A Sub-National Version of the GTAP Model for Italy

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Outline

- Introduction
- Database development
- Model improvement
- Validation
- Conclusions and further research

Introduction: the GTAP model

GTAP is a widespread model and database among *computable general equilibrium* (**CGE**) users, covering all the economic system at the world level.

One main constraint of such a global economic model is the geographical scale for the analysis. The highest detail is at country level.

Introduction: objective

•We build a **sub-national** version of the **GTAP** model for **Italy**, split in three sub-national regions (**North**, **Middle** and **South**).

• At this stage the aim is not to have a realistic picture of the trade/environmental policy effects but rather to understand how the model works.

•This model is a first version (**work in progress**). The final objective will be to extend it to the 20 Italian regions.

Introduction: motivations

• Very few global CGE model exist at the sub-national level. Nevertheless, the trade/environmental world policy may raise significant effects at sub-country level, highlighting distributional issues that may require consistent and differentiated actions.

• Especially for environmental shocks a more detailed geographical localization represents an important tool to assess more properly the economic consequences of climate change impacts.

• Italy is very diversified in an economic and geographical sense.

Database: GTAP 7

We start from **GTAP 7** database (Narayanan and Walmsley, 2008), a large *social accounting matrix* (SAM) for 57 sectors and 113 countries or groups of countries. The reference year is 2004.

Database development: ISTAT

• We integrate the GTAP information at country level with sub-national information coming from **ISTAT** (*Italian National Institute of Statistics*).

•**ISTAT economic data** on value added, labour and land are available for the 20 Italian regions and 40 sectors.

•**ISTAT transport data** in volume (tons of goods) are available for the 20 Italian regions and 8 sectors. A 20 x 20 matrix represents for each sector all the bilateral flows between the origin and the destination region.

Database development: three steps

First step: we split the Italian value added and primary factors in GTAP across the three Italian sub-national regions using the ISTAT production information available in the economic regional accounts.

Second step: we use the shares obtained from ISTAT transport data to split the sectoral GTAP Italian production between domestic sub-national demand and bilateral trade flows across Italian regions. This is only an initial computation of the trade flows across Italian regions.

Third step: we adjust the bilateral trade flows across Italian regions to make them consistent with the ISTAT data on the economic production by the bi-proportional **RAS** method.

Database development: first step

Splitting the production side

• We match the 40 ISTAT sectors with the 10 GTAP sectors chosen in our aggregation.

• We distribute the Italian value added and primary factors in GTAP across the three Italian regions using the shares of ISTAT for value added, labour and land. For natural resources we take the sub-national weight of value added in the relevant sectors as a proxy. Capital is computed as residual.

• The sub-national input-output tables are obtained assuming that intermediate inputs of origin sector *i* in the destination sector *j* are distributed according to the sub-national value added share in the origin sector *i*.

Database development: second step

The major effort in building a sub-national CGE database consists in determining the bilateral trade flows across sub-national regions because this type of information is very often missing.

This is usually done through the **gravitational approach (1)** as in Horridge and Wittwer (2010) and Dixon, Rimmer and Wittwer (2012).

An other approach is based on **transport data (2)** as in Canning and Tsigas (2000) and Dubé and Lemelin (2005). The last two authors integrate transport data with economic data by a cross-entropy optimization method.

Database development: second step

Initial computation of the trade flows across Italian regions

• We follow the approach of Dubé and Lemelin (2005).

• We use the shares π obtained from ISTAT **transport data** to split the sectoral GTAP Italian production y_{ITA} which is used domestically between **domestic sub-national demand** and **bilateral trade flows** across Italian regions.

• Matrix *D* represents the **domestic demand**, matrix *A* the **bilateral trade flows**:

$$\begin{pmatrix} \pi_{11} & \pi_{12} & \pi_{13} \\ \pi_{21} & \pi_{22} & \pi_{23} \\ \pi_{31} & \pi_{32} & \pi_{33} \end{pmatrix} \cdot y_{ITA} = \begin{pmatrix} d_{11} & 0 & 0 \\ 0 & d_{22} & 0 \\ 0 & 0 & d_{33} \end{pmatrix} + \begin{pmatrix} 0 & a_{12} & a_{13} \\ a_{21} & 0 & a_{23} \\ a_{31} & a_{32} & 0 \end{pmatrix} = D + A$$

Database development: third step

Adjusting the trade flows across the Italian regions by RAS

Consider the bilateral trade matrix A computed at the step 2. Consider also **target vectors** R and C, respectively aggregate sub-national exports and imports to/from the other sub-national regions computed using this formula: y = d + aggexp – aggimp, where y stems from ISTAT **economic data** on sub-national production.

The **RAS** method attempts to find a new similar matrix B, which is related to the original A via the following formula:

$$b_{ij} \approx rm_i \cdot cm_j \cdot a_{ij}$$

where rm_i, cm_j, a_{ij} and b_{ij} are, respectively, the general element of vectors RM and CM and matrices A and B. The **RAS** iterative procedure on the row and column multipliers stops when the following conditions are met simultaneously:

$$\sum_i b_{ij} \approx c_j \quad , \quad \sum_j b_{ij} \approx r_i$$

where r_i and c_j are, respectively, the general element of vectors R and C.

The Models

We use five different models to test how a sub-national model works from an economic point of view. We gradually increase the complexity to make markets more integrated and competitive at the sub-national level.

- The **AI** model (**A**ggregated **I**taly in the standard GTAP model).
- The **RI** model (**R**egionalised **I**taly in the standard GTAP model).
- The **RIMFM** model (**R**egionalised **I**taly with geographical **M**obility in **F**actors **M**arket).
- The **RIARM** model (**R**egionalised **I**taly with increased inter regional **Arm**ington elasticities).
- The **RIAFM** model (**R**egionalised **I**taly with both increased **A**rmington and mobility in **F**actors **M**arket).

The AI Model

Aggregated **I**taly in the standard GTAP model (**AI**): we use the standard GTAP model. It is not a sub-national model.

10 sectors: Grains and crops, Livestock meat products, Mining and extraction, Processed food, Textiles and clothing, Light manufacturing, Heavy manufacturing, Utilities and construction, Transport and communication, Other services.

Geographical aggregation: Italy, rest of European Union, rest of the World.

Factor endowments can not move outside the country or group of countries they belong.

International trade: standard Armington assumption. Products coming from different countries are not perfect substitutes.

The RI Model

Regionalized **I**taly in the standard GTAP model (**RI**): we use the same theoretical structure of GTAP. With respect to the AI model we have sub-national regions. They behave exactly like nations. RI is the basic model with the lowest degree of market integration and competition at the sub-national level.

Geographical aggregation: North of Italy, Middle Italy, South of Italy, rest of European Union, rest of the World.

Factor endowments can not move outside the sub-national region they belong.

Trade across sub-national regions: same structure as the GTAP countries. Even the values of Armington elasticity do not change.

Model improvement: the RIMFM model

Regionalized **I**taly with geographical **M**obility in **F**actors **M**arket (**RIMFM**): we use the same theoretical structure of the GTAP model except the factor supply in the sub-national regions.

Geographical aggregation: North of Italy, Middle Italy, South of Italy, rest of European Union, rest of the World.

Factor endowments of capital (K) and labour (L) can move outside the sub-national region r they belong within Italy (ITA). This is done by a **CET** (*constant elasticity of transformation*) function where the elasticity of transformation is the same for both factors, labour and capital ($\sigma_L = \sigma_K = \sigma_{FAC}$). Here below the FOC for the factor supply:

$$QL_r = QL_{ITA}\left(\frac{PL_{ITA}}{PL_r}\right)^{\sigma_L} \quad \text{with } \sigma_L < 1$$

$$\sum_r QL_r PL_r = QL_{ITA} PL_{ITA}$$

$$QK_r = QK_{ITA}\left(\frac{PK_{ITA}}{PK_r}\right)^{\sigma_K} \quad \text{with } \sigma_K < 1$$

$$\sum_r QK_r PK_r = QK_{ITA} PK_{ITA}$$

The **trade across sub-national regions** has the same structure of the standard GTAP model. Even the Armington elasticity values do not change.

Model improvement: the RIARM model

Regionalized **I**taly with increased inter regional **Arm**ington elasticity (**RIARM**): we use the same theoretical structure of the GTAP model except the trade structure for sub-national regions.

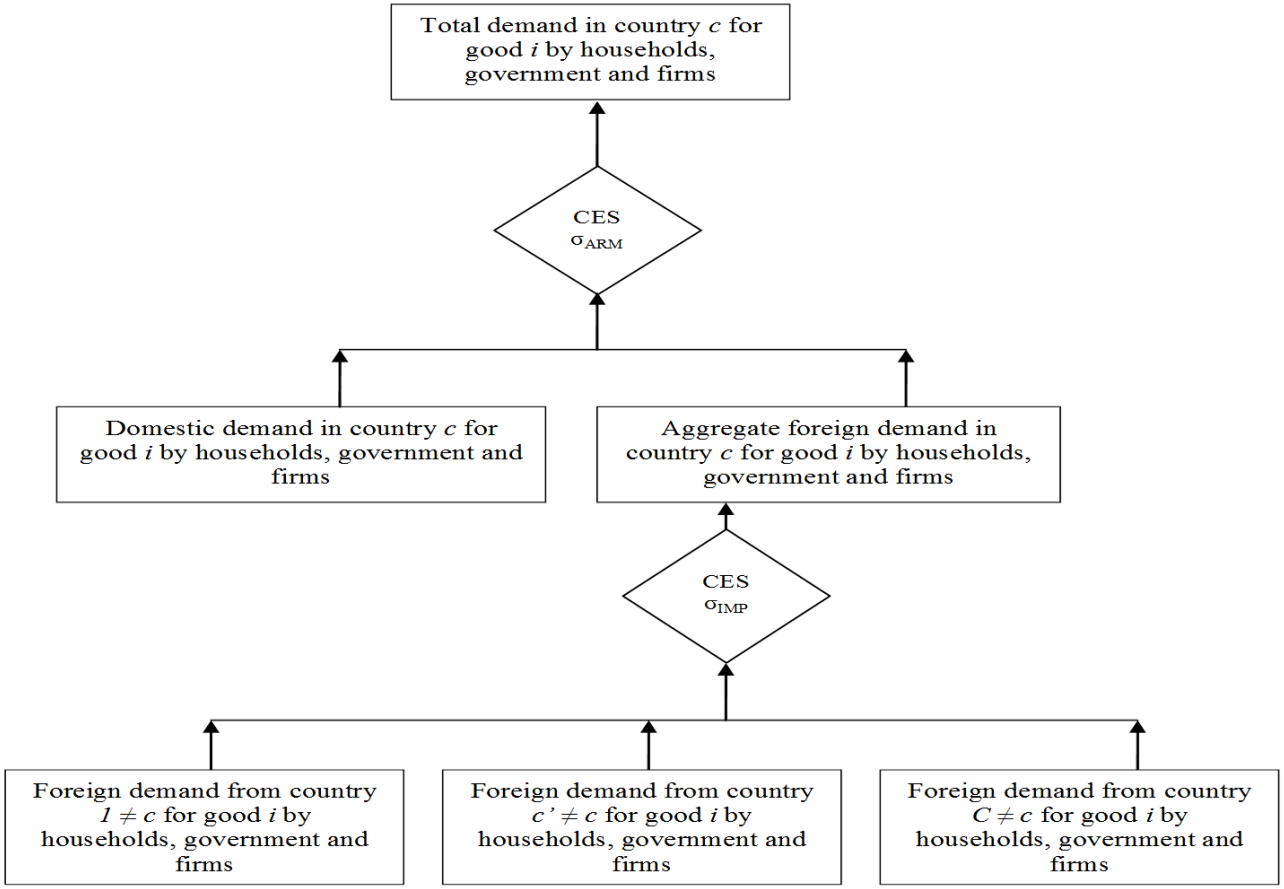
Geographical aggregation: North of Italy, Middle Italy, South of Italy, rest of European Union, rest of the World.

Factor endowments can not move outside the sub-national region they belong.

The **trade across sub-national regions** has a different structure with respect to that of GTAP. Consistent with the empirical evidence (McCallum, 1995), it is supposed that sub-national products are closer substitutes among them. The sub-national Armington elasticities are two times higher than the standard GTAP elasticities.

Model improvement: the RIARM model

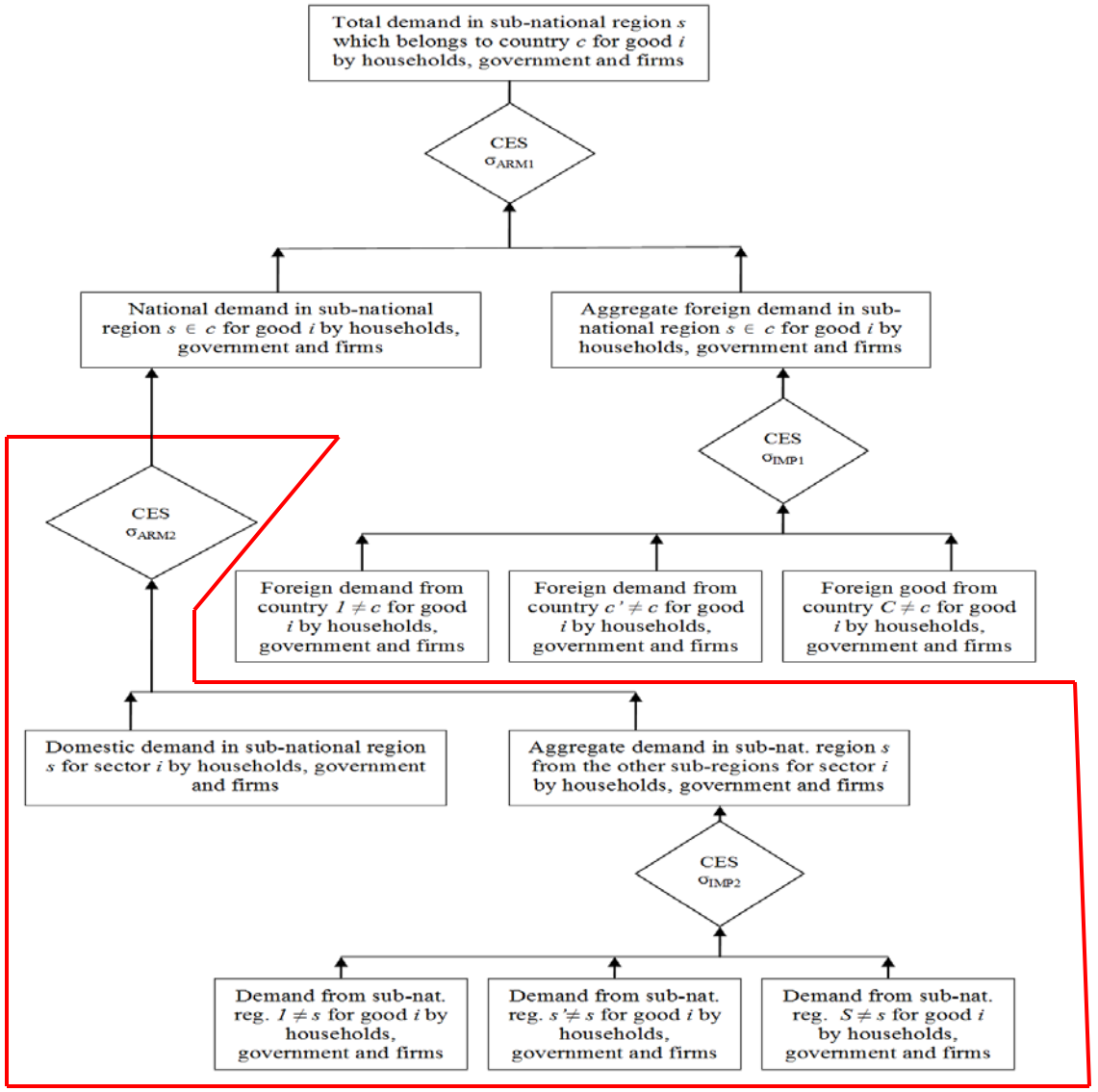
Trade structure in the standard GTAP model:



Model improvement: the RIARM model

Trade structure for sub-national regions:

Additional bundles



Model improvement: the RIAFM model

Regionalized **I**taly with both increased **A**rmington and mobility in **F**actors **M**arket (**RIAFM**): both changes in goods and factors market are incorporated. RIAFM is the **full model** with the highest degree of market integration and competition at the sub-national level.

Geographical aggregation: North of Italy, Middle Italy, South of Italy, rest of European Union, rest of the World.

Factor endowments of capital (K) and labour (L) can move outside the sub-national region they belong within Italy.

The **trade across the sub-national regions** has a different structure with respect to that of GTAP. Sub-national products are closer substitutes. The sub-national Armington elasticities are two times higher than the standard GTAP elasticities.

Validation: a simple experiment

We carry out a simple simulation: **20%** uniform **land productivity loss all over the world**.

The aim is threefold:

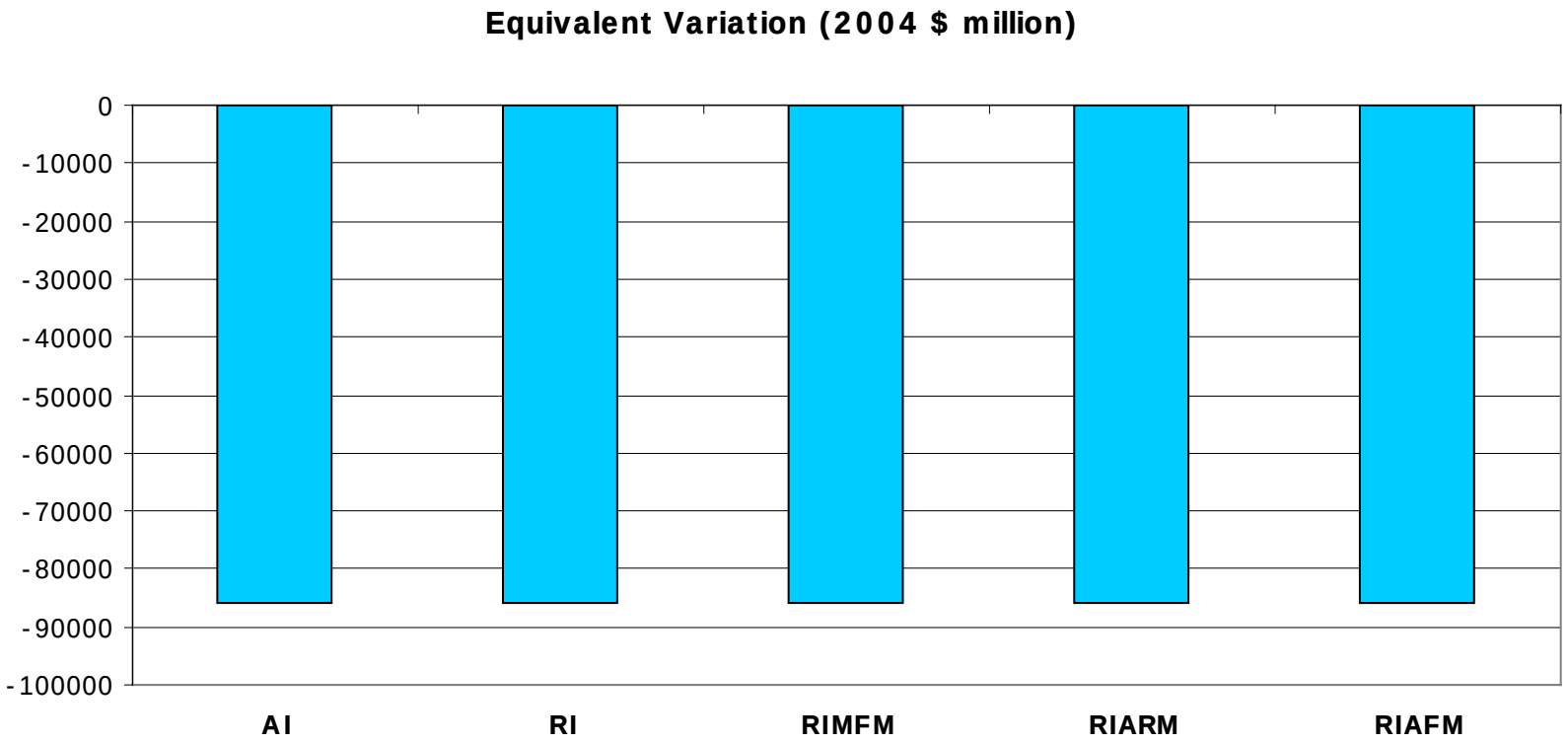
- Testing if our results are robust enough but at the same time verifying if welfare outcomes improve both at the Italian and world level when moving toward more competitive and integrated markets.

- Analysing the distributional effects at the sub-national level.

- Carrying out a sensitivity analysis to test the economic consistency of our results on the following parameters:

i) Armington elasticity for intra-national trade, and
ii) CET elasticity for intra-national factor mobility.

Validation: welfare outcomes in the World



Legend of models

AI	**A**ggregated **I**taly in the standard GTAP model
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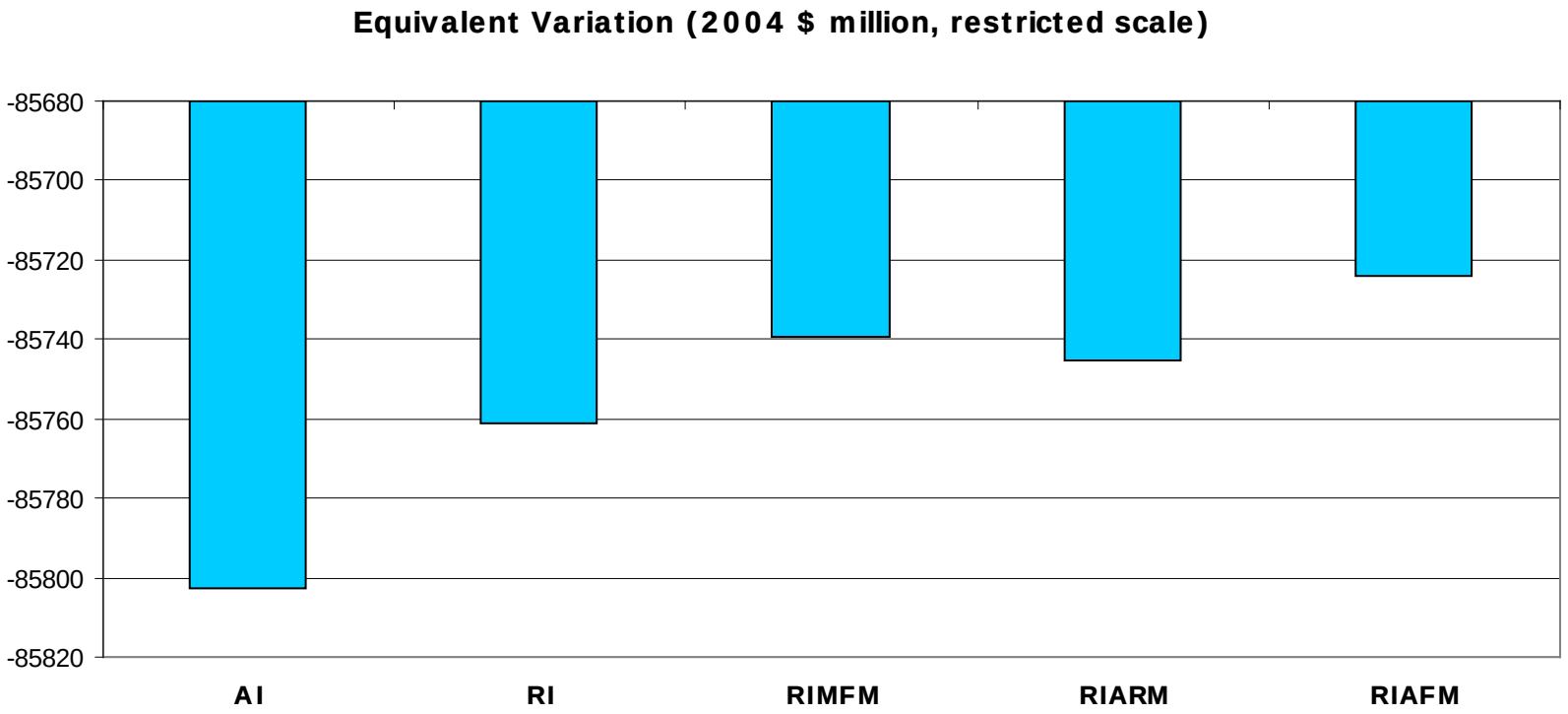

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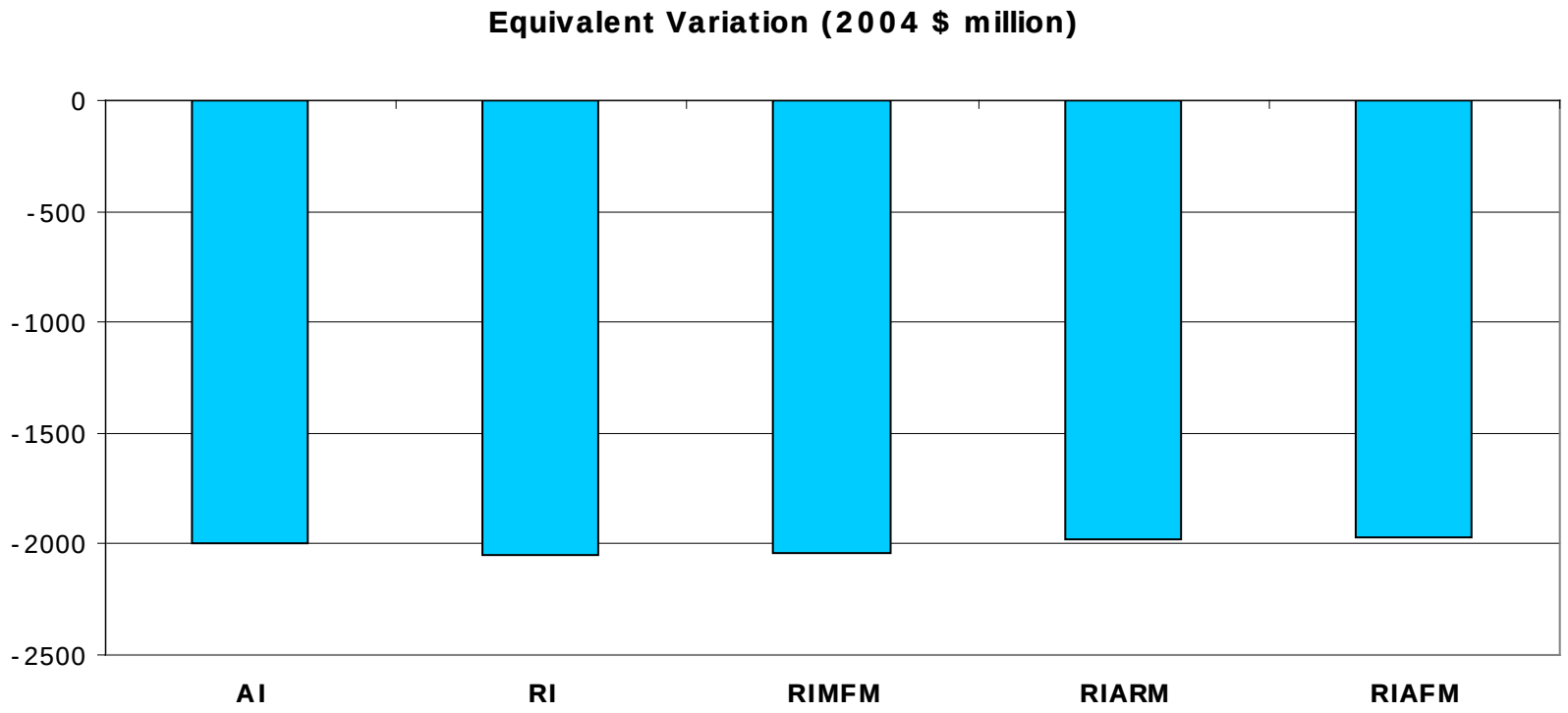
Validation: welfare outcomes in Italy



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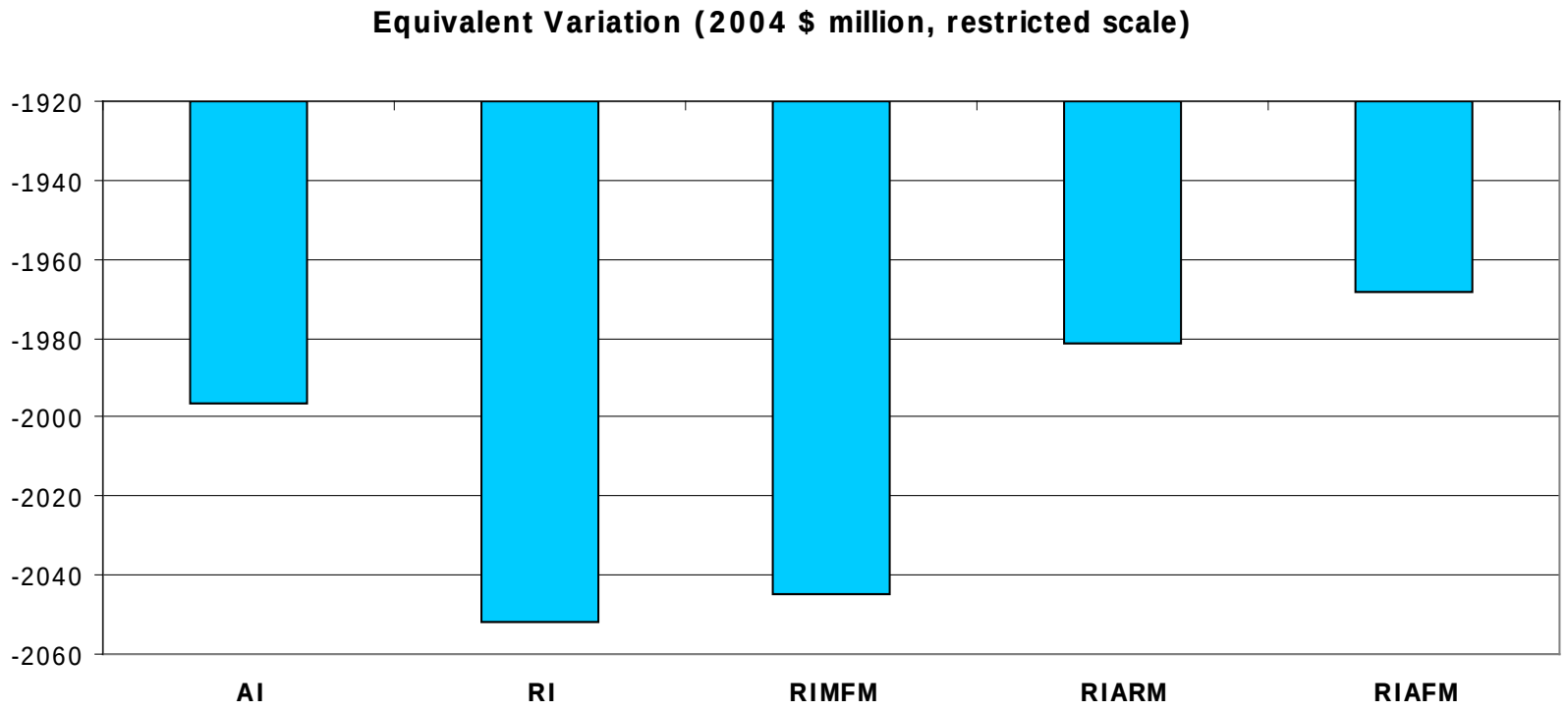

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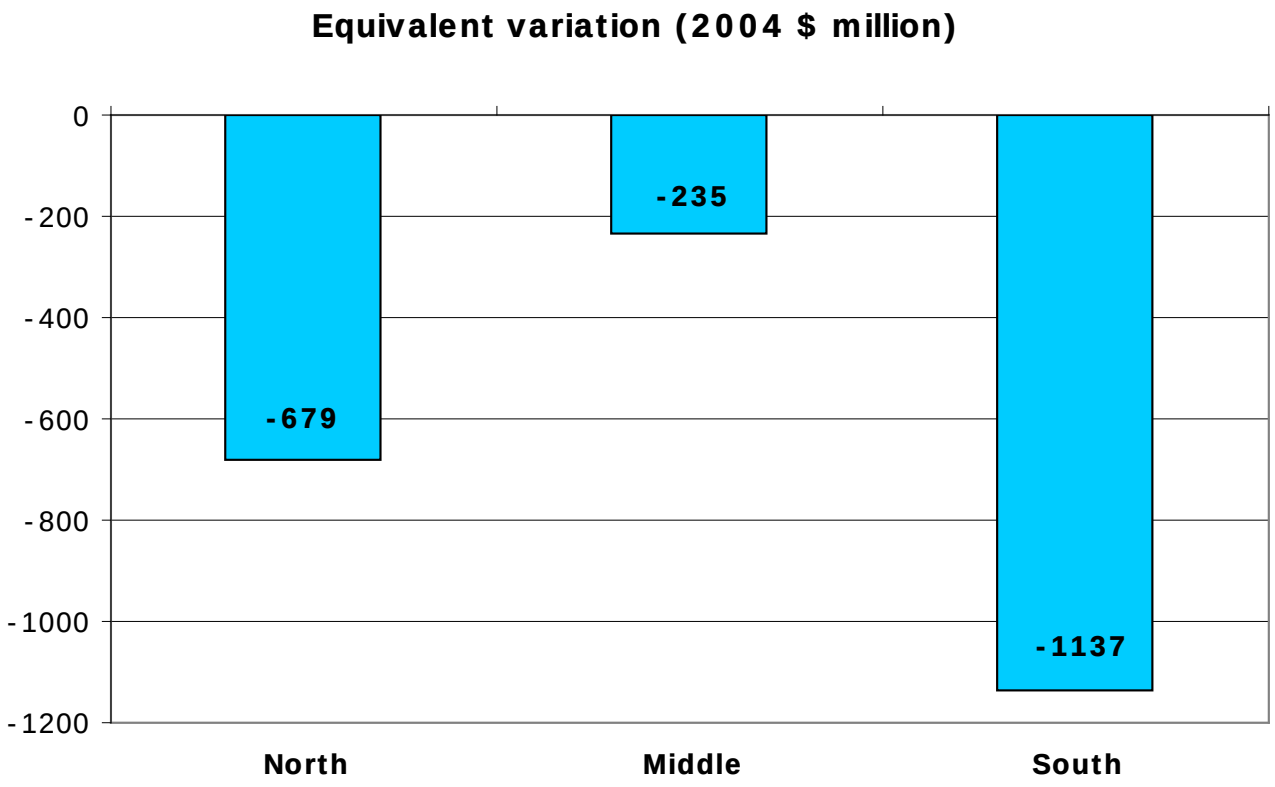
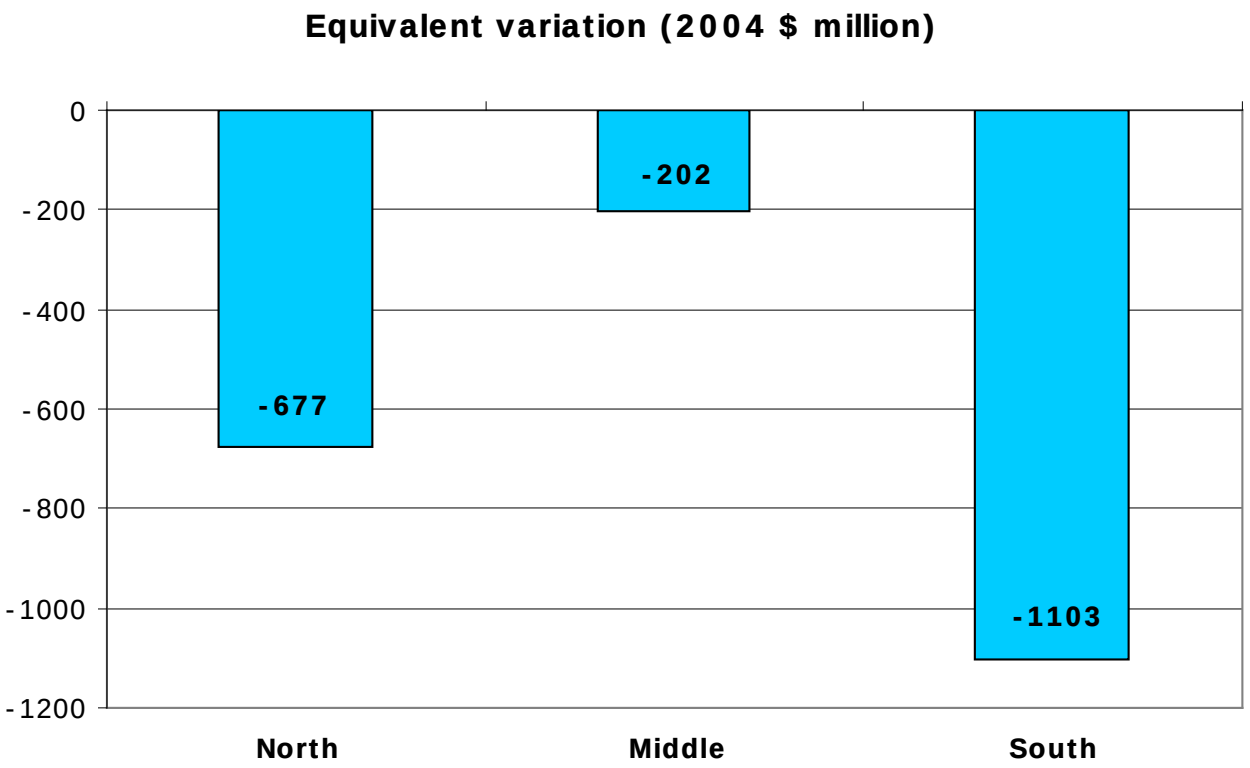
Validation: sub-national distributional effects

RI model: **R**egionalised **I**taly in the standard GTAP model



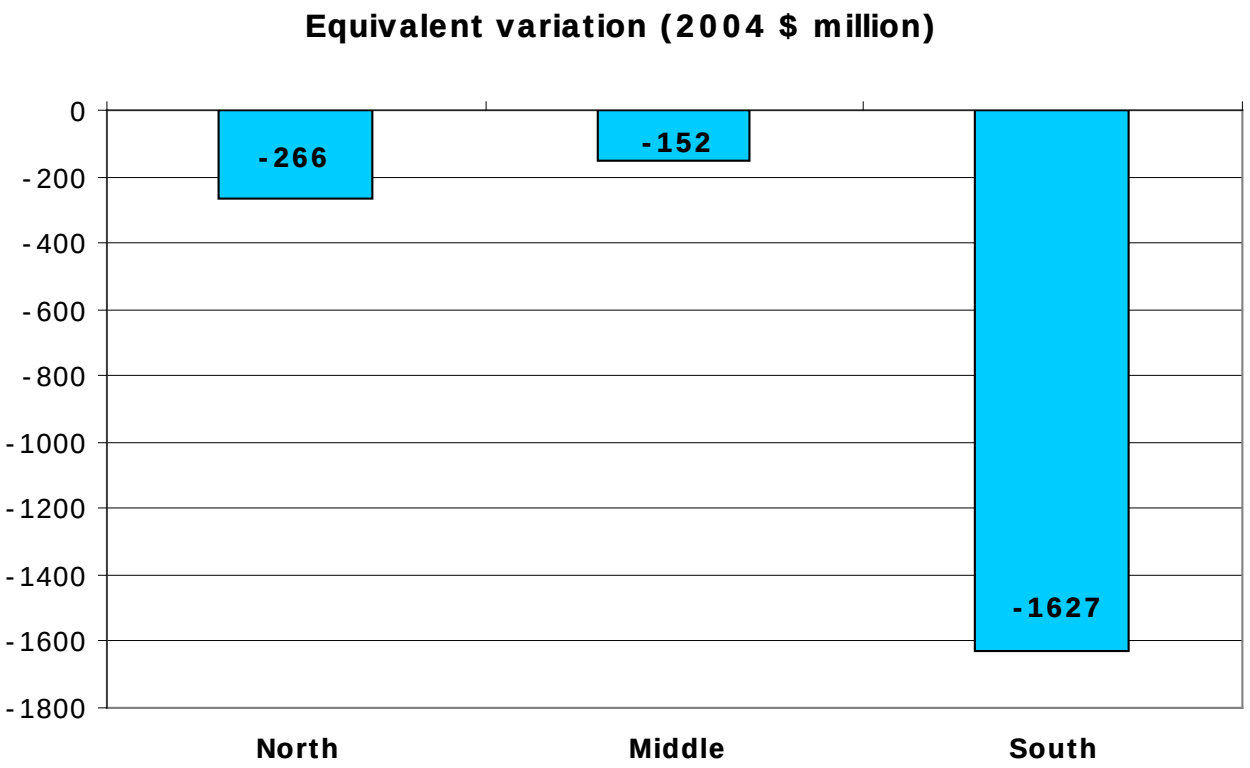
Validation: sub-national distributional effects

RIARM model: **R**egionalised **I**taly with increased inter regional **Arm**ington elasticities



Validation: sub-national distributional effects

RIMFM model: **R**egionalised **I**taly with geographical **M**obility in **F**actor **M**arkets



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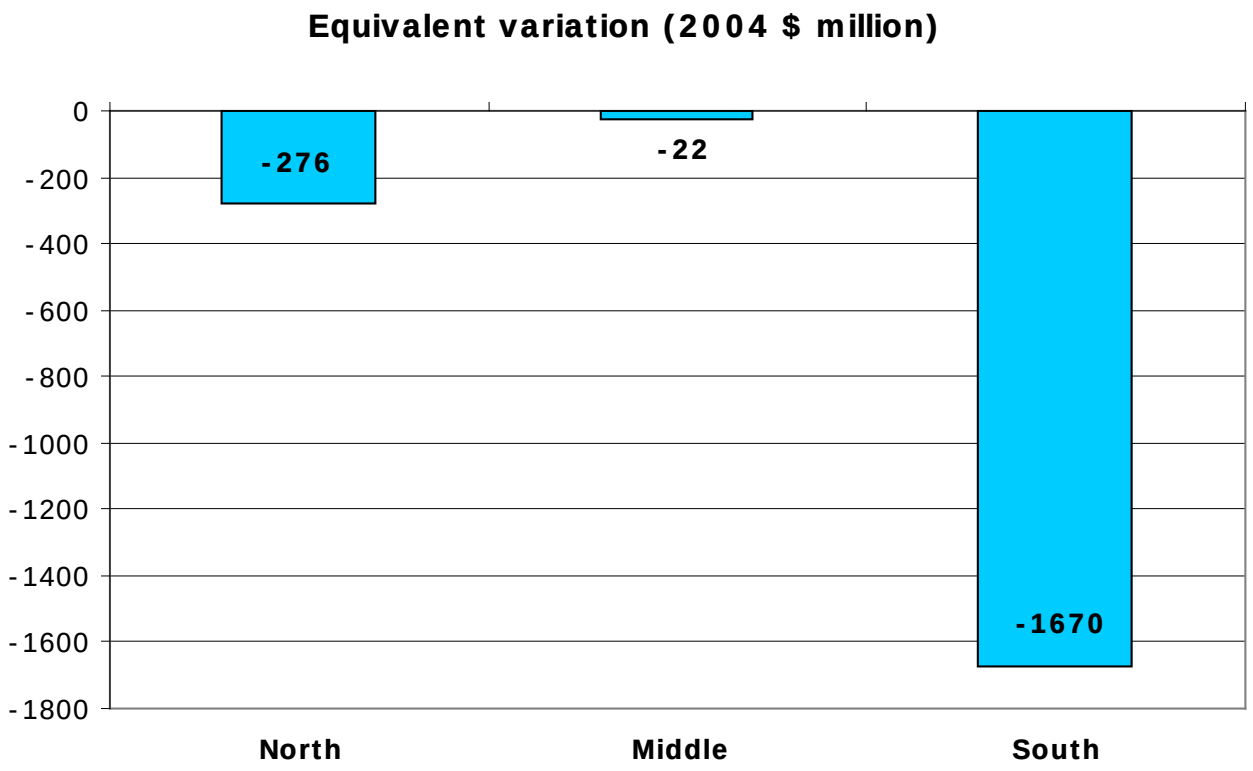

Validation: sensitivity analysis on the elasticity parameters

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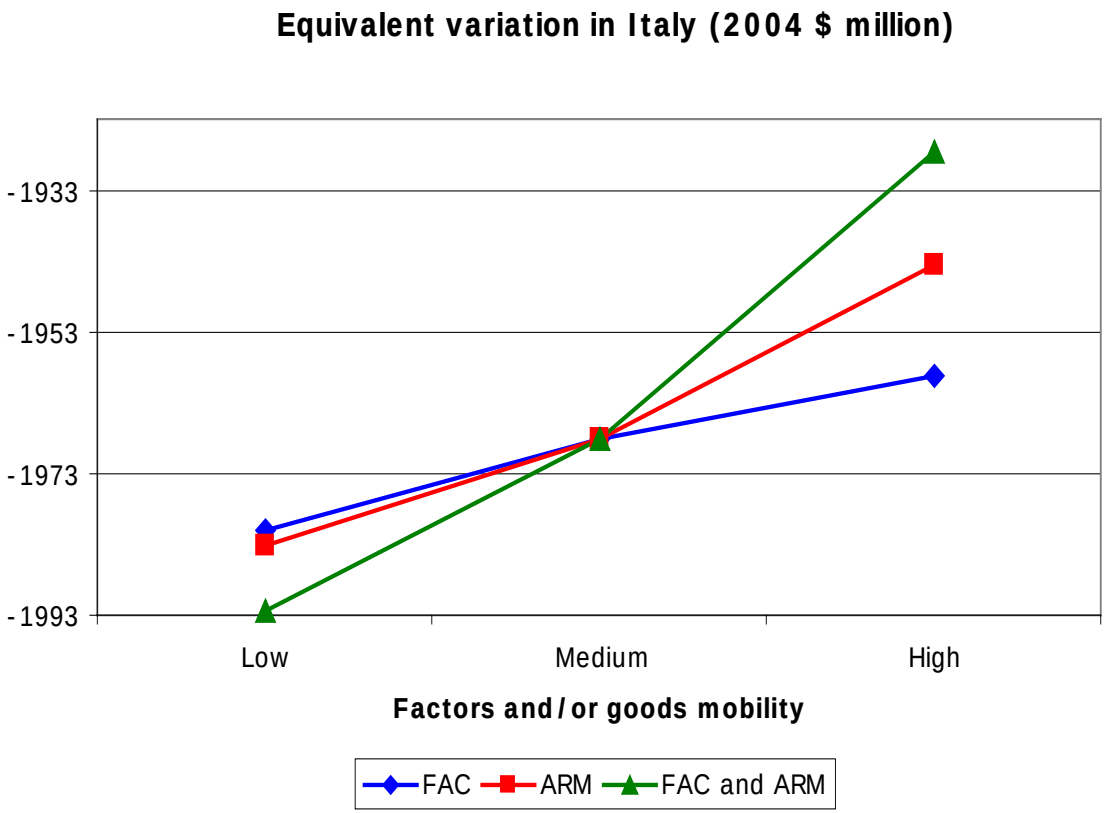


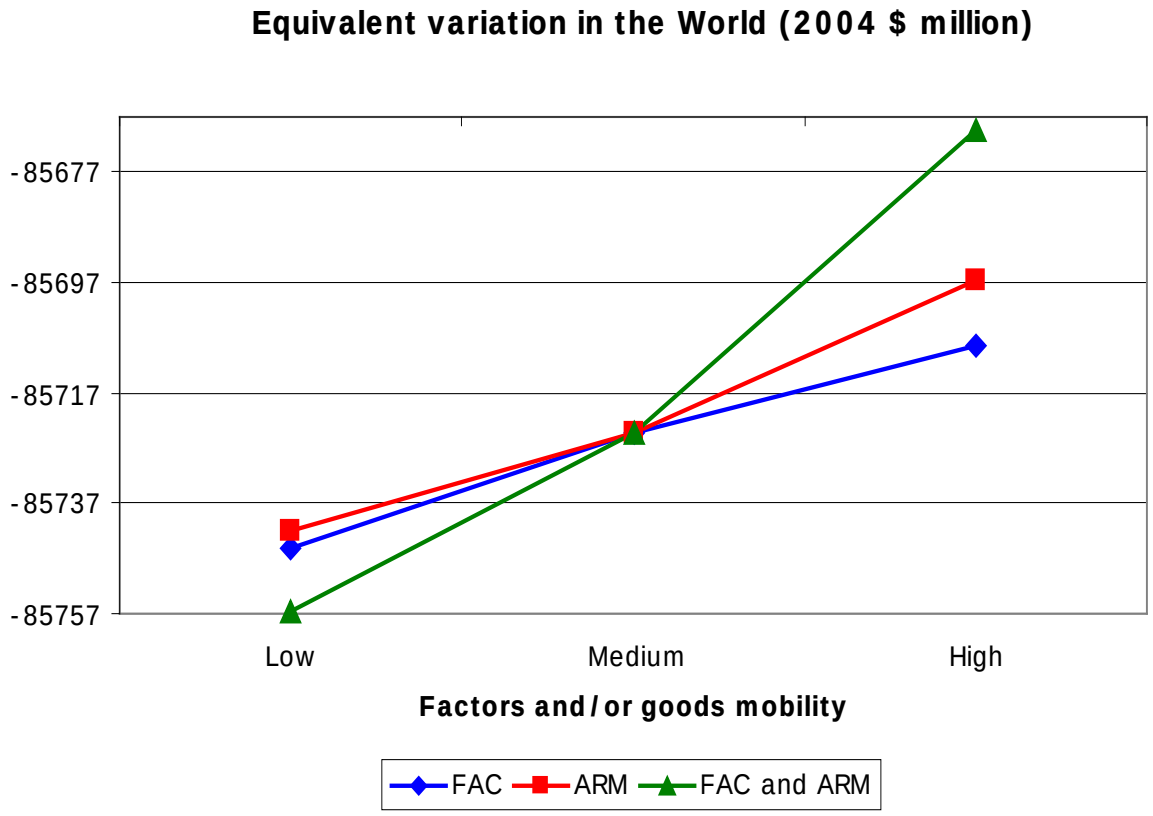
FAC: factors mobility within Italy
Low) $\sigma_{FAC} = 0$
Medium) $\sigma_{FAC} = -2$
High) $\sigma_{FAC} = -5$

ARM: products substitution within Italy
Low) $\sigma_{ARM2} = \sigma_{ARM1}$, $\sigma_{IMP2} = \sigma_{IMP1}$
Medium) $\sigma_{ARM2} = 2\ \sigma_{ARM1}$, $\sigma_{IMP2} = 2\ \sigma_{IMP1}$
High) $\sigma_{ARM2} = 5\ \sigma_{ARM1}$, $\sigma_{IMP2} = 5\ \sigma_{IMP1}$

FAC and ARM: factors mobility and products substitution within Italy
Low) $\sigma_{ARM2} = \sigma_{ARM1}$, $\sigma_{IMP2} = \sigma_{IMP1}$, $\sigma_{FAC} = 0$
Medium) $\sigma_{ARM2} = 2\ \sigma_{ARM1}$, $\sigma_{IMP2} = 2\ \sigma_{IMP1}$, $\sigma_{FAC} = -2$
High) $\sigma_{ARM2} = 5\ \sigma_{ARM1}$, $\sigma_{IMP2} = 5\ \sigma_{IMP1}$, $\sigma_{FAC} = -5$

Validation: sensitivity analysis on the elasticity parameters

RIAFM model: **R**egionalised **I**taly with both increased Armimgton and mobility in **F**actors **M**arket



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Conclusions and further research

Conclusions

Our approach uses both transport information and economic data in a consistent statistical framework.

Results are robust enough and welfare outcomes improve when moving toward more competitive and integrated markets.

Distributional economic effects are strongly uneven across sub-national regions even in the case of a uniform shock. Increasing mobility of factors (labour and capital) within Italy amplifies the uneven patterns across sub-national regions.

Sensitivity analysis on Armington and CET elasticity shows consistent economic results.

Conclusions and further research

Further research

Database development:

• Extending this first version to the 20 Italian regions.
• Finding a better estimation method to determine trade flows in the service sector, so far we use the overall amount of shipped goods as proxy.
• Cooperation with other countries inside and outside EU for collecting sub-national information and extending the database beyond Italy.

Modelling improvement:

• Testing the model with real shocks (e.g. extreme natural events as floods) to check which model parameterization produces more reasonable results.
• Combining ICES, the energy-oriented CGE model developed in FEEM, and the sub-national model to analyse deeper the linkages in the energy sector (RES included) and assess better CO2 emission patterns.

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Acknowledgments

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