Data Article

Transport cost to port through Brazilian federal roads network: Dataset for years 2000, 2005, 2010 and 2017

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\textbf{A B S T R A C T}

Transport costs can play a significant role in agricultural exports and businesses profitability. It can also influence farmers’ decisions regarding cropland expansion, intensification or land abandonment. Thus, transport is useful to take into account when modeling and evaluating land use and cover change related to agriculture production. The dataset described in this article represents the Infrastructure Capital in the work presented by Millington et al. (2021) [1], in which the CRAFTY-Brazil model is used to evaluate the impacts of changing global demand for agricultural products on land use and cover change. This modeling required a transport cost dataset that spanned the model calibration period, was consistent through time and covered the entire study area. The most recent federal road network (for year 2017) obtained in vector format (shapefile) was joined to road section surface status tables for past years (2000, 2005 and 2010) in order to reconstruct the historic road network. Export ports

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Specifications Table

| Subject | Transportation |
|---------|----------------|
| Type of data | Table |
| How data were acquired | All original data were downloaded from official governmental websites and processed using GRASS GIS v.7 [2]. |
| Data source location | Institution: Embrapa Agricultural Informatics |
| City/Town/Region | Campinas, SP |
| Country | Brazil |
| Data format | Raw |
| Parameters for data collection | Only data from official governmental sources were utilized. For some ports, the operational history was obtained from the portal website or regional news reports. |
| Description of data collection | Federal road network shapefiles and road status data were downloaded from the Brazilian National Department of Transport Infrastructure (DNIT) website. The two datasets used were the National Road System (SNV – Sistema Nacional de Viação) for year 2017, obtained from the DNITGeo website [3] and the road status tables from the National Road Plan (PNV) for years 2000, 2005 and 2010, obtained from [4]. Information on export port operations were obtained from the Agrostat website [5]. Also, some news reports and information on the history of selected ports were consulted in order to establish the start of operations. All data were processed in GRASS GIS [2] and the commands and scripts used to recreate the final road network status for years 2000, 2005 and 2010, along with the transport cost maps, are included in this dataset. |
| Data accessibility | Repository name: Mendeley Data |
| Data identification number | DOI: 10.17632/6xbjzyz3th.2 |
| Related research article | James D.A. Millington, Valeri Katerinchuk, Ramon Felipe Bicudo da Silva, Daniel de Castro Victoria, Mateus Batistella. Modelling drivers of Brazilian agricultural change in a telecoupled world. Environmental Modelling & Software. Volume 139, 2021, 105,024, ISSN 1364–8152. |
Value of the Data

- Transport cost and road infrastructure play an important role in agricultural exports. Information on how these costs change over time and across space can help understand the dynamics behind land use/cover change and the impact of infrastructure development on the agriculture sector. The dataset covers Brazil, a large and important producer of agricultural products traded internationally.
- The dataset can be used by researchers and decision-makers studying or concerned about land use/cover change and the impact of infrastructure on commodities export, how transport costs have changed over time, where new transportation and port infrastructure could be placed, or to identify bottlenecks in transport infrastructure. It could also be used to guide future infrastructure development plans.
- The dataset considers a relative cost difference among regions and road status and is accompanied by all codes and scripts used to create it. Thus, users of the dataset may adapt or improve upon the data, given their specific needs. All data were processed using open source software and are supplied in common formats supported by all major GIS. Thus, there is no need to acquire licenses to recreate or improve the results.
- Up-to-date roads network maps are available from the Brazilian transportation authority [3]. However, past road surface statuses are supplied as tables [4], not easily related to the road network, making it difficult to map past road conditions. The process described here links road sections to past surface status, resulting in transportation cost surfaces that are consistent and comparable across years.

1. Data Description

The dataset is organized in a folder structure that includes: i) a detailed description of the steps used to create the transport cost surface dataset; ii) the input datasets used to create the final transport cost iii) the actual transport cost dataset and iv) figures used in the detailed description report.

The contents of root folder of the dataset includes:

1. A brief description of the dataset folder structure (readme.md or readme.txt) in markdown format or text without formatting marks, respectively;
2. a detailed description of the dataset creation process, including all GRASS GIS commands used, explanatory text and results obtained. This is presented in markdown format (transport_cost.md) and also in a rendered PDF file (transport_cost.pdf);
3. Additional code used in the data creation process including a bash script (add_surface_code.sh) that inserts road status codes to the road network vector layer used inside GRASS GIS and a python script (fix_road_attrib.py) that matches road sections in the road network vector layer to road surface status in the status table for each year. Files matches_2000.txt, matches_2005.txt and matches_2010.txt contain the matches obtained by the python script.

The input folder contains the original data used to create the transport cost dataset. It contains the road networks vector files, the road surface status tables and export port locations, as described below:

1. Folder input/ports contains the location of all Brazilian soy export ports (SoyPorts.shp); internal soy Ports (internal_ports_soybean.shp), that sends the commodity to an export port; and a table (ports_year_active.ods or ports_year_active.xlsx) detailing which ports were active in each year. This dataset was built using the Brazilian Agrostat plataform [5]. Both location datasets are in shapefile format, which can be opened by all major GIS software. The readme.md file describes the data sources;
2. Folder `input/roads/PNV` contains the Brazilian Federal Road network in shapefile format (`SNV_201710b.shp` and accompanying files). This represents the road network status in the year 2017 and was obtained from the DNIT - National Department of Transport Infrastructure [3]. A brief description of the dataset is given in `readme_SNV_roads.md`;

3. Folder `input/roads/Brazil_federal_roads_SNV` contains federal road section and surface status for years 2000, 2005 and 2010. It was obtained from the DNIT - National Roads Plan (PNV) [4] in Microsoft Excel format (ex.: `PNV2000.xlsx`) and converted to CSV (ex.: `PNV2000.csv`) to allow for data import into Grass GIS. CSVT files (ex.: `PNV2000.csvt`) indicates data field types, needed to import data in the correct format. A brief description of the dataset is given in `readme_road_network_status.md`;

The output folder contains the results of the data analysis conducted on the input data by following the steps detailed in `transport_cost.md`. It contains:

1. `road_network_ports_2000_2017.zip` - Vector layers (GeoPackage format) of export ports and reconstructed federal road network status for years 2000, 2005, 2010 and 2017 (Fig. 1). Data is supplied in Geopackage format that can be opened by all major GIS software. Due to its size, the GeoPackage file has been compacted;

2. `road_distanceYYYY.zip` - Raster images (GeoTIFF format) of relative cost distance to the nearest export port for the Brazilian territory, years 2000, 2005, 2010 and 2017 (Fig. 2). Dataset uses WGS84 Spatial Reference System (EPSG:4326) with 36 arcsec spatial resolution (approx 550 m). The GeoTIFF format can be opened by all major GIS software.

The fig folder contains figures used here and in the full detailed report (`transport_cost.md` or `transport_cost.pdf`) in PNG format. These include the reconstructed Brazilian federal road network
Fig. 2. Cumulative cost distance to port, for years 2000, 2005, 2010 and 2017.

with road surface status and port locations for years 2000, 2005, 2010 and 2017 and the relative cost distance to the closest export port for years 2000, 2005, 2010 and 2017.

A summary of the folder structure and its contents is given in Table 1.

2. Experimental Design, Materials and Methods

This dataset was constructed to be used as the Infrastructure Capital input for the CRAFTY-Brazil model [1].

2.1. Road network reconstruction

A detailed federal road network vector dataset was downloaded from the National Department of Transport Infrastructure (DNIT) geospatial database [3]. This database contains road network vector layers, in shapefile format, beginning in 2013. The dataset for 2017 was used, along with road number, the road section code, road section start and stop km marks and road surface status, with the following classification (original class code and portuguese description in parentheses):

1. Planned (“PLA - Planejada”)
2. Unpaved network (“Rede não pavimentada”)
   1. Natural terrain. Open road, not conforming to construction regulations (“LEN - leito natural”)
   2. Under construction to be implemented (“EOI - em obras implantde implantação”)
## Table 1

Folder structure, files contained in the dataset and detailed description.

| Folder                      | Files                                                                 | Description                                                                                                                                                                                                 |
|-----------------------------|-----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| **imgs**                    | dnit2000_road_network_ports.pgw<br>dnit2000_road_network_ports.png<br>dnit2005_road_network_ports.pgw<br>dnit2005_road_network_ports.png<br>dnit2010_road_network_ports.pgw<br>dnit2010_road_network_ports.png<br>dnit2017_road_network_ports.pgw<br>dnit2017_road_network_ports.png<br>dnit_road_network_4years.png<br>dnit_road_network_4years_no_annotations.png<br>dnit_road_network_4years_no_annotations_simple_legend.png<br>dnit_road_distance2000.png<br>dnit_road_distance2005.png<br>dnit_road_distance2010.png<br>dnit_road_distance2017.png<br>dnit_road_distance_4years.png | Folder contains figures used in the full detailed report (transport_cost.md). Actual final dataset is in output folder. Brazilian federal road network with road surface status and port locations for years 2000, 2005, 2010 and 2017. Accompanying PGW files contain georeferencing information for the PNG files. Figure with all four years of road network and ports, with, without annotations and simplified legend. Relative cost distance to the closest export port for years 2000, 2005, 2010 and 2017. Figure with all four years of road network cost distance to closest port. Brief explanation of the ports input dataset. Shapefile with the location of internal and export ports that handle agricultural commodities. Shapefile format is comprised of several files, not all being mandatory. Shapefile with location of export ports that handle agricultural commodities. Shapefile format is comprised of several files, not all being mandatory. Spreadsheet detailing amount of soy exported by each port, each year, in order to determine when each export port was active. Available in LibreOffice format (ODS) and Excel (XLSX). Tables indicating federal road section and surface status for years 2000, 2005 and 2010. Original data from DNIT is in XLSX format. Converted to CSV for data import into Grass GIS. CSV file indicates data field types, needed to import data in the correct format. Brief indication of data source. Shapefile with the federal road network for the year 2017. Contains road surface status. |
| **input/ports**             | readme.md<br>internal_ports_soybean.cpg<br>internal_ports_soybean.dbf<br>internal_ports_soybean.prj<br>internal_ports_soybean.sbn<br>internal_ports_soybean.sbx<br>internal_ports_soybean.prj<br>internal_ports_soybean.dbf<br>internal_ports_soybean.cpg<br>ports_year_active.ods<br>ports_year_active.xlxs | Brief indication of data source and road status code and description in Portuguese and English. Shapefile with location of export ports that handle agricultural commodities. Shapefile format is comprised of several files, not all being mandatory. Spreadsheet detailing amount of soy exported by each port, each year, in order to determine when each export port was active. Available in LibreOffice format (ODS) and Excel (XLSX). Tables indicating federal road section and surface status for years 2000, 2005 and 2010. Original data from DNIT is in XLSX format. Converted to CSV for data import into Grass GIS. CSV file indicates data field types, needed to import data in the correct format. Brief indication of data source. Shapefile with the federal road network for the year 2017. Contains road surface status. |
| **input/roads/PNV**         | readme_road_network_status.md<br>PNV2000.csv<br>PNV2000.csvt<br>PNV2000.xls<br>PNV2005.csv<br>PNV2005.csvt<br>PNV2005.xls<br>PNV2010.csv<br>PNV2010.csvt<br>PNV2010.xls | Brief indication of data source and road status code and description in Portuguese and English. Shapefile with location of export ports that handle agricultural commodities. Shapefile format is comprised of several files, not all being mandatory. Spreadsheet detailing amount of soy exported by each port, each year, in order to determine when each export port was active. Available in LibreOffice format (ODS) and Excel (XLSX). Tables indicating federal road section and surface status for years 2000, 2005 and 2010. Original data from DNIT is in XLSX format. Converted to CSV for data import into Grass GIS. CSV file indicates data field types, needed to import data in the correct format. Brief indication of data source. Shapefile with the federal road network for the year 2017. Contains road surface status. |
| **input/roads/Brazil联邦_道路_SNV** | readme_SNV_roads.md<br>SNV_201710B.cpg<br>SNV_201710B.dbf<br>SNV_201710B.prj<br>SNV_201710B.sbn<br>SNV_201710B.sbx<br>SNV_201710B.shp<br>SNV_201710B.shx | Brief indication of data source. Shapefile with the federal road network for the year 2017. Contains road surface status. |
Table 1 (continued)

| Folder          | Files                          | Description                                                                                     |
|-----------------|--------------------------------|------------------------------------------------------------------------------------------------|
| output          | road_distance2000.zip          | Raster images (GeoTIFF format) of relative cost distance to the nearest export port for the    |
|                 | road_distance2005.zip          | Brazilian territory, years 2000, 2005, 2010 and 2017.                                            |
|                 | road_distance2010.zip          | Dataset uses WGS84 Spatial Reference System (EPSG:4326) with 36 arcsec spatial resolution       |
|                 | road_distance2017.zip          | (aprox 550 m)                                                                                  |
|                 | road_network_ports_2000_2017.zip | Vector layers (GeoPackage format) of export ports and reconstructed federal road network       |
| . (root)        | readme.md and readme.txt       | Brief directory structure description                                                           |
|                 | add_surface_code.sh            | Bash script to insert road surface status code to 2017 road network vector layer               |
|                 | fix_road_attrib.py             | Python script to identify matches from road sections in the road network vector layer to road  |
|                 | matches_2000.txt               | surface status table for each year.                                                             |
|                 | matches_2005.txt               | Results from the road section and status match python script.                                   |
|                 | matches_2010.txt               | Detailed description of dataset creation, including GRASS GIS commands used and results         |
|                 | transport_cost.md              | obtained. Report is in Markdown format (md) and is accompanied by a rendered PDF.               |
|                 | transport_cost.pdf             |                                                                                                 |

3. Established unpaved road ("IMP - implantada")
4. Under construction. Established road being paved ("EOP - em obras pavimentação")
3. Paved network ("rede pavimentada")
   1. Paved road single lane ("PAV - pista simples")
   2. Second lane under construction. Paved road being duplicated - ("EOD - em obra de duplicação")
3. Double lane ("DUP - pista dupla")

In order to reconstruct road networks and surface status prior to year 2013, road section information for the years 2000, 2005 and 2010 were obtained from the National Road System (SNV) [4]. This information comes as tables known as National Roads Plan (PNV – Plano Nacional de Viação) and includes information on road number, road section identification code, the Brazilian state crossed by the road, section start and stop landmarks and kilometer marks, section length and road surface status.

Unfortunately, road section identification codes from the vector network dataset for 2017 does not match all section codes found in the 2000, 2005 and 2010 tables. After joining the vector network dataset with the surface status tables, some road segments will remain unclassified. Thus, the best possible match between the vector network sections and surface status tables were obtained based on road number, Brazilian state and section start and stop kilometer marks. A python script (fix_road_attribute.py) was used to automate this process and identify possible matches. The script identifies all sections from the road network dataset without surface type information. It then searches the status table for sections with the same road number, that crosses the same Brazilian state and is either entirely within the section identified in the road network dataset or covers its start or end portions. Since this procedure can return more than one match, the most frequent surface type is assigned to the road section.

2.2. Port activity dataset

Brazilian ports that export agricultural commodities were identified based on information from Agrostat [5], a database for Brazilian agricultural exports, which includes among other
Table 2
Brazilian ports with agricultural commodities exports in 2000, 2005, 2010 and 2017 (0 indicates no exports. 1 indicates exports).

| Port                  | 2017 | 2010 | 2005 | 2000 | Observations                                                                 |
|-----------------------|------|------|------|------|-------------------------------------------------------------------------------|
| Manaus                | 1    | 1    | 1    | 1    | Soy exports only in 2017. But is REMOVED from the analysis since volume is very low (< 0.5% exports) |
| Itacuatiara*          | 1    | 1    | 1    | 1    | No soy export from 2002 to 2005 but active in other commodities               |
| São Luis              | 1    | 1    | 1    | 1    | REMOVED: < 0.5% soy exports                                                  |
| Aracajú               | 1    | 0    | 0    | 0    | Focused on mineral exports. Started operating ag. commodities in 2007 (cocoa) and 2008 (meat) |
| Salvador              | 1    | 1    | 1    | 1    |                                                                               |
| Ilheus                | 1    | 1    | 1    | 1    |                                                                               |
| Vitória               | 1    | 1    | 1    | 1    |                                                                               |
| Barcarena             | 1    | 1    | 0    | 0    |                                                                               |
| Belém                 | 0    | 0    | 0    | 0    |                                                                               |
| Santarém              | 1    | 1    | 1    | 0    |                                                                               |
| Santos                | 1    | 1    | 1    | 1    |                                                                               |
| Paranaguá             | 1    | 1    | 1    | 1    |                                                                               |
| São Francisco do Sul  | 1    | 1    | 1    | 1    |                                                                               |
| Itajaí                | 1    | 1    | 1    | 1    | Large meat export despite low soy exports                                    |
| Imbituba              | 1    | 1    | 1    | 1    | Old port that started exporting meat in year 2000                            |
| Rio Grande            | 1    | 1    | 1    | 1    |                                                                               |
| Porto Murtinho        | 1    | 0    | 1    | 0    | REMOVED: < 1% exports, varies in time                                         |
| Cáceres               | 0    | 0    | 1    | 1    | REMOVED: < 1% exports, varies in time - not operational anymore               |
| Porto Velho**         | 1    | 1    | 1    | 1    | Internal port, treated as export port                                         |

* AgroStat export data from 2007 to 2017 is 0 (zero) for this port. But data seems to be mixed with the Manaus port. Since the ports are very close, both ports were assumed open all the time.

** Porto Velho (RO) is a transbordo port (internal), which sends soy to Santarém and then exports. It’s included in a separate dataset, which is appended to the export ports and treated as such. Rondônia Port and Waterways web portal contains a report stating that in 2004 1.5 million tons of soy were exported, thus the port was active at least in 2004. ANTAQ: Port exported 1 million tons of soy in 2002 (http://web.antaq.gov.br/Portal/Anuarios/Portuario2002/InformacoesGeraisPortos/Portos/PortoVelho.htm).

Table 3
Cost to traverse a grid cell based on road surface type.

| Surface type          | Cost |
|-----------------------|------|
| No road network       | 50   |
| Unpaved road          | 36   |
| Paved road            | 16   |

things, the ports involved in the transaction. This information, along with regional reports from selected ports, were used to derive an indication of when each port started operations (Table 2). Ports with very low agricultural exports were removed from the dataset and the final surface cost analysis.

2.3. Transport cost analysis

Relative transport costs in Brazil were estimated as the cumulative cost of moving from each grid cell to the closest export port. Cost was considered as a unitless indicator of the difficulty in crossing a cell, as a function of surface type (Table 3). Its values were defined considering the differences between each surface type and not the actual travel cost. Thus, results indicate a relative cost difference from different regions and years for the Brazilian territory.
2.4. Data processing

All data were processed using the open source GRASS GIS software [2]. Manipulation of vector data attribute tables were done using GRASS GIS database capabilities [6], especially it’s ability to use SQL (Structured Query Language) and perform direct connection to the underlying Relational Database Management System (RDBMS). Cost surface was calculated using GRASS GIS r.cost command. A detailed description of the algorithm can be found in r.cost man page [7]. A detailed explanation of all commands used, sequences and expected results are given in the markdown file transport_cost.md (also available in PDF form). An overview of the process carried out in GRASS GIS is given bellow. For a better comprehension of GRASS GIS capabilities and concepts, refer to the Grass wiki, specially GRASS Help [8] and GIS Concepts in GRASS [9].

1. All process was carried out using EPSG:4326 projection;
2. Vector maps (road networks and pots locations) where imported into the GRASS database using v.in.ogr and command;
3. Ports layer were separated into different layers containing only the active ports for each year;
4. All planned roads from the 2017 road network layer where removed;
5. The 2010 road network layer was created by copying the 2017. The road surface status was removed and populated by joining with the 2010 road surface status table, based on road section id. Section ids not present in the 2010 road surface status table were joined based on road number and start/end km marks, using the fix_road_attribute.py code;
6. Step 5 was repeated for years 2005 and 2000;
7. For all years, cost value was added to the road network layer and convert to raster format. Active ports dataset was also converted to raster format;
8. Cost analysis (r.cost command) was carried out for all years, using the ports layer as the starting point

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

Supplementary Materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.dib.2021.107070.

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