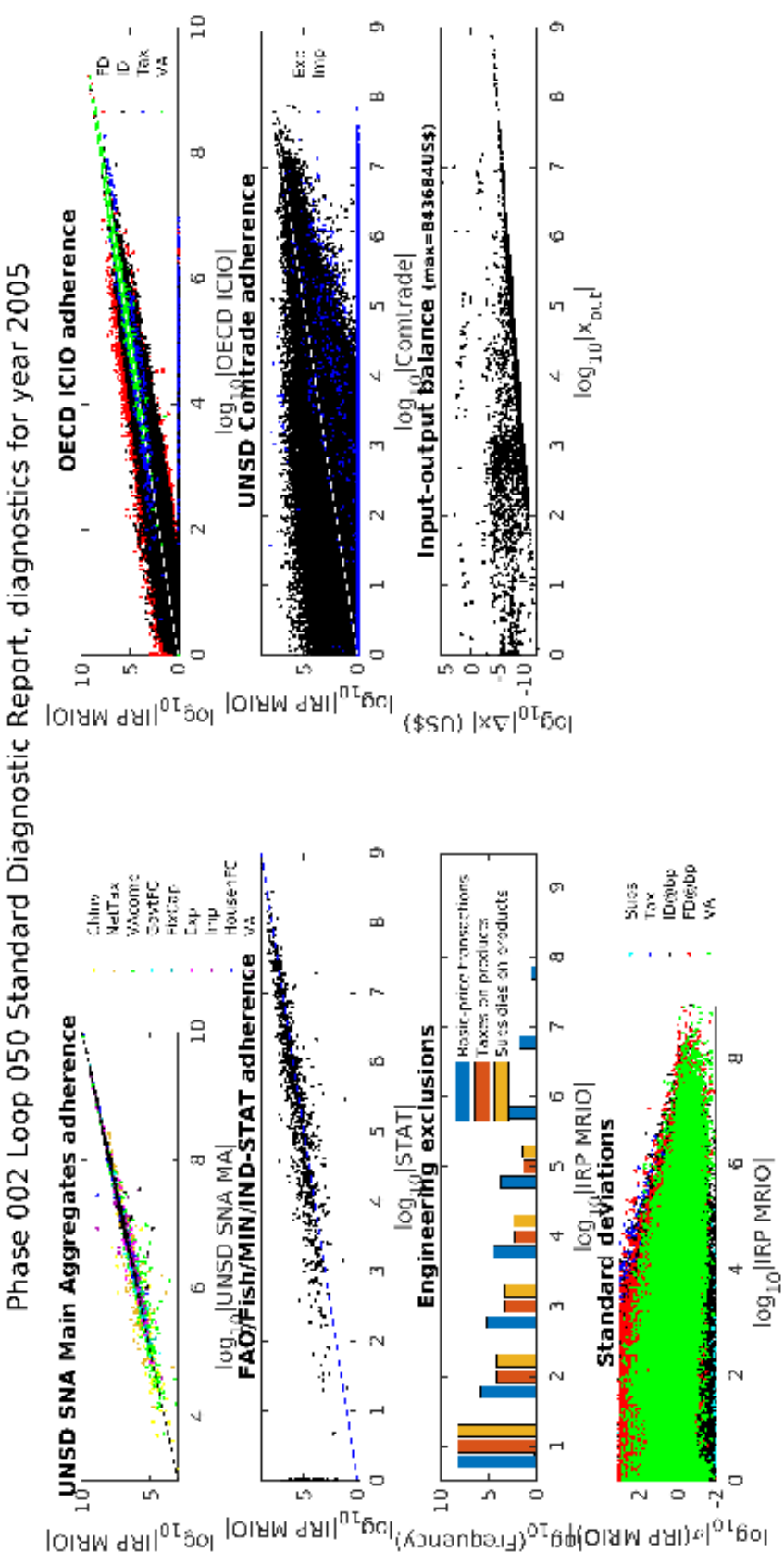


Fig. A32: Standard Diagnostics Report for the GLORIA DATABASE for 2005.

Phase 002 Loop 050 Standard Diagnostic Report, partial heat maps for year 2006

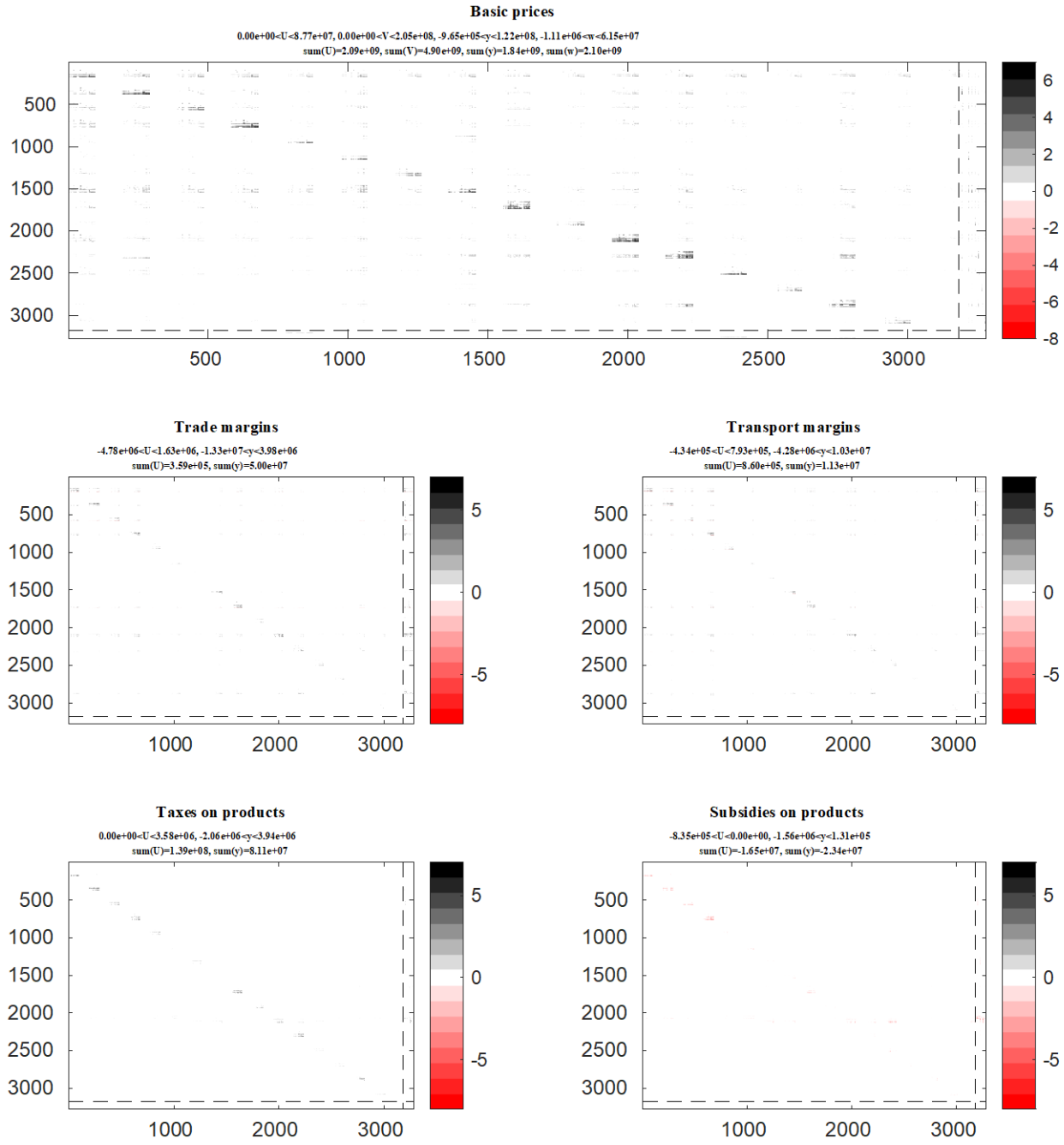


Fig. A33: Heat maps diagnostics for the GLORIA DATABASE for 2006

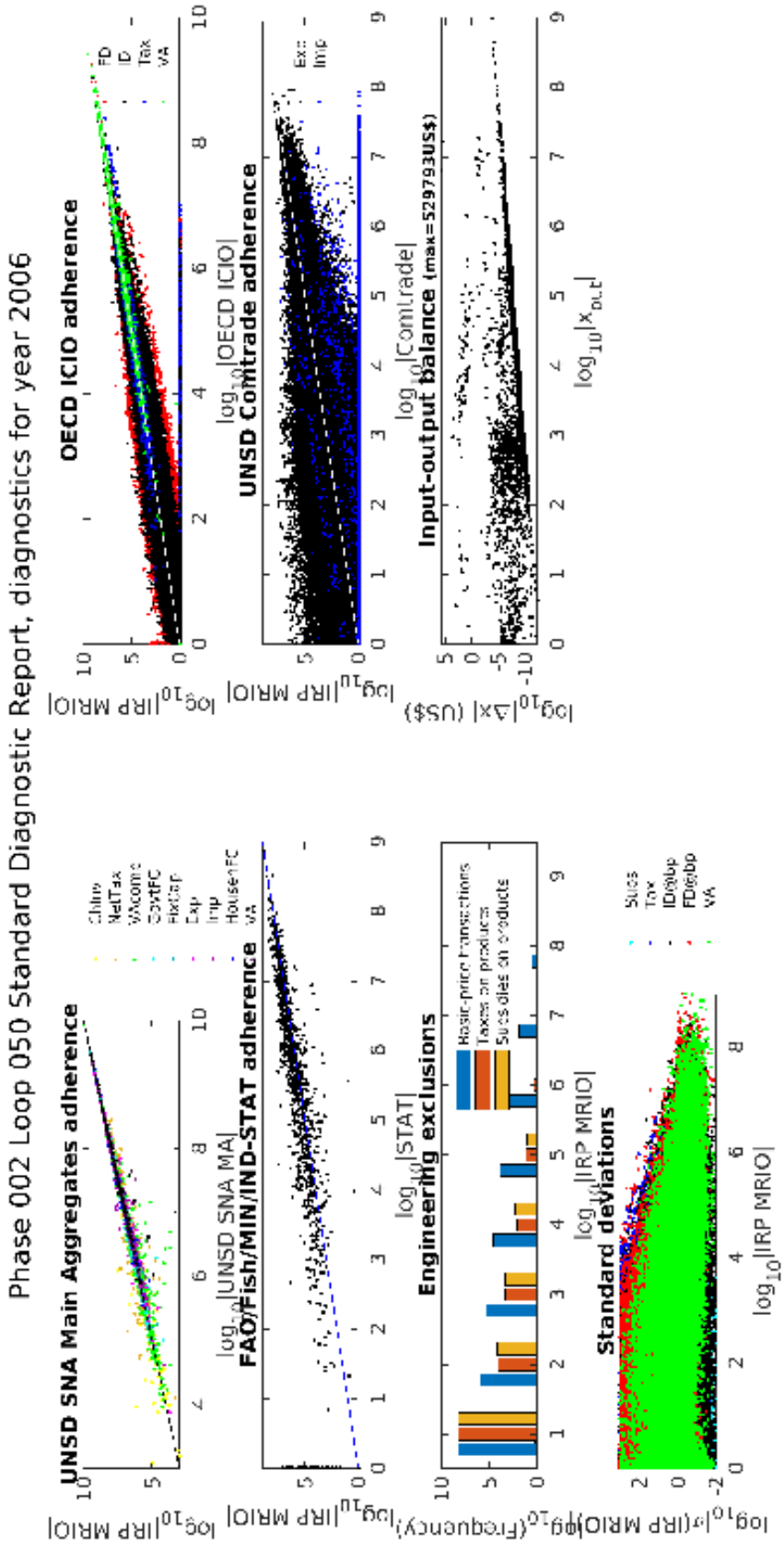


Fig. A34: Standard Diagnostics Report for the GLORIA DATABASE for 2006.

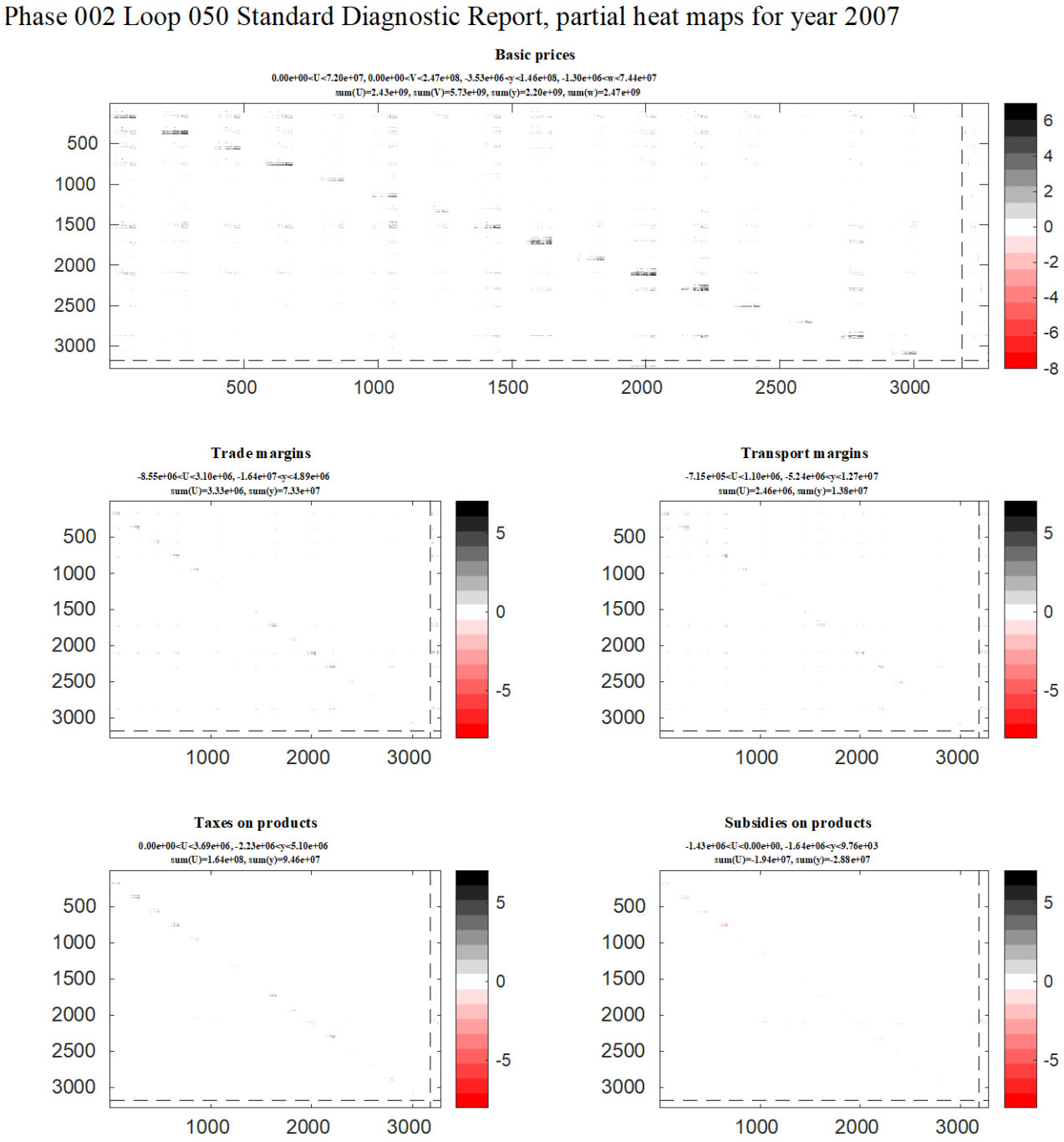


Fig. A35: Heat maps diagnostics for the GLORIA DATABASE for 2007

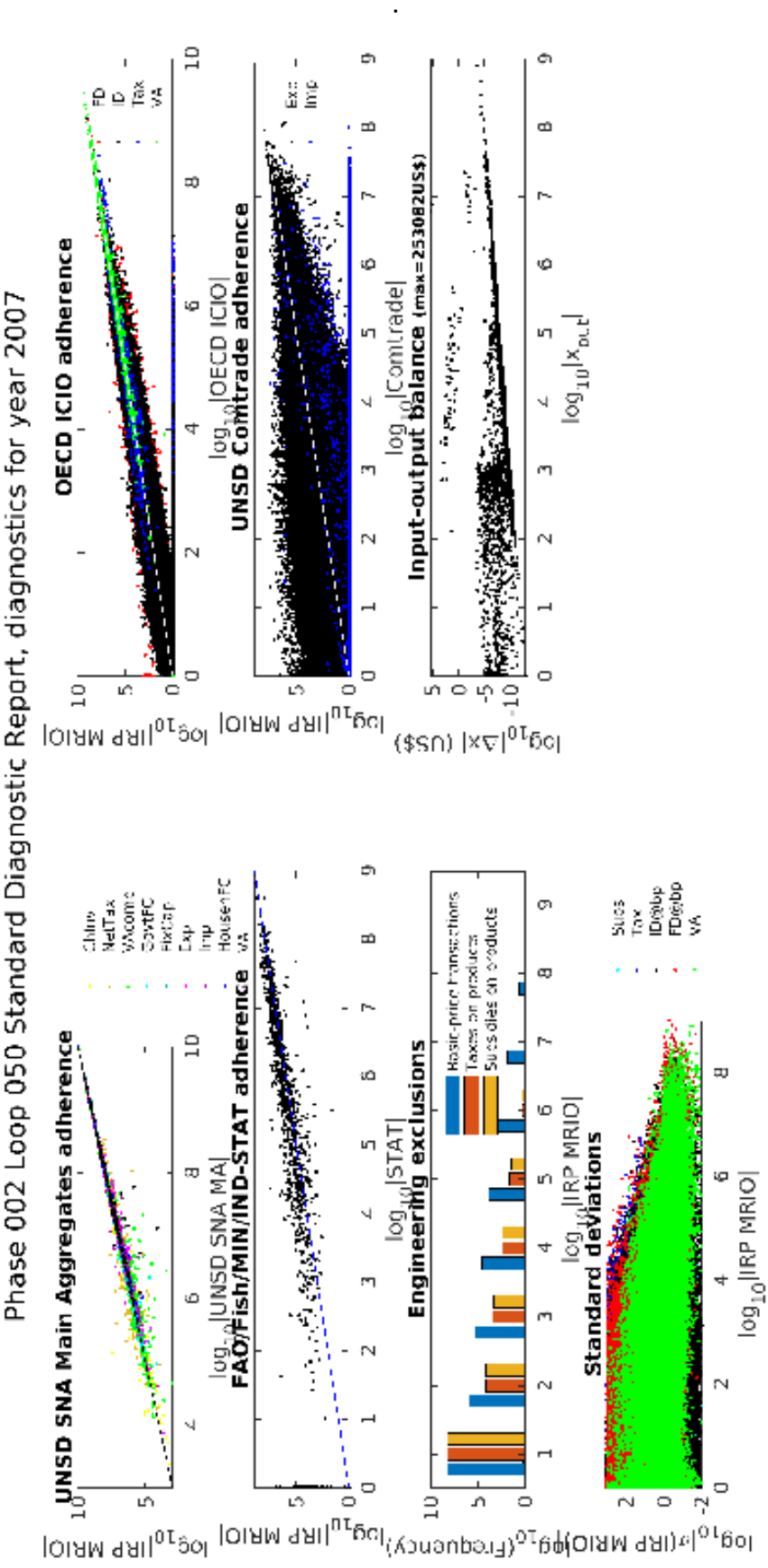


Fig. A36: Standard Diagnostics Report for the GLORIA DATABASE for 2007.

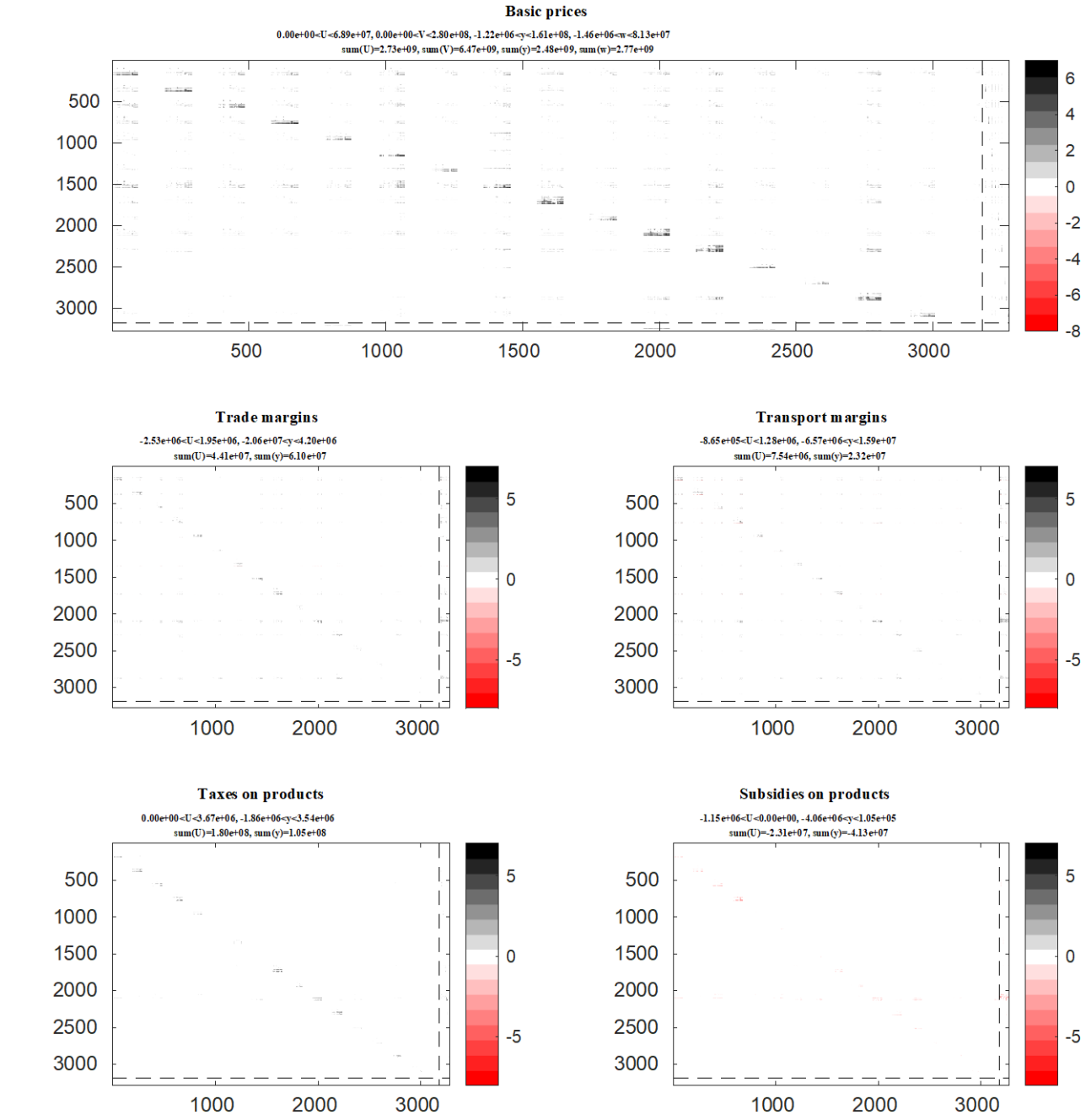


Fig. A37: Heat maps diagnostics for the GLORIA DATABASE for 2008

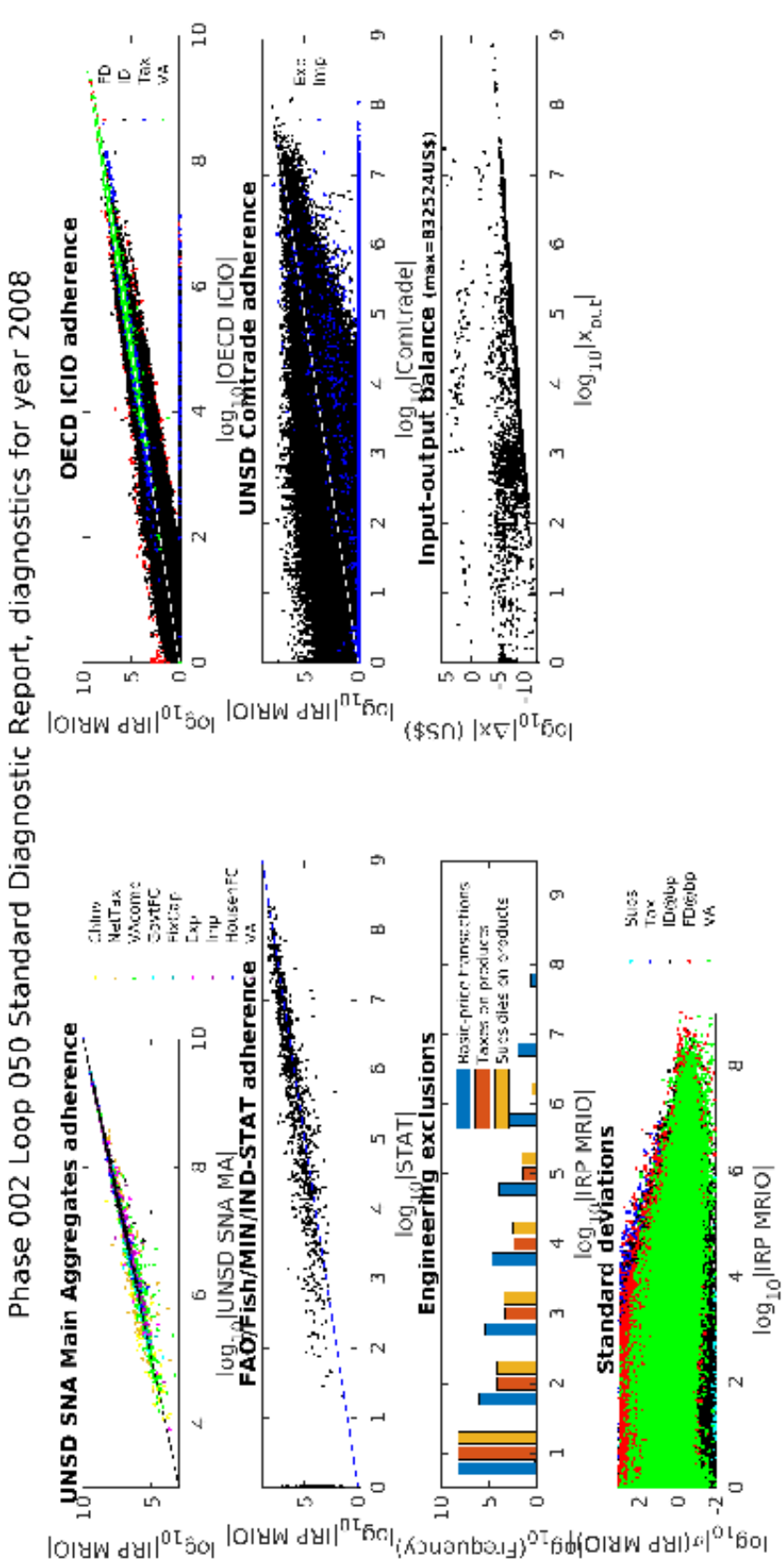


Fig. A38: Standard Diagnostics Report for the GLORIA DATABASE for 2008.

Phase 002 Loop 050 Standard Diagnostic Report, partial heat maps for year 2009

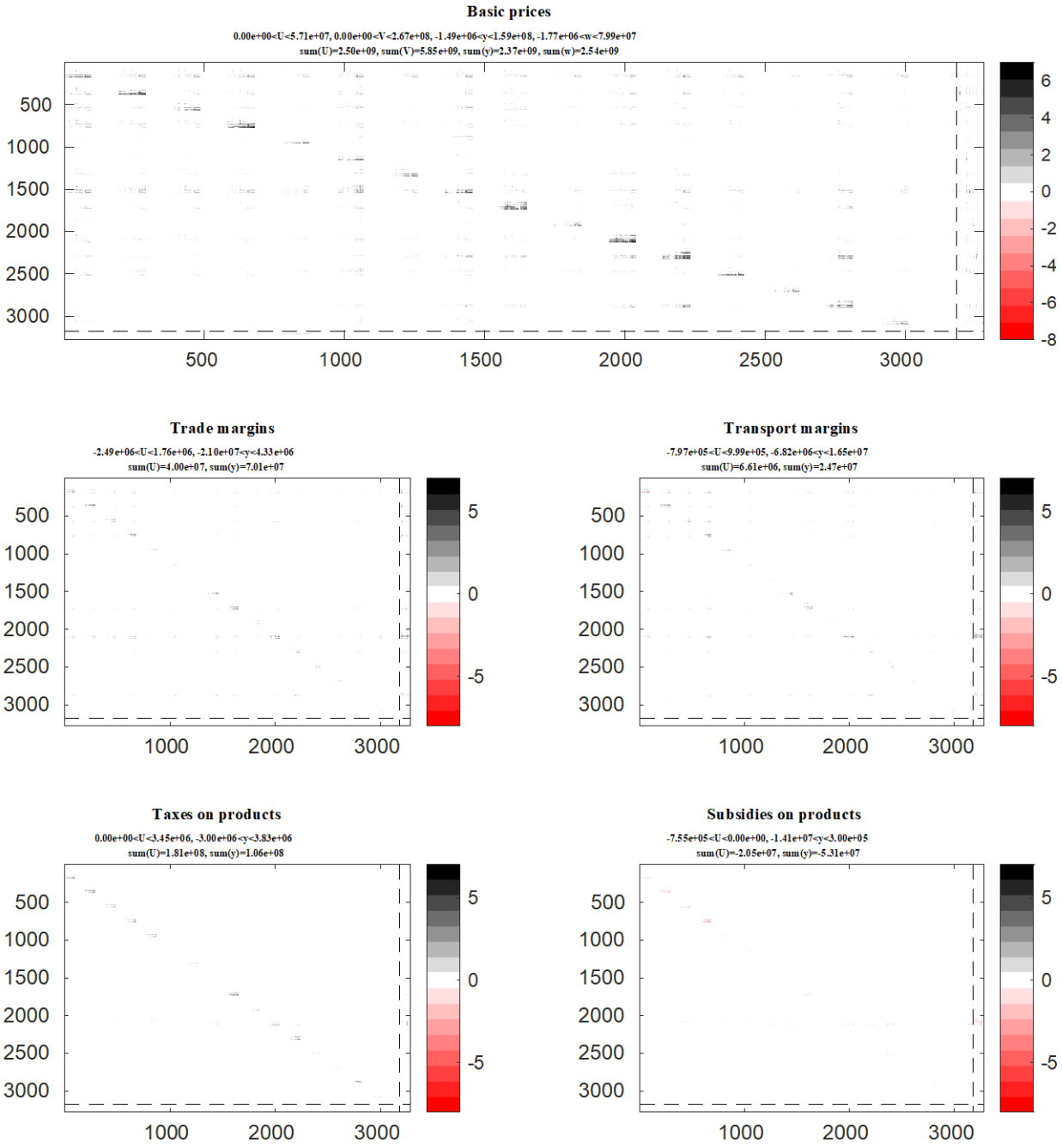


Fig. A40: Heat maps diagnostics for the GLORIA DATABASE for 2009

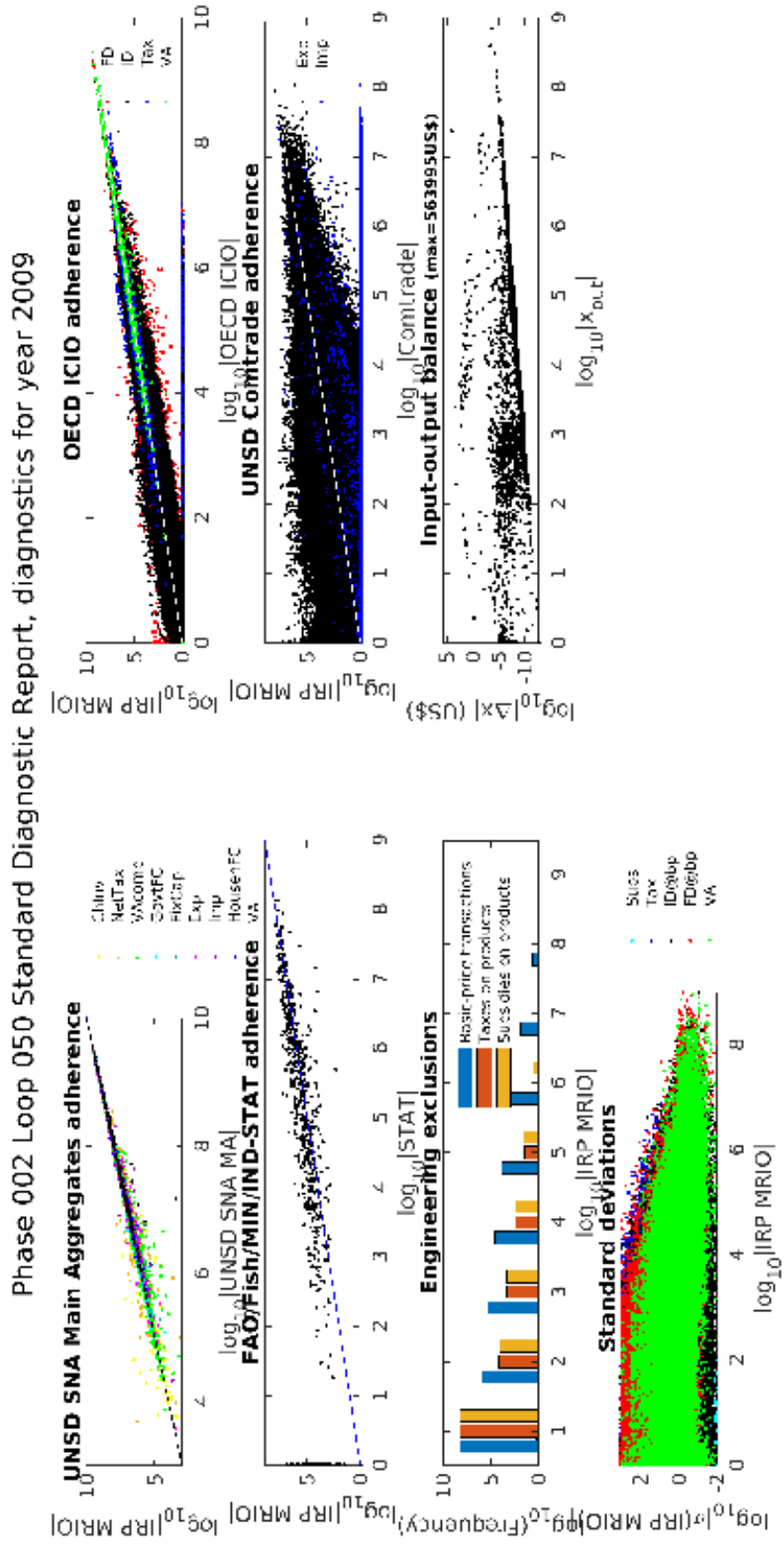


Fig. A41: Standard Diagnostics Report for the GLORIA DATABASE for 2009.

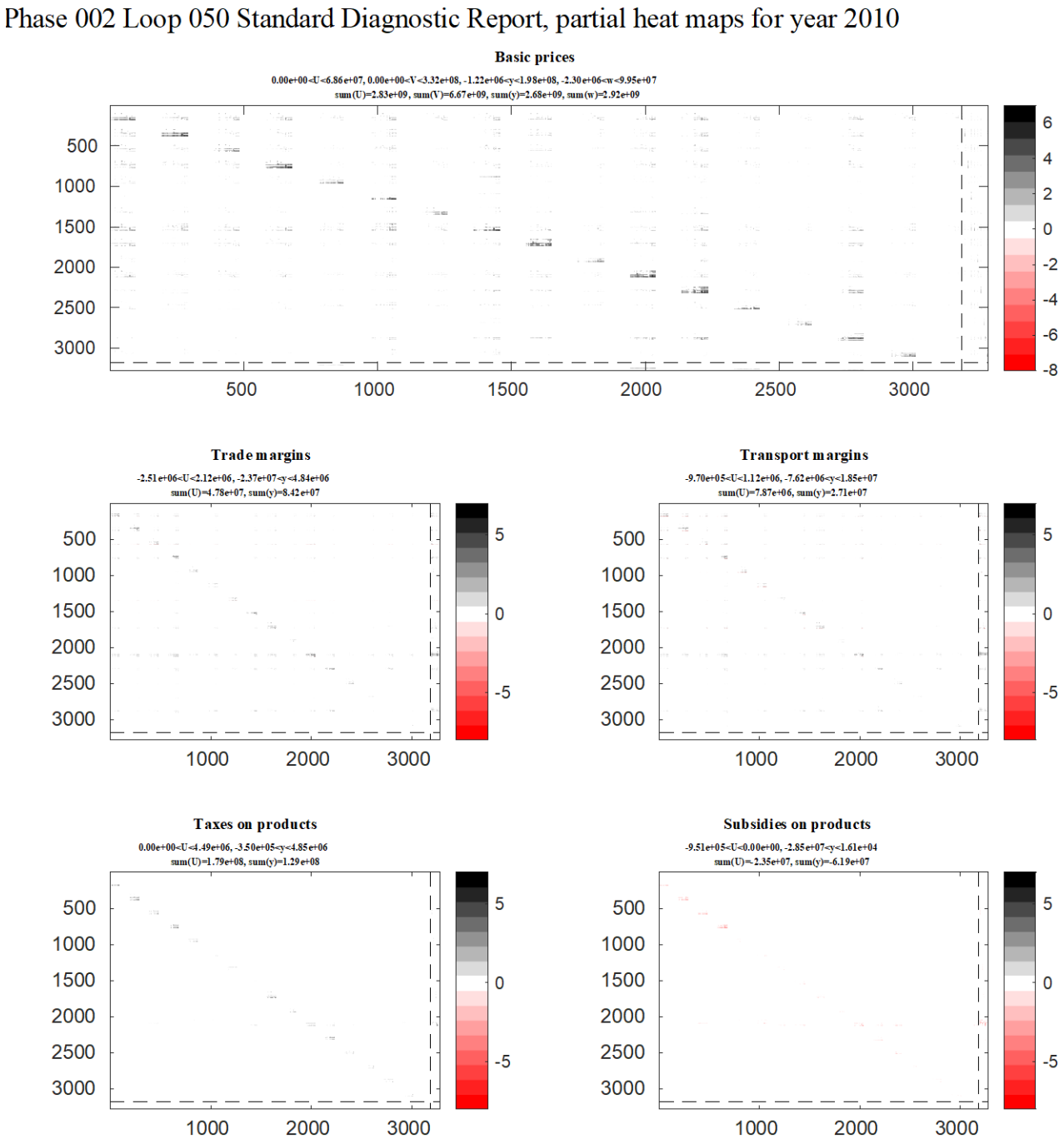


Fig. A42: Heat maps diagnostics for the GLORIA DATABASE for 2010

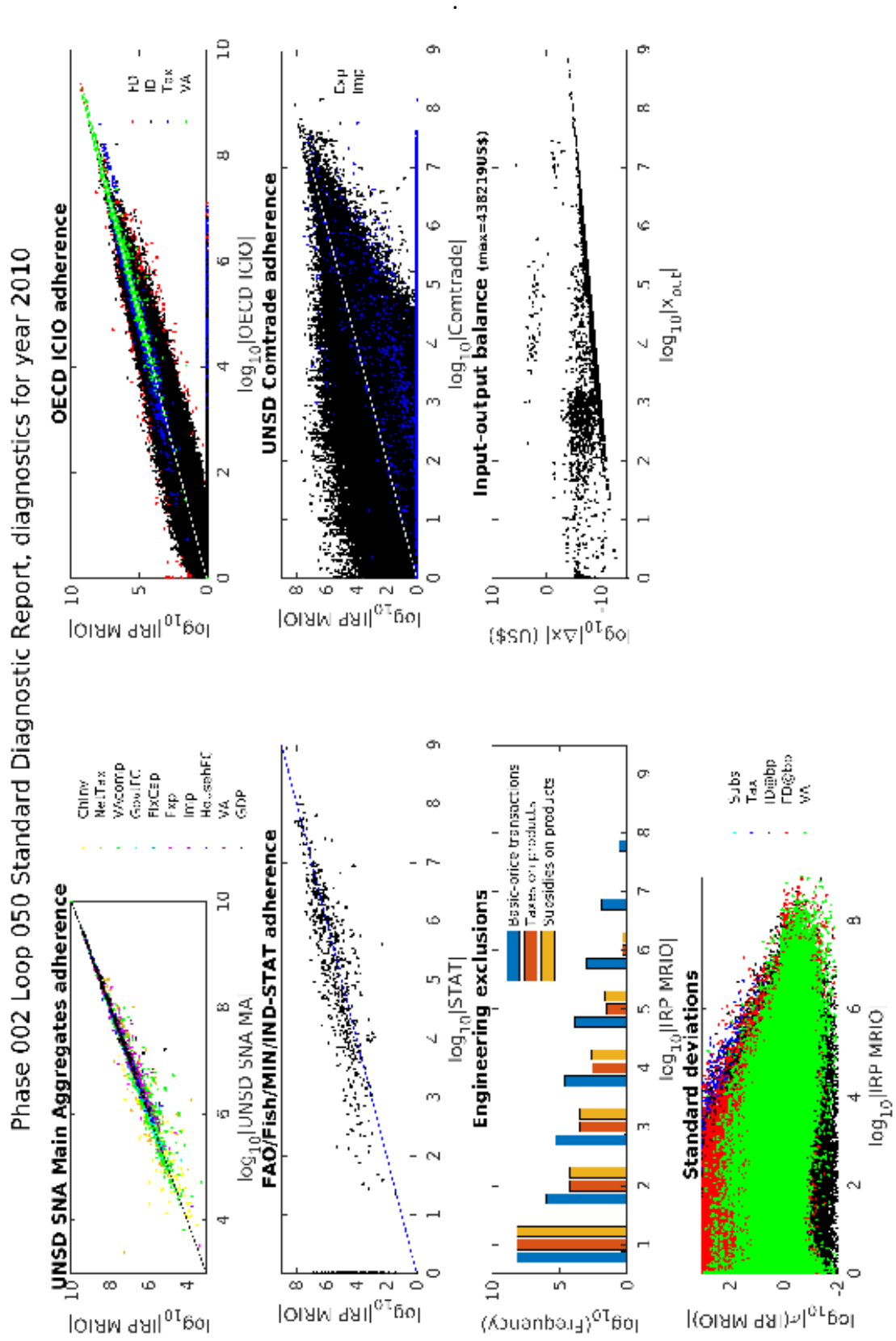


Fig. A43: Standard Diagnostics Report for the GLORIA DATABASE for 2010.

Phase 002 Loop 050 Standard Diagnostic Report, partial heat maps for year 2011

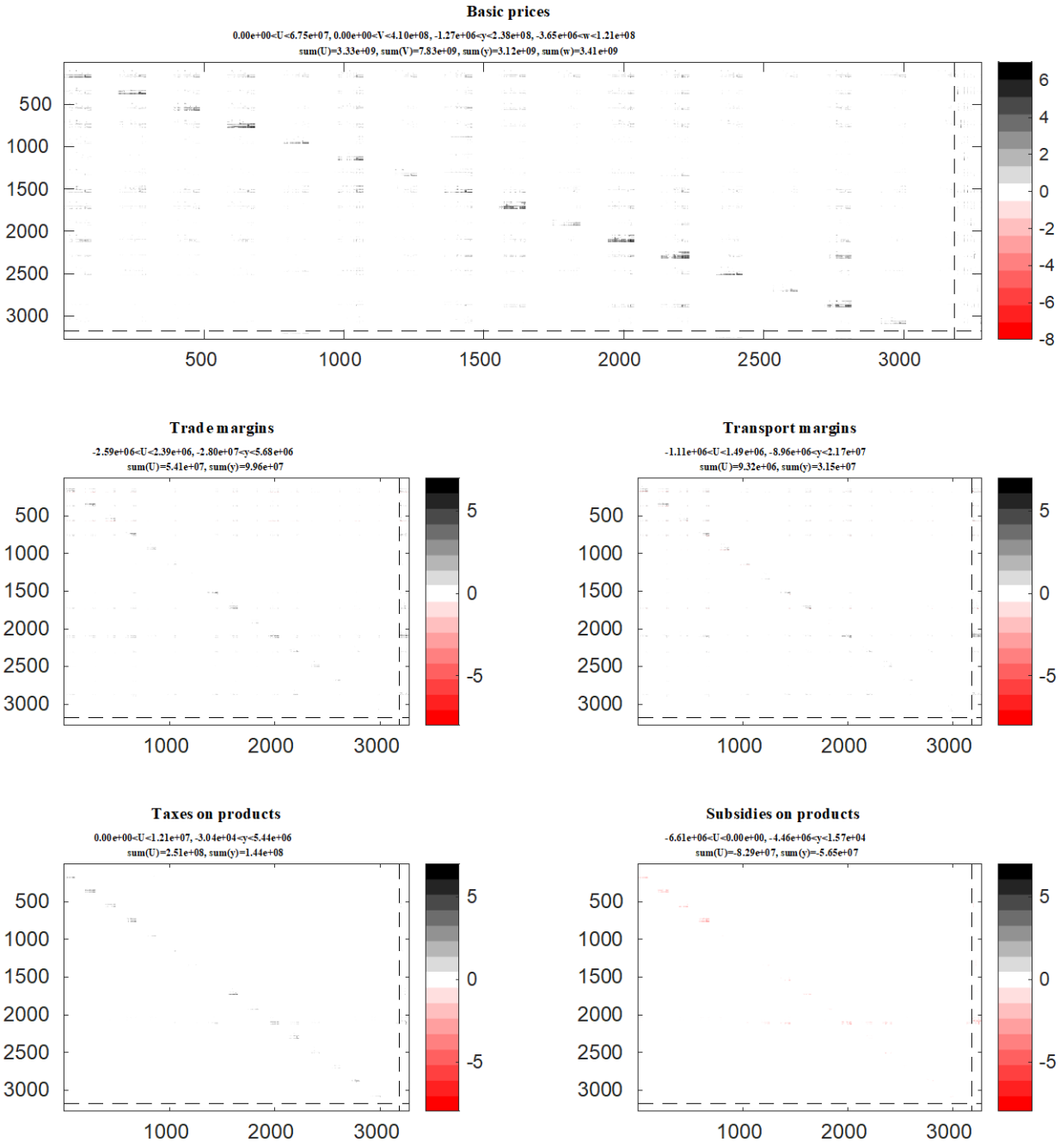


Fig. A44: Heat maps diagnostics for the GLORIA DATABASE for 2011

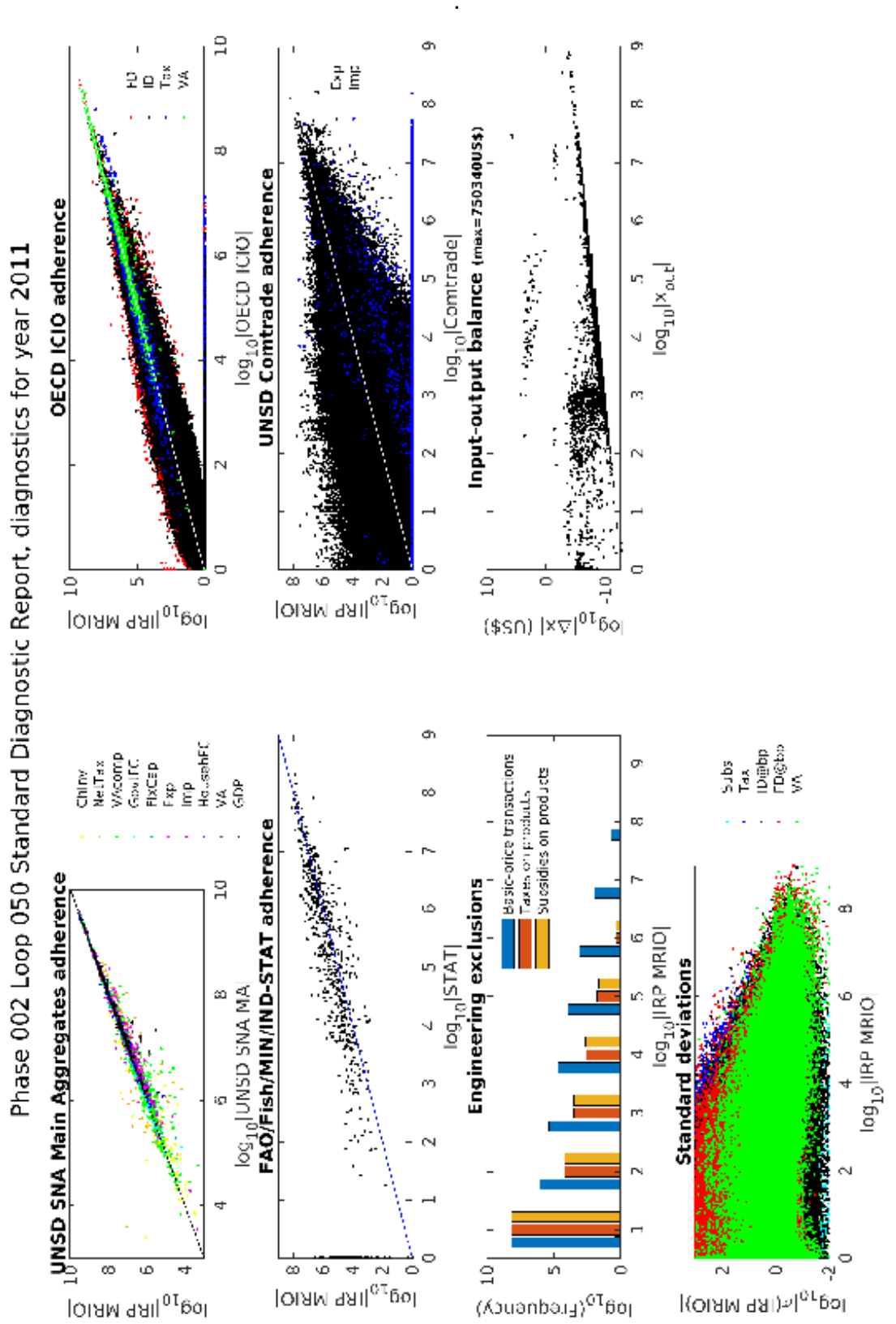


Fig. A45: Standard Diagnostics Report for the GLORIA DATABASE for 2011.

Phase 002 Loop 050 Standard Diagnostic Report, partial heat maps for year 2012

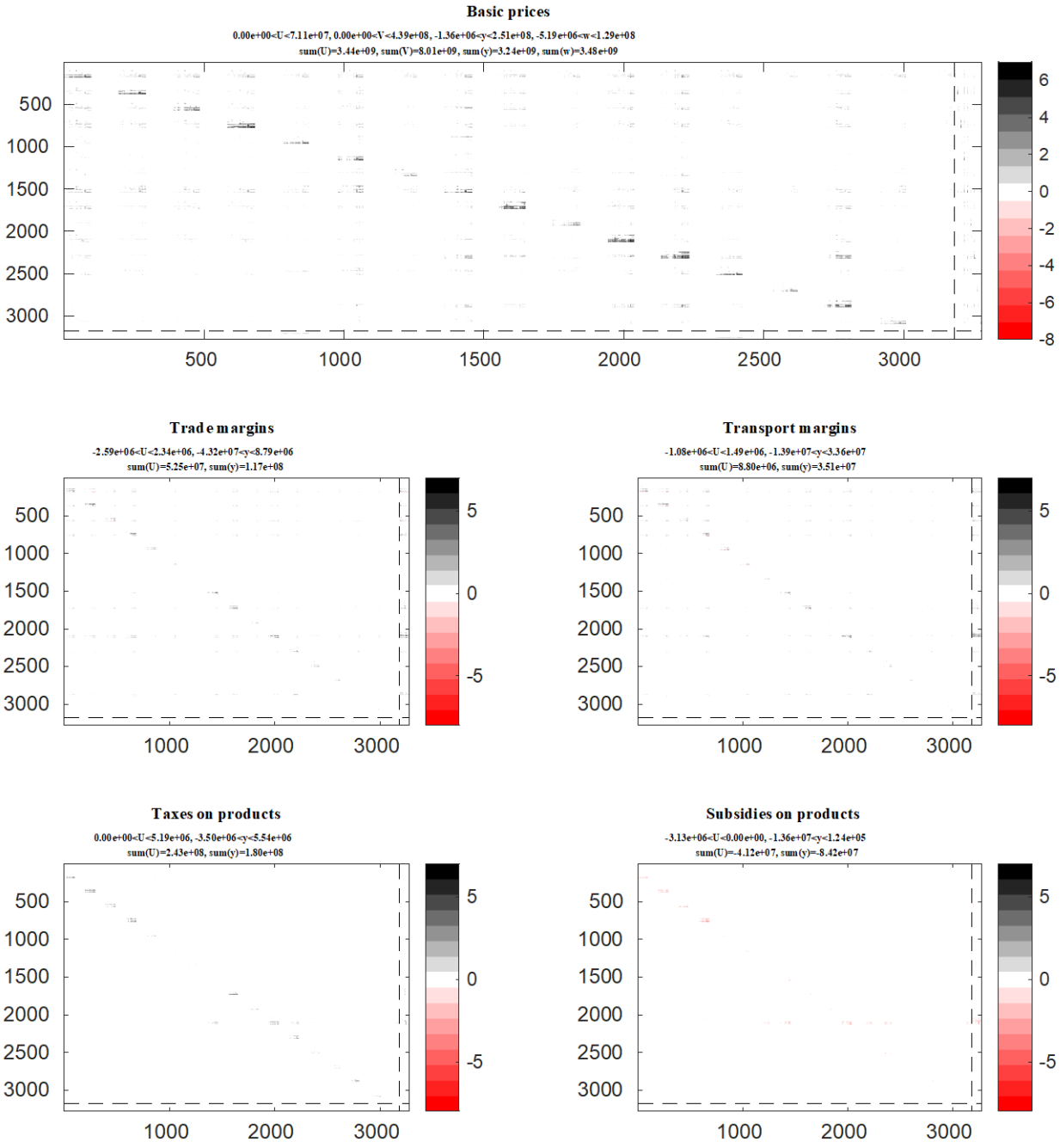


Fig. A46: Heat maps diagnostics for the GLORIA DATABASE for 2012

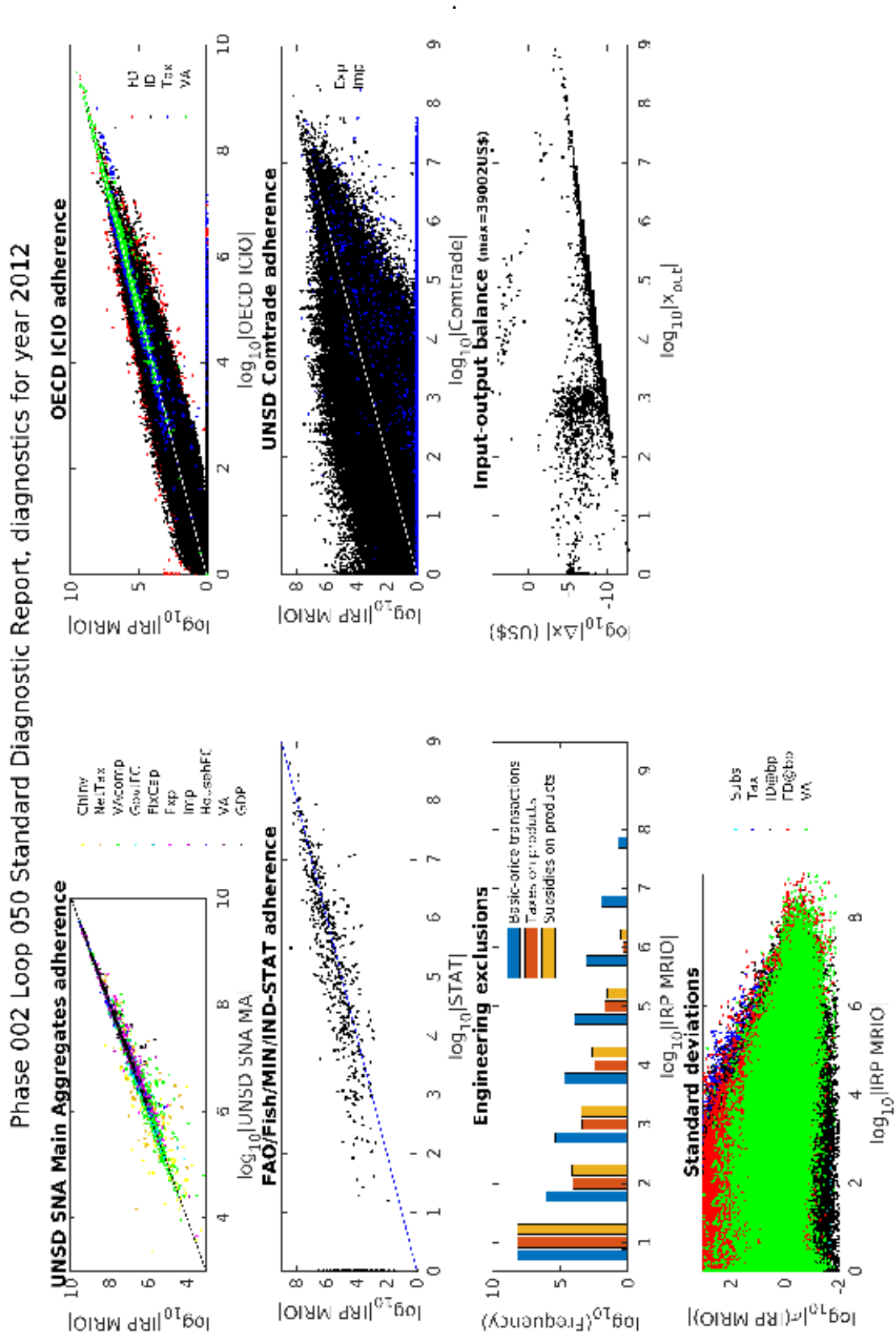


Fig. A47: Standard Diagnostics Report for the GLORIA DATABASE for 2012.

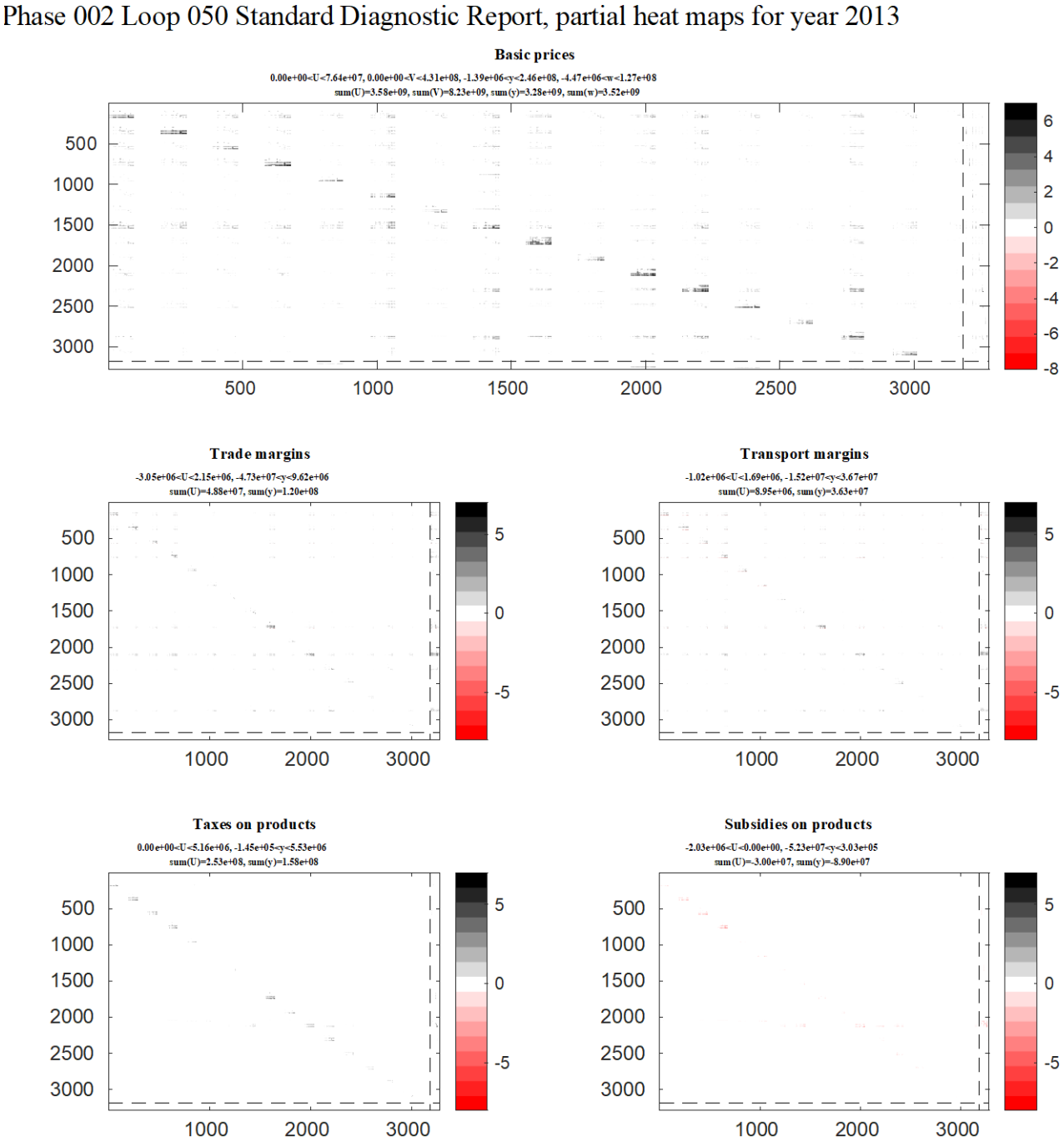


Fig. A48: Heat maps diagnostics for the GLORIA DATABASE for 2013

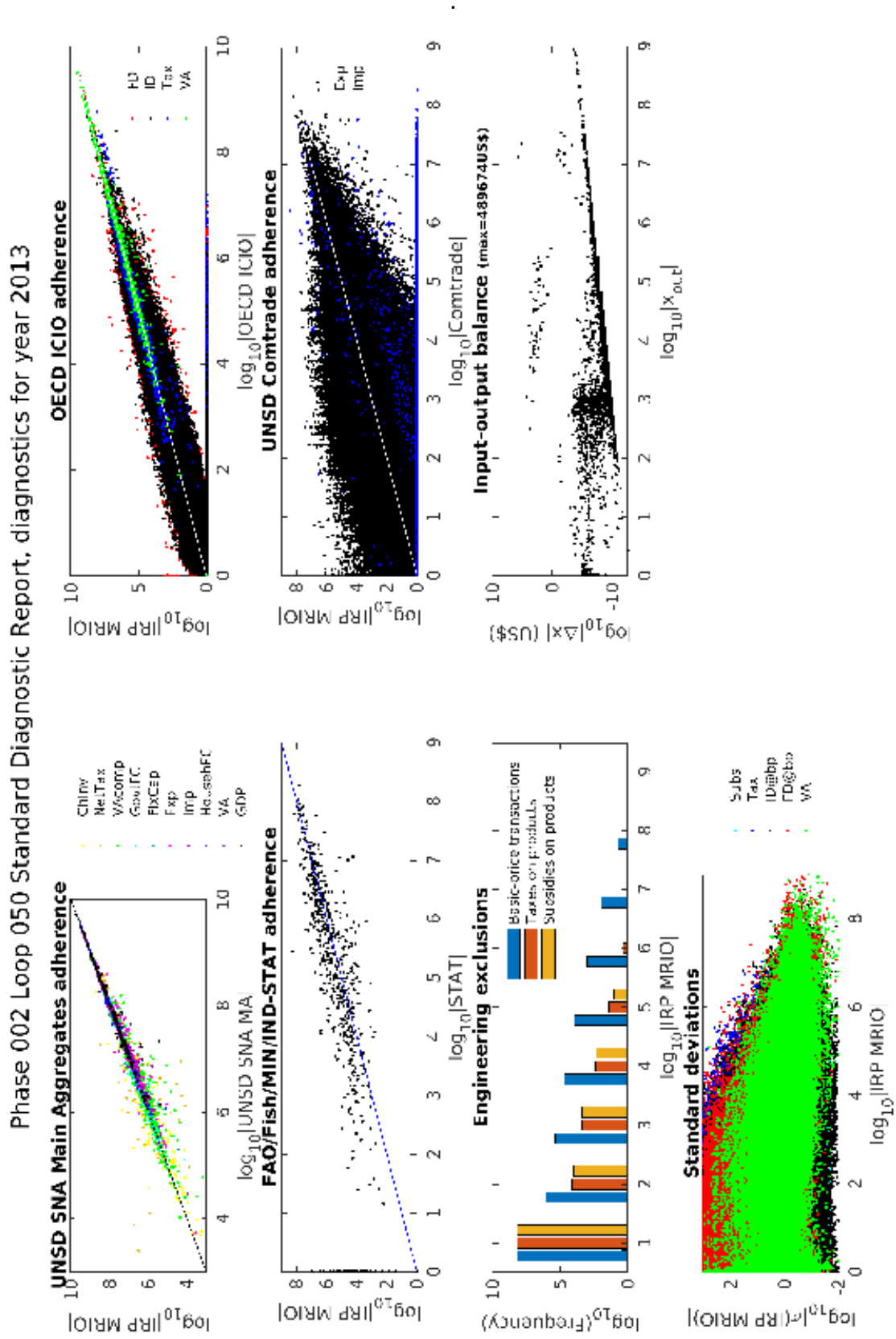


Fig. A49: Standard Diagnostics Report for the GLORIA DATABASE for 2013.

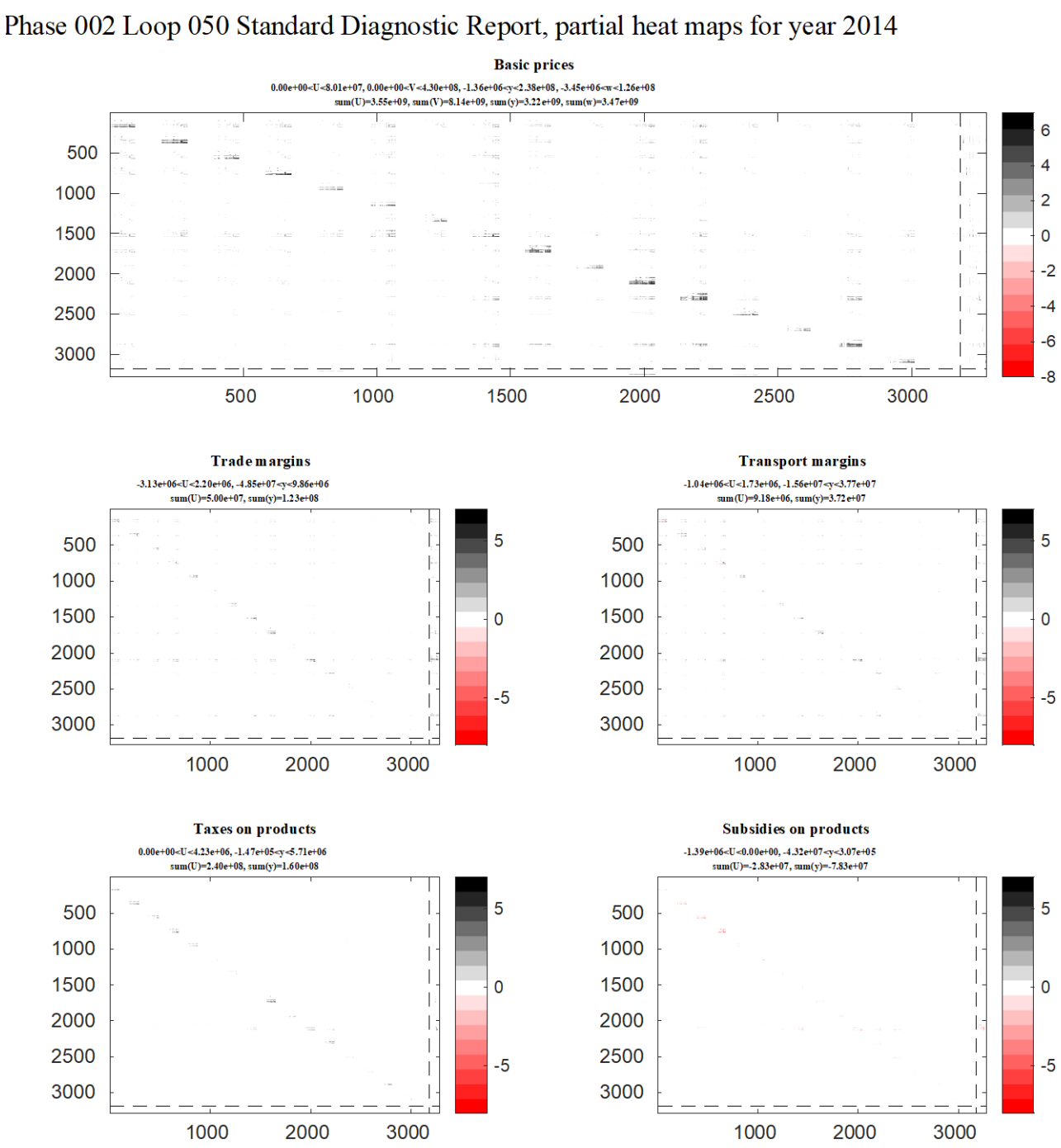


Fig. A50: Heat maps diagnostics for the GLORIA DATABASE for 2014

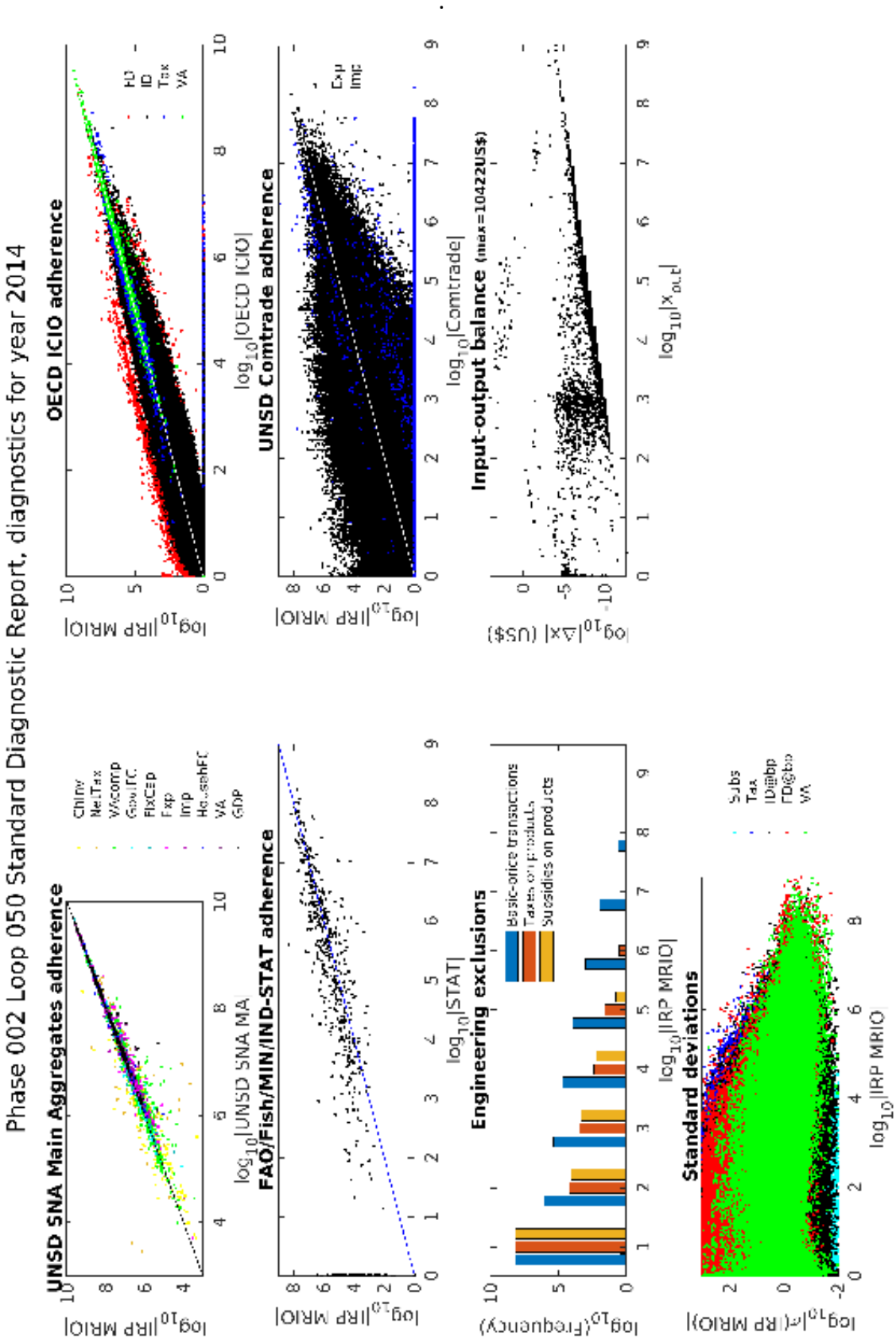


Fig. A51: Standard Diagnostics Report for the GLORIA DATABASE for 2014.

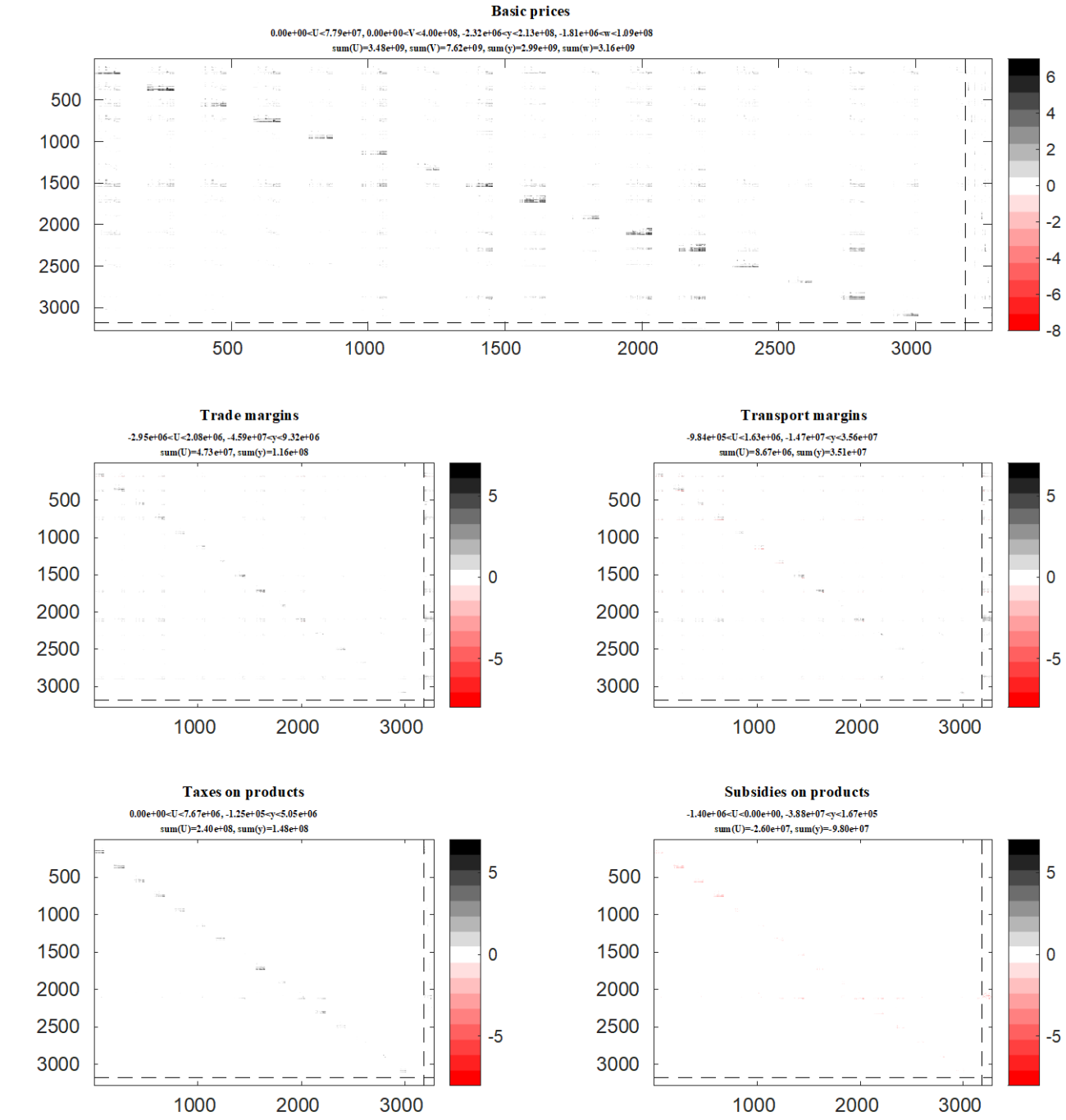


Fig. A52: Heat maps diagnostics for the GLORIA DATABASE for 2015

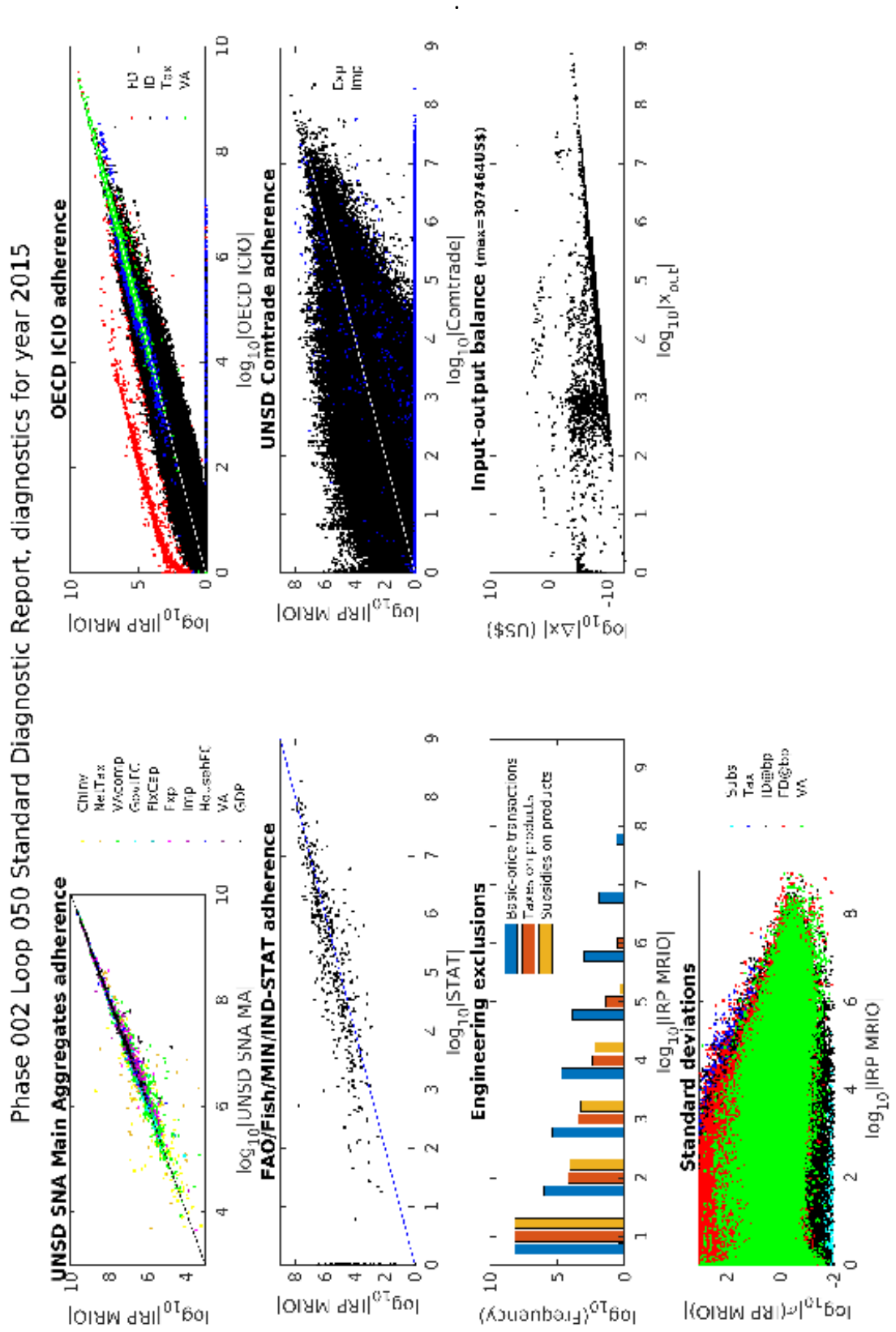


Fig. A53: Standard Diagnostics Report for the GLORIA DATABASE for 2015.

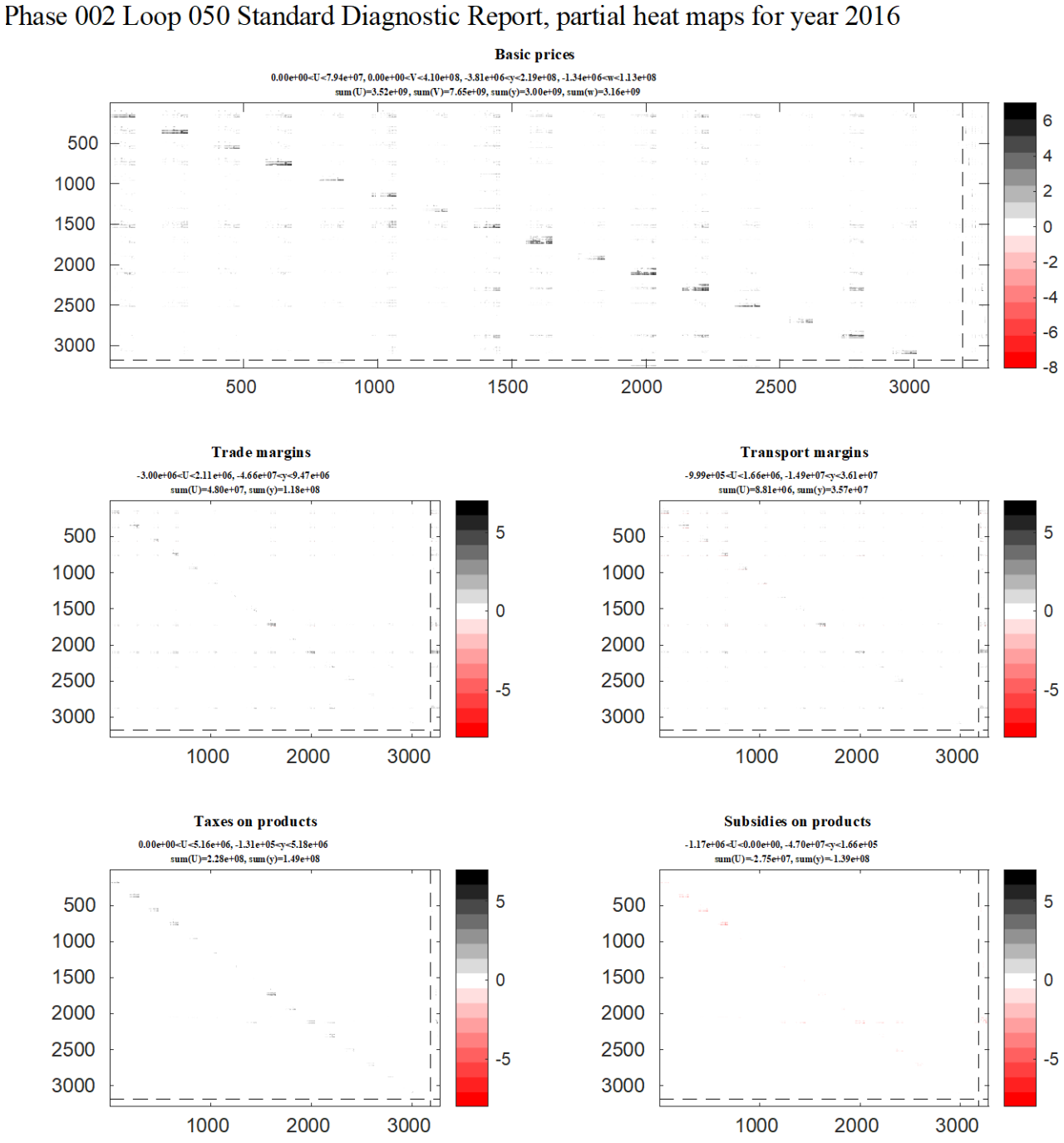


Fig. A54: Heat maps diagnostics for the GLORIA DATABASE for 2016

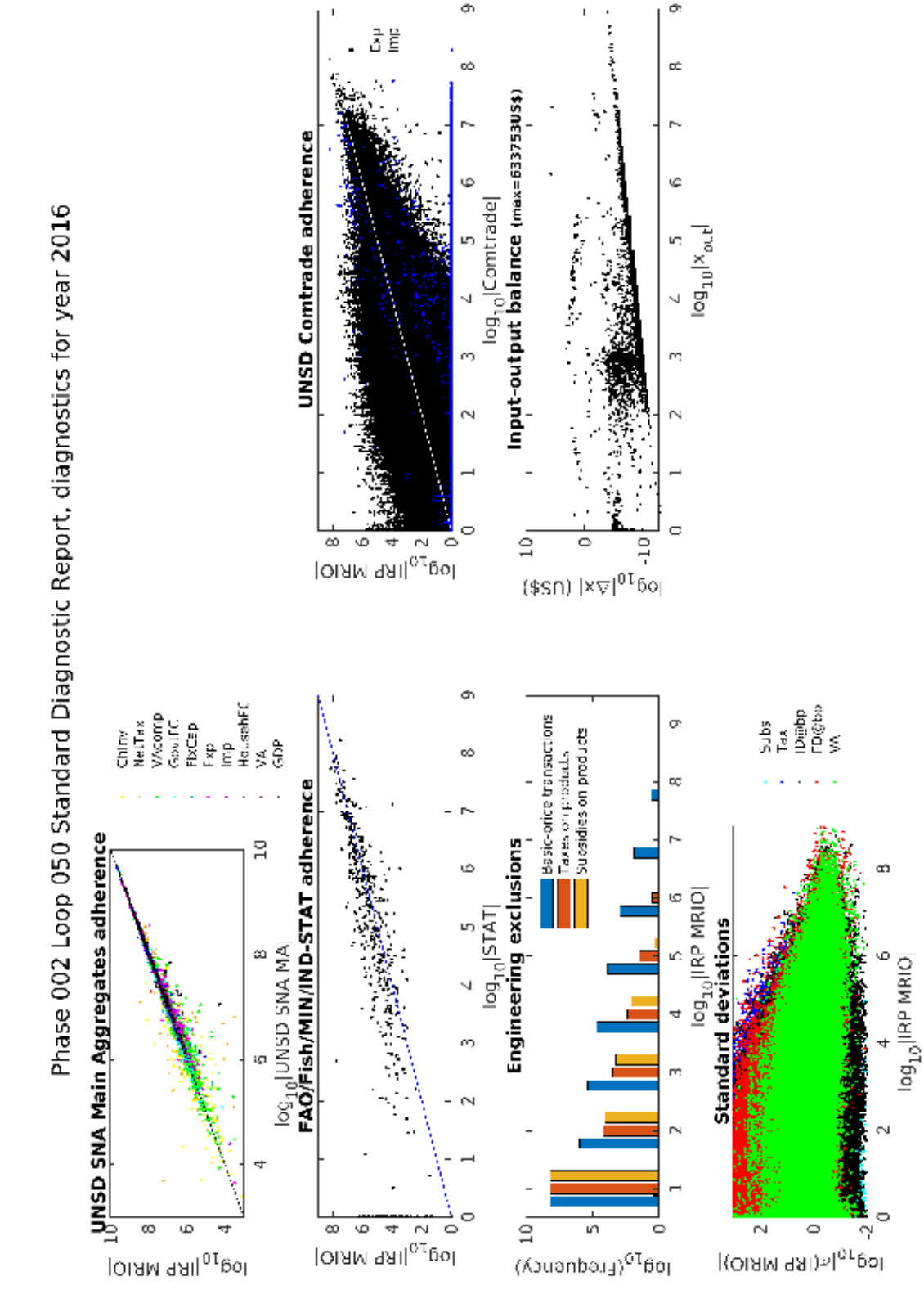


Fig. A55: Standard Diagnostics Report for the GLORIA DATABASE for 2016. Missing plots indicate that this data source was not available for 2016.

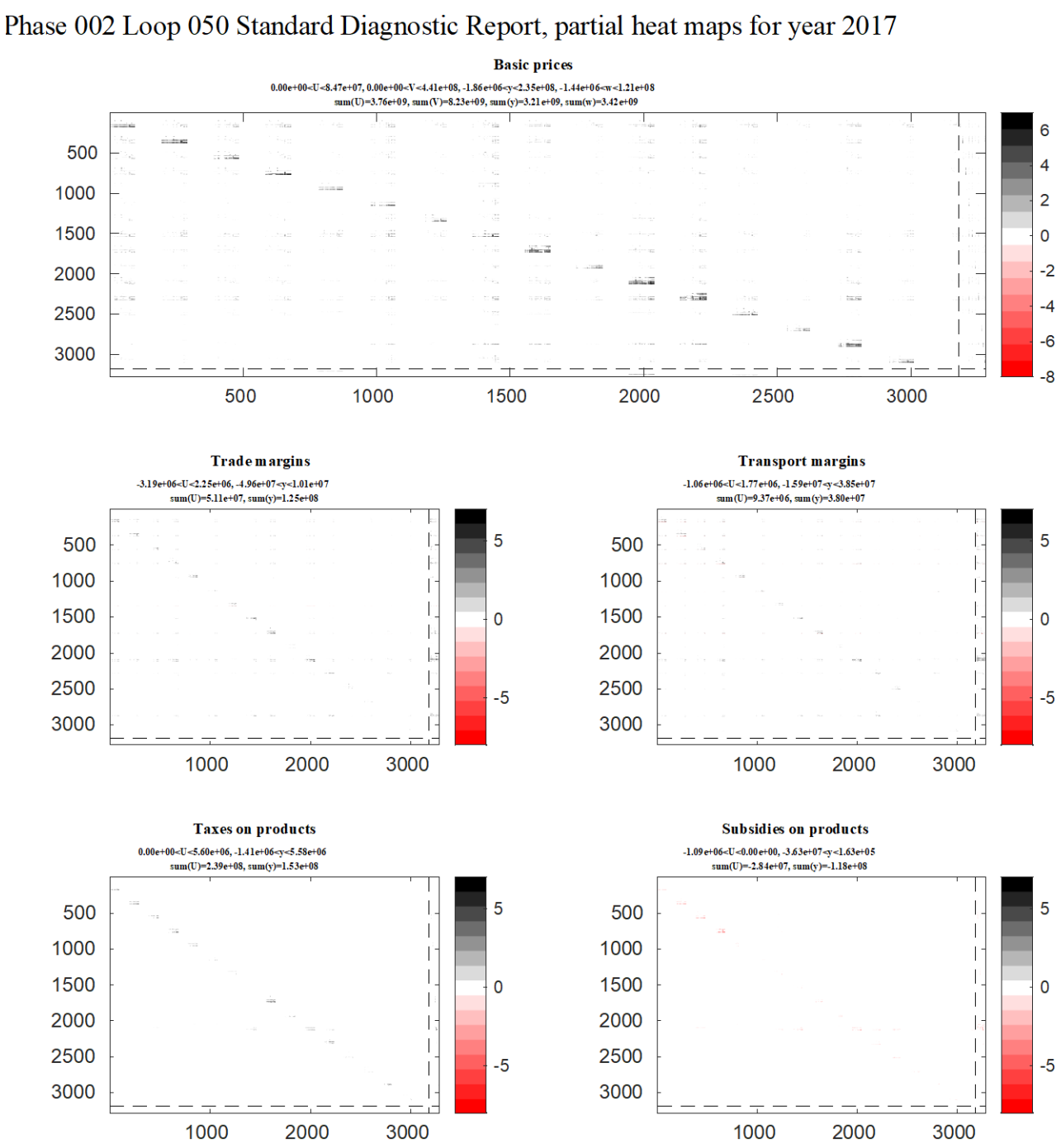


Fig. A56: Heat maps diagnostics for the GLORIA DATABASE for 2017.

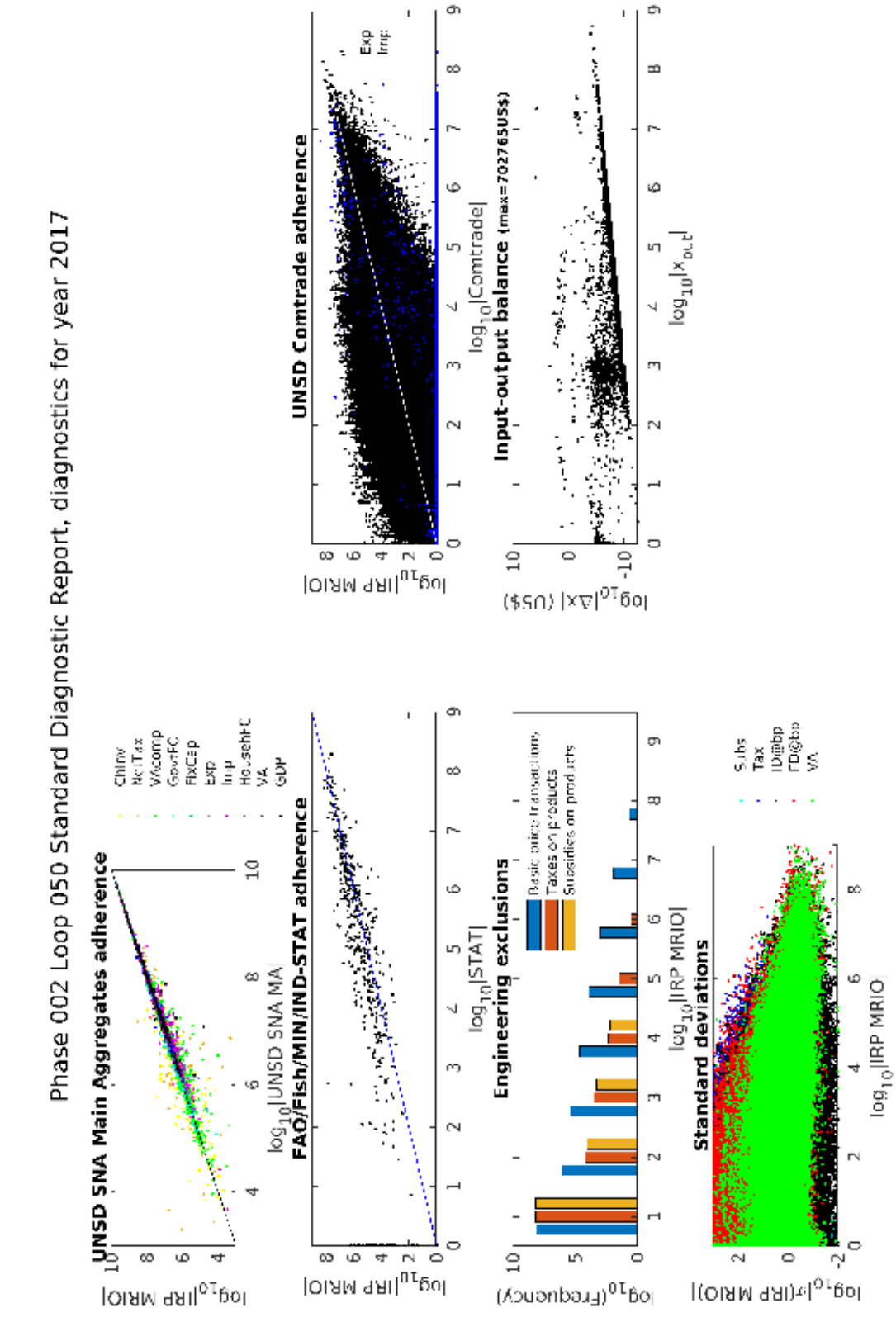


Fig. A57: Standard Diagnostics Report for the GLORIA DATABASE for 2017. Missing plots indicate that this data source was not available for 2017.

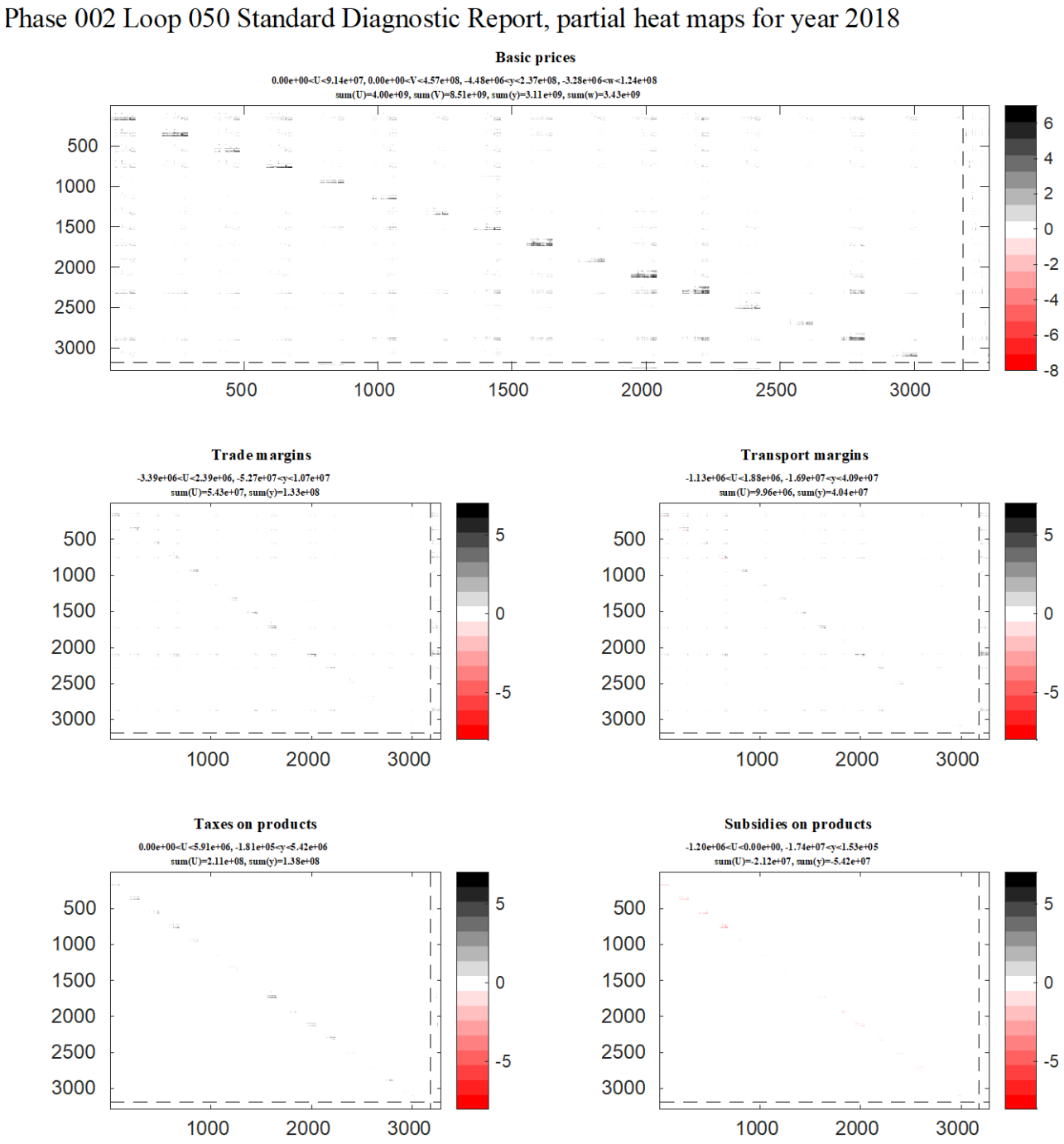


Fig. A58: Heat maps diagnostics for the GLORIA DATABASE for 2018.

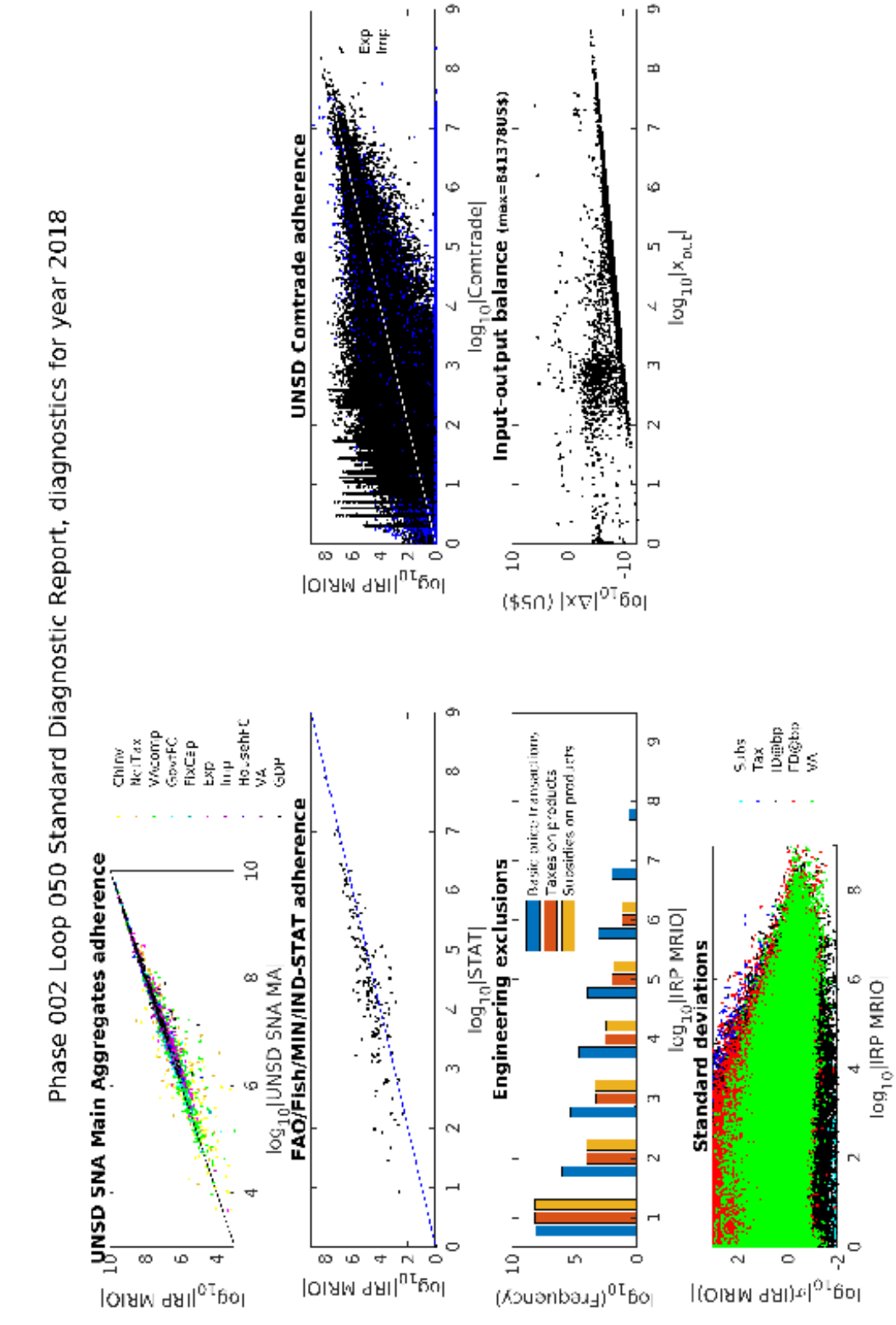


Fig. A59: Standard Diagnostics Report for the GLORIA DATABASE for 2018. Missing plots indicate that this data source was not available for 2018.

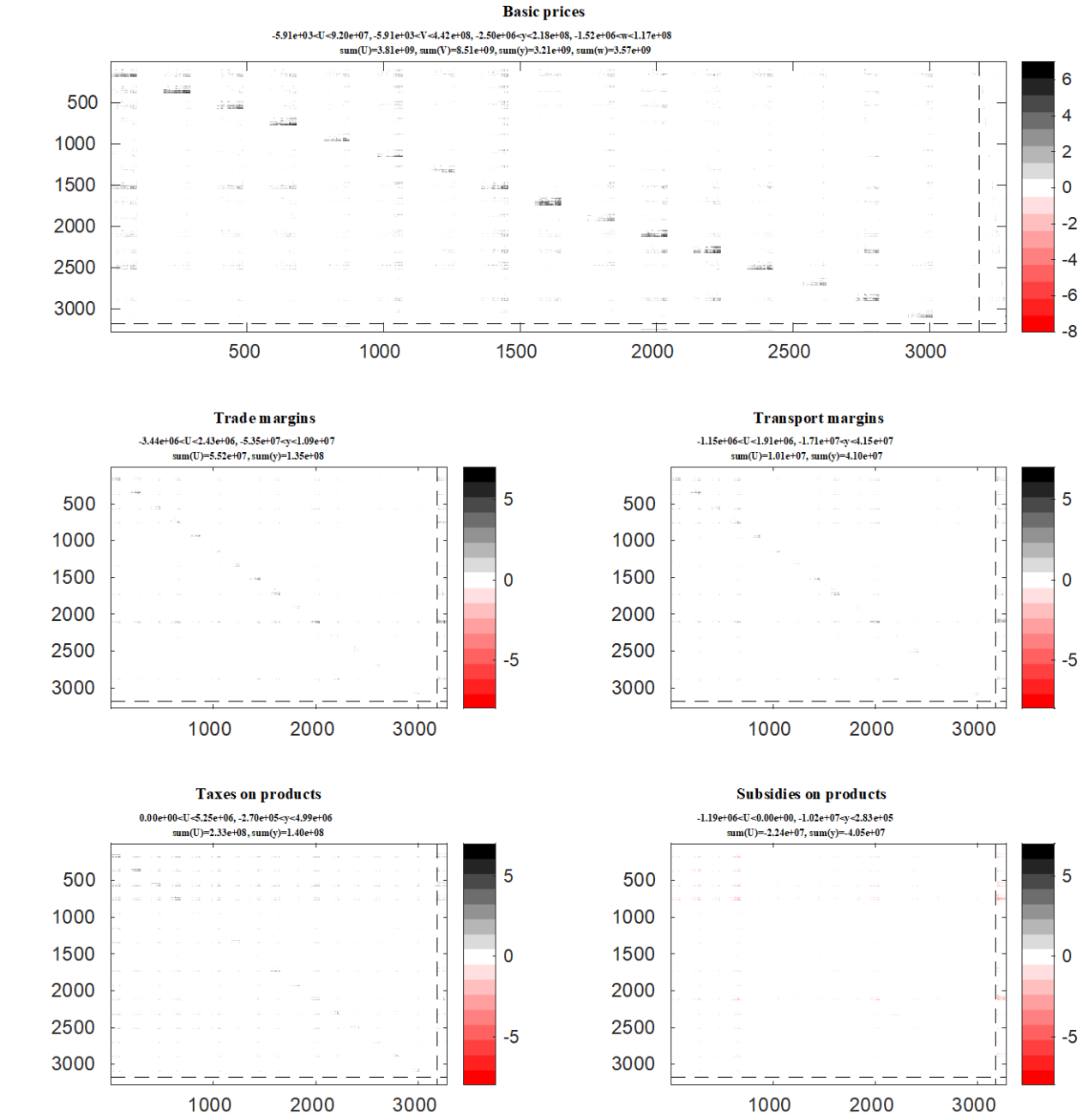


Fig. A60: Heat maps diagnostics for the GLORIA DATABASE for 2019.

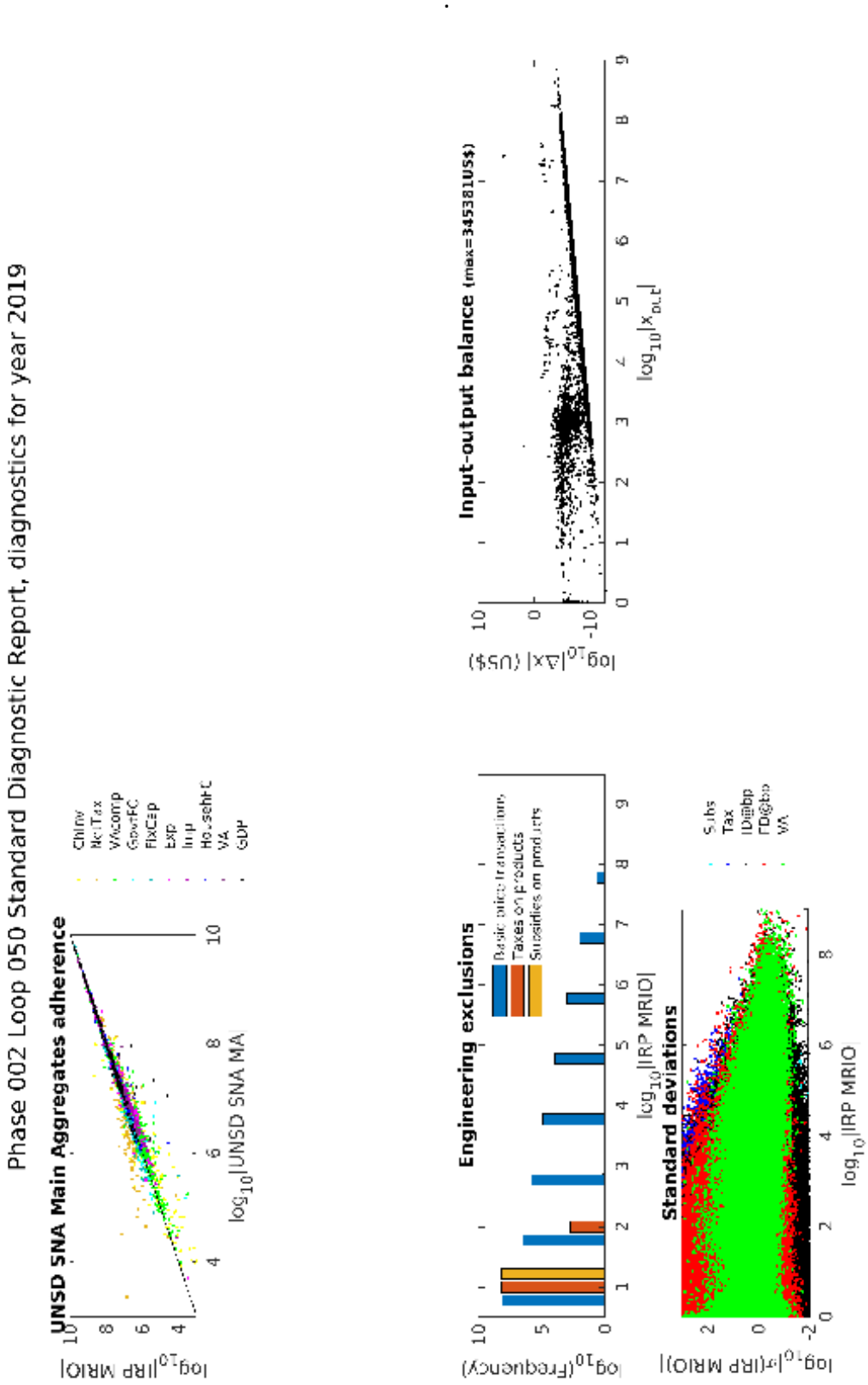


Fig. A61: Standard Diagnostics Report for the GLORIA DATABASE for 2019. Missing plots indicate that this data source was not available for 2019.

Appendix A7: Comparison of macro-economic indicators as provided by the UN SNA MA database and the GLORIA database

The UN SNA MA database offers a number of macro-economic indicators which were visually compared to their counterparts as provided by the GLORIA database. The results for each country/region in the GLORIA database are given in an individual plot. The plots do not have individual labels, and the data are to be interpreted as follows.

- dotted lines refer to the GLORIA database
- solid lines refer to the UN SNA MA database

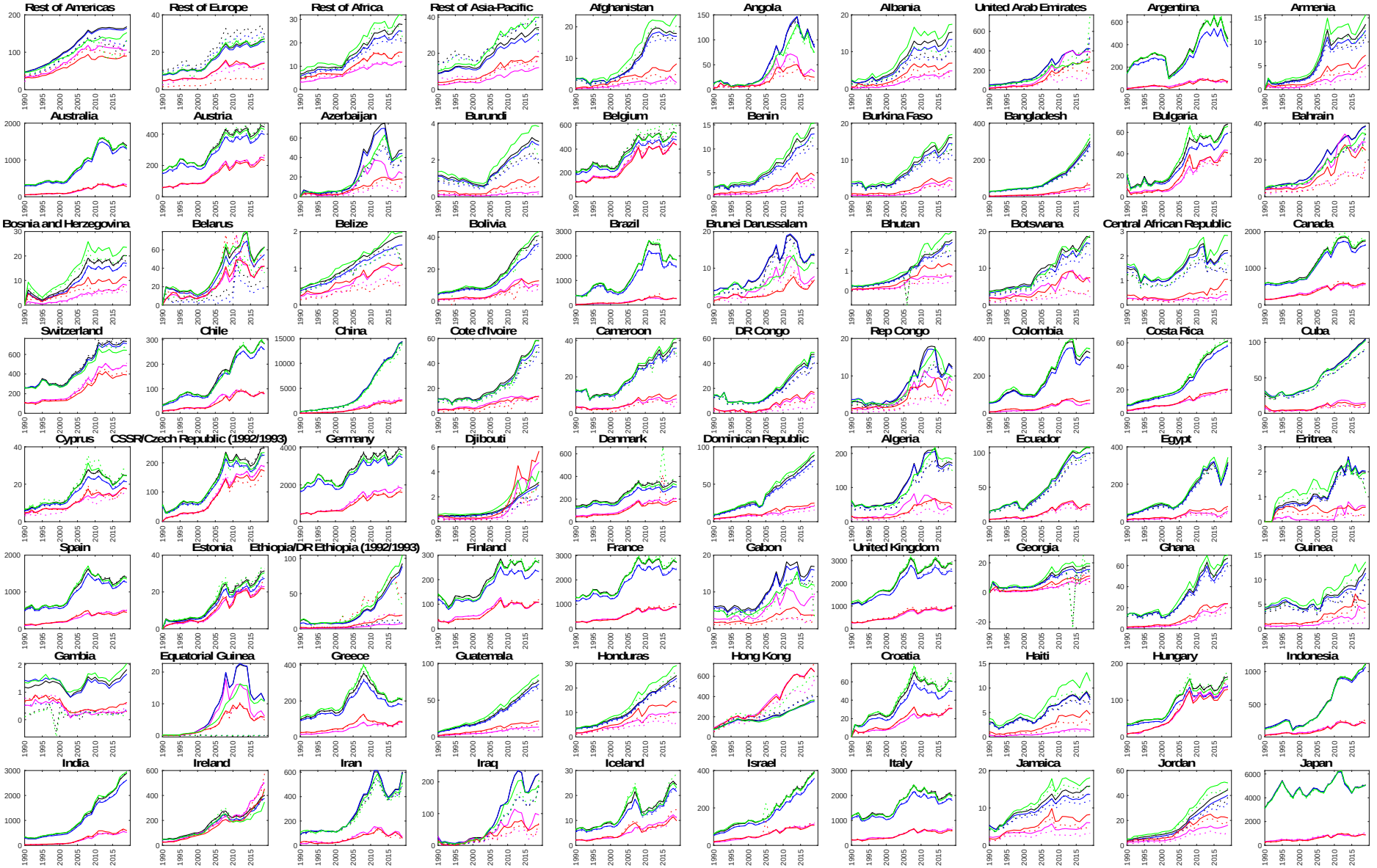
Axis labels:

- x-axis: year
- y-axis: amount in thousand US$ current price

The colour-coding is as follows:

- black: GDP
- blue: total value added
- magenta: total exports
- red: imports
- green: final demand

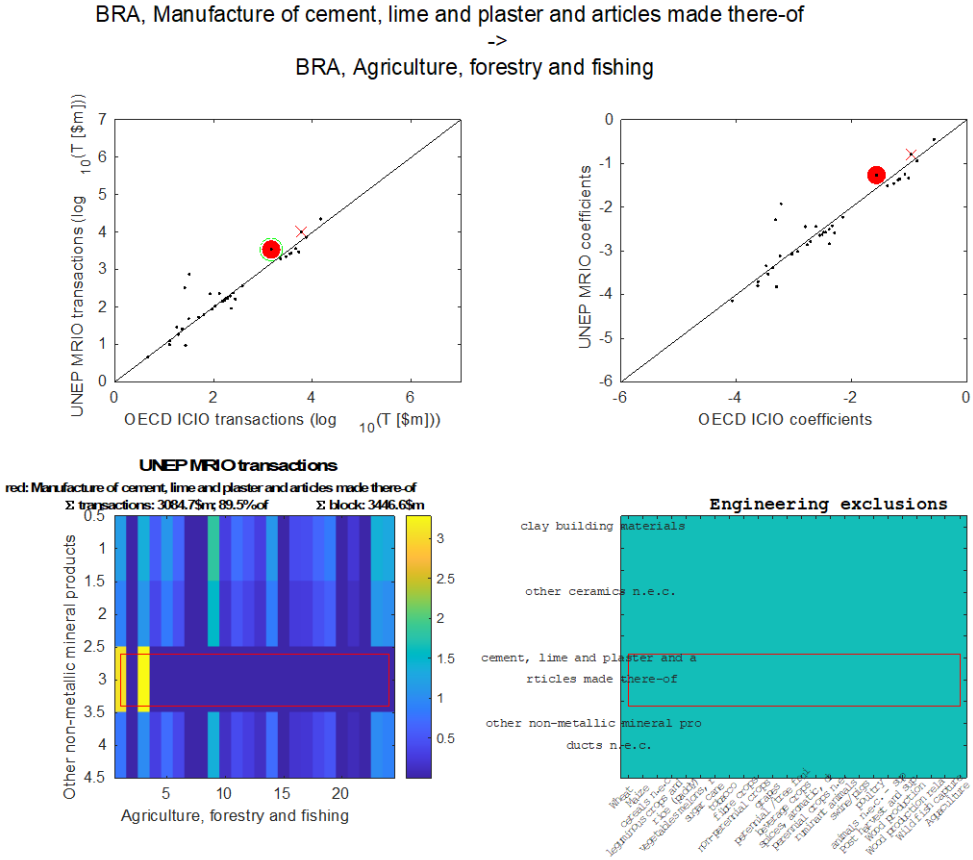
The following two pages contain the results plots for the individual 164 countries and regions given in the GLORIA database. The plots were embedded into this document in high resolution, and the interested reader is encouraged to zoom into individual countries for more detail.


Rest of Americas
Rest of Europe
Rest of Africa
Rest of Asia-Pacific
Afghanistan
Angola
Albania
United Arab Emirates
Argentina
Armenia
Australia
Austria
Azerbaijan
Burundi
Belgium
Benin
Burkina Faso
Bangladesh
Bulgaria
Bahrain
Bosnia and Herzegovina
Belarus
Belize
Bolivia
Brazil
Brunei Darussalam
Bhutan
Botswana
Central African Republic
Canada
Switzerland
Chile
China
Cote d'Ivoire
Cameroon
DR Congo
Rep Congo
Colombia
Costa Rica
Cuba
Cyprus
CSSR/Czech Republic (1992/1993)
Germany
Djibouti
Denmark
Dominican Republic
Algeria
Ecuador
Egypt
Eritrea
Spain
Estonia
Ethiopia/DR Ethiopia (1992/1993)
Finland
France
Gabon
United Kingdom
Georgia
Ghana
Guinea
Gambia
Equatorial Guinea
Greece
Guatemala
Honduras
Hong Kong
Croatia
Haiti
Hungary
Indonesia
India
Ireland
Iran
Iraq
Iceland
Israel
Italy
Jamaica
Jordan
Japan

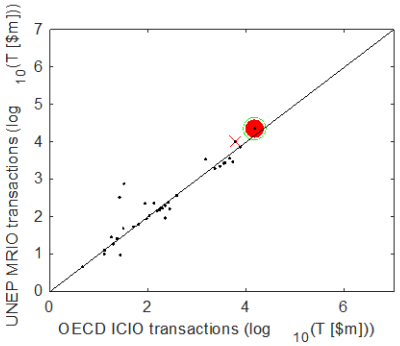
Appendix A8: Visual assessment of engineering exclusions of individual transaction values

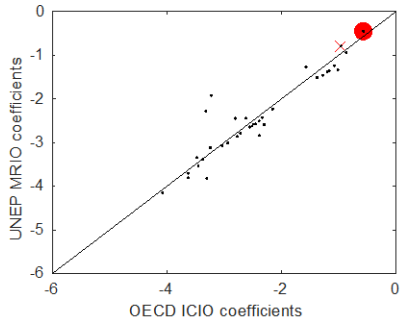
This section lists a number of charts for the assessment of the adherence of the GLORIA database to the engineering exclusion constraints. A detailed discussion of these charts are given in Section *Data-specific documentation -> Engineering constraints*, and in particular in the sub-section *QA process for engineering constraints*.

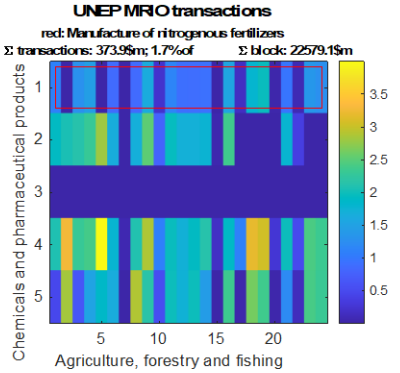
The charts are provided in this section without further comments as the headers hold all necessary information about the contents.

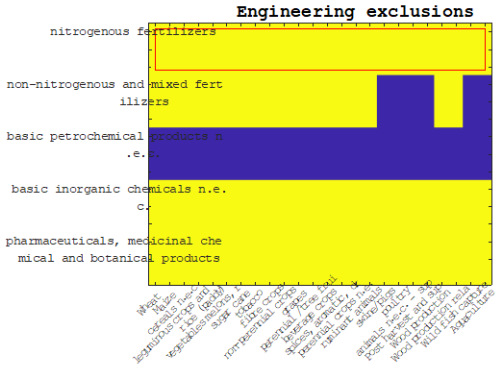


BRA, Manufacture of nitrogenous fertilizers
->
BRA, Agriculture, forestry and fishing

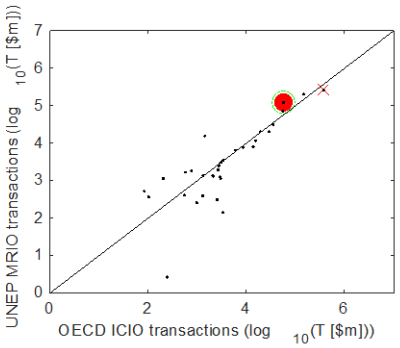


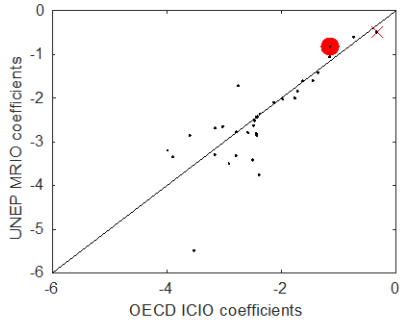


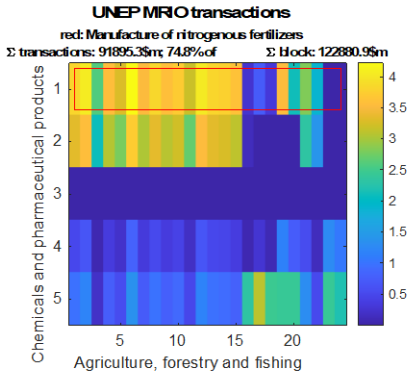


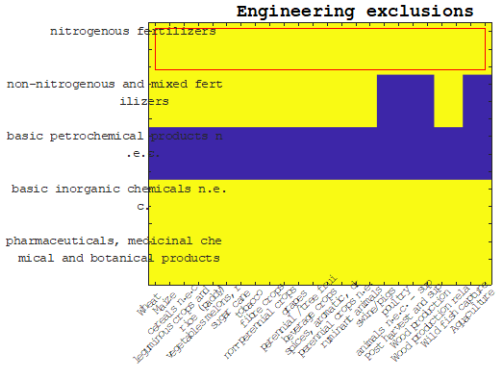


CHN, Manufacture of nitrogenous fertilizers
->
CHN, Agriculture, forestry and fishing

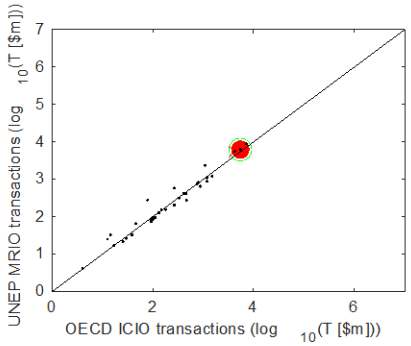


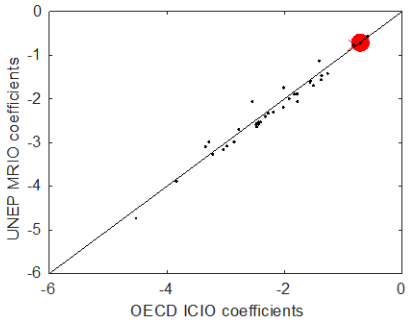


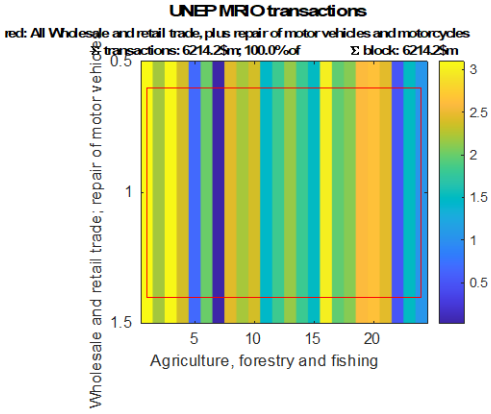


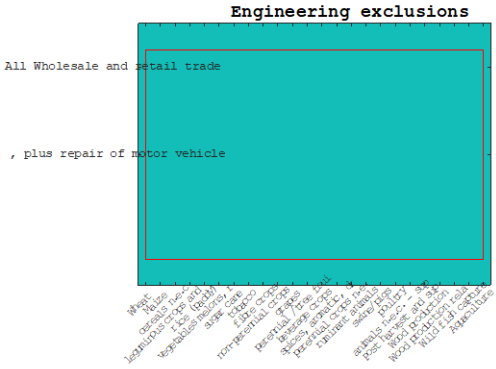


DEU, All Wholesale and retail trade, plus repair of motor vehicles and motorcycles
->
DEU, Agriculture, forestry and fishing

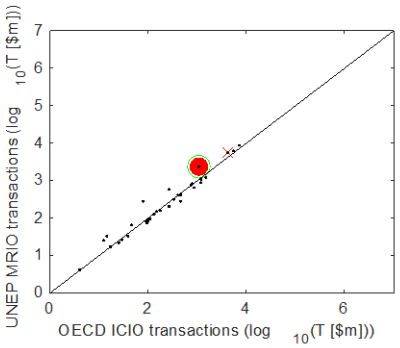


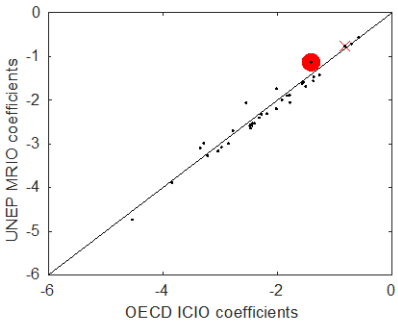


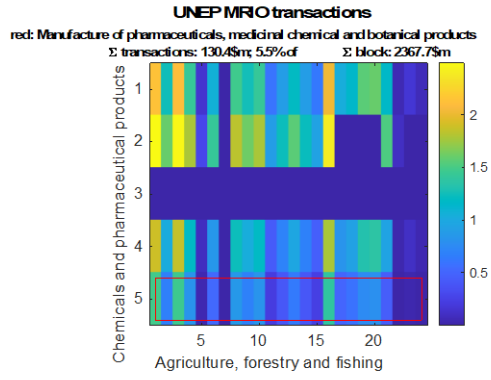


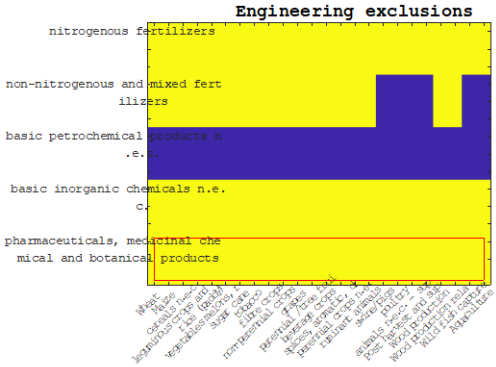


DEU, Manufacture of pharmaceuticals, medicinal chemical and botanical products
->
DEU, Agriculture, forestry and fishing

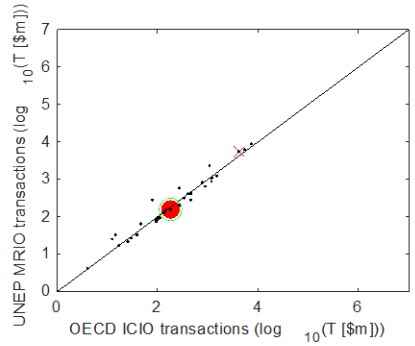


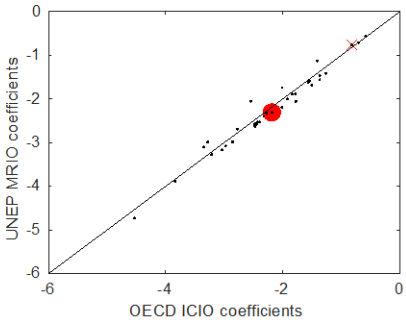


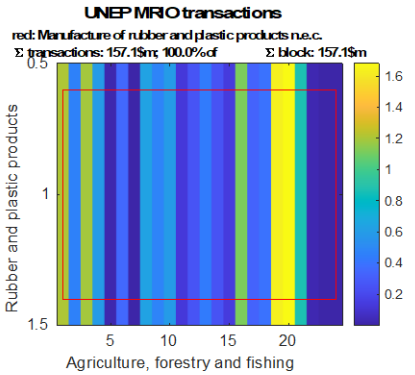


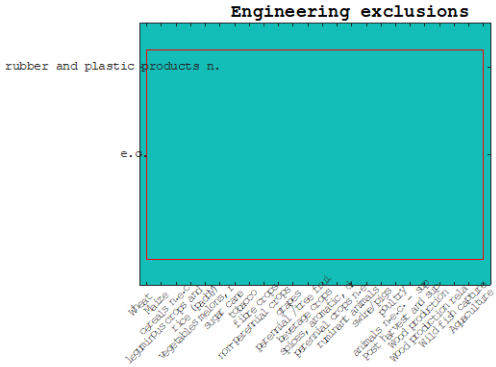


DEU, Manufacture of rubber and plastic products n.e.c.
->
DEU, Agriculture, forestry and fishing

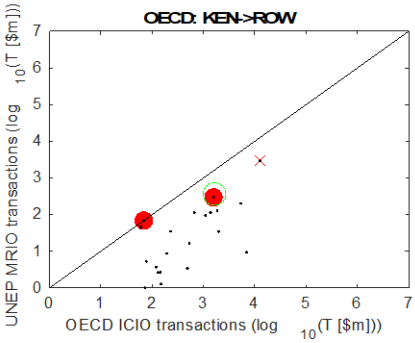


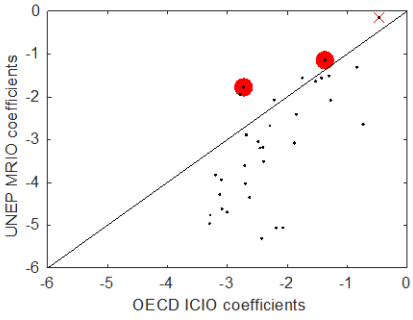


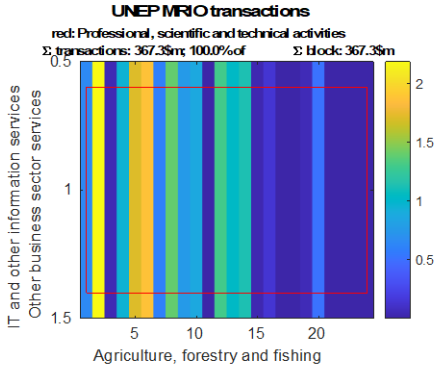


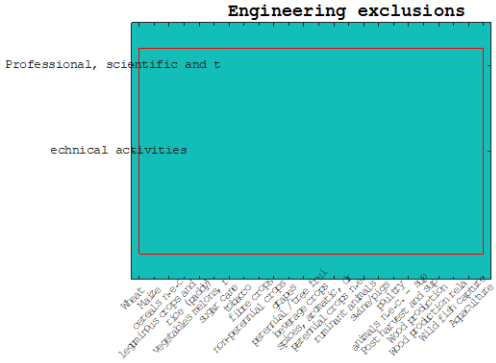


KEN, Professional, scientific and technical activities
->
KEN, Agriculture, forestry and fishing

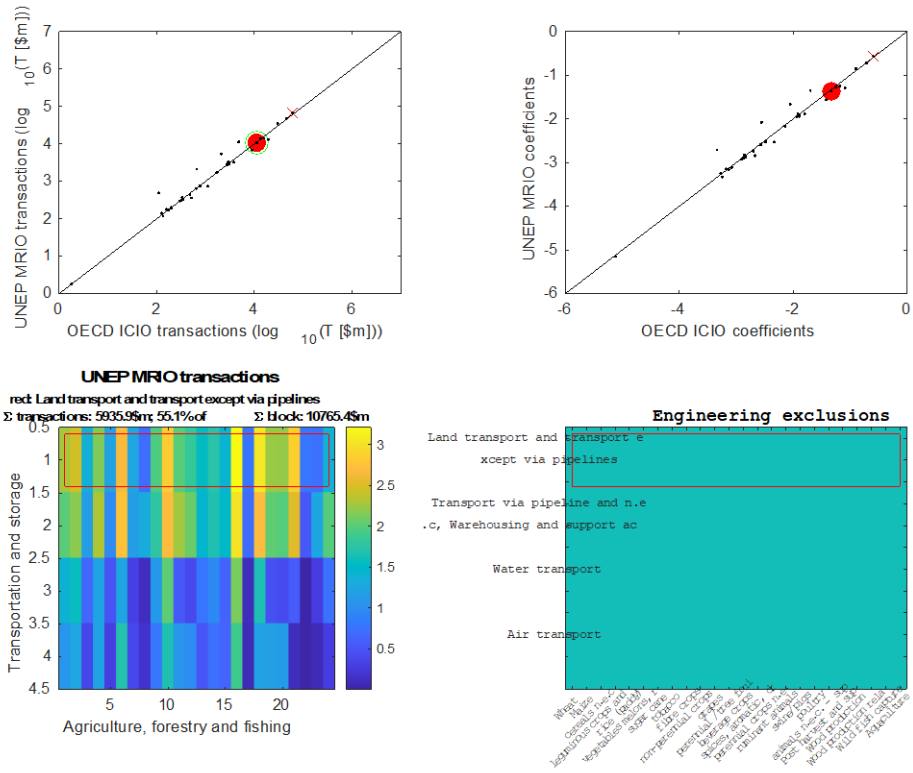






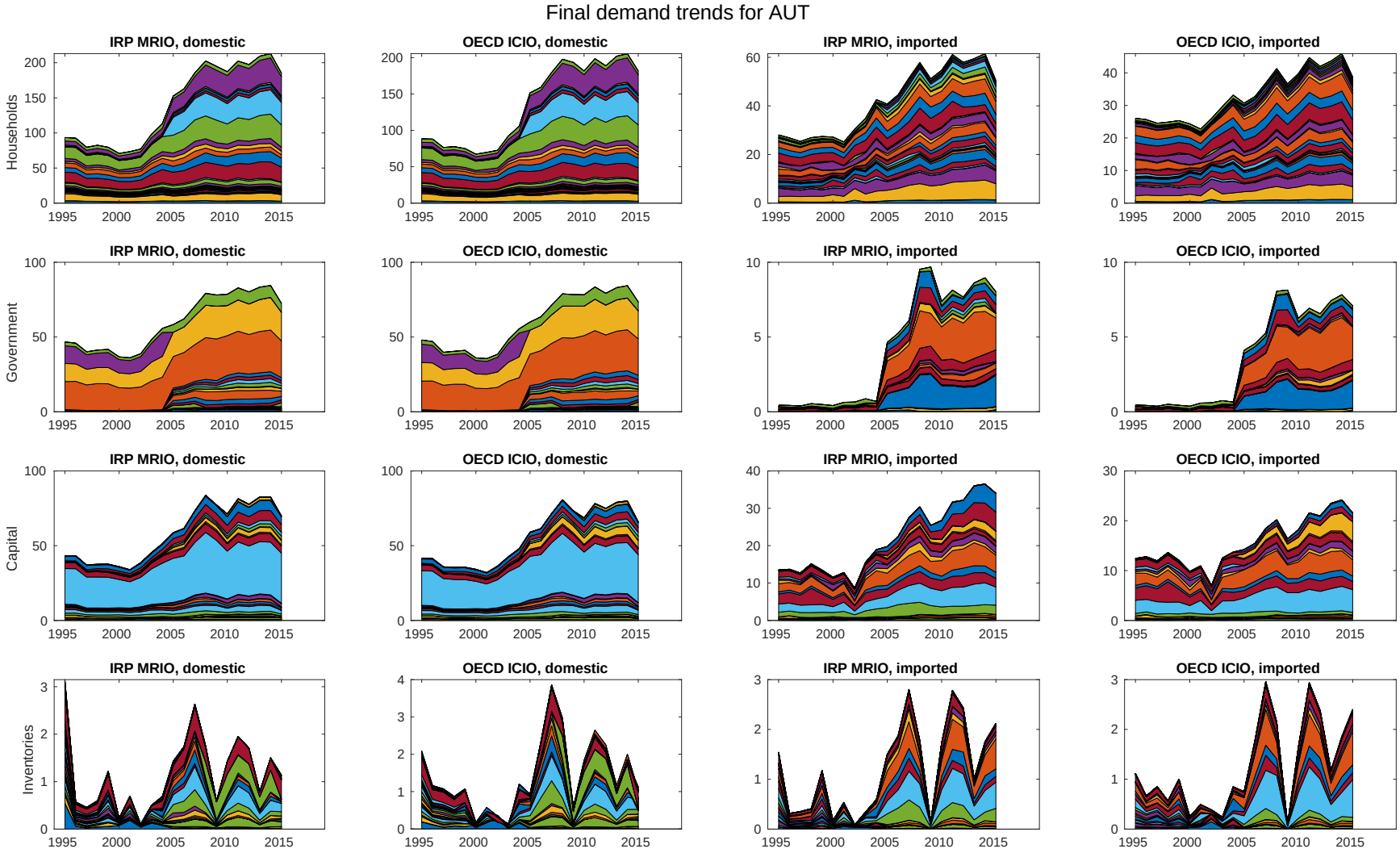


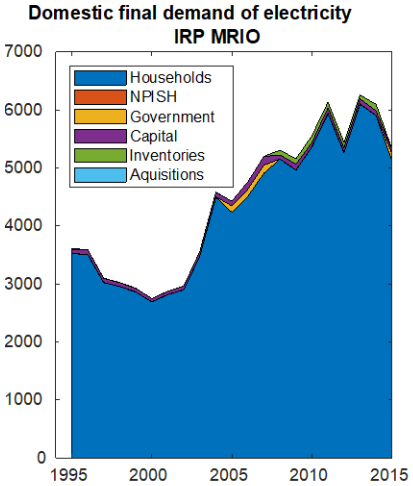
USA, Land transport and transport except via pipelines
->
USA, Agriculture, forestry and fishing

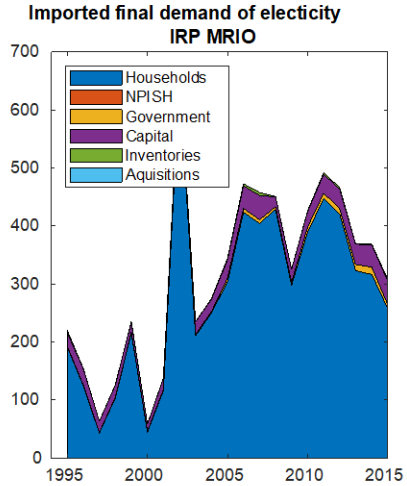


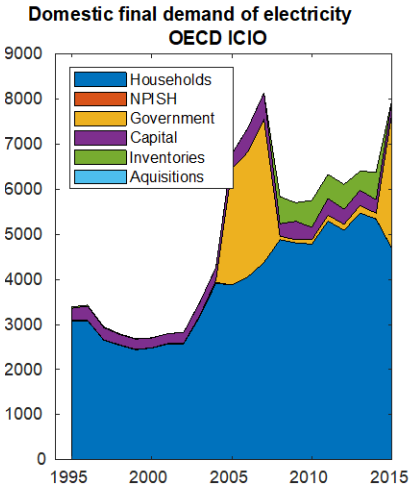
Appendix A9: In-depth energy assessments for selected countries

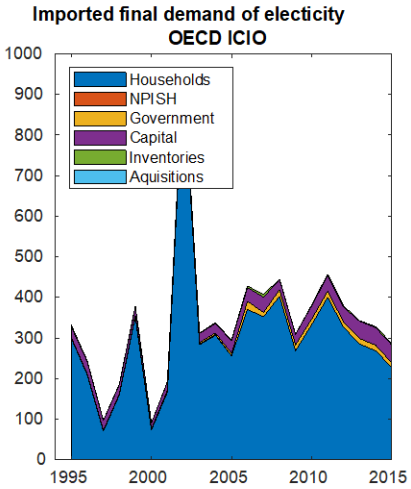
The plots presented in this section follow the same concepts as the plots for New Zealand presented and discussed in the *Section Energy footprints verification*. In all the plots shown in this section, the GLORIA database is referred to as the IRP MRIO.

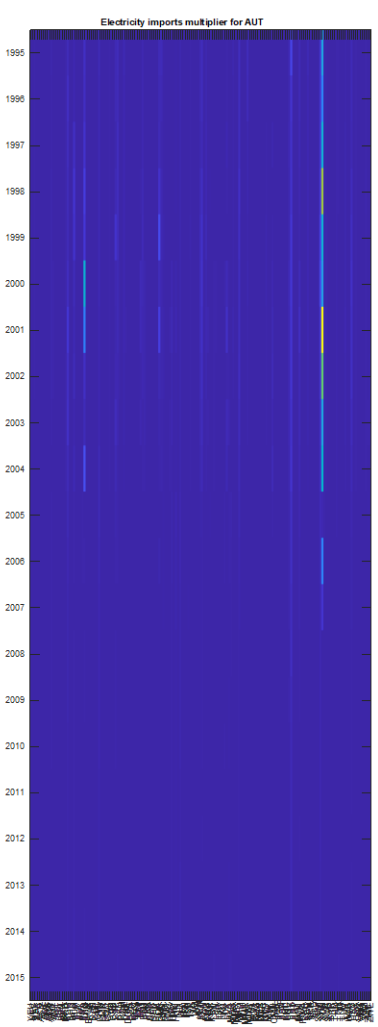

Final demand trends for AUT
IRP MRIO, domestic
OECD ICIO, domestic
IRP MRIO, imported
OECD ICIO, imported
Households
Government
Capital
Inventories
1995
2000
2005
2010
2015

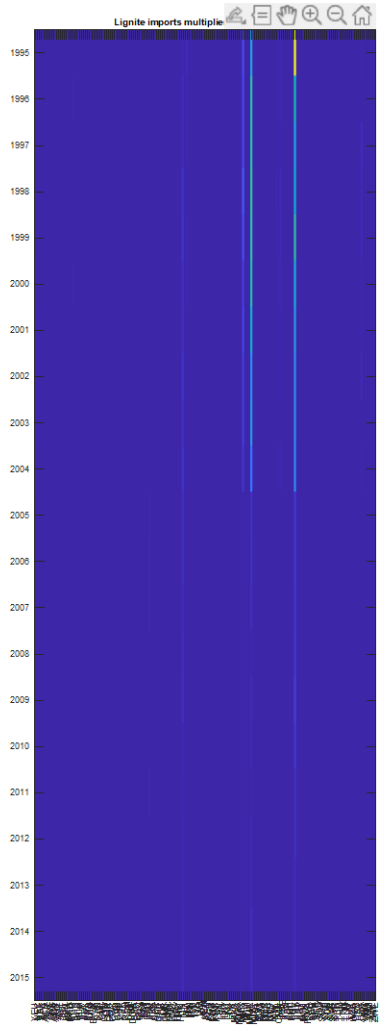

Domestic final demand of electricity
IRP MRIO
Households
NPISH
Government
Capital
Inventories
Aquisitions
7000
6000
5000
4000
3000
2000
1000
0
1995
2000
2005
2010
2015

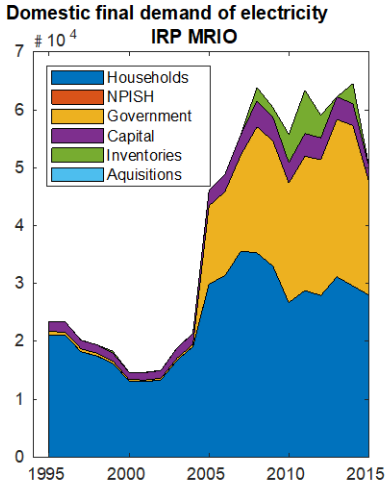

Imported final demand of electicity
IRP MRIO
Households
NPISH
Government
Capital
Inventories
Aquisitions
700
600
500
400
300
200
100
0
1995
2000
2005
2010
2015

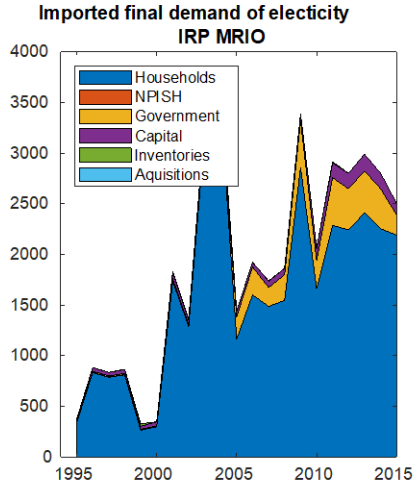

Domestic final demand of electricity
OECD ICIO
Households
NPISH
Government
Capital
Inventories
Aquisitions
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1995
2000
2005
2010
2015

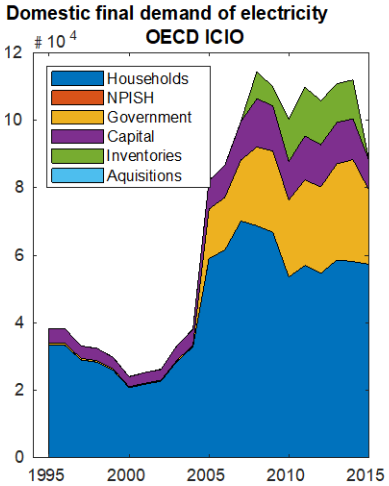

Imported final demand of electicity
OECD ICIO
Households
NPISH
Government
Capital
Inventories
Aquisitions
1000
900
800
700
600
500
400
300
200
100
0
1995
2000
2005
2010
2015

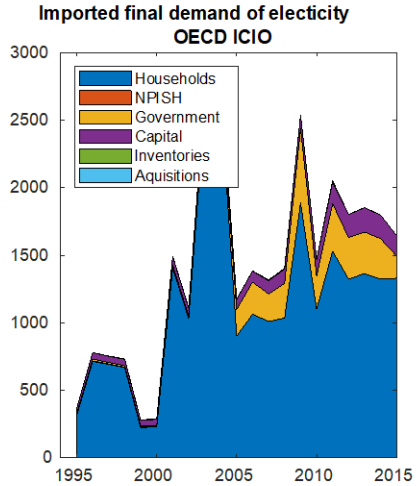

Electricity imports multiplier for AUT
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

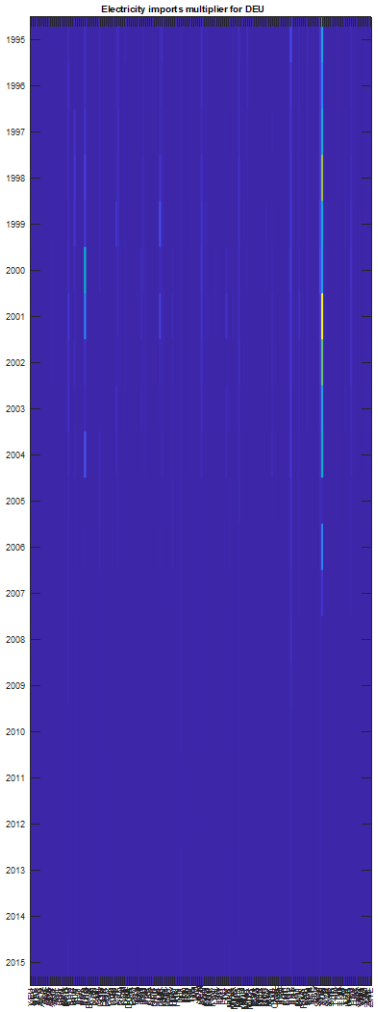

Lignite imports multiplie
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

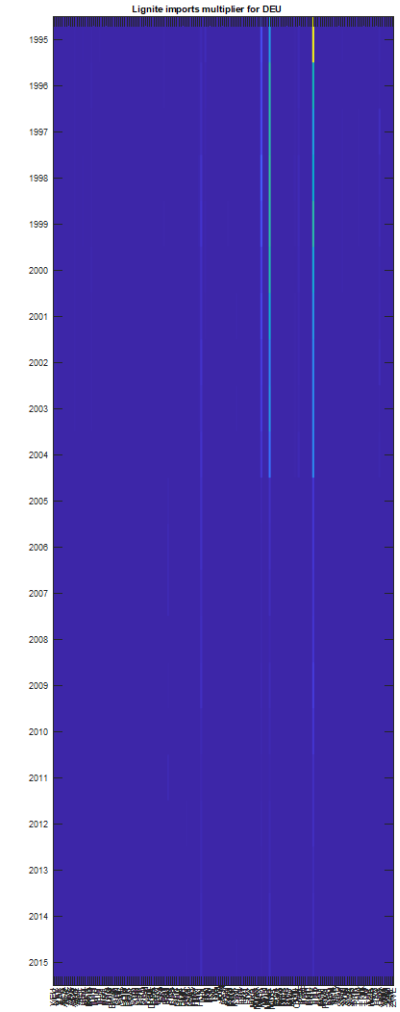

Domestic final demand of electricity
IRP MRIO
10 4
Households
NPISH
Government
Capital
Inventories
Aquisitions

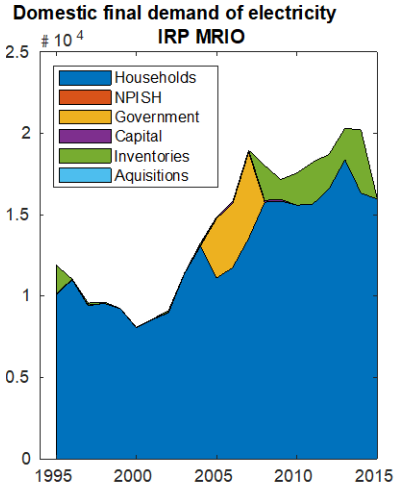

Imported final demand of electicity
IRP MRIO
Households
NPISH
Government
Capital
Inventories
Aquisitions

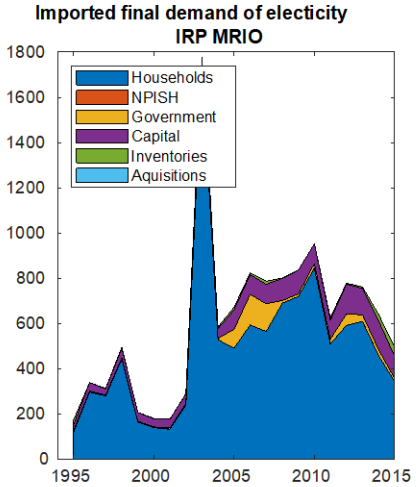

Domestic final demand of electricity
OECD ICIO
10 4
Households
NPISH
Government
Capital
Inventories
Aquisitions

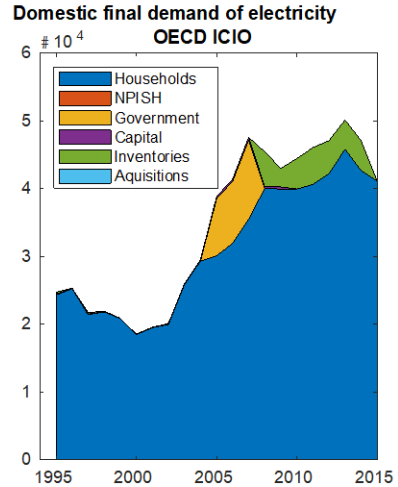

Imported final demand of electicity
OECD ICIO
Households
NPISH
Government
Capital
Inventories
Aquisitions

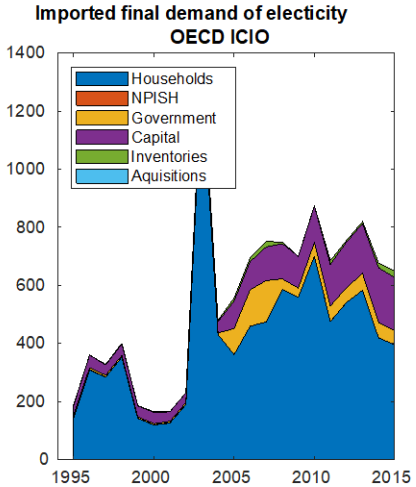

Electricity imports multiplier for DEU

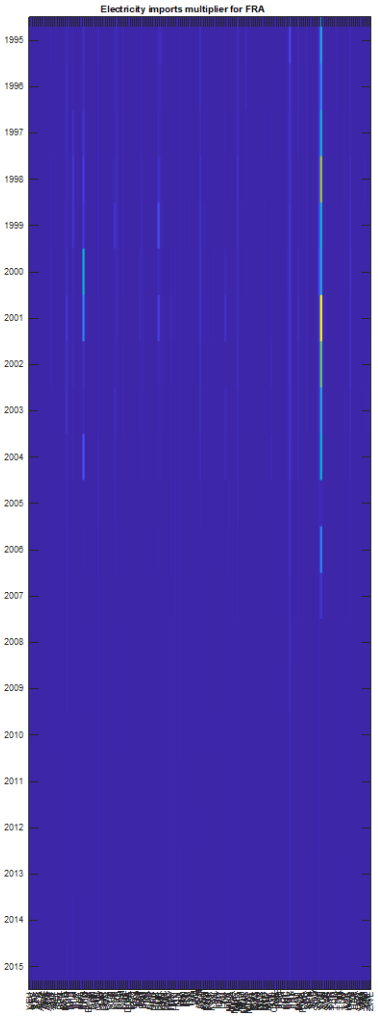

Lignite imports multiplier for DEU

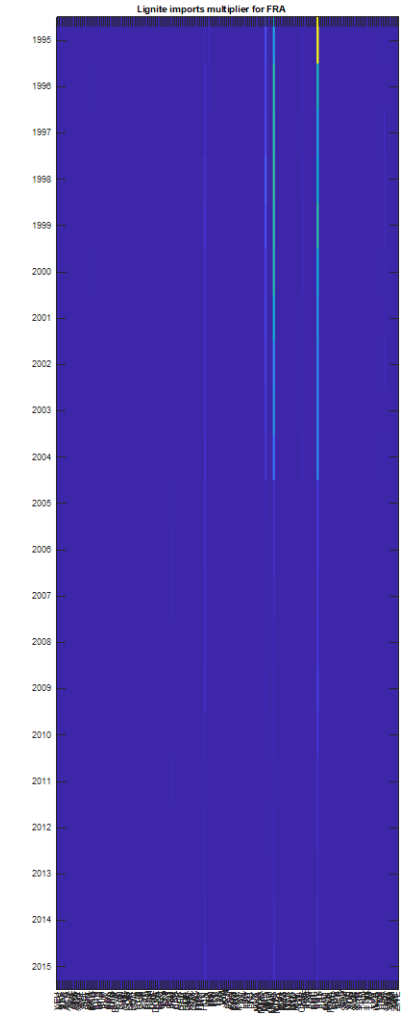

Domestic final demand of electricity
IRP MRIO
10 4
Households
NPISH
Government
Capital
Inventories
Aquisitions


Imported final demand of electicity
IRP MRIO
Households
NPISH
Government
Capital
Inventories
Aquisitions


Domestic final demand of electricity
OECD ICIO
10 4
Households
NPISH
Government
Capital
Inventories
Aquisitions

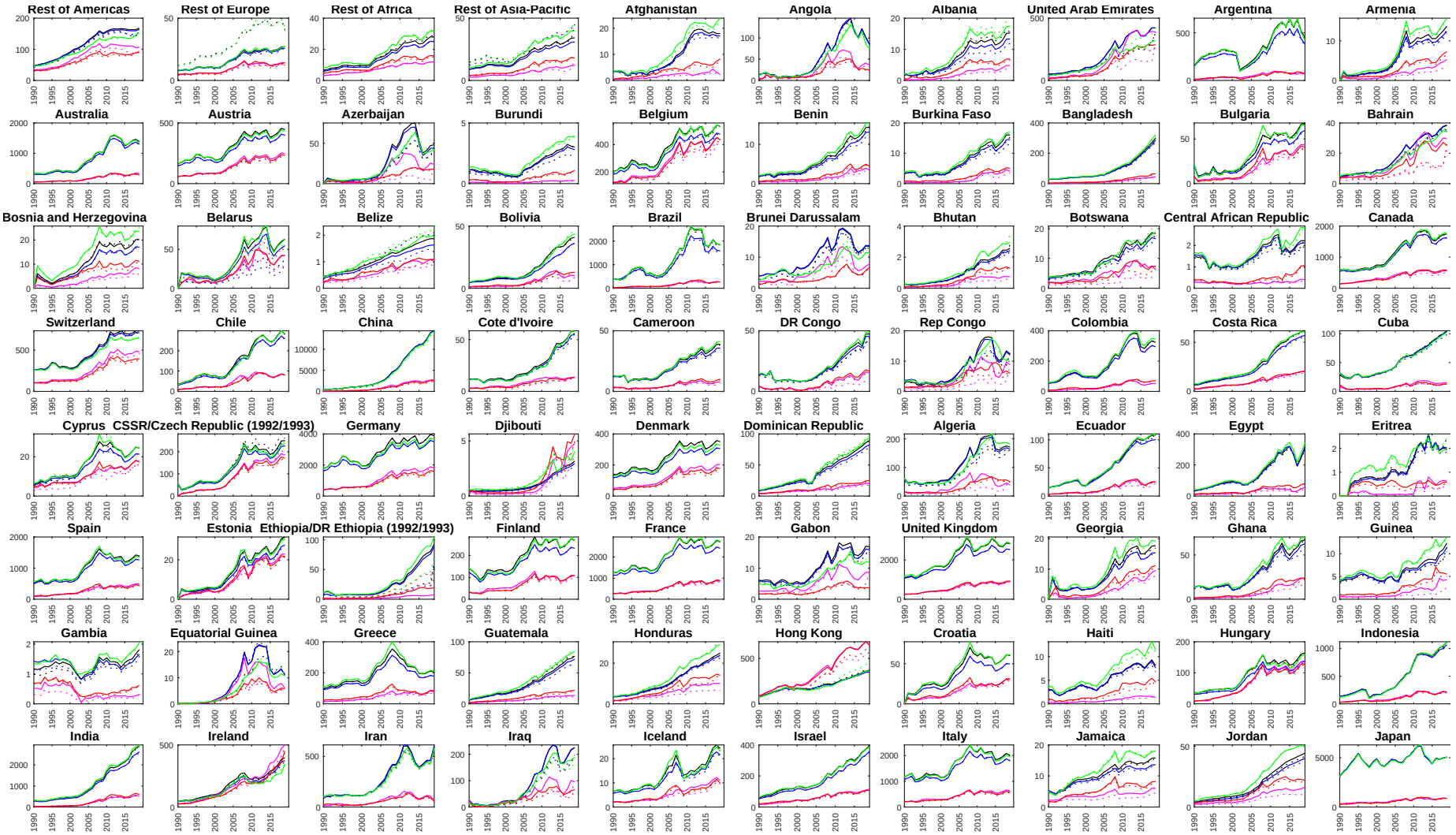

Imported final demand of electicity
OECD ICIO
Households
NPISH
Government
Capital
Inventories
Aquisitions


Electricity imports multiplier for FRA


Lignite imports multiplier for FRA

Appendix A10: Comparison of macro-economic indicators as provided by the UN SNA MA database and the GLORIA database after the improvement of the data reconciliation routine.

This section shows the plots described in Appendix A7, but following the improved data reconciliation approach. The spikes previously reported for Demnark, Niger, Macedonia, Slovakia, Israel, Poland, and Georgia


Rest of Americas
Rest of Europe
Rest of Africa
Rest of Asia-Pacific
Afghanistan
Angola
Albania
United Arab Emirates
Argentina
Armenia
Australia
Austria
Azerbaijan
Burundi
Belgium
Benin
Burkina Faso
Bangladesh
Bulgaria
Bahrain
Bosnia and Herzegovina
Belarus
Belize
Bolivia
Brazil
Brunei Darussalam
Bhutan
Botswana
Central African Republic
Canada
Switzerland
Chile
China
Cote d'Ivoire
Cameroon
DR Congo
Rep Congo
Colombia
Costa Rica
Cuba
Cyprus
CSSR/Czech Republic (1992/1993)
Germany
Djibouti
Denmark
Dominican Republic
Algeria
Ecuador
Egypt
Eritrea
Spain
Estonia
Ethiopia/DR Ethiopia (1992/1993)
Finland
France
Gabon
United Kingdom
Georgia
Ghana
Guinea
Gambia
Equatorial Guinea
Greece
Guatemala
Honduras
Hong Kong
Croatia
Haiti
Hungary
Indonesia
India
Ireland
Iran
Iraq
Iceland
Israel
Italy
Jamaica
Jordan
Japan

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FAO (2020b) *Value of Agricultural Production*. Internet site http://www.fao.org/faostat/en/#data/QV, Rome, Italy, Food and Agriculture Organization of the United Nations (FAO).

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Lenzen, M., A. Geschke, M.D. Abd Rahman, Y. Xiao, J. Fry, R. Reyes, E. Dietzenbacher, S. Inomata, K. Kanemoto, B. Los, D. Moran, H. Schulte in den Bäumen, A. Tukker, T. Walmsley, T. Wiedmann, R. Wood and N. Yamano (2017b) The Global MRIO Lab – charting the world economy. *Economic Systems Research* 29, 158-186.

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