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Conference Paper

Trade, Integration and Interregional Inequality

Beiträge zur Jahrestagung des Vereins für Socialpolitik 2014: Evidenzbasierte Wirtschaftspolitik - Session: International Trade and Development, No. D18-V3

Provided in Cooperation with:
Verein für Socialpolitik / German Economic Association

Suggested Citation: Hirte, Georg; Leßmann, Christian (2014) : Trade, Integration and Interregional Inequality, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2014: Evidenzbasierte Wirtschaftspolitik - Session: International Trade and Development, No. D18-V3, ZBW - Deutsche Zentralbibliothek für Wirtschaftswissenschaften, Leibniz-Informationszentrum Wirtschaft, Kiel und Hamburg

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Trade, Integration and Interregional Inequality*

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This version: February 20, 2013

Abstract

We study the effect of international trade and freeness of trade on interregional inequality within countries. We estimate a model derived from a structural economic geography approach where interregional inequality depends on weighted trade shares and trade costs and where we can derive an aggregate freeness of trade measure. These measures are instrumented based on constructed trade shares and trade costs fitted from a gravity model of bilateral trade, which covers 208 countries for the period 1948–2006. We analyze a cross country data set of regional inequality within countries, which covers 110 countries (1569 sub-national regions) for the year 2005, and a panel data set, which covers 56 countries (835 sub-national regions) for the period 1980–2009. IV and dynamic panel regressions show that trade increases interregional inequality within countries but an increase in freeness of trade is probably neutral. Because the latter is an indicator for integration in the world markets, we conclude that more integration neutralizes the negative interregional distribution effects of the increase in trade.

JEL classification: R10
Keywords: Regional inequality, trade, gravity model, panel data,

*We are grateful to Andrei Shleifer, Rafael La Porta and their coauthors for sharing their regional data with us. Moreover, we would like to thank the participants of the Winter Seminar of the German speaking section of ERSA in Matrei, the International Economic Policy Research Seminar at the Goethe University Frankfurt, participants at the ERSA conference Palermo and at the regional economists meeting of the German Economic Association for many helpful comments.

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1 Introduction

For a long time economists have been working on the effect of trade on inequality within countries. Most of this research is on intra-country wage inequality (overview in Pavcnik, 2013) but since the advent of the New Economic Geography spatial effects (review by Brühlhart, 2011), intra-group inequality (e.g. Egger and Kreickemeier, 2012), and interregional inequality (e.g. Brühlhart et al., 2012) aroused interest of scholars. We pick up this latter issue and study whether international openness contributes to interregional income inequality within countries.

A first glance at data reveals that openness and inequality are correlated in a number of countries. Take India and Bolivia as examples. While the per capita GDP of the poorest federal state in India, Bihar, was 24% of the richest state, Delhi, in 1980, its relative income decreased to 13% in 2005. In Bolivia, our second example, the income of the poorest department, Potosí, was 43% of that of the richest department, Santa Cruz, in 1988, but the relative performance of Potosí decreased to 29% in 2009. A potential cause of this development is international trade. Both countries have significantly increased their international trade integration. In India, the ratio of sum of exports and imports to GDP, i.e. the trade to GDP ratio, increased from 15.6% in 1980 to 41.2% in 2005, while trade in Bolivia increased from 41.9% in 1988 to 64.% of the GDP in 2009. This positive correlation between the trade-to-GDP ratio and interregional inequality gives a first hint at a link between both variables.

A high level of regional inequality is an issue of major concern because it may cause serious trouble. There is evidence that regional inequality is a breeding ground for separatist movements and a major determinant of internal conflict, such as civil war (e.g. Østby, 2009, Buhaug et al., 2012, Lessmann, 2013). Further, evidence suggests that interregional inequality determines about one third of interpersonal inequality (Yemtsov, 2005, Elbers et al., 2005). In light of these findings, it is important to understand the determinants of regional inequality.

In this paper we ask whether international trade and increasing openness to trade are among these determinants. We examine this issue for a huge number of countries all over the world and derive our empirical model from a structural economic geography approach.

The theoretical literature is ambiguous concerning the direction of the effects (see the overview by Brühlhart, 2011). In the traditional trade theory, trade increases regional inequality if the initially poorer regions of a country gain relatively less from the opening to the world market and

vice versa (Wood, 2002, Anderson, 2005)[1]. In models of the new economic geography the effect depends on other conditioning factors such as trade costs (Krugman and Livas Elizondo, 1996, Paluzie, 2001, Behrens et al., 2006), the initial level of inequality (Alonso Villar, 1999) the initial country size (Zhang and Zhang, 2010), or the strength of the market crowding effect (Brühlhart et al., 2004, Crozet and Koenig-Soubeyran, 2004).

While theory does not provide clear signs most empirical studies focusing on single countries provide evidence in favor of a positive link between openness and interregoinal inequality (e.g. Chiquiar, 2008 on Mexico, Zhang and Zhang, 2003, on China, Brühlhart et al., 2013, on Austria[2]) Those studies, do not answer the question whether there is a general impact of openness on interregional inequality. To explore this, studies on a data set over a large number of countries is required.

There are also studies on a panel of countries usually with a rather limited number of countries due to the scarcity of data. These studies are very heterogeneous concerning the number of countries they consider but also concerning the results and use a specific selection of countries. For instance, Egger et al. (2005) find evidence that trade raises interregional inequality in a panel of eight CEEC countries (central and eastern European countries) over 1991–1999. They find evidence that intermediate good exports significantly contribute to the increase in the standard deviation. In contrast, Milanovic (2005) finds no significant coefficient for the five most populated countries in the period 1978-2000.

Petrakos et al. (2005) examine the effect of growth and integration on interregional inequality in eight European countries from 1981-1997. They found that integration, measured as intra EU trade to GDP, raises inequality in France and Spain, declines inequality in the Netherlands and Portugal and is insignificant for Greece, Italy, and the UK.

Barrios and Strobl (2009) examine a panel of the EU 15 countries for 1970-2000. They find evidence that the coefficient of the real openness measure is positively significant providing evidence that real trade openness raises interregional inequality in the EU15. Eventually, Rodríguez-Pose (2012) studies an unbalanced panel of 28 countries for 1980–2005 and provides evidence that only interaction terms of trade with development and 'coincidence' measures are statistically

[1]Other channels are migration (Haaparanta, 1998, evidence by Chiquiar, 2008) the distribution of factor ownership (e.g. Anderson, 2005), or the willingness to redistribute via taxes and transfers (Rodrik and van Ypersele, 2001).

[2]See also Chiquiar (2008), González Rivas (2007), Hanson (1997, 1998), Sanchez-Reaza and Rodríguez-Pose (2002, 2005) on Mexico; Kanbur and Zhang (2005) on China, Pernia and Quising (2003) for the Philippines, Breau and Rigby (2010) on Canada, and Volpe (2010) for Brazil.

significant, while the coefficient of trade is insignificant.[3]

This literature left several open issues: (i) the size of the cross-country data base is usually very small and also biased in favor of industrial countries and hardly consider developing countries, hence there might be a selection bias; (ii) except for a few studies (e.g. Barrios and Strobl, 2009, Brühlhart et al., 2013) most empirical studies are not based on sound theoretical models; (iii) most empirical studies use the trade to GDP ratio as proxy for openness and, thus, do not consider integration based on trade agreements etc.

We are dealing with these three shortcomings in the following. There are two recently published cross-country data bases which we are gratefully to be able to work with. Gennaioli et al. (2013) provide a cross-section sample on regional income data for 110 countries with 1569 sub-national regions for the year 2005, while Lessmann's (2011) panel data base comprises 56 countries with 835 sub-national regions for the period 1980–2009. Therefore we consider a considerably higher number of countries than any study on that topic before, hence, avoid the selection bias present in other studies and provide much more general evidence. Our main inequality measure is the population-weighted coefficient of variation of regional income but we also consider alternative measures in the robustness checks.

Our regression models including the gravity approaches derive from a structural new economic geography model that is an extension of the approach of Pflüger (2004). In that way, we reconcile the empirical approaches with the respective theories, not yet done for a cross-country study in that context.

Because the Genaioli et al. data are restricted to 2005, the endogeneity bias cannot be attenuated by instrumenting with lags or past changes as done in the panel studies referred to. Nonetheless, it is by far the largest data base available. To exploit it we carefully address the endogeneity issue.

In our theoretical model trade is endogenously determined by country characteristics and trade costs, which are difficult to measure. Therefore, unobserved heterogeneity and omitted variables might result in an endogeneity bias in linear regressions. We have two strategies to cope with this problem. First, we construct an instrument for the real trade to GDP ratios from an estimated gravity model of bilateral trade (Frankel and Romer, 1999, and Alcalá and Ciccone, 2004). At

[3]There is another study of Rodríguez-Pose and Gill (2006) using an unbalanced panel for eight countries in 1970–2000. They, however, only use a graphical representation of the trade content index.

this, we combine the bilateral trade data for more than 200 countries of Head et al. (2010) with the estimation approaches suggested by Frankel and Romer (1999), Anderson and van Wincoop (2003) and Baier and Bergstrand (2007). Thereby, we augment the gravity equation with some standard determinants of trade following Head et al. (2010) and add country-pair fixed effects in order to deal with multilateral resistances (Anderson and van Wincoop, 2003). Then we use the constructed trade shares in the IV estimates as instrument for the trade to GDP ratio. As our second approach, we employ dynamic panel regressions using a system gmm estimator a la Arellano-Bover/Blundell-Bond.

While the literature predominantly uses the trade to GDP ratio, we apply further measures for openness. The trade to GDP ratio is usually used as proxy for outside market potential though it does not explicitly consider the freeness of trade which is one of the central ingredients of the external market potential in the theory. Consequently, we propose and use an aggregate freeness of trade index based on bilateral openness where bilateral openness is calculated according to Head and Ries (2001)[4]. The freeness of trade measure focuses on integration in the world market and, thus, implicitly considers regional free trade agreements etc. Since trade and openness might be endogenous as will free trade agreements, membership in the OECD etc., we instrument both measures. We derive the instruments by performing a gravity type regression, and build an aggregate openness index as well as the instrument for that for each country. Eventually, we also apply the 'degree of openness´-measure of Arrabias et al. (2009) in the robustness checks. Because this measure is endogenous we use it only in the system GMM approach but not in the cross-section estimates.

We find evidence that trade raises interregional inequality. The point estimate implies that an increase in the trade to GDP ratio by ten percentage points is on average associated with an increase in regional inequality by approx. 2%. A variety of robustness checks including semi-parametric estimates confirms our findings. Nonetheless, this finding implies that more trade increases interregional inequality. In contrast, we cannot identify a significant coefficient of freeness of trade in the panel regressions though it is significant in the IV cross-section estimates. This hints at the relevance of integration. The higher integration in the world markets the less less harmful is more trade to interregional inequality.

[4]By using this economic measure of trade openness we implicitly also consider *de jure* trade openness (e.g. Sachs and Warner, 1995).

The reminder of the paper is organized as follows: Section 2 presents the simple New Economic Geography model and derives our regression equation. Section 3 presents our econometric analysis. At this, we first discuss our measure of regional inequality (section 3.1.1), present our empirical approach (section **??**), and developed our instrument of trade shares (section 3.3). Subsequently we present our main results from cross-section and panel regressions. Then we provide different robustness tests, including alternative measures of regional inequality as dependent variable, semi-parametric regression results and different interaction variables. Section 4 summarizes our findings and concludes.

2 Theory

2.1 A simple model

Since interregional inequality might depend on spatial allocation of industry and households, a model that accounts for this link is required. Therefore, we derive the empirical model as well as the gravity approach from a model in the tradition of the New Economic Geography (Krugman, 1991). In particular, we adopt the two-region model of Pflüger (2004) and adjust it to our purpose. We use this model because it is able to handle all kinds of spatial allocation of industry and population and, thus, is better suited than models featuring only full dispersion or full agglomeration. Despite that it is easy to use though it preserves almost all features of the standard core-periphery model (Krugman, 1991).

There are two countries i and j where country i is called '*Home*'. We focus on *Home* that consists of S regions with indices r or s. Though we assume full symmetry between both countries, we simplify equations by considering the other country, called '*Foreign*' as a black box. It is straightforward how to extend the model to account for the internal structure of *Foreign*. There are two types of goods: (i) a homogenous tradable good, Z, produced with constant returns to scale, a unit demand of the only input labor and zero trade costs, and (ii) a mass of varieties of a monopolistic good produced with one unit of skilled labor per variety as fix input and c units of labor per output as variable input. We normalize the wage to unity and due to the construction of the homogeneous good sector, the price of these goods is also unity. In the following we focus on *Home* and simplify notations by dropping the index i when we look at country i's regions indexed

r or s. Aggregate variables of *Home* or *Foreign* are indexed by i.

Each country is endowed with a fixed supply of skilled labor or entrepreneurs, K_i, and each region with a fixed amount of other types of labor, L_r, simply called 'labor'. Regional skilled labor is endogenous on account of migration. Regional population is given by $P_r = L_r + K_r$.

Each household in a region consumes the local good Z_r and varieties, m of the aggregate monopolistic good, M_r. Upper level utility is represented by the quasi-linear utility function (Pflüger, 2004) and subutility by an Spence-Dixit-Stiglitz utility function with love for variety, thus,

$$U_r = Z_r + \alpha_r \ln M_r \qquad M_r = \left(n_r m_{rr}^{\frac{\sigma-1}{\sigma}} + n_s m_{sr}^{\frac{\sigma-1}{\sigma}} + n_j m_{jr}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

where α denotes expenditures on M, m_{sr} is the demand for a variety produced in region s and σ is the elasticity of substitution that also represents the price elasticity of demand. n_r is the mass of varieties produced in region r, n_i the mass produced in *Home* and a mass $n_j = N - n_i$ is produced abroad. The budget constraint is $G_r = Z_r + Q_r M_r$, where G_r denotes household income and Q_r is the perfect price index for monopolistic goods.

Transport of monopolistic goods is subject to Iceberg transportation costs. Following Behrens et al. (2007) 'transportation costs' refer to intra-country transportation cost and 'trade costs' to international costs. Transportation costs between regions, Ψ, are assumed to by symmetric and $\Psi > 1$ per unit of a variety. We assume that trade costs are symmetric for imports and exports, that there is no distinction concerning the region of destination or origin in *Foreign* but that they might be different among regions of country i. $T_r > 1$ represents the trade costs of *Home's* region r to *Foreign*.

Demand functions for the varieties are

$$m_{rr} = \alpha_r \frac{Q_r^{\sigma-1}}{q^\sigma}, \quad m_{sr} = \alpha_r \frac{Q_r^{\sigma-1}}{\Psi^\sigma q^\sigma}, \quad m_{jr} = \alpha_r \frac{Q_r^{\sigma-1}}{T_r^\sigma q^\sigma},. \tag{2}$$

In the monopolistic sector a mass of goods is produced by identical firms with a increasing returns to scale technology giving rise to Chamberlains monopolistic competition. The mass of firms n_r is equal to the mass of entrepreneurs K_r and we can use n instead of K below and λ_r determines the share of region r on all firms of country i. Since firms are identical we drop the indices of firms and regions. Further, $\lambda_r = n_r/n_i$ and $\mu_i = n_i/N$ denote regional shares and the

national number of firms and country i's share on the world number of firms, respectively. Because we consider a mass of firm, profit maximization implies that the mill price is a mark-up on marginal costs, i.e.

$$q = \frac{(\sigma - 1)}{\sigma} c. \tag{3}$$

Accordingly, the perfect price indices are

$$Q_r = Nq \left[\mu_i \left(\lambda_r + \psi \lambda_s \right) + \phi_r \mu_j \right]^{\frac{1}{1-\sigma}}, \qquad Q_j = Nq \left(\mu_i \sum_s \phi_s \lambda_s + \mu_j \right)^{\frac{1}{1-\sigma}}, \tag{4}$$

where $\psi \equiv \Psi^{1-\sigma} \in [0,1]$ is the index of internal integration while $\phi_r \equiv T_r^{1-\sigma} \in [0,1]$ represents trade freeness between *Home's* region r and *Foreign*.

On account of zero profits operating profits, R, equal fixed costs, i.e. $R = (q - c)x$. Hence, a firm's scale is $x = (\sigma - 1)(R/c)$ and its cost function is $\sigma R = R + cx$ implying $\sigma R = qx$. Clearing of the market of a variety implies that revenue equals the value of sales to all regions, i.e.

$$\sigma R = q x_r = P_r q m_{rr} + q P_s \Psi m_{rs} + P_j T_r m_{rj}. \tag{5}$$

After substituting (2), and (4) into (5) we see that the factor income in manufacturing is a function of the nominal market access (MA) of the region. The latter is the sum over local market access, interregional market access and international market access, thus[5]

$$\sigma R_r = \underbrace{P_r \alpha_r \left(\frac{Q_r}{q} \right)^{\sigma - 1}}_{\text{local MA}} + \underbrace{\psi P_s \alpha_s \left(\frac{Q_s}{q} \right)^{\sigma - 1}}_{\text{interregional MA}} + \underbrace{\phi_r P_j \alpha_j \left(\frac{Q_j}{q} \right)^{\sigma - 1}}_{\text{international MA}}. \tag{6}$$

This is region's income from manufacturing. Full regional income requires to add labor employed in homogeneous tradables[6]. In the following we derive differences in per capita income. Because the extension to income from the homogeneous good sector is straightforward we focus only on income from manufacturing.

In addition there is some kind of dynamics in the model because λ is endogenous. Entrepreneurs

[5]The core periphery model of Krugman (1991) as well as other NEG approaches produce the same general pattern of this equation. Therefore, the following holds for all that kind of models.

[6]Redding and Venables (2004) solve for marginal costs that are included in q above. Then marginal costs, or factor income, depend on the real market access divided by σ. Our solution refers to zero profits. Then σR represents rewards from skilled and unskilled labor in manufacturing. Then $(\sigma - 1)R$ is equivalent to wages paid to the variable factor. For this reason, it is not necessary to solve for q and the RHS represents the real market access.

move into the region offering them the higher real reward, i.e. the higher indirect utility. Therefore λ depends on all parameters of the model.

2.2 Income inequality

Equation (6) is the basis for the whole econometric analysis. We use this equation in several ways. First, we rewrite the equation to determine inequality depending on different definitions of trade openness.

The standard approach to get a link between market access and trade openness is to assume that the trade to GDP ratio is a proxy for international market access divided by Ricardian profits (e.g. Redding and Venables, 2004). This, however, is not fully consistent with the a typical NEG model, e.g. the model we use. Market access in (6) refers to exports. To consider imports we have to extend this equation. Second, freeness of trade or '*phiness*', i.e. ϕ, is an important determinant of regional income. It is, thus, much more natural to use '*phiness*' as measure of openness in these models.

Rearranging (6) will show, how freeness of trade determines interregional inequality. A further problem arises, when we switch to a world with more than two countries. Than bilateral openness has to be extended to a multilateral openness measure. The following exercise will provide an idea how such an multilateral '*phiness*' has to look like. Later on we can also derive a gravity equation to estimate and construct the instruments for both openness measures.

2.2.1 Inequality measures using the trade to GDP ratio

For the time being we assume that workers are equally distributed across regions and technologies are identical. Since we, further assume constant marginal productivity of labor, income differences across regions depend on Ricardian profits. We define per capita income of region r as $y_r = (n_r \sigma R_r)/P_r$ and y_i as *Home*'s average income p.c. Next, to simplify matters we define local market access, A_{rr}, market access of r in s, A_{rs}, and international market access, i.e. exports E_r to all countries. These are

$$A_{rr} \equiv n_r P_r \alpha_r \left(\frac{Q_r}{q}\right)^{\sigma-1}, \qquad A_{rs} \equiv \Psi_{rs} n_r P_s \alpha_s \left(\frac{Q_s}{q}\right)^{\sigma-1}, \qquad E_r \equiv n_r T_{rj} P_j \alpha_j \left(\frac{Q_j}{q}\right)^{\sigma-1}. \quad (7)$$

We use these definitions to rewrite the region's expenditure for varieties as well as (6), thus, giving us the two accounting equations for the use of income and the use of production[7]

$$Y_r = A_{rr} + A_{sr} + I_r \qquad\qquad Y_r = A_{rr} + A_{rs} + E_r.$$

Adding up and dividing by P_r implies

$$y_r = \frac{A_{rr}}{P_i p_r} + \frac{1}{2}\left(\frac{A_{rs} + A_{sr}}{P_i p_r}\right) + \frac{1}{2}\frac{I_r + E_r}{P_i p_r}, \tag{8}$$

where p_r is the region r's share in *Home*'s population. Aggregating over all regions gives the countries per capita income y_i

$$y_i = \frac{A_{rr} + A_{ss}}{P_i} + \frac{A_{rs} + A_{sr}}{P_i} + \frac{1}{2}\frac{I_i + E_i}{P_i}. \tag{9}$$

A region's relative deviation in per capita income from the average is then

$$\frac{y_r - y_i}{y_i} = \left(\frac{e_{A_r}}{p_r} - 1\right) + \frac{1}{2p_r}\left[(e_{I_r} - p_r e_{I_i}) + (e_{E_r} + p_r e_{E_i} - 2e_{A_r} eE_r + p_r)\right] T_i, \tag{10}$$

where I represents imports and E denotes exports. e_{I_r} and e_{E_r} are region r's import and export shares on the country's aggregate trade $I_i + E_i$, respectively, e_{I_i} and e_{E_i} are shares of imports and exports to trade of country i, and T_i is the trade to GDP ratio of the country. Further, we used the definitions for absorption, the regions share in absorption and the link between exports and absorption given by

$$A_i \equiv A_{rr} + A_{ss} + A_{rs} + A_{sr}, \qquad e_{A_r} \equiv \frac{A_{rr} + \frac{1}{2}A_{rs} + \frac{1}{2}A_{sr}}{A_i}, \quad \frac{A_i}{Y_i} = \frac{Y_i - E_i}{Y_i}.$$

Equation (10) states that a region's relative income depends on two components. The first term is a measure of intra-country openness. If the regions share on all intra-country trade in relation to its population share is larger than that of the average region, the region is relatively rich. In this case it trades more within itself or with other regions implying gains from intracountry trade.

[7] As we have shown above, we can use nominal export values due to the link between Ricardian profits and factor income. This is in contrast to the approach used in Egger et al. (2005), Redding and Venables (2004) or Head and Mayer (2006) who use real exports.

In addition the markup on prices, and, thus, income depends on the tightness of competition in that region. The second term is the weighted trade to GDP ratio of the country, where the weights depend on the deviation of regions' shares of imports and exports from the country shares.

This implies the econometric model

$$I_{it} = a_i + b_{1kt}\mathbf{Z}_{ikt} + b_2\mathbf{X}_{iht} + b_3 T_{it} + b_4\mathbf{X}_{iht} \times T_{it} + d_t + \varepsilon_i, \tag{11}$$

where I_{it} is a measure for interregional inequality in country i at time t, $\mathbf{Z}_{ikt}$ are exogenous control variables, T_{it} is the trade to GDP ratio, $\mathbf{X}_{ikt}$ are other control variables that interact with this measure and represent the weights in (10), d_t are time effects, a_i are country fixed effects, and e_{it} is the error term. In the specifications that use the cross-section data set, we estimate a similar model, which, of course, has no fixed effects and no time dimension.

2.2.2 Inequality measure using the freeness of trade

In our model, freeness of trade enters all parts of the inequality equation (10) and, thus, is an important determinant of interregional inequality. Despite that "phi-ness" (Baldwin et al.˜,2005) it is not used in the empirical studies on interregional inequality.[8]

We substitute the price indices (6) into the equation for operating profits (6) and divide by P_r to get

$$y_r = N^\sigma \mu_i \frac{\lambda_r}{p_r}\left(\frac{p_r\alpha}{\Delta_r} + \psi\frac{p_s\alpha}{\Delta_s} + \phi_{rj}\frac{P_i\alpha_j}{P_i\Delta_j}\right), \tag{12}$$

where

$$\Delta_r \equiv \mu_i\left(\lambda_r + \psi\lambda_s\right) + \phi_{rj}\mu_j, \qquad \Delta_j \equiv \mu_i\sum_s \phi_s\lambda_s + \mu_j,$$

are terms inversely related to the price indices. A countries income per capita is given by aggregating (6) and dividing by P_i (see Appendix)

$$y_i = N^\sigma \mu_i \sum_s \lambda_s\left(\frac{p_s\alpha}{\Delta_s} + \psi\frac{p_k\alpha}{\Delta_k} + \phi_{sj}\frac{P_j\alpha_j}{P_i\Delta_j}\right). \tag{13}$$

[8] Combes et al. (2005) provide an example for the empirical use of bilateral freeness of trade in a study on another topic.

Manipulating the difference, eventually yields (see Appendix)

$$\frac{y_r - y_i}{y_i} = \left(\frac{e_{E_r}}{p_r} - \frac{e_{A_r}}{p_r} \right) \frac{E_i}{Y_i} = N^{\sigma} \left(\frac{\lambda_r}{p_r} - \frac{\frac{\lambda_r p_r}{\Delta_r} + \psi \frac{\lambda_s p_s}{\Delta_s p_r}}{(1+\psi) \sum_s \frac{\lambda_s p_s}{\Delta_s}} \right) \Phi_i, \tag{14}$$

where γ_i is the ratio of *Home*'s GDP to the aggregate GDP of all destination countries. Further, we assume that the ratio of region r's trade costs to the country's trade cost is constant across all destination countries. We now have a measure for aggregate freeness of trade of *Home*:

$$\Phi_i = \sum_j \frac{\gamma_j}{\gamma_i} \frac{\mu_i \phi_{ij}}{\mu_i \phi_{ij} + \mu_j}, \tag{15}$$

where γ_j is the ratio of country j's GDP to the aggregate GDP of all destination countries and ϕ_{ij} are symmetric bilateral trade costs between countries i and j. Interregional differences in the income depend now on the weighted aggregate freeness of trade where the weight refers to the regional freeness of trade, the regions population share and the region production share to the country's absorption.

After linearization we get the econometric model

$$I_{it} = a_i + b_{1kt} Z_{ikt} + b_2 \Phi_{it} + d_t \epsilon_i, \tag{16}$$

where $a = N^{\sigma}$, Z_{ik} is a vector of controls for the term in square brackets in (14) and Φ is the overall freeness of trade of country i defined in 15 and I_i is the logarithm of the income distribution measure.

Unfortunately, bilateral trade openness also enters the price indices (14) and determines λ. For this reason we have to test linearity and also consider interaction terms below.

3 Empirical Analysis

3.1 Data and Variables

3.1.1 Interregional inequality

Below we measure regional inequality (I) by the population weighted coefficient of variation of the regional GDP per capita as calculated by

$$I_{it} := \frac{1}{\bar{y}_{it}} \left[\sum_{r=1}^{S} p_{rit} \left(y_{rit} - \bar{y}_{it} \right)^2 \right]^{1/2} . \tag{17}$$

where $\bar{y}_{it}$ is country i's average GDP p.c. in period t, y_{rit} is the per capita income of region r in country i, p_{rit} is the share of the country's total population in region r, and n is the number of spatial units. This measure has frequently been used in economic geography, and was introduced by Williamson (1965) (see Lessmann, 2013, for detailed descriptions of the data). The measure is mean-independent, independent of the sizes and the number of spatial units, and it satisfies the Pigou–Dalton transfer principle, which states that a transfer from rich to poor regions should reduce the inequality measure (see Dalton, 1920, Pigou, 1912, and Sen, 1973, for details].

We use two different data sets to calculate the measures of regional inequality. First, we refer to Lessmann (2011), who has collected a panel data set of regional inequality. It covers 56 countries (835 sub-national regions) for the period 1980–2009. Second, we use the regional data provided by Gennaioli et al. (2013). This cross-section data set covers 110 countries (1569 sub-national regions) for the year 2005. Both data sources have their strengths and weaknesses. The data provided by Gennaioli et al. (2013) covers more countries, in particular less developed countries, which brings more variation to the cross-section. But this data set has no panel structure, which is the advantage of Lessmann (2011). Therefore, we decided to use both data sets and to compare the results.

The territorial level, at which the regional income is measured, differs slightly between Lessmann (2011) and Gennaioli et al. (2013). While Lessmann (2011) concentrates on NUTS2 regions for European countries or state/province level data otherwise, Gennaioli et al. (2013) focuses on the sub-national level with the highest political authority. Therefore, the regions are more heterogeneous in terms of size in the data set of Gennaioli et al. (2013). Another small difference is the

measure of regional income: while Lessmann (2011) uses the regional per capita GDP, Gennaioli et al. (2013) also include regional wage data and data on household income where GDP data is not available. The correlation between the inequality measures based on the different data sources is with 0.7724 fairly high.

To get a first impression of the data, Table 1 shows our inequality measure for all countries considered in the cross-section.

We have grouped the countries by their gross national income per capita using the 2013's World Bank classification. Most countries in our data set are high income countries, but we have also a good representation of low and middle income countries. Interestingly, high income countries have on average lower regional inequality than upper middle income countries, and upper middle income countries have lower regional inequality compared to lower middle income countries. This is in line with the theory of Kuznets (1955) and Williamson (1965), which suggests an inversely u–shaped relationship between regional inequality and development (see Barrios and Strobl, 2009, and Lessmann, 2011, for empirical evidence of the *Kuznets curve* in regional inequality). The smaller number of low income countries have higher regional inequality contrasting these findings. However, if we merge the groups of low income countries and lower middle income countries, we have average regional inequality of 0.38, which again supports the 'inverted u' hypothesis. Note that the quality of the regional data in low income countries is not very high. Gennaioli et al. (2013) have to make several data adjustments to make them compatible with country level income data as reported by the World Development Indicators, therefore we should be cautious when interpreting the data of low income countries.

3.1.2 Openness measures

T_i is the trade to GDP ratio (e.g. Redding and Venables, 2004). We measure it by the sum of exports and imports to GDP of country i in purchasing power parities (see Alcalá and Ciccone, 2004). The actual trade shares come from the World Development Indicators Series while the trade to GDP ratio is provided by *Penn World Tables 7.1* (Heston et al., 2012).

Because interregional inequality might affect this trade to GDP ratio, for instance by enforcing protection, it might be endogenous. To handle this issue we apply IV estimates. We first estimate the trade to GDP ratio, $\hat{T}_i$, by applying a gravity approach to bilateral trade. The trade instrument is calculated using the data by Head et al. (2010), who refer to the International Monetary

Table 1: Population-weighted coefficient of variation of regional GDP p.c. based on Gennaioli et al. (2013)

High Income Countries (GNI per capita $12,476 or more)		*Upper Middle Income Countries (GNI per capita $4,036 to $12,475)*		*Lower Middle Income Countries (GNI per capita $1,026 to $4,035)*		*Low Income Countries (GNI per capita $1,025 or less)*	
Country	*I*	Country	*I*	Country	*I*	Country	*I*
Argentina	0.73	Azerbaijan	0.12	Albania	0.50	Benin	0.50
Australia	0.09	Brazil	0.48	Armenia	0.19	Burkina Faso	0.13
Austria	0.22	Chile	0.36	Belize	0.26	Cambodia	0.38
Belgium	0.36	China	0.54	Bolivia	0.36	Cameroon	0.30
Bosnia and Herz.	0.09	Colombia	0.38	Egypt	0.33	Congo, Dem. Rep.	0.85
Bulgaria	0.24	Dominican Rep.	0.32	El Salvador	0.28	Ghana	0.38
Canada	0.21	Ecuador	0.29	Georgia	0.19	Kenya	0.91
Croatia	0.34	Gabon	0.24	Guatemala	0.47	Kyrgyz Republic	0.49
Czech Republic	0.40	Iran	0.63	Honduras	0.44	Madagascar	0.32
Denmark	0.24	Jordan	0.20	India	0.44	Malawi	0.12
Estonia	0.42	Kazakhstan	0.30	Indonesia	0.87	Mozambique	1.01
Finland	0.16	Latvia	0.59	Lao PDR	0.32	Nepal	0.17
France	0.26	Lebanon	0.24	Lesotho	0.35	Niger	0.42
Germany	0.20	Lithuania	0.31	Moldova	0.29	Tanzania	0.35
Greece	0.29	Macedonia, FYR	0.45	Mongolia	0.57	Uganda	0.30
Hungary	0.41	Malaysia	0.38	Morocco	0.23	Zimbabwe	0.32
Ireland	0.17	Mexico	0.58	Nicaragua	0.36		
Israel	0.12	Namibia	0.72	Nigeria	0.43		
Italy	0.26	Panama	0.48	Pakistan	0.08		
Japan	0.30	Peru	0.47	Paraguay	0.29		
Korea, Rep.	0.22	Romania	0.40	Philippines	0.25		
Netherlands	0.14	Russia	0.93	Senegal	0.16		
New Zealand	0.19	Serbia	0.39	Sri Lanka	0.50		
Norway	0.35	South Africa	0.44	Swaziland	0.21		
Poland	0.26	Thailand	0.87	Syrian Arab Rep.	0.11		
Portugal	0.26	Turkey	0.34	Ukraine	0.57		
Slovak Republic	0.53	Uruguay	0.37	Uzbekistan	0.43		
Slovenia	0.26	Venezuela	0.29	Vietnam	0.33		
Spain	0.20			Zambia	0.34		
Sweden	0.21						
Switzerland	0.27						
United Arab Em.	0.44						
United Kingdom	0.22						
United States	0.17						
Mean (unweighted)	*0.27*		*0.43*		*0.35*		*0.43*
Standard deviation	*0.13*		*0.19*		*0.16*		*0.27*

Fund's *Direction of Trade Statistics* (DOTS). Subsequently, we apply an IV estimation with $\hat{T}_i$ as instruments for the trade to GDP ratio.

When we use the second approach, the major problem is likely endogeneity of trade openness. Therefore, we follow the same procedure described above. Though we have an exact measure of trade openness, we do not have data on the number of firms. Further, bilateral freeness of trade depends on imports and exports and, thus, endogeneity issues are similar to those in the case of the trade to GDP ratio. For this reason we instrument Φ_i by an proxy calculated from the estimates of bilateral trade freeness in a gravity approach. Because the GDP is the weight in the measure and because this might be endogenous, we use population shares to approximate the weights in the constructed freeness index.

We calculate bilateral trade openness following Head and Ries (2001) according to

$$\phi_{ij} = \sqrt{\frac{I_{ji}}{Y_i - E_{ij}} \frac{I_{ij}}{Y_j - E_{ji}}} \tag{18}$$

The correlation among both measures is 0.3679. **Figure ??** provides a scatterplot of trade to GDP and freeness of trade showing that larger countries, e.g. USA, China, Germany tend to have a higher freeness measure in comparison to their trade to GDP ratio.

Third, we use the openness measure based on exports to standardized GDP provided by Arrabias et al. (2009) as third measure of openness, to control for robustness. Due to endogeneity we use this measure only in the system gmm estimates. The correlation among these measures is displayed in **Table 2**

	T_i	Φ_i	DO_i
T_i	1.0000		
Φ_i	0.3024	1.0000	
DO_i	0.4860	0.3309	1.0000

DO_i degree of openness á la Arrabias et al. (2009)
observations 489589

Table 2: Correlation of openess measures

3.1.3 Weights and interregional accessiblity

As theory shows (see (10) and (14)) interregional allocation matters, too. It determines the weights in the trade to GDP ratio as well as the nonlinearity in the freeness of trade, shown in the price

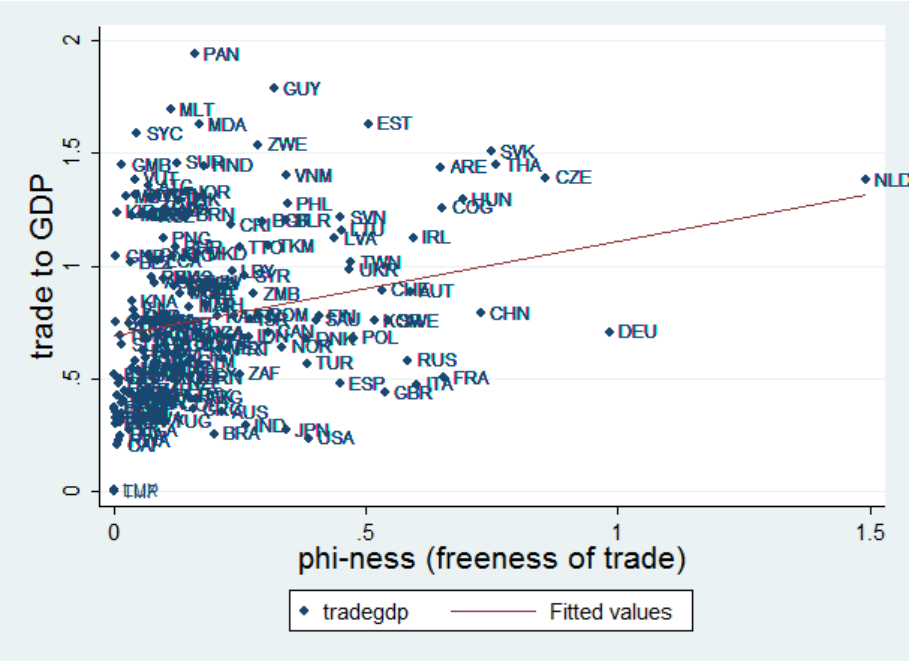


Figure 1: Trade to GDP ratio versus trade freeness ('phi-ness')

indices in local and interregional market access. As discussed above we approximate this through interaction terms in the econometric specification, see (11) and (16), and also by applying semi-parametric estimates.

Due to the lack of data on interregional accessibility, the number of firms, interregional trade, and trade between regions and other countries, we have to choose proxies for the internal structure of a country. We use the degree of urbanization as proxy for the distribution of agglomeration effects, firms and population and the share of agriculture as proxy for the importance of industry that determines the agglomeration-periphery pattern. As third alternative measure, we use the road density –measured by road km to country size – that refers to infrastructure and, indirectly, to accessibility within the country.[9]. These controls are also used as proxies for interregional and local market access if required.

In the cross-section estimations, we control for the number of sub-national units within countries (in logs), country size (ln of area in square kilometers), and an fraction of these two variables to control for average unit size. These are also used as proxis for the internal structure of a country and also control for political economy effects (e.g. Lessmann ,2011).

[9]At this, we deviate from Rodríguez-Pose (2012), who uses a joint index of rail and road density. Since data on rail ways are lacking for many countries, we decided to focus on roads solely.

3.2 Other controls

To account for Kuznets-curve effects (see above), we control for income by the per capita GDP and its square.

Following Rodríguez-Pose (2012) and Lessmann (2011), we, further, control for policy issues: government size (measured by the expenditure to GDP ratio), a federal dummy, and EU membership. There is a quite large literature on the effect of decentralization on regional inequality, which shows that federal countries have lower regional inequalities, in particular if high income countries are considered (e.g., Rodríguez-Pose and Ezcurra, 2010 and Lessmann, 2012). The EU membership dummy and the government size measure should proxy for redistributive politics within countries, performed by international donors or the national government. However, the EU dummy also controls for a high level of internal integration specific to a selection of countries. Table A.2 in the appendix provides a detailed description and source information of all variables considered in the analysis. **Table 3** and **Table ??** show descriptive statistics.

Table 3: Descriptive Statistics (Gennaioli et al., 2013)

Variable	Obs	Mean	Std.Dev.	Min	Max
covwshleifer	105	0.3606	0.1910	0.0839	1.0123
tradegdp	105	0.8077	0.3740	0.2190	2.0520
$\hat{tradegdp}$	105	0.6259	0.3431	0.1534	1.6930
Φ	105	0.2543	0.2931	0.0016	2.1583
$\hat{\Phi}$	105	0.1987	0.2302	0.0013	1.3148
logunits	105	2.4291	0.6395	0.6931	4.3820
logarea	105	12.4143	1.5688	9.2301	16.6128
log(area/units)	105	5.4930	1.8261	3.1572	16.0722
urban(ization)	105	56.2137	21.6385	12.2600	97.1800
roaddens	83	68.2550	84.9324	1	490.3333
agri	103	14.3068	12.3885	0.8836	51.8000

3.3 Constructing the instrument for trade shares

The major problem for our econometric analysis is that trade shares might be endogenously determined by regional inequality. Consider for example a shock in regional inequality, caused by the discovery of natural resources or a boom in a single industry of one region of a country. It is obvious that the shock will also affect the trade statistics of the country. Therefore trade and regional inequality are simultaneously determined. Another source of endogeneity are omitted variables and/or measurement errors in variables. For example, regional inequality might cause

political instability (see Buhaug et al., 2012, Deiwiks et al., 2012, and Lessmann, 2013, for empirical evidence). This will discourage foreign and domestic investments, increase protection and reduce income, thereby reducing international trade and freeness of trade. For this reason we construct an instrument for trade shares and use it in instrumental variable regressions.

We derive the gravity equation for the bilateral trade-to-GDP ratio from our model giving us (see Appendix B)

$$\ln \frac{I_{ji} + E_{ij}}{Y_j} = \beta_0 + \beta_1 \ln Y_j + \beta_2 \ln Y_i + \beta_3 \ln \phi_{ij} + \beta_4 \ln \left(\frac{Q_j^{\sigma-1}}{\Pi_i} + \frac{P_i^{\sigma-1}}{\Pi_j} \right) + \varepsilon. \tag{19}$$

Bilateral trade between country i and country j depends on both countries' income, Y_i, Y_j, on trade openness between both countries, ϕ_{ij}, plus two terms describing the relative attractiveness of the destination country in comparison to the Rest of the World and the relative market access to all countries. The latter it the multilateral resistance (ML) term Π of the country of origin. It has to be considered when estimating bilateral trade (Anderson and van Wincoop, 2003)[10].

3.3.1 The bilateral trade equation

When estimating a gravity equation five problems arise: (1) there might be endogeneity of the GDP (Frankel and Romer, 1999) and (2) endogeneity of trade cost controls such as free trade agreements (e.g. Baier and Bergstrom, 2007). (3) one has to take care of multilateral resistance terms, (4) a huge number of zero trade flows are present in the data, and (5) there will unobserved heterogeneity across countries.

Even though endogeneity of GDP might not be a huge problem because the GDP depends on net exports which is only a small contributor to GDP (e.g. Baier and Bergstrom, 2007), we follow Frankel and Romer (1999). However, we need a time-varying instrument of trade flows and, hence, extend their approach according to Head et al. (2010). We use population of the countries and other time invariant geographic variables, e.g. distance and access to the sea, instead of the endogenous GDP.

To consider the multilateral resistance term (Anderson and van Wincoop, 2003) we follow Feenstra (2004) and include country-pair fixed effects. These dummy variables capture all time-invariant factors that are country-pair specific (e.g. distance, common language, etc.)[11]. In doing

[10] A similar expression has been provided by Helpman and Krugman (1985) and Helpman (1987).

[11] Cheng and Wall (1999) and Egger and Pfaffermayr (2003) have shown that neglecting these country-pair fixed

so we also deal with endogeneity of trade openness variables that affect trade such as regional trade agreements (see Baier and Bergstrand, 2004). We further use distance and the interaction term of time and distance as additional proxies for trade openness.

Trade costs and a country's price index depend also on some intracountry variables such as the degree of agglomeration. However, because interregional inequality also depends on the degree of agglomeration and intracountry trade costs, controls that are used as proxy for those variables are not used in the gravity equation. Otherwise the instrument would become closely correlated with interregional inequality. Instead we use bilateral country-pair fixed effects to allow for a basic level of such effects.

Further we control for exogenous changes in transport costs by an interaction term of distance and time and for the importance of common institutional settings by considering an interaction term of the common legislative tradition with population size and, alternatively, an interaction term of the dummy of common history with the population size. This refers to market access costs and to exogenous restrictions due to institutional settings[12].

To summarize: we apply a regression with country-pair fixed effects and time fixed effects for constructing the cross-section proxy for the real trade-to-GDP ratio (see Baier and Bergstrom, 2007). As Cheng and Wall (1999) and Egger and Pfaffermayr (2003) have shown, neglecting these country-pair fixed effects would cause an estimation bias.

Our final bilateral gravity model has the following form

$$\begin{aligned} \ln(\frac{\tau_{ijt}}{GDP_{it}}) =& \alpha_{ij} + \beta_1 \ln POP_{it} + \beta_2 \ln POP_{jt} \\ &+ \beta_4 \left(Comlang_{ij} * \ln POPjt\right) + \beta_3 \left(Comlang_{ij} * \ln POP_{it}\right) \\ &+ \beta_5 \left(Time_t * Distance\right) + \qquad \mu_t + \epsilon_{ijt} \end{aligned} \tag{20}$$

where τ_{ijt} is bilateral trade between countries i and j at time t measured as exports plus imports, GDP_{it} is the income of country i at time t and $Comleg_{ij}$ represents common language that is used to account for close historical and cultural links between countries. Thereby, we concentrate on bilateral trade-to-GDP ratios (trade shares) following the approach of Frankel and Romer (1999), not on exports as Head et al. (2010).

effects causes an estimation bias.

[12]One might think of extractive versus inclusive institutions as suggested by Acemoglu, Johnson and Robinson (Acemoglu and Robinson, 2000, Acemoglu et al., 2002).

Country size is considered by including the natural logarithm of the population size of country i and j ($POP_{i,j}$). Finally, α_{ij} are country pair fixed effects, μ_t are time fixed effects, and ϵ_{ijt} is the error term. Note that time invariant trade determinants, such as the country size measured by the surface area, are not included in the empirical model, since the country pair fixed effects, are perfectly correlated with these variables.

3.3.2 Results

We use the same data set as Head et al. (2010).[13]. The original data source of the trade data is the International Monetary Fund's *Direction of Trade Statistics* (DOTS). The final data set covers the 1948–2006 period and contains trade data of 208 countries.

The main estimation results of the gravity model are reported in Table 4[14].

Column (1) of **Table 4** displays the independent variable, column (2) the estimated coefficients, column (3) the robust standard errors, and column (4) the significant levels. The regression is based on 714,343 observations of 28,621 trade pairs (208 countries)..

The figures in column (1) provide evidence that trade openness is increasing in the population size of country i, while there is no significant unconditional effect of the size of country j. Concerning the interaction variables, only the interaction of the population in country j and the border dummy is significant with a positive coefficient. Thus, the population size of trade partner countries j has only an effect in neighboring countries, not in general.

Concerning trade freeness, column(2) show that trade freeness of a country declines with its population and with distance, while size of the destination country is insignificant.

The estimated coefficients are then used to make linear predictions of the bilateral trade flows. Note that we use the full data set for this exercise, not only those countries, which are included in the data base used below. If we calculate the pairwise correlation between predicted bilateral trade and the dependent variable, $\ln(\tau_{ijt}/GDP_{it})$, we get a high correlation of 0.9060. This is however, a correlation between logarithms at the country pair level, which is not the variable that we use in the main part of the paper. The correlation between bilateral trade freeness and the predicted trade freeness is 0.7643.

[13] The data set can be downloaded at http://www.cepii.fr

[14] We used many other specifications including the idea of a common law or a shared history instead of common language. We also applied a Poisson pseudo-maximum likelihood estimation with bilateral fixed effects to account for the large number of zeros (e.g. Santos Silva and Tenreyo, 2011). Two account for dyadic FE in that approach we applied xtpqml written by T. Simcoe

Table 4: The bilateral trade equation

VARIABLES	(1) logflow_GDP	(2) phiness
logpop_o	0.0732*	-0.161***
	(0.0390)	(0.0372)
logpop_d	0.0375	-0.409
	(0.0363)	(0.0372)
comlangXlogpop_o	0.0542	
	(0.0746)	
comlangXlopop_d	-0.191**	
	(0.0753)	
tdummy_dist	-0.00581***	-0.00563***
	(0.000470)	(0.000475)
Constant	-5.214***	-4.440***
	(0.248)	(0.259)
Observations	714,343	489,724
R-squared	0.013	0.031
Number of countrypair	28,621	24,287
F	48.39	77.24

Notes: The dependent variable in (1) is $\ln(\tau_{ijt}/GDP_{it})$.
Notes: The dependent variable in (2) is Φ_i.
Robust standard errors in parentheses.
***, **, and * indicate significance at 1%, 5%, and 10%.
Country pair fixed effects and time effects are not reported due to space limitations.

3.3.3 Aggregate trade and quality of the instrument

The predictions of the bilateral trade flows have to be aggregated for each country i. At this, we closely follow Frankel and Romer (1999). First, we rewrite equation (20) as

$$\ln(\tau_{ijt}/GDP_{it}) = \alpha_{ij} + \hat{\beta}\mathbf{X}_{i,j,t} + \mu_t \tag{21}$$

where $\hat{\beta}$ is the vector of the estimated coefficients as reported in Table 4, and $\mathbf{X}_{ijt}$ is the vector of trade determinants. Country i's overall constructed trade share is then given by

$$\hat{T}_{it} = \sum_{j \neq i} \mathrm{e}^{\alpha i,j + \hat{\beta}\mathbf{X}_{ij,t}}. \tag{22}$$

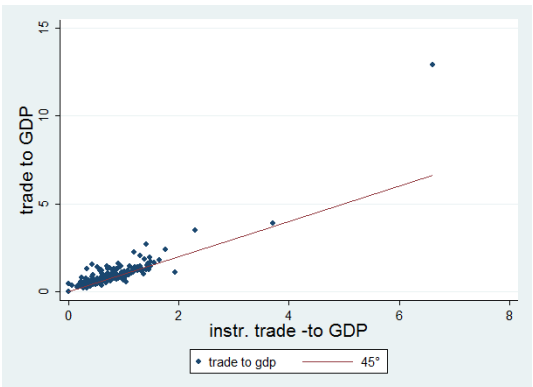
The constructed trade share of country i is given by the sum of the estimated bilateral trade with each country of the world. We are able to construct $\hat{T}_{it}$ for 208 countries in the world. Note that

the constructed trade flows are only based on the variables used in the gravity model, in particular the trade shares are independent of country i's income, which might be endogenously determined by trade and/or regional inequality. We are also able to construct trade shares even for those countries, where trade data is missing, but trade determinants are available.

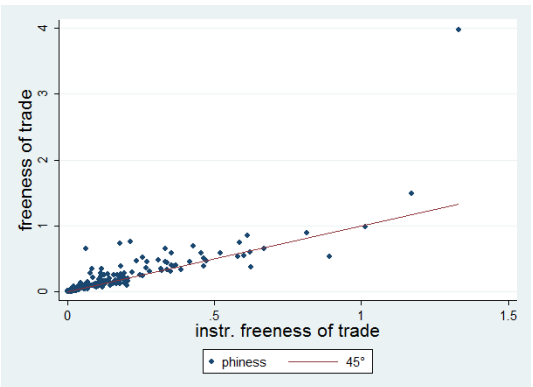
Figure 2 shows the relationship between constructed openness measures $\hat{T}_{it}$ and $\hat{\Phi}$, and actual openness measures, T_{it} as reported by the World Development Indicators Series and Φ as calculated from the World Development Indicator Series. Panel (a) and (b) displays it for the year 2005 and panels (c) and (d) for the whole time period considered.

Figure 2: Constructed versus actual openness measures

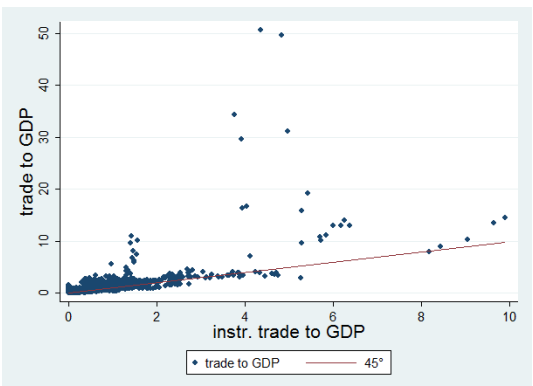
(a) Constructed vs. actual trade share - 2005



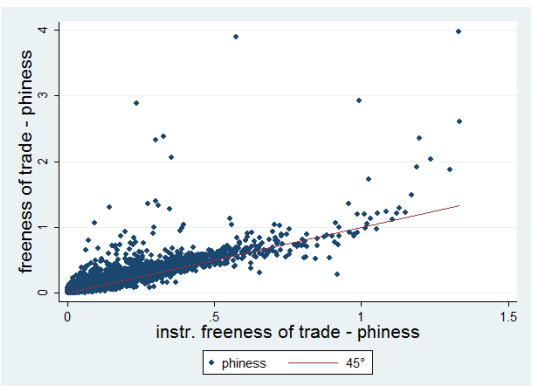
(b) Constructed vs. actual trade freeness



(c) Constructed vs. actual trade share - all years



(d) Constructed vs. actual trade freeness - all years



The correlation between the constructed trade shares and actual trade shares is quite high with a correlation coefficient of 0.7797. In the case of trade freeness the correlation is 0.8504. The figures also include the bisecting line, which indicates where actual and fitted openness measures are equal.

3.4 IV regressions: cross country results

In the following, we present the results of instrumental variable regressions using the cross-section data set. At this, the trade share is treated as endogenous, and the constructed trade shares from the gravity model as used as instruments. In order to reduce the effect of single outliers in the trade data, we build a 5-year period average of all variables (2000–2004). In the cross-section analysis, we refer to the data set constructed based on the regional incomes used in Gennaioli et al. (2013) who compile the data for the year 2005. The final sample consists of 105 countries. **Table 5** presents the results of the trade to GDP regressions and **Table ??** the second-stage results of the freeness of trade estimates[15].

In all IV estimates the first round results provide a Kleinberger-Paap Wald statistic (widstat) that is always above 16 indicating that the instruments are not weak (see Stock and Yogo, 2005, for critical values). Further tests on endogeneity and underidentification (idstat) have the right signs, too.

Concerning the trade to GDP estimates (**Table 5**) the point estimates imply that an increase in the trade to GDP ratio by ten percentage points is associated with an increase in regional inequalities by approx. 2%. The regressions also imply that country size plays a role. In line with Lessmann (2011) we find evidence of an inverted u-relationship between development and regional inequalities. The effects of urbanization and infrastructure are not significant, but it is quite suggestive that the regression coefficients are negative. The share of agriculture is also not significantly related to regional inequality as well as the political variables government size, federal dummy, and the EU dummy.

Table ?? presents the cross-section results concerning the trade freeness measure with the Gennaioli et al. (2013) data. The coefficient of the freeness measure is always positive but changes between beeing significanct and insignificanct. The findings is much less robust. This has clear implications on policy as discussed below.

Next, we present similar estimations using a cross-section of the regional data provided by Lessmann (2011). Here, our sample is significantly smaller considering a number of maximal 54 countries. **Table 7** presents the results of the second stage regressions.

[15] Because OLS is very sensitive to outliers we apply MM-estimators as suggested by Yohai (1987) in the non-IV estimates. We applied mmregress of Verardi and Croux (2009) to identify outliers with vertical and bad leverage and a robust estimator (robreg, see Jann 2010). As a robustness check we carried out IV estimates without outliers. But this did not change the findings.

Table 5: Cross section with trade to GDP, Gennaioli-Data

	(1) IV0	(2) IV1	(3) IV2	(4) IV3	(5) IV4	(6) IV5	(7) IV9	(8) IV10	(9) RobR2
VARIABLES	covw	covw	covw	covw	covw	covw	covw	covw	covw
tradegdp	-0.0192	0.209***	0.229***	0.199**	0.226***	0.242***	0.204**	0.211**	0.0899**
	(0.0557)	(0.0798)	(0.0843)	(0.0862)	(0.0856)	(0.0904)	(0.0879)	(0.0941)	(0.0422)
loggdppc	0.131	0.0167	0.0595	0.198*	0.0573	0.142	0.120	0.0682	0.198*
	(0.162)	(0.131)	(0.156)	(0.113)	(0.156)	(0.202)	(0.190)	(0.189)	(0.113)
loggdppc2	-0.0104	-0.0034	-0.0052	-0.0129*	-0.005	-0.0094	-0.009	-0.0046	-0.0136**
	(0.00984)	(0.00800)	(0.00907)	(0.00684)	(0.00910)	(0.0111)	(0.0110)	(0.0113)	(0.00663)
urban			-0.0014	-0.0019	-0.0015	-0.0015	-0.0017	-0.0019	-0.00053
			(0.0015)	(0.0014)	(0.0015)	(0.0015)	(0.0016)	(0.0016)	(0.0012)
roaddens				-5.55e-05					
				(0.0002)					
popdens					-2.09e-05				
					(5.35e-05)				
agri						0.0024			
						(0.0038)			
govsize							-0.00087	-0.00035	
							(0.0022)	(0.0022)	
oecd								-0.0704	
								(0.0643)	
Constant, logunits, logarea, logarea/logunits									
Observations	105	105	105	83	105	103	83	83	105
R-squared	0.088	0.304	0.304	0.329	0.306	0.293	0.387	0.390	
F	6.097	10.89	9.098	7.493	7.959	7.447	9.129	7.964	.
rss	3.460	2.640	2.641	1.589	2.634	2.636	1.883	1.874	.
idstat	20.36	10.61	11.32	9.239	11.06	12.11	9.131	8.408	.
idp	6.41e-06	0.0011	0.0008	0.0024	0.00089	0.0005	0.0025	0.0037	.
widstat	133.5	28.37	41.07	57.74	39.41	35.90	36.17	33.65	.

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 6: Cross section with trade freeness, Gennaioli-Data

	(1) IVS0	(2) IVS1	(3) IV2	(4) IV3	(5) IV4	(6) IV5	(7) IV9	(8) IV10	(9) RobR2
VARIABLES	covw	covw	covw	covw	covw	covw	covw	covw	covw
phiness	0.0977	0.0971*	0.103*	0.126	0.151***	0.0985	0.0970	0.106*	0.0950***
	(0.0718)	(0.0558)	(0.0584)	(0.108)	(0.0584)	(0.0618)	(0.0600)	(0.0613)	(0.0271)
loggdppc	0.138	0.109	0.169	0.315***	0.161	0.144	0.210	0.165	0.262***
	(0.160)	(0.137)	(0.171)	(0.106)	(0.167)	(0.219)	(0.207)	(0.206)	(0.101)
loggdppct2	-0.0115	-0.00968	-0.0124	-0.0202***	-0.0120	-0.0112	-0.0151	-0.0112	-0.0181***
	(0.0099)	(0.0085)	(0.0101)	(0.0063)	(0.0098)	(0.0124)	(0.0121)	(0.0123)	(0.00600)
urban			-0.0017	-0.0022	-0.0018	-0.0017	-0.002	-0.0023	-0.0009
			(0.0014)	(0.0015)	(0.0014)	(0.0015)	(0.0016)	(0.0016)	(0.00094)
roaddens				-0.00030					
				(0.0004)					
popdens					-0.0001**				
					(5.29e-05)				
agri						-0.0010			
						(0.0032)			
govsize							-0.0002	0.0003	
							(0.0019)	(0.0018)	
oecd								-0.0666	
								(0.0669)	
Constant, logunits, logarea, logarea/logunits									
Observations	105	105	105	83	105	103	83	83	105
R-squared	0.115	0.296	0.308	0.345	0.331	0.302	0.399	0.406	
F	5.909	8.853	7.229	6.796	7.215	5.918	8.452	7.433	.
rss	3.357	2.673	2.625	1.552	2.540	2.603	1.847	1.826	.
idstat	5.712	6.227	6.525	7.881	6.685	6.663	6.641	6.099	.
idp	0.0168	0.0126	0.0106	0.0050	0.0097	0.0098	0.010	0.0135	.
widstat	35.43	37.58	38.00	52.21	34.61	36.61	34.63	30.79	.

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 7: Regional inequality and trade (cross-section, Lessmann (2011) data)

	(1) IV1	(2) IV2	(3) IV3	(4) IV4	(5) IV5	(6) IV9	(7) IV10	(8) RobR2
VARIABLES	covw	covw	covw	covw	covw	covw	covw	covw
tradegdp	0.316***	0.341***	0.331***	0.338***	0.301***	0.356***	0.353***	0.235***
	(0.0774)	(0.0778)	(0.0889)	(0.0762)	(0.0765)	(0.0817)	(0.0788)	(0.0641)
urban		-0.0032**	-0.0012	-0.0033**	-0.0036**	-0.0037**	-0.0042***	-0.0012
		(0.0015)	(0.0013)	(0.0016)	(0.0018)	(0.0015)	(0.0016)	(0.0011)
roaddens			-0.0002					
			(0.0002)					
popdensity				-7.45e-05				
				(5.42e-05)				
agri					-0.0100**			
					(0.0047)			
govsize						-0.0028	-0.0019	
						(0.0022)	(0.0021)	
oecd							-0.106*	
							(0.0564)	
Constant, logunits, logarea, logarea/logunits								
Observations	53	53	46	53	52	49	49	54
R-squared	0.636	0.672	0.682	0.681	0.684	0.679	0.697	
F	14.57	10.76	9.289	9.723	9.853	8.661	7.681	.
rss	0.739	0.666	0.530	0.647	0.617	0.628	0.594	.
idstat	15.43	16.75	14.96	16.80	15.29	15.81	15.90	.
idp	8.57e-05	4.27e-05	0.0001	4.16e-05	9.22e-05	6.99e-05	6.67e-05	.
widstat	123.7	109.2	93.37	106.1	93.04	99.64	92.01	.

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 8: Regional inequality and trade freeness (cross-section, Lessmann (2011) data)

	(1) IVLEp0	(2) IVLEp1	(3) IVLEp2	(4) IVLEp4	(5) IVLEp5	(6) IVLEp9	(7) IVLEp10	(8) RobRLEp2
VARIABLES	covw	covw	covw	covw	covw	covw	covw	covw
phiness	0.131**	0.0905	0.0987*	0.114**	0.0364	0.112*	0.119*	0.0885**
	(0.0579)	(0.0582)	(0.0593)	(0.0556)	(0.0784)	(0.0653)	(0.0687)	(0.0369)
loggdppc	0.139	0.267	0.379	0.335	-0.302	0.263	0.276	0.298
	(0.203)	(0.185)	(0.237)	(0.249)	(0.358)	(0.308)	(0.312)	(0.273)
loggdppc2	-0.0145	-0.0206*	-0.0262*	-0.0238*	0.0095	-0.0191	-0.0182	-0.0215
	(0.0118)	(0.0109)	(0.0135)	(0.0141)	(0.0195)	(0.0175)	(0.0176)	(0.0151)
urban			-0.0025	-0.0022	-0.0027	-0.003	-0.0034*	-0.00018
			(0.002)	(0.002)	(0.0024)	(0.0019)	(0.002)	(0.0014)
popdens				-9.51e-05				
				(6.66e-05)				
agri					-0.0172***			
					(0.0056)			
govsize						-0.0028	-0.0022	
						(0.00322)	(0.00320)	
oecd							-0.0786	
							(0.0813)	
Constant, logunits, logarea, logarea/logunits								
Observations	53	53	53	53	52	49	49	53
R-squared	0.453	0.543	0.565	0.581	0.585	0.579	0.589	
F	12.68	11.90	12.82	10.74	11.68	13.53	12.83	.
rss	1.111	0.928	0.883	0.850	0.812	0.825	0.806	.
idstat	4.492	5.283	5.656	5.155	6.138	5.700	5.741	.
idp	0.0341	0.0215	0.0174	0.0232	0.0132	0.0170	0.0166	.
widstat	24.49	27.08	26.39	23.16	21.73	25.30	24.56	.

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Again, we find a positive and significant effect of trade on regional inequality. The effect is slightly larger with regression coefficients between 0.22 and 0.32. Note that the country sample is biased towards high income countries. As before the coefficient of freeness of trade is positive but its significance is not robust. We take this coincidence with the results of the Gennaioli et al. data as indicator that the Lessmann data do not suffer from a strong selection bias and its panel results can be used to derive inference for the larger database.

3.5 IV regressions with panel data

A second source of a potential endogeneity bias in our regression analysis is unobserved heterogeneity between countries. There may be an infinite number of unobserved variables, which could render our relationship between trade and inequality endogenous. These omitted variables can be a serious source of bias in our estimated parameters. In our empirical investigation it is very likely that an omitted variable bias occurs, since regional inequalities are affected by several geographic and historical patterns we cannot measure satisfactorily. Using panel data, we can control for unobserved factors by including country fixed effects and time fixed effects.

We estimate four different specifications. The first model is a pooled robust regression with time fixed effects, the second is a two-way fixed effect approach, the third approach is a panel IV approach with the constructed openness measures as instrument and the last approach is a system GMM model (Arellano and Bover, 1995, and Blundell and Bond, 1998). The system gmm estimator was designed for small-T large-N panels, which is true for our data set. Note that we only consider the time varying control variables in the panel regressions. The measure of regional inequality comes from Lessmann (2011) and covers the period 1980–2009. We use 5-year averaged data to take care of the gaps in the data.[16] **Table 9** reports the results considering the trade to GDP ratio and **Table ??** those for the freeness of trade measure.

In these estimates we find a significantly positive coefficient of trade. The standard tests suggest in all IV specifications that trade to GDP is endogenous and that our instruments are not weak. The findings are confirmed for other controls, too (see Table **??** in the appendix). To sum up, the panel regressions support the findings from the cross-section analysis: trade increases interregional inequality within countries.

However, when we control for EU membership the coefficient becomes insignificant. This

[16] Period 1: 1980–1984, period 2: 1985-1989, ..., period 6: 2005–2009.

Table 9: Regional inequality and trade (panel, Lessmann (2011) data)

	(1) Pool2	(2) Pool3	(3) FE2	(4) FE3	(5) PanIV2	(6) PanIV3	(7) SysGMMT2	(8) SysGMMT3	(9) SysGMMT4
VARIABLES	covw	covw	covw	covw	covw	covw	covw	covw	covw
tradegdp	0.136***	0.237***	0.139**	0.117**	0.385***	0.381***	0.0345**	0.108***	0.0388**
	(0.0325)	(0.0532)	(0.0537)	(0.0516)	(0.100)	(0.102)	(0.0147)	(0.036)	(0.0169)
loggdppc	0.187***	0.309*	0.209	0.265**	0.241**	0.264**	0.0086	-0.186	-0.0639
	(0.0707)	(0.179)	(0.135)	(0.121)	(0.107)	(0.108)	(0.0468)	(0.141)	(0.0593)
loggdppc2	-0.0147***	-0.0209*	-0.0116	-0.0150*	-0.0172**	-0.0186**	-0.0013	0.0094	0.0022
	(0.0042)	(0.0109)	(0.0079)	(0.008)	(0.0073)	(0.0073)	(0.003)	(0.0076)	(0.0032)
urban		-0.00062		-0.0049*		-0.0018		0.0031***	0.0013
		(0.001)		(0.0026)		(0.0024)		(0.0013)	(0.00084)
roaddens		-7.86e-05						-0.000211**	
		(0.0002)						(9.01e-05)	
L.covw							0.941***	1.001***	0.922***
							(0.0760)	(0.0741)	(0.0611)
popdensity									-2.91e-05
									(1.96e-05)
Constant	-0.489*	-1.544*	-31.90	-23.90	-52.84*	-50.27*	0.0350	0.635	0.313
	(0.284)	(0.823)	(25.93)	(24.74)	(29.63)	(30.15)	(0.159)	(0.611)	(0.243)
Constant, logunits, logarea, logarea/logunits, time dummies									
Observations	200	75	200	200	194	194	149	63	146
r2 w	0.823	0.779	0.468	0.497	0.271	0.282			
ar1p							0.0402	.	0.0697
ar2p							0.235	.	0.297

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 10: Panel - phiness

	(1) Pool2	(2) Pool3	(3) FE2	(4) FE3	(5) PanIV2	(6) PanIV3	(7) SyGMM2	(8) SyGMM3	(9) SyGMM4
VARIABLES	covw	covw	covw	covw	covw	covw	covw	covw	covw
phiness	0.0855***	0.134***	0.0594	0.0103	0.0624	0.0369	-0.0012	-0.0014	0.0120
	(0.0289)	(0.0365)	(0.0602)	(0.0918)	(0.126)	(0.234)	(0.0192)	(0.0220)	(0.0226)
loggdppc	0.318***	0.179	0.259*	-0.0159	0.260**	0.0457	0.0422	0.0423	0.0144
	(0.0694)	(0.359)	(0.133)	(0.308)	(0.102)	(0.612)	(0.0527)	(0.0896)	(0.0573)
loggdppc2	-0.0217***	-0.0149	-0.0143	0.0061	-0.0144*	0.0016	-0.0036	-0.0035	-0.0021
	(0.004)	(0.019)	(0.009)	(0.0234)	(0.008)	(0.0445)	(0.0032)	(0.0048)	(0.0033)
urban	-0.0009	0.0008	-0.0057*	-0.0034	-0.0057***	-0.0035	0.0004	0.0012	0.0007
	(0.0006)	(0.0017)	(0.0029)	(0.0036)	(0.0018)	(0.005)	(0.0007)	(0.0014)	(0.0007)
roaddens		-0.0002		-0.00015		-0.00016		-4.51e-05	
		(0.0003)		(0.0003)		(0.0007)		(4.33e-05)	
L.covw							0.903***	0.975***	0.902***
							(0.0421)	(0.0459)	(0.0406)
popdens									-2.21e-05*
									(1.19e-05)
Constant, logunits, logarea, logarea/logunits, time dummies									
Observations	194	73	194	73	194	73	144	61	141
r2_w	0.771	0.759	0.472	0.356	0.472	0.350			
ar1p							0.0198	.	0.0267
ar1							-2.331	.	-2.216
ar2p							0.259	.	0.306
ar2							-1.129	.	-1.023

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

indicates that integration might offset the negative impact of trade on interregional inequality. Therefore we use freeness of trade that is our measure of market access to examine the impact of integration. The estimates do not provide significant coefficients of freeness of trade except for the pooled regression. This is ambiguous evidence that an increase in freeness of trade, i.e. an increase in integration in the world markets, tends to be neutral with respect to interregional inequality.

3.6 Robustness tests

We performed many different robustness tests, some of them are presented below. We first, test for nonlinearities, present results for different inequality measures, add results with a third openness measure (Arrabias et al. 2009), present findings for interaction terms and discuss endogeneity of the gdp variable. Here, we carry out estimates with lagged GDP. Further estimates we do not present are robust non-IV regressions that are close to the IV estimates presented above[17].

3.6.1 Nonlinearities

Our theoretical model shows that effects might be non-linear. To control whether we can use the linear model because non-linearities are weak, we perform semiparametric estimates and test the null hypothesis that the linear and non-linear approaches do not significantly differ[18]. The equation to be estimated has the following form (omitting subscripts for reasons of clarity):

$$I = \alpha + f(T) + \gamma X + \epsilon, \tag{23}$$

where X is a set of explanatory variables that are assumed to have a linear effect on regional inequality I, $f(\cdot)$ is an unknown smooth function of trade T, which might be nonlinear, and ϵ is a random error term. Thus, γX represents the parametric and $f(Y)$ the nonparametric part of the model. We refer to the estimator proposed by Robinson (1988). The intuition for this estimator is the following: in a first step, an estimate of $\hat{\gamma}$ is obtained using a procedure that is similar to the way in which variables can be partialed out of an OLS regression (but using nonparametric regressions); in a second step, a kernel regression of $I - \hat{\gamma}X$ on T is performed. In all stages, a Gaussian kernel

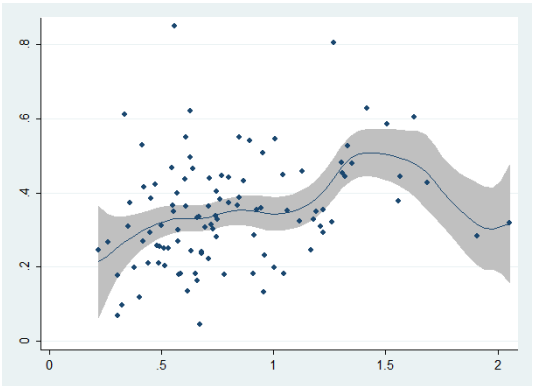
[17] We even identified outliers with the mmregress procedure in stata for each IV estimate, eliminated the outliers and carried out the same IV estimates as presented above. This did not change the results, so that we decided to present the results with the full sample. This implied nicer pictures for semiparametric estimates presented below, which we, however, do not refer to. The results are not affected.

[18] For instance, DiNardo and Tobias (2001) provide a discussion of semiparametric methods.

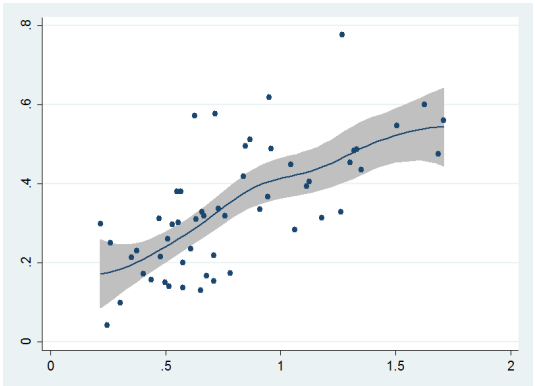
weighted local polynomial fit is used for kernel regressions. This estimation procedure has been implemented in *Stata* by Verardi and Debarsy (2012). The result are presented in **Figure 3**.

Figure 3: Semiparametric estimates. Note: Plots of the estimated partial-regression functions. The inequality measure has been adjusted for the effects of the linear explanatory variables in the model [see equation (6)]. Shaded areas correspond to 90% confidence bands.

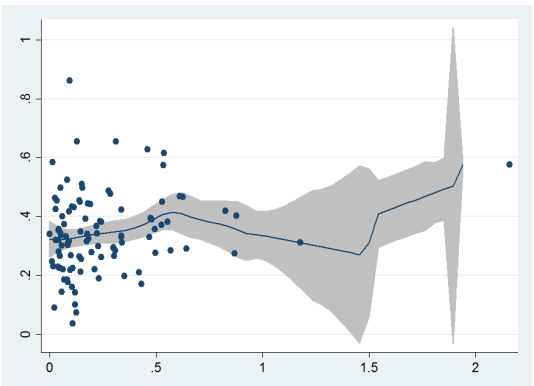
(a) Semiparametric - tradegdp Genn



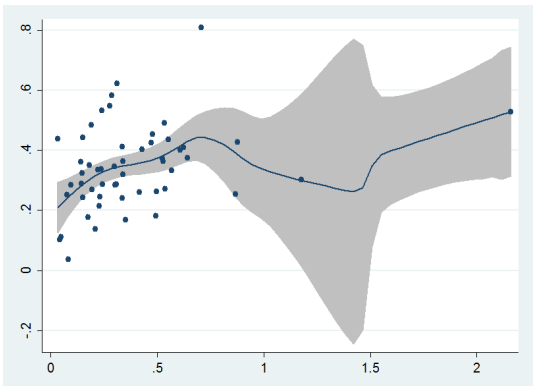
(b) Semiparametric - tradegdp Less



(c) Semiparametric - freeness Genn



(d) Semiparametric - freeness Less



Importantly, there is no sign of a systematic nonlinearity in the trade–inequality relationship. This is confirmed by the Hardle and Mammen (1993) statistic, which does not reject the null hypothesis that parametric linear and non-parametric fits are not different (p-values: from upper left to lower right 0.15 0.74 / 0.52 0.29).

3.6.2 Alternative inequality measures

Next we consider alternative measures of regional inequality in the cross-section data set as well as in the panel. Different inequality measures usually do not provide an unambiguous country

ranking. For example, the Gini coefficient is most sensitive to inequalities in the middle part of a distribution, while the coefficient of variation is strongly influenced by anomalously low or high income values. Moreover, the inequality measure used in the main part of the paper weighs the income of sub-national regions by their population share. One can therefore interpret this measure as intergroup inequality measure, where the groups of the population are defined by their location. If one is interested in purely geographic inequality, one should omit the population weights. We have, therefore, also considered unweighted inequality measures. For this purpose we calculate the Gini coefficient and the (unweighted) coefficient of variation of regional incomes. Table 11 shows pairwise correlation coefficients between the different inequality measures based on the data provided by Gennaioli et al. (2013).

Table 11: Alternative inequality measures

	weighted coefficient of variation	Gini coefficient	coefficient of variation
weighted coefficient of variation	1.0000		
Gini coefficient	0.8997	1.0000	
coefficient of variation	0.8848	0.9383	1.0000

Notes: Pairwise correlation between different inequality measures calculated based on Gennaioli et al. (2013).

The correlation is around 0.9 suggesting that the particular measurement of regional inequality does not make much of a difference in the regression analysis.

Nevertheless, we check whether our findings are robust to the consideration of alternative inequality measures. For this purpose we run IV regressions in the large cross-section and System gmm estimations in the panel. The results are reported in **Table 12**.

In column (1) and (2), we consider the Gini coefficient as dependent variable, in column (3) and (4) we consider the coefficient of variation. Column (1) and (3) report IV regressions in the cross-section, and column (2) and (4) panel estimates. Using the Gini coefficient yields similar effects to the results reported in the previous sections. We find a positive and significant effect of trade on regional inequality. Using the unweighted coefficient of variation as dependent variable produced a positive and significant effect in the cross-section, and a positive – but insignificant effect – in the panel.

Table 12: Alternative inequality measures

Instrument: trade-to-GDP - GINI COV

	(1)	(2)	(3)	(4)	(5)
	Rr1	Rr2	Rr3	Rr4	Rr5
VARIABLES	covw	adgini	covw	cov	adgini
L.covw			0.923***		
			(0.0454)		
tradegdp	0.329***	0.212***	0.0464**	0.0481	0.0315***
	(0.0449)	(0.0247)	(0.0206)	(0.0291)	(0.0103)
loggdppc	0.341***	0.215***	-0.0508	-0.0721	-0.0256
	(0.0824)	(0.0443)	(0.0651)	(0.0639)	(0.0307)
loggdppc2	-0.0221***	-0.0137***	0.00149	0.00281	0.000878
	(0.00484)	(0.00258)	(0.00360)	(0.00354)	(0.00171)
urban	-0.00268***	-0.00147***	0.00125	0.000456	0.000192
	(0.000781)	(0.000375)	(0.000839)	(0.000958)	(0.000418)
logunits	0.139***	0.0644***			
	(0.0234)	(0.0123)			
logarea	0.0324***	0.0261***			
	(0.00772)	(0.00347)			
logarea/logunits	0.00226	0.00616**			
	(0.00503)	(0.00264)			
L.cov				0.905***	
				(0.0535)	
L.adgini					0.879***
					(0.0414)
Constant	-1.781***	-1.218***	0.248	0.395*	0.152
	(0.362)	(0.198)	(0.233)	(0.226)	(0.110)
time dummies					
Observations	194	198	149	148	151
R-squared	0.665	0.610			
F	37.01	37.19	151.7	170.4	194.6
widstat	405.8	411.9			
idp	0	0			
iddf	1	1			
idstat	46.85	47.36			
ar1p			0.0328	0.107	0.0884
ar1			-2.135	-1.612	-1.704
ar2p			0.223	0.971	0.273
ar2			-1.217	0.0366	-1.097
hansenp			0.936	0.838	0.907
hansen			34.89	40.17	36.51
sarganp			0	1.76e-06	0
sargan			256.0	110.7	145.9

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

3.6.3 Lagged income

One might reasonably argue that income is also endogenous, since regional inequality might have a negative feedback effect on income. Therefore, we have repeated our cross-section estimations using historical income data instead of contemporaneous values. The period where we observe the per capita GDP refers to 1990–1994 while all other variables in the model refer to the period 2000–2004 (inequality refers to 2005). The results are reported in **Table ??** in the appendix and confirm our finding of a positive effect of trade on regional inequality.

3.6.4 Interactions

A final set of robustness tests is related to a interaction terms that are important for the trade to GDP measure as shown in the theory. Because interaction terms with trade are endogenous, we build instruments with the exogenous variables, e.g. urban, and the instruments for trade to GDP and perform IV estimates.

Table ?? presents the results for the IV regressions with interaction terms. The tests indicate that endogeneity cannot be rejected and that the instruments might not be weak. Though theory suggests to control for interaction terms, the results are hardly to interpret. In general, problems of multi-collinearity are present. The VIF is high for all variables. This implies high standard errors and, thus, might explain the insignificant coefficients of trade to GDP. In different cases coefficients of the interaction term and of the variable used in the interaction term are of the same size and have opposite signs, though they are highly correlated. This is in particular true for oecd, eu and govsize. Nontheless, the oecd and eu dummy might control for integration. This could explain these findings.

4 Summary and Conclusions

This paper studies the impact of international opennes on regional inequalities within countries. We derive two measures for international openness from a simple New Economic Georaphy model. One is the usually used trade to GDP ratio. Our derivations provides a rational why nonlinearities and interaction terms might determine the effect of trade on interregional inequality. The other is an aggregate freeness of trade measure giving us a rule for aggregating bilateral freeness of trade (phi-ness) to construct a country's freeness of trade measure. Again we see, that interaction terms

Table 13: Interaction effects (cross-section [36] data)

	(1) IV3	(2) IV4	(3) IV5	(4) IV6	(5) IV7	(6) IV8	(7) IV9
VARIABLES	covw	covw	covw	covw	covw	covw	covw
tradegdp	0.400	0.195	0.179*	0.231**	0.0521	0.162	0.147
	(0.346)	(0.135)	(0.102)	(0.0942)	(0.208)	(0.111)	(0.114)
loggdppc	0.00767	0.197*	0.0800	0.138	0.150	0.0184	0.133
	(0.191)	(0.114)	(0.162)	(0.200)	(0.188)	(0.151)	(0.186)
loggdppc2	-0.0021	-0.0128*	-0.0063	-0.0091	-0.0105	-0.0006	-0.0095
	(0.0111)	(0.0068)	(0.0094)	(0.0109)	(0.0109)	(0.0089)	(0.0107)
urban	0.00057	-0.0019	-0.0017	-0.0015	-0.0018	-0.0021	-0.0021
	(0.0039)	(0.0014)	(0.0015)	(0.0016)	(0.0016)	(0.0014)	(0.0017)
roaddens		-6.67e-05					
		(0.0003)					
popdens			-0.00017				
			(0.00017)				
agri				0.0011			
				(0.0054)			
govsize					-0.0059		-0.0004
					(0.0058)		(0.0022)
oecd						-0.200*	
						(0.110)	
eu							-0.119
							(0.112)
trade × urban	-0.0023						
	(0.0041)						
trade × roaddens		0.001					
		(0.0225)					
trade × popdens			0.0002				
			(0.0002)				
trade × agri				0.00208			
				(0.00646)			
trade × govsize					0.00569		
					(0.0062)		
trade × oecd						0.127	
						(0.103)	
trade × eu							0.127
							(0.116)
Constant, logunits, logarea, logarea/logunits, time dummies							
Observations	105	83	105	103	83	105	83
R-squared	0.261	0.330	0.301	0.280	0.396	0.354	0.419
F	7.789	6.665	7.169	6.451	8.696	8.093	8.337
rss	2.806	1.589	2.652	2.685	1.856	2.452	1.786
idstat	4.071	8.788	11.40	10.02	10.27	5.526	3.670
idp	0.0436	0.003	0.0007	0.0015	0.0014	0.0187	0.0554
widstat	2.467	31.65	20.30	14.89	14.54	8.681	7.501

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

that depend on the internal structure of countries has to be considered.

Further, we use two recent data sets on sub-national regions of countries, which allow us to calculate (time-varying) measures of regional inequality for a wide range of countries including many developing countries. Up to 106 countries are considered in our cross-section data set; our panel data set consists of 54 countries for the period 1980–2009.

In empirical part we used our constructed proxies as instruments. The IV regressions suggest a positive and significant effect of trade as well as of freeness of trade on regional inequality for the cross-section of countries. The point estimate implies that an increase in the trade to GDP ratio by ten percentage points is associated with an increase in regional inequalities by approx. 2%. Our findings for the trade to GDP ratio is confirmed for the panel of countries, where we apply dynamic panel data models. In the dynamic approach we also use an export based measure of openness (see Arrabias et al., 2009) that provides the same results. In contrast, the panel approaches did provide only insignificant coefficients of freeness of trade.

What do we learn from this study? If countries increase trade interregional inequalities increase. This outcome is fairly robust. Consequently, we have a classical trade-off between efficiency and distribution: while incomes rises in response to increased trade, inequalities rise, too.

References

[1] Acemoglu, D., Johnson, S., Robinson, J.A., 2000. The colonial origins of comparative development: an empirical investigation. *NBER Working Paper* w7771.

[2] Acemoglu, D., Johnson, S., 2000. Reversal of fortune: geography and institutions in making of the modern world income distribution. *Quarterly Journal of Economics* 117, 1231-1294.

[3] Alcalá, P., Ciccone, A., 2004. Trade and productivity. *Quarterly Journal of Economics* 119, 612–645.

[4] Alesina, A., Perotti, R., 1996. Income distribution, political stability, and investment. *European Economic Review* 40, 1203–1228.

[5] Alonso Villar, O., 1999. Spatial distribution of production and international trade: a note. *Regional Science and Urban Economics* 29, 371–380.

[6] Anderson, E., 2005. Openness and inequality in development countries: a review of theor and recent evidence. *World Development* 33, 1045–1063.

[7] Anderson, J.E., van Wincoop, E., 2003. Gravity with Gravitas: A Solution to the Border Puzzle. *American Economic Review* 93, 170–192.

[8] Arellano, M., Bover, O., 1995. Another look at the instrumental variables estimation of error-components models. *Journal of Econometrics* 68, 29–51.

[9] Arrabias, I., Pérez, F., Tortosa-Ausina, E., 2009. Measuring globalization of international trade: Theory and evidence. *World Development* 37, 127-145.

[10] Baier, S.L., Bergstrand, J.H., 2007. Do free trade agreements actually increase member's international trade? *Journal of International Economics* 71, 72-95.

[11] Baldwin, R., Forslid, R., Martin, P., Ottaviano, G., Robert-Nicoud, F., 2005. *Economic Geography & Public Policy*. Princton University Press.

[12] Barrios, S., Strobl, E., 2009. The dynamics of regional inequalities. *Regional Science and Urban Economics* 39, 575–591.

[13] Behrens, C., Gaingné, C., Ottaviano, G.I.P., Thisse, J., 2007. Countries, regions and trade: On the welfare impacts of economic integration. *European Economic Review* 51, 1277-1301.

[14] Blundell, R., Bond, S., 1998. Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics* 87, 115–143.

[15] Breau, S., Rigby, D.L., 2010. International trade and wage inequality in Canada. *Journal of Economic Geography* 10, 55–86.

[16] Brülhart, M., Carrere, C., Trionfetti, F., 2012. How wages and employment adjust to trade liberalisation: Quasi-experimental evidence from Austria. *Journal of International Economics* 86, 68–81.

[17] Brühlhart, M., 2011. The spatial effects of trade openness: a survey. *Review of World Economics* 147, 59–83.

[18] Brülhart, M., Crozet, M., Koenig, P., 2004. Enlargement and the EU periphery: the impact of changing market potential. *World Economy* 27, 853–875.

[19] Buhaug, H., Gleditsch, K., Holtermann, H., Østby, G., Tollefsen, A.F., 2012. It's the local economy, stupid! Geographic wealth dispersion and conflict outbreak location. *Journal of Conflict Resolution* 55, 814–840.

[20] Cheng, I.-H., Wall, H.-J., 1999. Controlling for heterogeneity in gravity models of trade and integration. Working Paper 1999-010E, Federal Resreve Bankd of St. Louis.

[21] Chiquiar, D., 2005. Why Mexico's regional income convergence broke down. *Journal of Development Economics*. 77, 257–275.

[22] Chiquiar, D., 2008. Globalization, regional wage differentials and the Stolper–Samuelson theorem: Evidence from Mexico. *Journal of International Economics* 74, 70–93.

[23] Combes, R.-P., Lafourcade, M., Mayer, T., 2005. The trade-creating effect of business and social networks: evidence from France. *Journal of International Economics* 66, 1-29.

[24] Crozet, M., Koenig-Soubeyran, P., 2004. EU enlargement and the internal geography of countries. *Journal of Comparative Economics* 32, 265–278.

[25] Dalton, H., 1920. The Measurement of the Inequality of Incomes. *Economic Journal* 30, 348–361.

[26] Deiwiks, C., Cederman, L., Gleditsch, K., 2012. Inequality and conflict in federations. *Journal of Peace Research* 49, 289–304.

[27] DiNardo, J., Tobias, J. L., 2001. Nonparametric Density and Regression Estimation. *Journal of Economic Perspectives* 15, 11–28.

[28] Egger, H., Kreickemeier, U., 2012. Fairness, trade, and inequality *Journal of International Economics* 86, 184-196.

[29] Egger, P., Huber, P., Pfaffermayr, M., 2005. A note on export openness and regional wage disparity in Central and Eastern Europe. *Annals of Regional Science* 39, 63–71.

[30] Egger, P., Pfaffermayr, M., 2003. The proper panel econometric specification of the gravity equation: a three-way model with bilateral interaction effects. *Empirical Economic* 28, 571-580.

[31] Elbers, C., Lanjouw, P., Mistiaen, J., Özler, B., Simler, I.R., 2005. Are Neighbours Equal? Estimating Local Inequality in Three Developing Countries. In R. Kanbur and A. Venables (eds.), Spatial Inequality and Development, New York: Oxford University Press, pp. 37 – 76.

[32] Faber, B., 2007. Towards the spatial patterns of sectoral adjustments to trade liberalisation: The case of NAFTA in Mexico. *Growth and Change* 38, 567–594.

[33] Feenstra, R. 2004. Advanced International Trade. Princeton University Press, Princeton.

[34] Frankel, J.A., Romer, D., 1999. Does trade cause growth? *American Economic Review* 89, 379–399.

[35] Frankel, J.A., Rose, A., 2002. An estimate of the effects of common currencies on trade and income. *Quarterly Journal of Economics* 117, 437–466.

[36] Gennaioli, N., La Porta, R. L., de Silanes, F. L., Shleifer, A., 2013. Human Capital and Regional Development. *Quartely Journal of Economics,* forthcoming.

[37] Gonzalez Rivas, M., 2007. The effects of trade openness on regional inequality in Mexico. *Annals of Regional Science* 41, 545–561.

[38] Haaparanta, P., 1998. Regional concentration, trade, and welfare. *Regional Science and Urban Economics* 28, 445–463.

[39] Hardle W., Mammen, E., 1993. Comparing nonparametric versus parametric regression fits. *Annals of Statistics* 21, 1926–1947.

[40] Hanson, G. H., 1997. Increasing returns, trade and the regional structure of wages. *Economic Journal* 107, 113–133.

[41] Hanson, G. H., 1998. Regional adjustment to trade liberalisation. *Regional Science and Urban Economics* 28, 419–444.

[42] Head, K., Mayer, T., 2006. Regional wage and employment responses to market potential in the EU. *Regional Science and Urban Economics* 36, 573–594.

[43] Head, K., Mayer, T., Ries, J., 2010. The erosion of colonial trade linkages after independence. *Journal of International Economics* 81, 1–14.

[44] Head, K., Ries, J., 2011. Increasing returns versus national product differentiation as an explanation for the pattern of U.S.-Canada trade. *American Economic Review* 91, 858–876.

[45] Helpman, E., 1998. The size of regions, in: D. Pines, E. Sadka, I. Zilcha (eds.), *Topics in Public Economics. Theoretical and Empirical Analysis*. Cambridge: Cambridge University Press, 33-54.

[46] Heston, A., Summers, R., Aten, B., 2012. *Penn World Table Version 7.1.* Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania.

[47] Jann, B. (2010). robreg: Stata module providing robust regression estimators. Available from http://ideas.repec.org/c/boc/bocode/s457114.html.

[48] Junius, K., 1999. Primacy and economic development: Bell shaped or parallel growth of cities? *Journal of Economic Development* 24, 1–22.

[49] Kanbur, R., Venables, A., 2005. Spatial Inequality and Development. In: R. Kanbur and A. Venables (editors), *Spatial Inequality and Development*, 3–11. New York: Oxford University Press.

[50] Kanbur, R., Zhang, X., 2005. Fifty years of regional inequality in China: A journey through central planning, reform and openness. *Review of Development Economics* 9, 87–106.

[51] Kessler, A.S., Hansen, N.A., Lessmann, C., 2011. Interregional Redistribution and Mobility in Federations: A Positive Approach. Review of Economic Studies 78, 1345–1378.

[52] Krugman, P., 1991. Increasing returns and economic geography. *Journal of Political Economy* 99, 483–499.

[53] Krugman, P., Livas Elizondo, R., 1996. Trade policy and the third world metropolis. *Journal of Development Economics* 49, 137–150.

[54] Kuznets, S., 1955. Economic Growth and Income Inequality. *American Economic Review* 45, 1–28.

[55] Lessmann, C., 2013. Regional inequality and internal conflict. CESifo Working Paper No. 4112, CESifo Group: Munich.

[56] Lessmann C, 2012. Regional inequality and decentralization: an empirical analysis. *Environment and Planning A* 44, 1363–1388.

[57] Lessmann, C., 2011. Spatial Inequality and Development – Is there an Inverted-U Relationship? CESifo Working Paper Series No. 3622, CESifo Group Munich.

[58] Milanovic B, 2005. Half a world: regional inequality in five great federations. *Journal of the Asia Pacific Economy* 10:408-445.

[59] Monfort, P., Nicolini, R., 2000. Regional convergence and international integration. *Journal of Urban Economics* 48, 286–306.

[60] Monfort, P., van Ypersele, T., 2003. Integration, regional agglomeration and international trade. (CEPR Discussion Paper #3752).

[61] Østby, G., Nordås, R., Rød, J.K., 2009. Regional Inequalities and Civil Conflict in Sub-Saharan Africa. *International Studies Quarterly* 53, 301–324.

[62] Paluzie, E., 2001. Trade policies and regional inequalities. *Papers in Regional Science* 80, 67–85.

[63] Pavcnik, N., 2013. Globalization and within-country income inequality, in: M. Bacchetta and M. Jansen (eds.). *Making Globalization Socially Sustainable*, chp. 7, Geneva: ILO. (www.wto.org/english/res_e/booksp_e/glob_soc_sus_e_chap7_e.pdf)

[64] Pernia, E. M., Quising, P. F., 2003. Trade openness and regional development in a developing country. *Annals of Regional Science* 37, 391–406.

[65] Petrakos G., Rodríguez-Pose, A., Rovolis, A., 2005. Growth, integration, and regional disparities in the European Union. *Environment and Planning A* 37, 1837–1855.

[66] Pflüger, M., 2004. A simple, analytically solvable, Chamberlinian agglomeration model. *Regional Science and Urban Economics* 34, 565-573.

[67] Pflüger, M., Suedekum, J., 2008. Integration, agglomeration and welfare. *Journal of Urban Economics* 63, 544-566.

[68] Pigou, A. C., 1912. *Wealth and Welfare*. London: Macmillan.

[69] Redding, S., Sturm, D., 2008. The costs of remoteness: Evidence from German division and reunification. *American Economic Review* 98, 1766–1797.

[70] Redding, S., Venables, A., 2004. Economic Geography and international inequality. *International Economic Review* 62, 53-82.

[71] Rodríguez-Pose, A., 2012. Trade and Regional Inequality. *Economic Geography* 88, 109–136.

[72] Rodríguez-Pose A, N Gil, 2006. How does trade affect regional disparities? *World Development* 34, 201-222.

[73] Rodríguez-Pose, A., Ezcurra, R. 2010. Does Decentralization Matter for Regional Disparities? A Cross-Country Analysis. *Journal of Economic Geography* 10, 619–644.

[74] Rodríguez-Pose, A., Sanchez-Reaza, J., 2005. Economic polarization through trade: Trade liberalization and regional growth in Mexico. In A. J. Venables and R. Kanbur (eds.), Spatial inequality and development. Oxford, UK: Oxford University Press.

[75] Robinson, P. M., 1988. Root- N-Consistent Semiparametric Regression. *Econometrica* 56, 931–54.

[76] Rodrik D., van Ypserle, T. 2001. Capital mobility, distributive conflict and international tax coordination. *Journal of International Economics* 54, 57–73.

[77] Sachs, J. D. and A. Warner, 1995. Economic Reform and the Process of Global Integration. *Brookings Papers on Economic Activity* 1995, 1-118.

[78] Sanchez-Reaza J., Rodríguez-Pose, A., 2002. The impact of trade liberalization on regional disparities in Mexico. *Growth and Change* 33, 72–90.

[79] Santos Silva, J.M.C., Tenreyro, S., 2011. Further simulation evidence of the performance of the Poisson pseudo-maximum likelihood estimator. *Economics Letters* 112, 220-222.

[80] Sen, A., 1973. *On Economic Inequality*. New York: Norton.

[81] Stock, J.H., Yogo, M., 2005. Testing for Weak Instruments in Linear IV Regression. In D. W. K. Andrews and J. H. Stock (eds.), *Identification and Inference for Econometric Mod- els: A Festschrift in Honor of Thomas J. Rothenberg*. Cambridge, UK: Cambridge University Press, 80–104.

[82] Treisman, D. (2008). Decentralization dataset. http://www.sscnet.ucla.edu/polisci/faculty/treisman/.

[83] Verardi, V., Courx, Ch., 2009. Robust regression in Stata. *Stata Journa* 9, 439-453.

[84] Verardi, V., Debarsy, N., 2012. Robinson's square root of N consistent semiparametric regression estimator in Stata. *Stata Journal* 12, 726–735.

[85] Volpe Martincus, C., 2010. Spatial effects of trade policy: Evidence from Brazil. *Journal of Regional Science* 50, 541–569.

[86] Williamson, J.G., 1965. Regional Inequality and the Process of National Development: A Description of Patterns. *Economic Development and Cultural Change* 13, 3–45.

[87] Wood A, 2002. Globalization and wage inequalities. a synthesis of three theories. *Weltwirtschaftliches Archiv* 138, 54–82.

[88] World Bank, 2011. World Development Indicators 2010. Washington D. C.: World Bank.

[89] Yemtsov, R., 2005. Quo Vadis? Inequality and Poverty Dynamics across Russian Regions. In R. Kanbur and A. Venables (eds), Spatial Inequality and Development, New York: Oxford University Press, pp. 348–408.

[90] Yohai, V.J. 1987. High breakdown-point and high efficiency robust estimates for regression. *Annals of Statistics* 15, 642-656.

[91] Zhang, X., Zhang, K.H., 2003. How does globalization affect regional inequality within a developing country? Evidence from China. *Journal of Development Studies* 39, 47-67.

A Income inequality. Phi-ness of trade

We substitute the price indices (4) into the equation for operating profits (6), divide by P_r to get (12). Next, we calculate the difference

$$\frac{y_r - y_i}{y_r} = \left(\frac{e_{E_r}}{p_r} - \frac{e_{A_r}}{p_r} \right) \frac{E_i}{Y_i} \tag{24}$$

First, exports of *Home* are

$$E_i = N^\sigma \mu_i \sum_j \left(\frac{P_j \alpha_j}{\Delta_j} \sum_s \lambda_s \phi_{sj} \right) = N^\sigma Y_i^d \sum_j \gamma_j \frac{\mu_i \phi_{ij}}{\mu_i \phi_{ij} + \mu_j} = N^\sigma Y_i^d \gamma_i \Phi_i,$$

where $\phi_{ij} = \sum_s \lambda_s \phi_{sj}$ and $\gamma_j = (P_j \alpha_j)/Y_i^d$ with Y_i^d as aggregate GDP of all destination countries of exports of *Home*, and Φ_i as openness of country i. Further, the export share of region r is

$$e_{E_r} = \frac{N^\sigma Y_i^d \sum_j \frac{\gamma_j \mu_i \lambda_r \phi_{rj}}{\Delta_j}}{N^\sigma Y_i^d \Phi_i} = \frac{\sum_j \frac{\gamma_j \mu_i \lambda_r \phi_{rj}}{\Delta_j}}{\Phi_i} = \lambda_r \sum_j \frac{\phi_{rj}}{\phi_{ij}}. \tag{25}$$

Next we assume that intra-country transport costs are symmetric and identical across regions $\psi = \psi_{rs}$ and that expenditure for manufacturing are also identical across regions. Accordingly, the absorption share of region r is

$$e_{A_r} = \frac{\frac{\lambda_r p_r}{\Delta_r} + \psi \frac{\lambda_s p_s}{\Delta_s}}{(1+\psi) \sum_s \frac{\lambda_s p_s}{\Delta_s}}. \tag{26}$$

Putting (25), (25), and (26) into (27) yields the relative income difference

$$\frac{y_r - y_i}{y_i} = \frac{N^\sigma}{p_r} \left(\lambda_r \sum_j \frac{\phi_{rj}}{\phi_{ij}} - \frac{\frac{\lambda_r p_r}{\Delta_r} + \psi \frac{\lambda_s p_s}{\Delta_s}}{(1+\psi) \sum_s \frac{\lambda_s p_s}{\Delta_s}} \right) \Phi_i, \tag{27}$$

where γ_i is the relative GDP of the country of origin i to the aggregate GDPs of all destination countries. If we assume that $\phi_{rj} = \phi_{ij}$ we get (14).

B The theoretical gravity equation

We can derive a gravity equation for bilateral trade from our theoretical model. To simplify matters we derive the equation for manufacturing and assume identical firms in Home. Imports of country i from another country j is the sum of nominal imports of the regions of country i (2), i.e.

$$\begin{aligned} I_{ji} &= \sum_r n_j P_i T_{jr} q_j m_{jr} \qquad (28) \\ &= n_j q_j^{1-\sigma} \left(\alpha_r P_r T_{jr} Q_r^{\sigma-1} + a_s P_s T_{js} Q_s^{\sigma-1} \right) \\ &= n_j q_j^{1-\sigma} Y_i \left(e_{Y_r} T_{jr} Q_r^{\sigma-1} + e_{Y_s} T_{js} Q_s^{\sigma-1} \right) \\ &= n_j q_j^{1-\sigma} Y_i T_{ij} Q_i^{\sigma-1}. \qquad (29) \end{aligned}$$

T_{ij} denotes bilateral trade costs and Q_i is countrys consolidated price index. e_{y_r} is the income share of region r of country i is the consolidated price index of country b. Next we can define a country's constraint for monopolistic goods. Income of a country j arising from monopolistic production depends on all sales of monopolistic goods to all other countries including the country j itself, i.e.

$$Y_i = \sum_j A_{ji}. \qquad (30)$$

Substituting I_{ji} (see (29)) for A_{ji} and rearranging yields

$$n_j p_j^{1-\sigma} = \frac{Y_j}{\Pi_j}, \qquad (31)$$

with the income share s_Y and the multilateral resistance term

$$\Pi_j \equiv \sum_i Y_i \phi_{ji} Q_i^{\sigma-1}.$$

The multilateral resistance (ML) term is the relative accessibility of all regions for exports and, thus, represents the attractiveness of alternative export destinations (e.g. Anderson and van Wincoop, 2003). Exports of country j to another country i are defined analogous to (28)

$$E_{ji} = n_j p_j^{1-\sigma} Y_i \phi_{ij} Q_i^{\sigma-1}. \qquad (32)$$

Putting in (**??**) yields

$$E_{ji} = \frac{Y_i}{\Pi_i} Y_j \phi_{ij} Q_j^{\sigma-1}. \tag{33}$$

Adding bilateral imports (**??**) and exports (**??**) yields, with symmetric bilateral trade freeness,

$$I_{ij} + E_{ji} = Y_j Y_i \phi_{ij} \left(\frac{Q_j^{\sigma-1}}{\Pi_i} + \frac{Q_i^{\sigma-1}}{\Pi_j} \right). \tag{34}$$

From this we get the econometric equation for the bilateral trade-to-GDP ratio

$$\ln \frac{I_{ji} + E_{ij}}{Y_j} = \beta_0 + \beta_1 \ln Y_j + \beta_2 \ln Y_i + \beta_3 \ln \phi_{ij} + \beta_4 \ln \left(\frac{Q_j^{\sigma-1}}{\Pi_i} + \frac{P_i^{\sigma-1}}{\Pi_j} \right) + \varepsilon. \tag{35}$$

Table A.3 reports the results of the first-stage regressions, **Table A.4** the lower part the results of the second stage regressions.

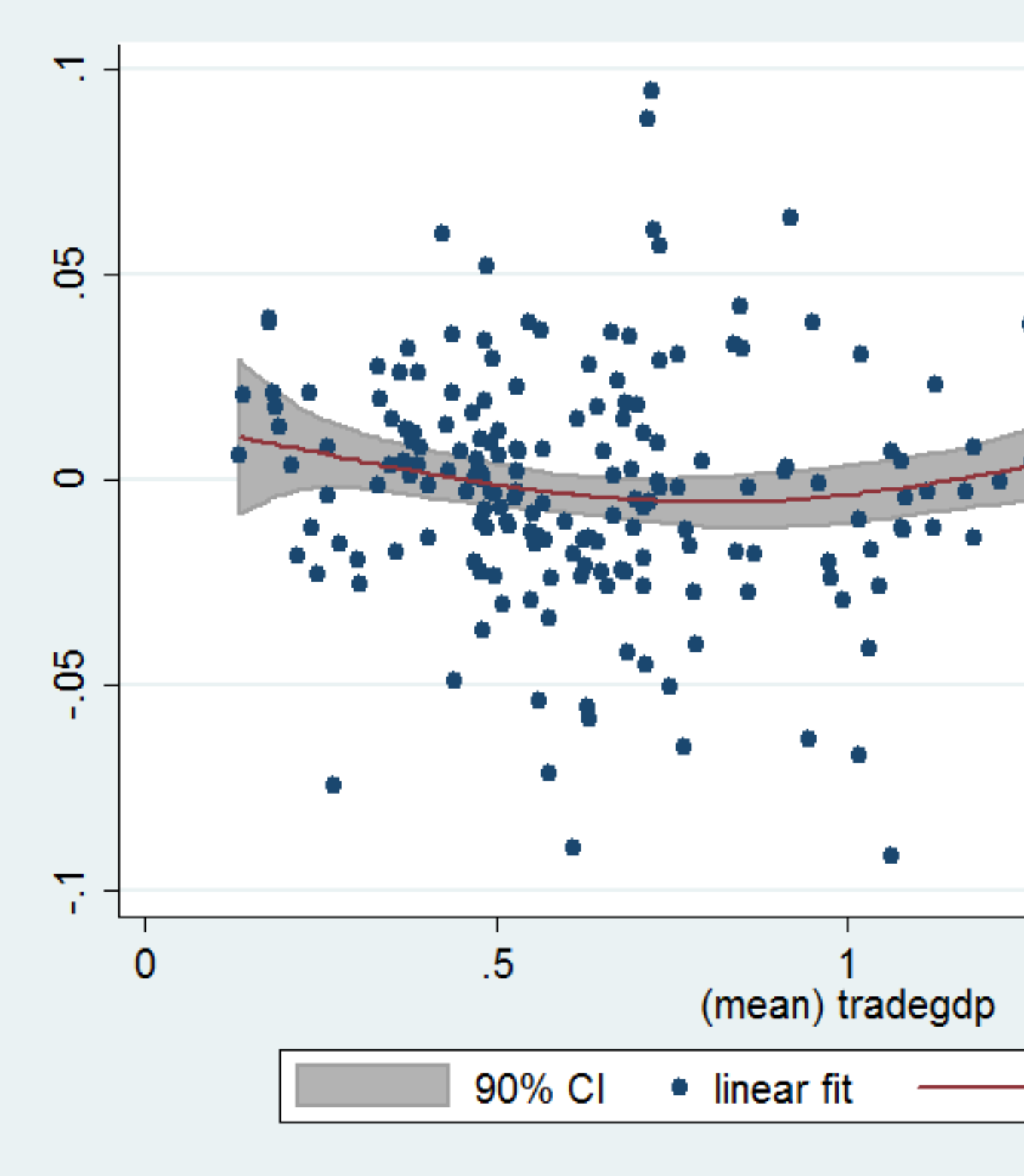


Figure 4: Semiparametric FE panel

Table 14: Interaction effects freeness of trade (cross-section [36] data)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	IV1	IV2	IV3	IV4	IV5	IV6	IV7
VARIABLES	covw	covw	covw	covw	covw	covw	covw
phiness	0.371	0.335	0.340	0.236**	0.0218	-0.107	0.416**
	(0.315)	(0.399)	(0.328)	(0.104)	(0.0714)	(0.169)	(0.175)
loggdppc	0.117	0.304***	0.284**	0.142	0.0644	0.116	0.0666
	(0.182)	(0.115)	(0.111)	(0.165)	(0.219)	(0.198)	(0.212)
loggdppc2	-0.0095	-0.0199***	-0.0189***	-0.0111	-0.0059	-0.0076	-0.0057
	(0.0105)	(0.0065)	(0.0065)	(0.0096)	(0.0124)	(0.0120)	(0.0126)
urban	-0.000921	-0.00193	-0.00212	-0.00163	-0.00148	-0.00164	-0.00181
	(0.00173)	(0.00162)	(0.00144)	(0.00145)	(0.00150)	(0.00177)	(0.00161)
roaddens		-2.89e-05					
		(0.0005)					
popdens			-0.00012*	-7.72e-05			
			(7.08e-05)	(6.49e-05)			
agri					-0.0023		
					(0.0031)		
govsize						-0.0122	0.0006
						(0.0099)	(0.0018)
oecd							0.0186
							(0.0838)
Φ×urban	-0.00329						
	(0.00354)						
Φ×roaddens		-0.0448	-0.0365				
		(0.0777)	(0.0525)				
Φ×popdens				-0.00015			
				(0.00012)			
Φ×agri					0.0224*		
					(0.0124)		
Φ×govsize						0.0127	
						(0.0105)	
Φ×oecd							-0.378**
							(0.189)
Constant, logunits, logarea, logarea/logunits							
Observations	105	83	83	105	103	83	83
R-squared	0.323	0.344	0.362	0.342	0.299	0.292	0.416
F	6.504	6.783	6.761	8.640	5.056	6.697	7.352
rss	2.571	1.554	1.511	2.497	2.616	2.175	1.794
idstat	24.35	7.480	12.53	12.35	13.87	2.217	12.15
idp	8.03e-07	0.00624	0.000401	0.000440	0.000196	0.136	0.000492
widstat	46.07	18.90	30.61	28.21	64.29	0.901	34.11

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A.1: Summary statistics based on cross-section data

Variable	Obs.	Mean	Stand. Dev.	Min.	Max.
Regional inequality	106	0.359	0.191	0.084	1.012
Trade share	106	0.802	0.376	0.219	2.052
Constructed trade share	106	0.634	0.357	0.142	1.753
GDP p.c.	106	7.759	1.581	4.419	10.557
Spatial units	106	2.443	0.653	0.693	4.382
Area	106	12.448	1.600	9.230	16.613
Urbanization	106	56.436	21.657	12.260	97.180
Share agriculture	104	14.181	12.395	.884	51.800
Road density	84	3.527	1.274	0.000	6.195
Government size	84	25.371	9.853	8.335	46.100
Federal dummy	106	0.179	0.385	0.000	1.000
EU dummy	106	0.226	0.420	0.000	1.000

Table A.2: Data sources & definitions

Variable	Definition	Source
Regional inequality	Population-weighted coefficient of variation of regional GDP per capita.	Gennaioli et a
GDP p.c.	GDP per capita in 2005 $ prices.	World Bank (
spatial units	ln of the number of regions considered for the calculation of measures of regional inequality.	Gennaioli et a
area	Ln of area in square kilometers.	World Bank (
trade share	Sum of imports and exports (total trade) as a share of the GDP.	World Bank (
constructed trade share	trade share as estimated based on a gravity model of bilateral trade.	Head et al. (2
urbanization	Share of urban living population in total population.	World Bank (
Share agriculture	Share of agricultural value added in total gross value added.	World Bank (
Road density	Kilometers of paved roads as share of country size.	World Bank (
Government size	Share of government expenditures to GDP.	World Bank (
federal dummy	Dummy for countries with a federal constitution.	Treisman (200

Table A.3: Regional inequality and trade (cross-section, Gennaioli et al. (2013) data)

First stage regression					
	(1)	(2)	(3)	(4)	(5)
	IV1r	IV2r	IV3r	IV4r	IV5r
VARIABLES	tradegdp	tradegdp	tradegdp	tradegdp	tradegdp
hatflowGDP	0.706***	0.746***	0.805***	0.698***	0.671***
	(0.135)	(0.117)	(0.138)	(0.134)	(0.140)
loggdppcc	0.238	0.474**	0.326	0.198	-0.163
	(0.181)	(0.220)	(0.212)	(0.150)	(0.312)
loggdppcc2	-0.0166	-0.0282**	-0.0216*	-0.0140	0.00351
	(0.0109)	(0.0124)	(0.0129)	(0.0092)	(0.0169)
urban		-0.0048*			
		(0.0026)			
roaddens			-0.0001		
			(0.0003)		
popdenssh				-0.00014	
				(9.40e-05)	
agri					-0.0123
					(0.0075)
Constant, logunits, logarea, logarea/logunits					
Observations	101	103	81	102	98
R-squared	0.560	0.578	0.657	0.569	0.583
F	25.95	26.85	34.61	27.61	24.74
Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1					

Table A.4: Regional inequality and trade (cross-section, Gennaioli et al. (2013) data)

VARIABLES	(1) IV1 covw	(2) IV2 covw	(3) IVSh3 covw	(4) IV4 covw	(5) IV5 covw	(6) RobR2 covw
tradegdp	0.163**	0.214**	0.129**	0.182**	0.171**	0.0899**
	(0.0686)	(0.0836)	(0.0628)	(0.0741)	(0.0728)	(0.0422)
loggdppc	0.194**	0.289**	0.184*	0.0410	0.343***	0.198*
	(0.0822)	(0.113)	(0.100)	(0.134)	(0.125)	(0.113)
loggdppc2	-0.0138***	-0.0184***	-0.0128**	-0.0045	-0.0222***	-0.0136**
	(0.00514)	(0.0067)	(0.0063)	(0.0083)	(0.0072)	(0.0067)
urban		-0.0024*				-0.0005
		(0.0013)				(0.0012)
roaddens			-1.17e-05			
			(0.0002)			
popdens				-2.21e-05		
				(4.65e-05)		
agri					0.0026	
					(0.0027)	
Constant, logunits, logarea, logarea/logunits						
Observations	101	103	81	102	98	105
R-squared	0.413	0.346	0.379	0.378	0.370	
F	11.96	9.330	11.07	10.65	7.055	.
rss	1.480	2.042	1.080	1.729	1.655	.
idstat	10.42	11.35	9.113	10.16	11.11	.
idp	0.00125	0.0008	0.0025	0.0014	0.0009	.
widstat	27.55	40.51	34.17	26.93	23.12	.

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A.5: Pooled robust regression - trade to GDP - Lessmann

VARIABLES	(1) Pool2 covw	(2) Pool03 covw	(3) Pool4 covw	(4) Pool5 covw	(5) Pool6 covw	(6) Pool7 covw	(7) Pool8 covw
tradegdp	0.136***	0.237***	0.136***	0.124***	0.203**	0.456***	0.219***
	(0.0325)	(0.0532)	(0.0407)	(0.0374)	(0.0871)	(0.0795)	(0.0724)
loggdppc	0.187***	0.309*	0.0454	0.105	0.333	0.673***	0.343
	(0.0707)	(0.179)	(0.334)	(0.0891)	(0.544)	(0.174)	(0.301)
loggdppc2	-0.0147***	-0.0209*	-0.0068	-0.0108**	-0.0234	-0.0360***	-0.0231
	(0.0042)	(0.0109)	(0.0177)	(0.0049)	(0.0349)	(0.0087)	(0.0171)
urban		-0.00062	-0.00078	-0.0005	-0.0012	-0.0055***	-0.0019
		(0.001)	(0.0006)	(0.0007)	(0.0009)	(0.0017)	(0.0012)
roaddens		-7.86e-05					
		(0.0002)					
popdens			-0.00014				
			(0.0001)				
agri				-0.0041**			
				(0.0017)			
govsize					0.002	-0.0027	0.0021
					(0.0096)	(0.0017)	(0.0021)
oecd						-0.155**	
						(0.0649)	
eu							-0.0466
							(0.0502)
Constant, logunits, logarea, logarea/logunits, time dummies							
Observations	200	75	200	195	115	115	115

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A.6: FE regession - trade to GDP - Lessmann

	(1) FE2	(2) FE3	(3) FE4	(4) FE5	(5) FE6	(6) FE7	(7) FE8
VARIABLES	covw	covw	covw	covw	covw	covw	covw
tradegdp	0.139**	0.117**	0.0447	0.110**	0.107*	0.0415	0.0415
	(0.0537)	(0.0516)	(0.104)	(0.0503)	(0.0548)	(0.0606)	(0.0606)
loggdppc	0.209	0.265**	-0.00441	0.384*	0.229	0.450*	0.450*
	(0.135)	(0.121)	(0.217)	(0.201)	(0.149)	(0.235)	(0.235)
loggdppc2	-0.0116	-0.0150*	0.0049	-0.0229*	-0.0129	-0.0243	-0.0243
	(0.0079)	(0.008)	(0.0172)	(0.0132)	(0.009)	(0.0147)	(0.0147)
urban		-0.00487*	-0.00234	-0.00468*	-0.00643*	-0.0103*	-0.0103*
		(0.00260)	(0.00473)	(0.00260)	(0.00333)	(0.00544)	(0.00544)
roaddens			-0.000271				
			(0.000263)				
popdens				-0.000199			
				(0.000157)			
agri					-0.00179		
					(0.00383)		
govsize						-0.00332*	-0.00332*
						(0.00174)	(0.00174)
Constant, logunits, logarea, logarea/logunits, FE, time dummies							
Observations	200	200	75	200	195	115	115
R-squared	0.468	0.497	0.367	0.507	0.505	0.562	0.562
N	200	200	75	200	195	115	115
F	6.733	6.540	3430	8.867	6.566	5.171	5.171
rss	0.158	0.149	0.00819	0.147	0.146	0.0471	0.0471

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.7: Panel IV - trade to GDP -Lessmann

	(1) FEIV2	(2) FEIV3	(3) FEIV4	(4) FEIV5	(5) FEIV6	(6) FEIV7	(7) FEIV8
VARIABLES	covw	covw	covw	covw	covw	covw	covw
tradegdp	0.385***	0.381***	-0.421	0.381***	0.219**	0.596*	0.596*
	(0.100)	(0.102)	(1.266)	(0.102)	(0.103)	(0.353)	(0.353)
loggdppc	0.241**	0.264**	-0.467	0.311**	0.269**	0.400	0.400
	(0.107)	(0.108)	(1.369)	(0.145)	(0.118)	(0.267)	(0.267)
loggdppc2	-0.0172**	-0.0186**	0.0408	-0.0217**	-0.0167**	-0.0237	-0.0237
	(0.00733)	(0.00725)	(0.104)	(0.00943)	(0.00749)	(0.0179)	(0.0179)
urban		-0.0018	-0.0125	-0.0017	-0.0043*	-0.0006	-0.0006
		(0.0024)	(0.0285)	(0.0024)	(0.0026)	(0.0093)	(0.0093)
roaddens			0.0008				
			(0.0031)				
popdens				-7.55e-05			
				(0.0002)			
agri					-0.00073		
					(0.0027)		
govsize						-0.0002	-0.0002
						(0.0036)	(0.0036)
Constant, logunits, logarea, logarea/logunits, FE, time dummies							
Observations	194	194	73	194	193	113	113
rss	0.216	0.213	0.0227	0.213	0.170	0.135	0.135

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A.8: System GMM - trade to GDP - constructed instrument not used

VARIABLES	(1) SysGMM2 covw	(2) SysGMM3 covw	(3) SysGMM4 covw	(4) SysGMM6 covw	(5) SysGMM7 covw	(6) SysGMM8 covw	(7) SysGMM9 covw
L.covw	0.941***	1.001***	0.922***	0.992***	0.992***	1.042***	0.963***
	(0.0760)	(0.0741)	(0.0611)	(0.0642)	(0.0642)	(0.0804)	(0.0746)
tradegdp	0.0345**	0.108***	0.0388**	0.0295*	0.0295*	0.0358*	0.0190
	(0.0147)	(0.0360)	(0.0169)	(0.0175)	(0.0175)	(0.0212)	(0.0158)
loggdppcc	0.0086	-0.186	-0.0639	0.0123	0.0123	0.0117	-0.0498
	(0.0468)	(0.141)	(0.0593)	(0.0710)	(0.0710)	(0.0947)	(0.0818)
loggdppcc2	-0.0013	0.0094	0.0022	-0.0017	-0.0017	-0.0008	0.0015
	(0.003)	(0.0076)	(0.0032)	(0.0041)	(0.0041)	(0.005)	(0.0044)
urban		0.0031***	0.0013	0.0004	0.0004	-0.00016	0.00105
		(0.0011)	(0.00084)	(0.0008)	(0.0008)	(0.0014)	(0.0011)
roaddens		-0.000211**					
		(9.01e-05)					
popdens			-2.91e-05				
			(1.96e-05)				
govsize				-0.0002	-0.0002	-0.0002	-0.0023***
				(0.0006)	(0.0006)	(0.0007)	(0.0009)
oecd						-0.0236	
						(0.0361)	
eu							0.0586**
							(0.0257)
Constant, time dummies							
Observations	149	63	146	96	96	96	96
ar1p	0.0402	.	0.0697	0.640	0.640	0.797	0.720
ar1	-2.052	.	-1.814	-0.467	-0.467	-0.257	-0.358
ar2p	0.235	.	0.297	0.623	0.623	0.880	0.238
ar2	-1.188	.	-1.042	0.492	0.492	0.151	1.180
hansenp	0.244	0.508	0.932	0.586	0.586	0.600	0.558
sargan	207.7	116.2	241.5	199.5	199.5	184.3	179.1

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A.9: PoolPhi - freeness of trade - Lessmann

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PoolP1	PoolP2	PoolP3	PoolP4	PoolP5	PoolP6	PoolP7	PoolP8
VARIABLES	covw	covw	covw	covw	covw	covw	covw	covw
phiness	0.0782***	0.0855***	0.134***	0.0933***	0.0453	0.110**	0.0934***	0.107***
	(0.0275)	(0.0289)	(0.0365)	(0.0239)	(0.0365)	(0.0510)	(0.0320)	(0.0350)
loggdppc	0.259***	0.318***	0.179	0.197	0.135	0.302	0.330***	0.371***
	(0.0548)	(0.0694)	(0.359)	(0.133)	(0.0963)	(0.526)	(0.0683)	(0.0770)
loggdppc2	-0.0187***	-0.0217***	-0.0149	-0.0152**	-0.0127**	-0.0218	-0.0217***	-0.0249***
	(0.00340)	(0.00400)	(0.0194)	(0.0072)	(0.0052)	(0.0295)	(0.0042)	(0.0044)
urban		-0.0009	0.0008	-0.0004	-0.0006	-0.0005	-0.0012*	-0.0009
		(0.0006)	(0.0017)	(0.0007)	(0.0006)	(0.0011)	(0.0007)	(0.0008)
roaddens			-0.0002					
			(0.0003)					
popdens				-8.99e-05**				
				(4.22e-05)				
agri					-0.0053***			
					(0.002)			
govsize						-0.0002		
						(0.0071)		
oecd							-0.0380	
							(0.0535)	
eu								-0.0497**
								(0.0216)
Constant, logunits, logarea, logare/logunits, time dummies								
Observations	194	194	73	194	189	113	194	194
r2 w	0.774	0.771	0.759	0.786	0.790	0.732	0.759	0.789
r2 rho	0.433	0.439	0.466	0.458	0.446	0.448	0.446	0.449

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Robust regression with outlier detection

Table A.10: FE - freeness of trade - Lessmann

VARIABLES	(1) FEP1 covw	(2) FEP2 covw	(3) FEP3 covw	(4) FEP4 covw	(5) FEP5 covw	(6) FEP6 covw	(7) FEP7 covw	(8) FEP8 covw	(9) FEP9 covw
phiness	0.0690	0.0594	0.0103	0.0103	0.0585	0.0552	0.0390	0.0390	0.0390
	(0.0692)	(0.0602)	(0.0918)	(0.0918)	(0.0594)	(0.0600)	(0.0543)	(0.0543)	(0.0543)
loggdppc	0.187	0.259*	-0.0159	-0.0159	0.395*	0.215	0.493**	0.493**	0.493**
	(0.160)	(0.133)	(0.308)	(0.308)	(0.235)	(0.159)	(0.240)	(0.240)	(0.240)
loggdppc2	-0.0098	-0.0143	0.0061	0.0061	-0.0232	-0.0119	-0.0270*	-0.0270*	-0.0270*
	(0.0093)	(0.0088)	(0.0234)	(0.0234)	(0.0156)	(0.0097)	(0.0153)	(0.0153)	(0.0153)
urban		-0.0057*	-0.0034	-0.0034	-0.0055*	-0.0074**	-0.0106**	-0.0106**	-0.0106**
		(0.0029)	(0.0036)	(0.0036)	(0.0029)	(0.0036)	(0.0053)	(0.0053)	(0.0053)
roaddens			-0.00015	-0.00015					
			(0.00027)	(0.00027)					
popdens					-0.0002				
					(0.0002)				
agri						-0.0022			
						(0.004)			
govsize							-0.0035*	-0.0035*	-0.0035*
							(0.0018)	(0.0018)	(0.0018)
Constant, logunits, logarea, logarea/logunits, two way FE									
Observations	194	194	73	73	194	189	113	113	113
R-squared	0.431	0.472	0.356	0.356	0.484	0.483	0.563	0.563	0.563
rss	0.169	0.156	0.00829	0.00829	0.153	0.152	0.0469	0.0469	0.0469
rmse	0.0304	0.0293	0.0114	0.0114	0.0291	0.0294	0.0214	0.0214	0.0214
r2 w	0.431	0.472	0.356	0.356	0.484	0.483	0.563	0.563	0.563
F	4.921	5.140	15242	15242	7.191	5.250	4.878	4.878	4.878

Robust standard errors in parentheses;** p<0.01, ** p<0.05, * p<0.1

Table A.11: Panel IV - freeness of trade - Lessmann

VARIABLES	(1) PanIVP1 covw	(2) PanIVP2 covw	(3) PanIVP3 covw	(4) PanIVP4 covw	(5) PanIVP5 covw	(6) PanIVP6 covw	(7) PanIVP7 covw	(8) PanIVP8 covw	(9) PanIVP9 covw
phiness	0.171	0.0624	0.0369	0.0369	0.0454	0.0499	0.167*	0.167*	0.167*
	(0.130)	(0.126)	(0.234)	(0.234)	(0.125)	(0.130)	(0.0978)	(0.0978)	(0.0978)
loggdppc	0.226**	0.260**	0.0457	0.0457	0.391***	0.213*	0.598***	0.598***	0.598***
	(0.107)	(0.102)	(0.612)	(0.612)	(0.128)	(0.121)	(0.184)	(0.184)	(0.184)
loggdppc2	-0.0143*	-0.0144*	0.00158	0.00158	-0.0227**	-0.0117	-0.0348***	-0.0348***	-0.0348***
	(0.0084)	(0.008)	(0.0445)	(0.0445)	(0.0094)	(0.0086)	(0.0127)	(0.0127)	(0.0127)
urban		-0.0057***	-0.0035	-0.0035	-0.0055***	-0.0074***	-0.0091**	-0.0091**	-0.0091**
		(0.0018)	(0.005)	(0.005)	(0.0018)	(0.0021)	(0.0045)	(0.0045)	(0.0045)
roaddens			-0.00016	-0.00016					
			(0.0007)	(0.0007)					
popdens					-0.0002*				
					(0.0001)				
agri						-0.0022			
						(0.0025)			
govsize							-0.003	-0.003	-0.003
							(0.00192)	(0.0019)	(0.0019)
Constant, logarea, logarea/logunits, FE, time dummies									
Observations	194	194	73	73	194	189	113	113	113
r2 w	0.405	0.472	0.350	0.350	0.483	0.483	0.506	0.506	0.506
rss	0.176	0.156	0.00837	0.00837	0.153	0.152	0.0530	0.0530	0.0530
F f	31.27	33.86	48.76	48.76	32.51	32.63	29.38	28.52	29.20

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.12: System GMM - freeness of trade - Lessmann

VARIABLES	(1) SysGMMP1 covw	(2) SysGMMP2 covw	(3) SysGMMP3 covw	(4) SysGMMP4 covw	(5) SysGMMP5 covw	(6) SysGMMP6 covw	(7) SysGMMP7 covw	(8) SysGMMP8 covw
L.covw	0.984***	0.903***	1.458***	1.374***	0.907***	0.955***	0.972***	0.979***
	(0.0841)	(0.0421)	(0.160)	(0.116)	(0.0449)	(0.0615)	(0.0599)	(0.0569)
phiness	-0.0087	-0.0011	-0.0133	-0.0044	-0.00546	-0.007	-0.0052	-0.0237
	(0.0186)	(0.0192)	(0.0177)	(0.0147)	(0.0163)	(0.0157)	(0.0165)	(0.0167)
loggdppc	0.0425	0.0422	0.0249	-0.0623	-0.0465	0.0379	0.0369	-0.0672
	(0.0507)	(0.0527)	(0.0587)	(0.0381)	(0.0583)	(0.0679)	(0.0708)	(0.0757)
loggdppc2	-0.003	-0.0036	-0.0014	0.0031	0.0009	-0.0033	-0.0031	0.0026
	(0.0034)	(0.0032)	(0.0033)	(0.0023)	(0.0034)	(0.004)	(0.0039)	(0.0043)
urban		0.0004	-0.00026	0.00035	-8.60e-05	0.0001	9.25e-05	0.0011
		(0.00066)	(0.0007)	(0.0003)	(0.0007)	(0.001)	(0.001)	(0.0011)
L2.covw			-0.429***	-0.411***				
			(0.152)	(0.122)				
roaddens			-9.50e-06					
			(5.15e-05)					
popdens				-1.05e-05				
				(1.15e-05)				
agri					-0.0039**			
					(0.0016)			
govsize						0.0002	0.00025	-0.0024**
						(0.0007)	(0.0006)	(0.0011)
oecd							-0.00293	
							(0.0271)	
eu								0.0776***
								(0.0286)
Constant, logunits, logarea, logarea/logunits, time dummies								
Observations	144	144	50	91	141	94	94	94
ar2	-1.127	-1.129	.	0.141	-1.285	0.585	0.551	1.333
ar2p	0.260	0.259	.	0.888	0.199	0.559	0.582	0.183
ar1	-2.219	-2.331	.	-1.709	-2.370	-1.053	-0.953	-0.765
ar1p	0.0265	0.0198	.	0.0875	0.0178	0.292	0.340	0.444

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A.13: IV regression with lagged GDP

VARIABLES	(1) IVLE1 covw	(2) IVLE2 covw	(3) IVLE3 covw	(4) IVLE4 covw	(5) IVLE5 covw	(6) IVLE9 covw	(7) IVLE10 covw
tradegdp	0.272***	0.305***	0.407***	0.303***	0.274***	0.327***	0.320***
	(0.0446)	(0.0482)	(0.0814)	(0.0452)	(0.0485)	(0.0553)	(0.0524)
loggdppc	0.161**	0.297***	0.307*	0.200**	0.143	0.436***	0.517***
	(0.0672)	(0.0842)	(0.170)	(0.0988)	(0.109)	(0.122)	(0.125)
loggdppc2	-0.0130***	-0.0198***	-0.0199*	-0.0142**	-0.0121**	-0.0277***	-0.0297***
	(0.0041)	(0.0049)	(0.0103)	(0.0057)	(0.006)	(0.0072)	(0.0071)
urban		-0.0026***	-0.0027**	-0.0022**	-0.0029***	-0.0038***	-0.0048***
		(0.00084)	(0.0013)	(0.00091)	(0.00097)	(0.001)	(0.0011)
roaddens			-6.78e-05				
			(0.0002)				
popdensity				-0.0001***			
				(3.04e-05)			
agri					-0.0061***		
					(0.0022)		
govsize						-0.00289*	-0.0023*
						(0.00138)	(0.0012)
oecd							-0.126***
							(0.0332)
Constant, logunits, logarea, logarea/logunits, time dummies							
Observations	194	194	73	194	189	113	113
R-squared	0.646	0.664	0.651	0.680	0.675	0.692	0.723
F	48.49	37.69	12.24	35.65	35.07	22.99	23.04
rss	2.171	2.061	1.055	1.963	1.937	1.287	1.155
idstat	44.38	46.42	22.18	46.44	41.62	32.56	33.84
idp	0	0	2.48e-06	0	1.11e-10	1.16e-08	5.98e-09
widstat	451.5	384.5	126.8	383.8	318.7	245.7	254.6

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1